The Crew

The prime crew consists of John Young, Commander, Charlie Duke, LM pilot, and Ken Mattingly, CM pilot. Young was the pilot with Gus Grissom on the first manned Gemini flight almost exactly 7 years ago. A year later, he was command pilot on Gemini 10 with Mike Collins as the pilot. For Apollo missions, he was backup CM pilot on Apollo 7, CM pilot on 10, and backup commander on 13. Duke served as backup LM pilot for Apollo 13. Ken Mattingly was the CM pilot on Apollo 13. Because of exposure to German measles, Ken was removed from flight status on that mission only a few days before launch.

The Apollo 16 backup crew consists of Fred Haise, Commander, Stu Roosa, CM pilot, and Ed Mitchell, LM pilot. Several photographs of the prime and backup crews are shown in figures 79 through 86.

This crew, like previous ones has undergone intensive training during the past few months and somewhat more casual training during the last few years. In addition to the many exercises needed to learn to fly proficiently their spacecraft, the astronauts have learned much about science, and in particular, about lunar science. After all, they will each spend many hours on the Moon or in orbit around the Moon performing scientific research.

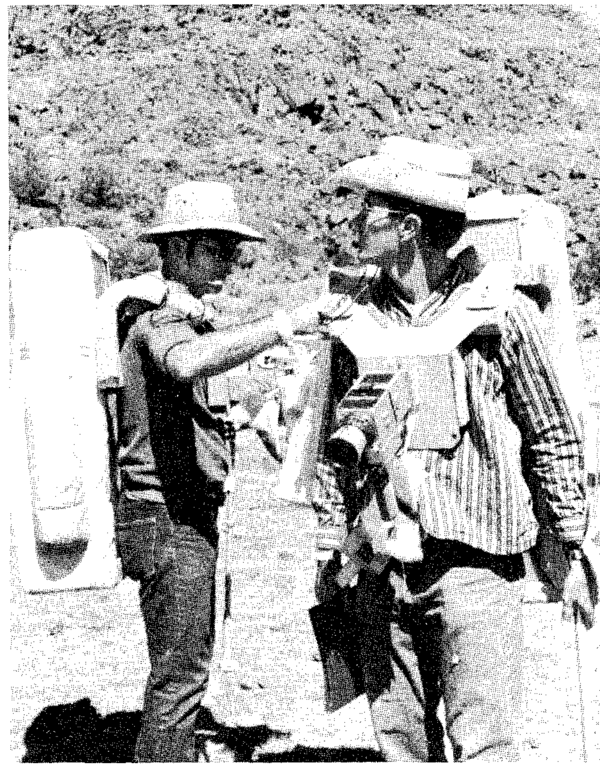

FIGURE 80.—Astronauts John Young and Charlie Duke. They are shown here on a geology training trip to Taos, New Mexico. Note the hand tools and the microphones. Their observations are recorded on tape recorders and later analyzed to improved their powers of observation and techniques of reporting. The rocks in the background are basalts. NASA PHOTO S-71-51605.

FIGURE 79.—Astronauts John Young and Charlie Duke. Young holds a sample bag while Duke practices with the scoop. Note the gnomon. The backpacks simulate PLSS's. The cameras and tools are very similar to the flight articles. Note the layers in the distant wall. These layers are basalt flows. NASA PHOTO S-71-49398.

The surface astronauts have had tutorial sessions with many of the nation's best scientists. They are able to set up experiments, such as those of

FIGURE 81.—The Rio Grande Gorge near Taos, New Mexico. This photograph symbolizes the beauty of the American West. The rocks are basalt. At one time in the past, they were continuous across the gorge. The steady erosion by the flowing water, now seen far below the surface, has cut the valley. Astronaut Charlie Duke is studying the geology. The horizon isn't really curved—the wide angle photographic lens produced this effect. NASA PHOTO S-71-51613.

FIGURE 82.—Astronauts Fred Haise and Ed Mitchell. Haise is about to shoot a series of photographs to document the sample to be collected. Mitchell is setting the gnomon in place. The rock on the surface and exposed in the walls of the Rio Grande gorge is basalt. If you look closely at the photograph you can see some holes in the rocks caused by gas when the rock was liquid. These holes are called vesicles and have an entirely different origin from the zap pits in lunar rocks. Some lunar rocks also contain vesicles as well as zap pits. NASA PHOTO S-71-49406.

FIGURE 83.—Fred and Ed meet a geological problem. Before each field exercise, several experienced geologists prepare maps in minute detail. Between the time that the maps were prepared for this exercise and the time they were used, this thin basalt flow, in Hawaii in September 1971, covered a part of the area. So the flow was not shown on the map. The astronauts recognized the flow, corrected the map and proceeded with the day's training. NASA PHOTO S-72-16313.

FIGURE 84.—Astronauts John Young and Charlie Duke. Young is shooting a picture of the distant wall of the Rio Grande gorge near Taos, New Mexico with the 500 mm telephoto lens on the Hasselblad camera. The rocks exposed in the walls of the gorge are basalts. I believe they are similar to the ones that Young and Duke will collect at the Descartes site. The piles of loose and broken rocks that you see here at the foot of the walls are called talus, a term that you may hear during the 16 misson. The curved horizon is an optical effect of the wide angle lens used by A. Patnesky to take this photograph. NASA PHOTO S–71–51614.

FIGURE 85.—Astronaut Stu Roosa. Even though the CM pilot will not examine rocks on the Moon's surface, an understanding of geology is absolutely essential. Roosa is shown here studying intensely a piece of basalt. This picture, taken in Iceland four years ago, indicates the long and continued effort of the crew to learn as much as possible about the science which they will be doing on the mission. The hand lens, probably 10X, allows him to see more clearly the individual crystals and to recognize them. NASA PHOTO S–67–38510.

FIGURE 86.—Astronauts Ken Mattingly and Neil Armstrong. They are shown studying geology in Iceland about four years ago. Note the geologic hammer carried by Mattingly. NASA PHOTO S-67-38609.

ALSEP, but more importantly, they understand the scientific purposes behind the various experiments.

Most of the time on the lunar surface during Apollo 16 will be spent observing geologic features and collecting samples. Obviously anyone can pick up rocks with which to fill boxes and bags. Only a person highly trained in the geosciences, however, can properly select those few rocks, from many, that are likely to yield the greatest scientific return when examined in minute detail in the laboratory back on Earth. The Apollo 16 crew has spent many hours studying rocks under the guidance of geologists from the U.S. Geological Survey, several universities, and NASA's Manned Spacecraft Center.

Bibliography

This bibliography is not intended to be extensive. It is a guide to simply-written, and mostly inexpensive, books that I believe useful for additional reading. I have included a few references to more advanced material.

Alter, Dinsmore, editor, *Lunar Atlas*, Dover Publications, Inc., New York, 1968. Excellent and very inexpensive. Contains many photographs of various features on the Moon. Strongly recommended for the interested layman. Paperbound, $5.00.

American Association for the Advancement of Science, Washington, D.C., *Apollo 11 Lunar Science Conference*, McCall Printing Company, 1970. Historic milepost in lunar science. Contains the first public release of information obtained on the Apollo 11 samples by several hundred scientists. Written for fellow scientists. Obtain from AAAS, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005, Hardback $14.00, Paperback $3.00.

Baldwin, Ralph B., *The Measure of the Moon*, The University of Chicago Press, 1963. Exhaustive study of the Moon. Important summary of knowledge of the Moon that existed before the lunar flights began. Although in places, the reading may be a little difficult, it is generally accessible to the layman, $13.50.

Cortright, Edgar M., ed., *Exploring Space with a Camera*, NASA SP–168, NASA, Washington, D.C. Inexpensive. Contains many beautiful photographs obtained from space. Well worth the small investment for the layman with even mild interest in space. Government Printing Office, Washington, D.C., $4.25.

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Hess, Wilmot, Robert Kovach, Paul W. Gast and Gene Simmons, *The Exploration of the Moon*, Scientific American, Vol. 221, No. 4, October 1969, pp. 54–72. General statement of plans for lunar exploration. Written before first lunar landing. Suitable for layman. The authors were all instrumental in planning the lunar surface scientific operations of the Apollo program. Reprint available from W. H. Freeman and Company, 600 Market St., San Francisco, Calif. 94104, 25¢ postage paid.

Jastrow, Robert, *Red Giants* and *White Dwarfs*, Harper and Row, 1967, 176 pp., $5.95. Very readable story of the evolution of stars, planets, and life.

Kopal, Zdenek, *An Introduction to the Study of the Moon*, Gordon and Breach, New York, N.Y., 1966. For the mathematically inclined person, this book is an excellent introduction.

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Levinson, A. A., editor, *Proceedings of the Second Lunar Science Conference*, 1971. Very extensive coverage. Good source of advanced material. Intended for fellow scientists. The MIT Press, Cambridge, Mass., 3 volumes, $70.

Levinson, A. A., editor, *Proceedings of the Apollo 11 Lunar Science Conference*, 1970. Extensive coverage of the first public release of information obtained from Apollo 11. Advanced. Intended for fellow scientists. Pergamon Press, 3 Volumes.

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Mason, Brian and W. G. Melson, *The Lunar Rocks*, 1970. Suitable for those with some familiarity with science. J. Wiley and Sons, 179 pp.

McGraw-Hill *Encyclopedia of Space*, 1967. Easy to read. Profusely illustrated. Excellent source of information written in an easy-to-read style. Covers unmanned and manned space exploration, 831 pp., $27.50.

Mutch, Thomas A., *Geology of the Moon*, A Stratigraphic view, Princeton University Press, Princeton, New Jersey, 1970. Excellent introduction to lunar geology. Written before Apollo 11 landing but still quite current. Previous geological training not necessary. $17.50.

NASA, *Ranger IX Photographs of the Moon*, NASA SP–112, NASA, Washington, D.C., 1966. Beautiful close-up photographs of the Moon, obtained on the final mission of the Ranger series, U.S. Government Printing Office, Washington, D.C., $6.50.

NASA, *Earth Photographs from Gemini VI through XII*, NASA SP–171, NASA, Washington, D.C., 1968. Contains many beautiful photographs of the Earth from space. In color. U.S. Government Printing Office, Washington, D.C., $8.00.

NASA, *Surveyor Program Results*, NASA SP–184, NASA, Washington, D.C., 1969. Final report of the results obtained in the Surveyor Program. Surveyor was the first soft-landed spacecraft on the Moon and provided many important data. Because only one of the Surveyor sites has been revisited, the data given in this book are very important to our current understanding of the Moon. Part is easily readable by the layman; some is more difficult. U.S. Government Printing Office, Washington, D.C., $4.75.

Scientific American. Several articles on the scientific findings of lunar research have appeared in the past two years. They are accurate, informative, and written in easy-to-read style. Copies of each article may be obtained for 25¢. I suggest you see the magazine index for articles on the Moon.

Shelton, W.R., *Man's Conquest of Space*, 1968. Beautifully illustrated overview of space exploration. National Geographic Soc., 200 pp., $4.25.

Wood, John A., *Meteorites and the Origin of Planets*, 1968. Inexpensive. Suitable for layman. Good introduction to meteorites, McGraw-Hill Book Company.

NASA PICTURE SETS

The picture sets described below are available, at prices quoted, from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

NASA Picture Set No. 1 Apollo—"In the Beginning . . ."—Seven 11″ x 14″ color lithographs that illustrate highlights from the Apollo 8, 9 and 10 missions. $1.25 per set.

NASA Picture Set No. 2 Men of Apollo.—Five 11″ by 14″ color lithographs that include portraits of the crews of Apollo 7, 8, 9, 10 and 11. $1.00 per set.

NASA Picture Set No. 3 Eyewitness to Space.—Twelve 16″ x 20″ color lithographs that reproduce the paintings of space program scenes by artists Mitchell Jamieson, Peter Hurd, James Wyeth, Lamar Dodd, George Weymouth, Nicholas Solovioff, Hugh Laidman, Fred Freeman, Billy Morrow Jackson, Paul Calle and Frank McMahon. $2.75 per set.

NASA Picture Set No. 4 First Manned Lunar Landing.—Twelve 11″ x 14″ color lithographs depict the historic journey of Apollo 11, man's first visit to another celestial body. $1.75 per set.

NASA Picture Set No. 5 Man on the Moon.—One 16″ x 20″ color lithograph that best illustrates man's moment of success, the first step in his conquest of space. $1.00 per copy.

NASA Picture Set No. 6 Apollo 12—Pinpoint Landing on the Moon.—Eight 11″ x 14″ color lithographs and two 11″ x 14″ black and white lithographs illustrating man's return to the Moon. $1.50 per set.

NASA EDUCATIONAL PUBLICATIONS

NASA publications in the EP (for educational publications) series have included several dealing with the Apollo program and Apollo flights. Titles listed below may be ordered from the Superintendent of Documents, Government Printing Office, Washington D.C., 20402.

EP–70 Mission Report/Apollo 10.—The Apollo mission took two astronauts to within 50,000 feet of the lunar surface in a full dress rehearsal of the Apollo 11 lunar landing. This booklet describes that mission as the final test of all elements of the Apollo system. In full color. 12 pages. 35 cents.

EP–71 "In This Decade . . ." Mission to the Moon.—This "pre-launch" booklet outlines the complex steps leading to a manned lunar landing. The many and varied areas of research and development conducted by the National Aeronautics and Space Administration are illustrated. In color. 48 pages. $1.25.

EP–72 Log of Apollo 11.— The greatest voyage in the history of mankind, the journey of Apollo 11, is documented in this booklet. In color. 12 pages. 35 cents.

EP–73 The First Lunar Landing/As Told by the Astronauts.—The Apollo 11 postflight press conference is recorded in the astronauts' own words. They describe the history-making mission and answer reporters' questions. 24 pages. 75 cents.

EP–74 Apollo 12/A New Vista for Lunar Science.—The mission described as ". . . a thousand, maybe even a million times more important than Apollo 11", is shown as a significant addition to man's knowledge of the universe. 20 pages. 65 cents.

EP–76 Apollo 13. "Houston, We've Got a Problem."—Failure of one of Apollo 13's oxygen tanks made it necessary to continue flight in an emergency mode to and around the Moon, and back to splashdown in the Pacific Ocean. The story of this dramatic flight is told mainly in excerpts from the conversations between the astronauts and Mission Control. 25 pages. 75 cents.

EP–91 Apollo 14: Science at Fra Mauro.—Exploration of the upland Fra Mauro area of the Moon incorporated the most extensive scientific observations in manned lunar exploration up to that time. The story is presented in text, a traverse map and spectacular color photographs. The Fra Mauro area is believed to hold debris hurled out of the Moon's interior by the massive impact of an object from space. 48 pages. $1.25.

EP–94 Apollo 15 At Hadley Base.—The flight of Endeavour and Falcon to the Apennine Mountain area. The ability of the Apollo 15 astronauts to explore was significantly enhanced by the use of a Lunar Roving Vehicle. The story is presented in text and full color pictures. 32 pages. 75 cents.

Glossary

ALBEDO *al-beé-doh*	Relative brightness. It is the ratio of the amount of electromagnetic radiation reflected by a body to the amount of incident radiation.
ALPHA PARTICLE	A positive particle consisting of 2 protons and 2 neutrons. It is the nucleus of a helium atom.
ANGSTROM UNIT *anǵ-strom*	A unit of length equal to 10^{-10} meters or 10^{-4} microns. It is approximately four-billionths of an inch. In solids, such as salt, iron, aluminum, the distance between atoms is usually a few Angstroms.
APERTURE *á-per-ture*	A small opening such as a camera shutter through which light rays pass to expose film when the shutter is open.
ATTENUATION *a-teń-u-eh-shun*	Decrease in intensity usually of such wave phenomena as light or sound.
BASALT *baá-salt*	A type of dark gray rock formed by solidification of molten material. The rocks of Hawaii are basalts.
BISTATIC RADAR *bí-sta-tic raý-dar*	The electrical properties of the Moon's surface can be measured by studying the characteristics of radio waves reflected from the Moon. If the radio transmitter and receiver are located at the same place, the term monostatic radar is used. If they are located at different places, then bistatic is used. In the study of the Moon with bistatic radar, the transmitter is aboard the CSM and the receiver is on the Earth.
BRECCIA *brech́-ya*	A coarse-grained rock composed of angular fragments of pre-existing rocks.
BOUNDARY LAYER	The interaction layer between the solar wind bow shock and the magnetopause. (See text and figure 76.)
BOW SHOCK	The shock wave produced by the interaction of the solar wind with the Earth's magnetosphere. (See text and figure 76.)
CARTOGRAPHY	The production and science of accurately scaled maps.
CASSETTE *kuh-seí*	Photographic film container.
CISLUNAR *sís-lune-ar*	Pertaining to the space between the Earth and Moon or the Moon's orbit.
COLLIMATOR	A device for producing beams of parallel rays of light or other electromagnetic radiation.
COLORIMETRIC *kol-i-má-ter*	Pertaining to the measurement of the intensities of different colors as of lunar surface materials.
COSMIC RAYS *koś-mik*	Streams of very high energy nuclear particles, commonly protons, that bombard the Earth and Moon from all directions.
COSMOLOGY *kos-mol-uh-gee*	Study of the character and origin of the universe.
CRATER *craý-ter*	A naturally occurring hole. On Earth, a very few craters are formed by meteorites striking the Earth; most are caused by volcanoes. On the Moon, most craters were caused by meteorites. Some lunar craters were apparently formed by volcanic processes. In the formation of lunar craters, large blocks of rock (perhaps as large as several hundred meters across) are thrown great distances from the crater. These large blocks in turn from craters also—such craters are termed secondary craters.
CROSS-SUN	A direction approximately 90 degrees to the direction to the Sun and related to lunar surface photography.
CROSSTRACK	Perpendicular to the instantaneous direction of a spacecraft's ground track.
CRYSTALLINE ROCKS	Rocks consisting wholly or chiefly of mineral crystals. Such rocks on the Moon are usually formed by cooling from a liquid melt.
DIELECTRIC *dyé-ee-lek-trik*	A material that is an electrical insulator. Most rocks are dielectrics.

DIURNAL *dye-eŕr-nal*
: Recurring daily. Diurnal processes on Earth repeat themselves every 24 hours but on the Moon repeat every 28 Earth days. The length of a lunar day is 28 Earth days.

DOPPLER TRACKING *doṕp-lur*
: A system for measuring the trajectory of spacecraft from Earth using continuous radio waves and the Doppler effect. An example of the Doppler effect is the change in pitch of a train's whistle and a car's horn on passing an observer. Because of this effect, the frequency of the radio waves received on Earth is changed slightly by the velocity of the spacecraft in exactly the same way that the pitch of a train's whistle is changed by the velocity of the train.

DOWN-SUN
: In the direction that is directly away from the Sun and related to lunar surface photography.

EARTHSHINE
: Illumination of the Moon's surface by sunlight reflected from the Earth. The intensity is many times smaller than that of the direct sunlight.

ECLIPTIC PLANE *ee-kliṕ-tik*
: The plane defined by the Earth's orbit about the Sun.

EFFLUENT *eff-flu-ent*
: Any liquid or gas discharged from a spacecraft such as waste water, urine, fuel cell purge products, etc.; also any material discharged from volcanoes.

EGRESS *eé-gress*
: A verb meaning to exit or to leave. The popularization of this word has been attributed to the great showman, P. T. Barnum, who reportedly discovered that a sign marked exit had almost no effect on the large crowds that accumulated in his exhibit area but a sign marked "to egress" led the crowds outdoors. In space terminology it means simply to leave the spacecraft.

EJECTA *ee-jek-tuh*
: Lunar material thrown out (as resulting from meteoroid impact or volcanic action).

ELECTRON *ee-lek-tron*
: A small fundamental particle with a unit of negative electrical charge, a very small mass, and a very small diameter. Every atom contains one or more electrons. The *proton* is the corresponding elementary particle with a unit of positive charge and a mass of 1837 times as great as the mass of the electron.

EXOSPHERE
: The outermost portion of the Earth's or Moon's atmosphere from which gases can escape into outer space.

FIELD
: A region in which each point has a definite value such as a magnetic field.

FIELD OF VIEW
: The region "seen" by the camera lens and recorded on the film. The same phrase is applied to such other equipment as radar and radio antennas.

FILLET *fiĺl-it*
: Debris (soil) piled against a rock; several scientists have suggested that the volume of the fillet may be directly proportional to the time the rock has been in its present position and to the rock size.

FLUORESCENCE *flur-eś-ence*
: Emission of radiation at one wavelength in response to the absorption of energy at a different wavelength. Some lunar materials fluoresce. Most do not. The process is identical to that of the familiar fluorescent lamps.

FLUX
: The rate of flow per unit area of some quantity such as the flux of cosmic rays or the flux of particles in the solar wind.

FRONT
: The more or less linear outer slope of a mountain range that rises above a plain or plateau. In the U.S., the Colorado Front Range is a good example.

GALACTIC *ga-laḱ-tik*
: Pertaining to a galaxy in the universe such as the Milky Way.

GAMMA
: A measure of magnetic field strength; the Earth's magnetic field is about 50,000 gamma. The Moon's magnetic field is only a few gamma.

GAMMA-RAY
: One of the rays emitted by radioactive substances. Gamma rays are highly penetrating and can traverse several centimeters of lead.

GARDENING
: The overtu'rning, reworking, and changing of the lunar surface due to such processes as meteoroid impact, volcanic action, aging and such.

GEGENSCHEIN *geǵ-en-schine*
: A faint light covering a 20-degree field-of-view projected on the celestial sphere about the Sun-Earth vector (as viewed from the dark side of the Earth).

GEOCHEMICAL GROUP
: A group of three experiments especially designed to study the chemical composition of the lunar surface remotely from lunar orbit.

GEODESY *gee-odd́-eh-see*
: Originally, the science of the *exact* size and shape of the Earth; recently broadened in meaning to include the Moon and other planets.

GEOPHONE
: A small device implanted in the lunar surface during the deployment of the ASE to detect vibrations of the Moon from artificial and natural sources.

GEOPHYSICS *gee-oh-phýs-ics*
: Physics of planetary bodies, such as the Earth and Moon, and the surrounding environment; the many branches include gravity, magnetism, heat flow, seismology, space physics, geodesy, meteorology, and sometimes geology.

GNOMON *know-mon*	A rod mounted on a tripod in such a way that it is free to swing in any direction and indicates the local vertical; it gives Sun position and serves as size scale. Color and reflectance scales are provided on the rod and a colorimetric reference is mounted on one leg.
GRADIENT *graý-dee-unt*	The rate of change of something with distance. Mathematically, it is the space rate of change of a function. For example, the slope of a mountain is the gradient of the elevation.
IMBRIAN AGE	Two methods of measuring age on the Moon are used. One provides the absolute age, in years, and is based on radioactivity. The other gives only *relative* ages. A very old event on the Moon is that which produced the Imbrium basin. The age of other geologic features can be determined with respect to the Imbrium event.
INGRESS *iń-gress*	A verb meaning to enter. It is used in connection with entering the LM. See also "egress."
IN SITU *in-site-u*	Literally, "in place", "in its original position". For example, taking photographs of a lunar surface rock sample "in situ" (as it lies on the surface).
LIMB	The outer edge of the apparent disk of a celestial body, as the Moon or Earth, or a portion of the edge.
LITHOLOGY	The character of a rock formation.
LUNATION	One complete passage of the Moon around its orbit.
MANTLE	An intermediate layer of the Moon between the outer layer and the central core.
MARE *maár-ray*	A large dark flat area on the lunar surface (Lunar Sea). May be seen with the unaided eye.
MARIA *maaŕ-ya*	Plural of mare.
MASCONS *mass-conz*	Large mass concentrations beneath the surface of the Moon. They were discovered only three years ago by changes induced by them in the precise orbits of spacecraft about the Moon.
MASS SPECTROMETER *mass spek-troḿ-a-tur*	An instrument which distinguishes chemical species in terms of their different isotopic masses.
METEORITE *me-te-oh-rite*	A solid body that has arrived on the Earth or Moon from outer space. It can range in size from microscopic to many tons. Its composition ranges from that of silicate rocks to metallic iron-nickel. For a thorough discussion see *Meteorites* by Brian Mason, John Wiley and Sons, 1962.
METRIC PHOTOGRAPHY	Recording of surface topography by means of photography, together with an appropriate network of coordinates, to form the basis of accurate measurements and reference points for precise photographic mapping.
MICROSCOPIC	Of such a size as to be invisible to the unaided eye but readily visible through a microscope.
MINERALOGY	The science of minerals; deals with the study of their atomic structure and their general physical and chemical properties.
MONOPOLE *moń-oh-pole*	All known magnets have two poles, one south pole and one north pole. The existence of a single such pole, termed a monopole, has not yet been established but is believed by many physicists to exist on the basis of theoretical studies. Lunar samples have been carefully searched on Earth for the presence of monopoles.
MORPHOLOGY *mor-fol-uh-ge*	The external shape of rocks in relation to the development of erosional forms or topographic features.
MOULTON POINT	A theoretical point along the Sun-Earth line located 940,000 statute miles from the Earth at which the sum of all gravitational forces is zero.
NADIR	That point on the Earth (or Moon) vertically below the observer.
NAUTICAL MILE	It is 6,280 feet—19% larger than a "regular" mile.
NEUTRON	An uncharged elementary particle that has a mass nearly equal to that of a proton and is present in all known atomic nuclei except hydrogen.
OCCULTATION *ah-cull-taý-shun*	The disappearance of a body behind another body of larger apparent size. For example the occultation of the Sun by the Moon as viewed by an Earth observer to create a solar eclipse.
OZONE *oh-zone*	Triatomic oxygen (O_3); found in significant quantities in the Earth's atmosphere.
P-10	A gas mixture consisting of 90 percent argon, 9.5 percent carbon dioxide, and 0.5 percent helium used to fill the X-ray detectors of the X-Ray Fluorescence Experiment.
PANORAMA	A series of photographs taken from a point to cover 360 degrees around that point.

PENUMBRA
pe-nuḿ-bra
The part of a shadow in which the light (or other rays such as the solar wind) is only partially masked, in contrast to the umbra in which light is completely masked, by the intervening object.

PETROGRAPHY
Systematic description of rocks based on observations in the field (e.g. on the Moon), on returned specimens, and on microscope work.

PHOTOMULTIPLIER TUBE
An electron tube that produces electrical signals in response to light. In the tube, the signal is amplified to produce a measureable output current from very small quantities of light.

PLASMA
A gas composed of ions, electrons, neutral atoms and molecules. The interactions between particles is mainly electromagnetic. Although the individual particles are electrically positive or negative, the gas as a whole is neutral.

POSIGRADE
Lunar orbital motion in the direction of lunar rotation.

PRIMORDIAL
pry-moŕ-dee-uhl
Pertaining to the earliest, or original, lunar rocks that were created during the time between the initial and final formation stages of the Moon.

PROTON
The positively charged constituent of atomic nuclei.

RADON
Isotopes of a radioactive gaseous element with atomic number 86 and atomic masses of 220 and 222 formed by the radioactive decay of radium.

RAY
Bright material that extends radially from many craters on the Moon; believed to have been formed at the same time as the associated craters were formed by impacting objects from space; usually, but not always, arcs of great circles. They may be several hundred kilometers long.

REGOLITH
reǵ-oh-lith
The unconsolidated residual material that resides on the solid surface of the Moon (or Earth).

RETROGRADE
Lunar orbital motion opposite the direction of lunar rotation.

RILLE/RILL
A long, narrow valley on the Moon's surface.

RIM
Elevated region around craters and rilles.

SAMPLE
Small quantities of lunar soil or rocks that are sufficiently small to return them to Earth. On each mission several different kinds of samples are collected. Contingency sample consists of 1 to 2 pounds of rocks and soil collected very early in the surface operations so that at least some material will have been returned to Earth in the event that the surface activities are halted abruptly and the mission aborted. Documented sample is one that is collected with a full set of photographs to allow positive identification of the sample when returned to Earth with the sample in situ together with a complete verbal description by the astronaut. Comprehensive sample is a documented sample collected over an area of a few yards square.

S-BAND
A range of frequencies used in radar and communications that extends from 1.55 to 5.2 kilomegahertz.

SCARP
A line of cliffs produced by faulting or erosion.

SEISMIC
sizé-mik
Related to mechanical vibration within the Earth or Moon resulting from, for example, impact of meteoroids on the surface.

SHOCKED ROCKS
Rocks which have been formed by or subjected to the extremes of temperature and pressure from impacts.

SOLAR WIND
Streams of particles (mostly hydrogen and helium) emanating from and flowing approximately radially outward from the Sun.

SPATIAL
Pertaining to the location of points in three-dimensional space; contrasted with temporal (pertaining to time) locations.

SPECTROMETER
An instrument which separates radiation into energy bands (or, in a mass spectrometer, particles into mass groups) and indicates the relative intensities in each band or group.

SPUR
A ridge of lesser elevation that extends laterally from a mountain or mountain range.

STELLAR
Of or pertaining to stars.

STEREO
A type of photography in which photographs taken of the same area from different angles are combined to produce visible features in three-dimensional relief.

SUPPLEMENTARY SAMPLE STOP
A stop added to a traverse after the stations are numbered. Mission planning continues through launch and the supplementary sample stops are inserted between normal traverse stations.

SUPRATHERMAL
souṕ-rah-therḿ-al
Having energies greater than thermal energy.

SUBSATELLITE
A small unmanned satellite, deployed from the spacecraft while it is in orbit, designed to obtain various types of solar wind, lunar magnetic, and S-band tracking data over an extended period of time.

TALUS
taíl-us
Rock debris accumulated at the base of a cliff by erosion of material from higher elevation.

TEMPORAL	Referring to the passage or measurement of time.
TERMINATOR *term-ugh-nay-tor*	The line separating the illuminated and the darkened areas of a body such as the Earth or Moon which is not self-luminous.
TERRA *terr-ugh*	Those portions of the lunar surface other than the maria; the lighter areas of the Moon. They are visible to the unaided eye.
TIDAL	Referring to the very small movement of the surface of the Moon or the Earth due to the gravitational attraction of other planetary bodies. Similar to the oceanic tides, the solid parts of the Earth's crust rise and fall twice daily about three feet. Lunar tides are somewhat larger. The tides of solid bodies are not felt by people but are easily observed with instruments.
TIMELINE	A detailed schedule of astronaut or mission activities indicating the activity and time at which it occurs within the mission.
TOPOGRAPHIC *Top-oh-grá-fick*	Pertaining to the accurate graphical description, usually on maps or charts, of the physical features of an area on the Earth or Moon.
TRANSEARTH	During transit from the Moon to the Earth.
TRANSIENT	A short lived event that does not repeat at regular intervals, often occurring in a system when first turned-on and before reaching operating equilibrium. For example, the initial current surge that occurs when an electrical system is energized.
TRANSLUNAR	During transit from the Earth to the Moon.
TRANSPONDER *Trans-pón-der*	A combined receiver and transmitter whose function is to transmit signals automatically when triggered by a suitabl esignal. Those used in space are sensitive to radio signals.
UMBRA *um-bruh*	The dark central portion of the shadow of a large body such as the Earth or Moon. Compare penumbra.
UP-SUN	Into the direction of the Sun and related to lunar surface photography.
URANIUM *your-raiń-nee-um*	One of the heavy metallic elements that are radioactive.
VECTOR	A quantity that requires both magnitude and direction for its specification, as velocity, magnetic force field and gravitational acceleration vectors.
WAVELENGTH	The distance between peaks (or minima) of waves such as ocean waves or electromagnetic waves.
X-RAY	Electromagnetic radiation of non-nuclear origin within the wavelength interval of 0.1 to 100 Angstroms (between gamma-ray and ultra-violet radiation). X-rays are used in medicine to examine teeth, lungs, bones, and other parts of the human body; they also occur naturally.
ZODIACAL LIGHT *zo-dié-uh-cal*	A faint glow extending around the entire zodiac but showing most prominently in the neighborhood of the Sun. (It may be seen in the west after twilight and in the east before dawn as a diffuse glow. The glow may be sunlight reflected from a great number of particles of meteoritic size in or near the ecliptic in the planetoid belt).

Acronyms and Abbreviations

ALSD	Apollo Lunar Surface Drill
ALHT	Apollo Lunar Hand Tools
ALHTC	Apollo Lunar Hand Tool Carrier
ALSEP	Apollo Lunar Surface Experiments Package
ALSRC	Apollo Lunar Sample Return Container (Rock Box)
AMU	Atomic Mass Unit
ASE	Active Seismic Experiment
BLSS	Buddy Secondary Life Support System
BW	Black and White
CAPCOM	Capsule Communicator, the single individual on Earth who talks directly with the crew
CCIG	Cold Cathode Ion Gauge
CM	Command Module
CSM	Command and Service Module
CDR	Commander
CRD	Cosmic Ray Detector
C/S	ALSEP Central Station
CSVC	Core Sample Vacuum Container
DAC	Data Acquisition Camera
DPS	Descent Propulsion System
DOI	Descent Orbit Insertion
DSEA	Data Storage Electronics Assembly
ETB	Equipment Transfer Bag
EVA	Extravehicular Activity
FMC	Forward Motion Compensation
FOV	Field of View
FWD	Forward
GASC	Gas Analysis Sample Container
GCTA	Ground-Commanded Television Assembly
GET	Ground Elapsed Time
GMT	Greenwich Mean Time
GLA	Grenade Launch Tube Assembly
GN_2	Gaseous Nitrogen
HBW	High-Speed Black and White
HCEX	High-Speed Color Exterior
HEC	Hasselblad Electric Camera
HEDC	Hasselblad Electric Data Camera
HFE	Heat Flow Experiment
IMC	Image Motion Compensation
IR	Infrared
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
LBW	Low-Speed Black and White
LCRU	Lunar Communications Relay Unit
LDD	Lunar Dust Detector
LESC	Lunar Environment Sample Container
LDAC	Lunar Surface 16-mm Data Acquisition Camera
LGE	Lunar Geology Experiment
LM	Lunar Module
LMP	Lunar Module Pilot
LOI	Lunar Orbit Insertion
LP	Long-Period
LPM	Lunar Portable Magnetometer
LRL	Lunar Receiving Laboratory
LRRR	Laser Ranging Retro-Reflector (Pronounced LR–Cubed)
LRV	Lunar Roving Vehicle (Rover)
LSAPT	Lunar Samples Analysis and Planning Team
LSM	Lunar Surface Magnetometer
LSPET	Lunar Sample Preliminary Examination Team
LSUV	Lunar Surface UV Camera
MC	Mapping Camera
MCC	Mission Control Center
MESA	Modularized Equipment Stowage Assembly (A storage area in the LM that contains science equipment)
MIT	Massachusetts Institute of Technology
MPA	Mortar Package Assembly
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
NASA	National Aeronautics and Space Administration
NM	Nautical Mile
PC	Panoramic Camera
PET	Preliminary Examination Team
PI	Principal Investigator
PLSS	Portable Life Support System
PM	Portable Magnetometer (also LPM)
ppm	Parts per Million
PSCB	Padded Sample Collection Bag
PSE	Passive Seismic Experiment
RCH	A very small, though fuzzy, unit of length
RCS	Reaction Control System
REV	Revolution
RTG	Radioisotope Thermoelectric Generator
SC	Stellar Camera
S/C	Spacecraft
SCB	Sample Collection Bag
SEQ	Scientific Equipment Bay
SESC	Surface Environment Sample Container
SEVA	Standup Extravehicular Activity (An Apollo 15 term, not planned for 16)
SIDE	Suprathermal Ion Detector Experiment
SIM	Scientific Instrument Module
S–IVB	Saturn IVB (rocket stage)
SM	Service Module
SME	Soil Mechanics Experiment
SP	Short-Period

SPS	Service Propulsion System
SRC	Sample Return Container (=ALSRC)
SSD	Surface Sampler Device
SWC	Solar Wind Composition Experiment
SWP	Science Working Panel
TEC	Transearth Coast
TEI	Transearth Injection
TV	Television
UHT	Universal Hand Tool
USGS	U.S. Geological Survey
V/h	Velocity-to-Height
VHBW	Very High-Speed Black and White
VHF	Very High Frequency (the same term applies to VHF television)

Tables

Table 1.—*Timeline of Apollo 16 Mission Events*

Event	Time from liftoff hours and minutes	Day	Central Standard Time
Launch	0:00	4/16	11:54 a.m.
Earth Orbit Insertion	0:12	4/16	12:06 p.m.
Trans Lunar Injection	2:33	4/16	2:27 p.m.
Lunar Orbit Insertion	74:29	4/19	2:23 p.m.
Descent Orbit Insertion	78:36	4/19	6:30 p.m.
Spacecraft Separation	96:14	4/20	12:08 p.m.
Lunar Landing	98:47	4/20	2:41 p.m.
EVA 1	102:25	4/20	6:19 p.m.
EVA 2	124:50	4/21	4:44 p.m.
EVA 3	148:25	4/22	4:19 p.m.
Lunar Liftoff	171:45	4/23	3:39 p.m.
Spacecraft Docking	173:40	4/23	5:34 p.m.
Trans Earth Injection	222:21	4/25	6:15 p.m.
Trans Earth EVA	242:00	4/26	1:54 p.m.
Pacific Ocean Splashdown	290:36	4/28	2:30 p.m.

Table 2.—*LRV Exploration Traverse*

(The entries in this table are brief. They are explained in the text and in the glossary. The table should be considered a general guide only; not every item is mandatory at each stop. The times are especially likely to change during the mission. The reader may wish to mark the actual times for himself on the table.)

Station/activity	Segment time (hr:min)	Elapsed time at start (hr:min)	Geological features	Observations and activities
			EVA I	
LM	1:37		Cayley Plains	Egress, observe LM, prepare for departure from Moon, deploy LRV
ALSEP	2:24	1:37	Cayley Plains	ALSEP deployment. See Table 3 for details
Travel	0:14	4:01	Across Cayley Plains and Rays.	Observe Station 2 area and distribution of ray material
1—Flag Crater	0:30	4:15	Flag Crater, about 300 meters in diameter in Cayley Plains; adjacent ray from South Ray Crater	Exploration of the crater and excavated Cayley material, observations of adjacent ray: PAN Crater sampling LPM Site Measurement Rake/Soil Sample
Travel	0:06	4:45	Across Cayley Plains and Rays.	Assess Station 2 region for best sampling area
2—Spook Crater Vicinity	0:31	4:51	Spook Crater (about 300 m diameter) and small blocky crater to the north.	Inspect and describe the geology at this station. Divide time between Spook and blocky crater: PAN Documented sampling, including: Spook Crater rim Blocks associated with small crater 500 mm photography of outlying areas Grand Prix

TABLE 2.—*LRV Exploration Traverse*—Continued

Station/activity	Segment time (hr:min)	Elapsed time at start (hr:min)	Geological features	Observations and activities
				EVA I
Travel	0:08	5:22	Across Cayley Plains	Observe and describe ray patterns; area of EVA II route to Stone Mountain
3	0:50	5:30	Cayley Plains near LM and ALSEP	Soil/Rake Sample Double Core Tube Documented Sampling Soil Mechanics—trench and penetrometer measurements 500 mm Photography (if not done at Sta. 2) Soil Samples from Trench, Retrieve 2.6 m core Arm MP
LM	0:40	6:20	Cayley Plains	Closeout—store samples, ingress
LM	0:50	00	Cayley Plains	Egress and EVA preparation
Travel	36	50	Across Cayley Plains and Rays from South Ray to the lower slopes of Stone Mtn.	Observe and describe distribution of Rays, abundance of blocks, and secondary craters. Note the slope of Stone Mountain. Describe changes of the regolith.
4—Stone Mountain.	1:00	1:26	Small craters at base of terrace in Descartes formation. The highest point reached in the Descartes formation on Stone Mountain.	Observe, describe, and sample Descartes formation: PAN—(take one at beginning and a second at the most distant point from the LRV during sampling) Documented sampling, including Rake/Soil Sample Double core (consider triple) LPM reading 500 mm photography—include upslope targets Penetrometer
Travel	03	2:26	Descartes formation	Observe and describe terraces and any changes in bedrock and regolith
5—Stone Mountain.	0:45	2:29	Intermediate area in crated and terraced region of Descartes formation.	Station to be selected at some intermediate point on the way down Stone Mountain PAN Documented sampling 500 mm photography of South Ray Crater
Travel	07	3:14	Descartes formation	Observe and describe craters, blocks
6—Stone Mountain.	0:30	3:21	In Descartes formation at base of Stone Mountain.	Note and describe characteristics of Descartes formation and local gelogy and compare to adjacent Cayley: Describe upslope terraces: PAN Documented sampling, including: Surface Sampler (one on undisturbed soil, one on top of rock; return rock) Elongated SESC (single core)
Travel	07	3:51	Descartes formation	Observe terraces and any changes of bedrock and regollth
7—Stone Mountain-Stubby Crater Area.	0:20	3:58	In Descartes formation at base of Stone Mountain near Stubby.	Observe and describe relations between Cayley and Descartes formations in Stubby area: PAN Documented sampling of Stubby rim 500 mm photography, including south wall of Stubby
Travel	07	4:18	Across Cayley formation to Rays from South Ray Crater.	Observe and describe changes in regolith and note characteristics of Rays

TABLE 2.—*LRV Exploration Traverse*—Continued

Station/activity	Segment time (hr:min)	Elapsed time at start (hr:min)	Geological features	Observations and activities
				EVA I
8—Rays From South Ray Crater.	55	4:25	In Rays from South Ray Crater overlying Cayley.	Observe and describe blocky Ray area: PAN Double core (single if triple taken on Stone Mountain) Rake/Soil Sample Documented sampling, including Possible use of padded bags Possible boulder/permanent shadow SESC Sample large boulder
Travel	14	5:20	Cayley Plains	Describe characteristics of Cayley and Rays
9	0:15	5:34	Cayley Plains adjacent to South Ray deposits.	Examine, describe and sample Cayley/Ray area: PAN Documented Sampling Surface Soil Sample Shallow Trench Soil Sample
Travel	07	5:49	Across Cayley Plains	
10	20	5:56	Cayley Plains	Radial sampling of small crater
Travel	05	6:14	Across Cayley Plains	
LM	0:40	6:19	Cayley Plains	Closeout—store equipment and samples, ingress
				EVA III
LM	0:45	00	Cayley Plains	Egress and prepare for traverse
Travel	39	45	Across Cayley toward North Ray.	Observe Cayley, Describe features near Palmetto Crater Observe Rays and describe the material seen on the approach to North Ray Crater
11—North Ray Crater.	0:55	1:24	South rim of North Ray Crater.	Examine and describe ejecta and the crater interior Stereo Pan Documented sampling 500 mm photography of crater rim and interior Polarametric photography and sampling
Travel	03	2:19	Around North Ray rim	Note and describe variety and distribution of block
12—North Ray Crater.	1:00	2:22	Area of very large blocks on east rim on North Ray Crater.	Block field with large blocks of different albedo: PAN 500 mm photography of interior of North Ray Documented sampling Boulder sampling Rake/soil
Travel	08	3:22	From North Ray to base of Smoky Mountain (Descartes formation).	Observe and describe transition to Smoky Mountain
13—Travel	0:10	3:30	North Ray ejecta blanket	Rock/Soil Sample
	07	3:40		Observe and describe number, variety, and geographic distribution of blocks
14—Smoky Mountain.	0:40	3:47	Crater cluster at base of Smoky Mountain.	In Descartes formation: PAN Documented sampling of Smoky Mountain Double core Rake/soil 500 mm photography of Smoky Mountain
Travel	09	4:27	South across Cayley Plains towards Palmetto Crater.	Observe and describe Smoky Mountain and changes of Cayley characteristics
15	0:10	4:36	Dot Prime Crater	Soil sample Rock sample LPM reading

TABLE 2.—*LRV Exploration Traverse*—Continued

Station/activity	Segment time (hr:min)	Elapsed time at start (hr:min)	Geological features	Observations and activities
			EVA I	
Travel	09	4:46	Toward Palmetto Crater	Observe and describe changes in soil and rocks on approach to Palmetto Crater
16—Palmetto Crater	15	4:55	Rim of subdued crater 1 km in Cayley Plains.	PAN Soil and Rock Sample LPM
Travel	06	5:10	Across Cayley plains south of Palmetto toward LM.	Observe lateral changes in Cayley characteristics
17	33	5:16	Cayley plains	Documented sampling: Soil/rake sample LPM
Travel	16	5:49	Across Cayley plains toward LM.	Observe characteristics of Cayley plains
LM	55	6:05	Cayley plains	Grand Prix #2 Closeout: store samples and equipment: Ingress

TABLE 3.—*ALSEP Timeline*

Time hour/min.	ACTIVITY	
	Commander	LM pilot
1:25	Remove ALESP from LM	Remove RTG fuel from LM
1:40	Drive LRV to ALSEP site	Carry ALSEP to its site
1:50	Connect RTG to central station	HFE drill 1 hole
2:00	Deploy LSM	HFE emplace and connect probe 1
2:20	Install central station	HFE emplace and connect probe 1
2:30	Install central station	HFE set up equipment drill 2 hole
2:40	Install central station	HFE emplace and connect probe 2
2:50	ASE implant geophones	ASE implant geophones
3:00	ASE thumper	ALSEP photos
3:10	ASE thumper	ALSEP photos
3:20	ASE thumper	ALSEP photos
3:30	ASE thumper	ALSEP photos
3:40	ASE set up mortar	Deep core drilling
3:50	Core recovery	Drilling. Core recovery
4:00	Core recovery	Core recovery

Table 4.—*Apollo Science Experiments*

The science experiments carried on each Apollo mission are more numerous and also more complex than those carried on the previous missions. None of the Apollo 11 experiments is operating today (December 1971). About half of the Apollo 12 experiments still operate and all of the Apollo 14 and Apollo 15 experiments are operating. We expect that many of the experiments will continue to send data to the Earth for several years after the end of the Apollo Program.

At the time of writing this booklet (December 1971), the choice of landing site for Apollo 17 has not yet been entirely settled. Alphonsus though is the leading contender.

Number	Experiment	Mission and landing site						
		A–11 Sea of Tranquility	A–12 Ocean of storms	A–13 Mission aborted	A–14 Fra mauro	A–15 Hadley-Apennine	A–16 Descartes	A–17 (Alphonsus)
	Orbital experiments							
S–158	Multi-Spectral Photography		X					
S–176	CM Window Meteoroid				X	X	X	X
S–177	UV Photography—Earth and Moon					X	X	
S–178	Gegenschein from Lunar Orbit			X	X	X		
S–160	Gamma-Ray Spectrometer					X	X	
S–161	X-Ray Fluorescence					X	X	
S–162	Alpha Particle Spectrometer					X	X	
S–164	S-Band Transponder (CSM/LM)			X	X	X	X	X
S–164	S-Band Transponder (Subsatellite)					X	X	
S–165	Mass Spectrometer					X	X	
S–169	Far UV Spectrometer							X
S–170	Bistatic Radar			X	X	X	X	
S–171	IR Scanning Radiometer							X
S–173	Particle Shadows/Boundary Layer (Subsatellite).					X	X	
S–174	Magnetometer (Subsatellite)					X	X	
S–209	Lunar Sounder							X
	Surface experiments							
S–031	Passive Seismic	X	X	X	X	X	X	
S–033	Active Seismic				X		X	
S–034	Lunar Surface Magnetometer		X			X	X	
S–035	Solar Wind Spectrometer		X			X		
S–036	Suprathermal Ion Detector		X		X	X		
S–037	Heat Flow			X		X	X	X
S–038	Charged Particle Lunar Env			X	X			
S–058	Cold Cathode Ion Gauge		X		X	X		
S–059	Lunar Field Geology	X	X	X	X	X	X	X
S–078	Laser Ranging Retro-Reflector	X			X	X		
S–080	Solar Wind Composition	X	X	X	X	X	X	
S–151	Cosmic-Ray Detection (Helmets)	X						
S–152	Cosmic Ray Detector (Sheets)						X	
S–184	Lunar Surface Closeup Photography		X	X				
S–198	Portable Magnetometer				X		X	
S–199	Lunar Gravity Traverse							X
S–200	Soil Mechanics				X	X	X	X
S–201	Far UV Camera/Spectroscope						X	
S–202	Lunar Ejecta and Meteorites							X
S–203	Lunar Siesmic Profiling							X
S–204	Surface Electrical Properties							X
S–205	Lunar Atmospheric Composition							X
S–207	Lunar Surface Gravimeter							X
M–515	Lunar Dust Detector		X	X	X	X		
	Neutron Flux Monitor (Proposed)							X

TABLE 5.—*Apollo Science Principal Investigators and Instrument Contractors*

Listed here are the principal investigators for all the scientific experiments that will have been done in the Apollo program when it ends in 1973. The principal investigator is the individual directly responsible for the scientific interpretation of the data obtained on each experiment. In most cases, he has the help of a team of experts in his field of science. Seldom before in the study of the science of either the Moon or the Earth has so much talent been brought to bear on the interpretation of an individual experiment.

Also listed are the instrument contractors. Only the prime contractors are shown. Many subcontractors from widely different geographic areas also contributed significantly toward the success of the new scientific discipline LUNAR SCIENCE.

LUNAR SURFACE EXPERIMENTS

Experiment	Principal investigator	Instrument contractor
Lunar Passive Seismology	Dr. G. V. Latham Lamont-Doherty Geological Observatory, Columbia University, Palisades, N.Y. 10964	Bendix, Aerospace Division, Ann Arbor, Mich.
Lunar Active Seismology	Dr. R. L. Kovach Department of Geophysics, Stanford University, Stanford, Calif. 94305	Bendix
Lunar Tri-Axis Magnetometer	Dr. Palmer Dyal, Code N204-4 Ames Research Center, Moffett Field, Calif. 94034	Philco-Ford
Medium Energy Solar Wind	Dr. C. W. Snyder Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103	Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.
Suprathermal Ion Detector	Dr. J. W. Freeman Department of Space Science, Rice University, Houston, Tex. 77001	Time Zero Corp.
Lunar Heat Flow (with drill)	Dr. M. E. Langseth Lamont-Doherty Geological Observatory, Columbia University, Palisades, N.Y. 10964	Columbia University, Arthur D. Little, Cambridge, Mass., Martin-Marietta, Denver, Colo.
Cold Cathode Ionization Gauge	Dr. F. S. Johnson University of Texas at Dallas, Post Office Box 30365, Dallas, Tex. 75230	The Norton Co. Time Zero Corp.
Lunar Geology Investigation Apollo 11 and 12	Dr. E. M. Shoemaker California Institute of Technology, Pasadena, Calif. 91109	
Lunar Geology Investigation Apollo 14 and 15	Dr. G. A. Swann United States Geological Survey, Flagstaff, Ariz. 86001	
Lunar Geology Investigation Apollo 16 and 17.	Dr. W. R. Muehlberger Geology Department, University of Texas, Austin, Tex. 78712	
Laser Ranging Retro-Reflector	Dr. J. E. Faller Wesleyan University, Middletown, Conn. 06457	Bendix
Solar Wind Composition	Dr. J. Geiss University of Berne, Berne, Switzerland	University of Berne, Berne, Switzerland
Cosmic Ray Detector (sheets)	Dr. R. L. Fleischer General Physics Lab, G. E. R. & D. Center, Schenectady, N.Y. 12301	General Electric, R. & D. Center, Schenectady, N.Y.
Portable Magnetometer	Dr. Palmer Dyal, Code 204-4 Ames Research Center, Moffett Field, Calif. 94034	Ames Research Center (in-house)

TABLE 5.—*Apollo Science Principal Investigators and Instrument Contractors*—Continued

LUNAR SURFACE EXPERIMENTS—Continued

Experiment	Principal investigator	Instrument contractor
Lunar Gravity Traverse	Dr. M. Talwani Lamont-Doherty Geological Observatory, Columbia University, Palisades, N.Y. 10964	Massachusetts Institute of Technology—Draper Laboratory
Lunar Seismic Profiling	Dr. R. L. Kovach Department of Geophysics, Stanford University, Stanford, Calif. 94305	Bendix
Surface Electrical Properties	Dr. Gene Simmons Massachusetts Institute of Technology, Building 54-314, Cambridge, Mass. 02139	Massachusetts Institute of Technology, Center for Space Research, Cambridge, Mass., and Raytheon, Sudbury, Mass.
Lunar Atmospheric Composition	Dr. J. H. Hoffman Atmospheric & Space Sciences, University of Texas—Dallas, Post Office Box 30365, Dallas, Tex. 75230	Bendix
Lunar Surface Gravimeter	Dr. Joseph Weber Department of Physics & Astronomy, University of Maryland, College Park, Md. 20742	Bendix
Lunar Dust Detector	Mr. J. R. Bates, Code TD5 Manned Spacecraft Center, Houston, Tex. 77058	
Neutron Flux Monitor (Proposed experiment; it is now undergoing review.)	Dr. D. S. Burnett Division of Geology and Planetary Sciences, California Institute of Technology, Pasadena, Calif. 91109	
Soil Mechanics	Dr. James K. Mitchell University of California, Berkeley, Calif.	

LUNAR ORBITAL EXPERIMENTS

Experiment	Principal investigator	Instrument contractor
Gamma-Ray Spectrometer	Dr. J. R. Arnold Chemistry Department, University of California-San Diego, La Jolla, Calif. 92037	Jet Propulsion Laboratory
X-Ray Fluorescence	Dr. Isidore Adler Theoretical Studies Br., Code 641, Goddard Space Flight Center, Greenbelt, Md. 20771	American Science and Engineering, Inc., 11 Carleton St., Cambridge, Mass. 02142
Alpha Particle Spectrometer	Dr Gorenstein American Science & Engineering, Inc., 11 Carleton St., Cambridge, Mass. 02142.	American Science and Engineering, Inc.,
S-Band Transponder (subsatellite) S-Band Transponder (CSM/LM)	Mr. W. L. Sjogren Mail Code 156-251, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103	TRW Systems Group, One Space Park, Redondo Beach, Calif. 98278 None for CSM/LM S-Band
Mass Spectrometer	Dr. J. H. Hoffman Atmospheric & Space Sciences, University of Texas—Dallas, Post Office Box 30365, Dallas, Tex. 75230	University of Texas—Dallas, Division of Atmospheric and Space Sciences, Post Office Box 30365, Dallas, Tex. 75230

TABLE 5.—*Apollo Science Principal Investigators and Instrument Contractors*—Continued

LUNAR ORBITAL EXPERIMENTS—Continued

Experiment	Principal investigator	Instrument contractor
Far UV Spectrometer	Mr. W. E. Fastie The John Hopkins University, Baltimore, Md. 21218	Applied Physics Laboratory, 8621 Georgia Ave., Silver Springs, Md. 20910
Bistatic Radar	Mr. H. T. Howard Stanford Electronics Laboratory, Stanford University, Stanford, Calif. 94305	
IR Scanning Radiometer	Dr. Frank J. Low Rice University, Post Office Box 1892, Houston, Tex. 77001	Barnes Engineering Co., Defense and Space Contracts Division, 44 Commerce Road, Stamford, Conn.
Particle Shadows/Boundary Layer (Subsatellite)	Dr. Kinsey A. Anderson Space Science Laboratory, University of California, Berkeley, Calif. 94726	Analog Technology, 3410 East Foothill Blvd., Pasadena, Calif. 91907. Subcontractor to TRW Systems Group
Magnetometer (Subsatellite)	Dr. Paul J. Coleman, Jr Department of Planetary & Space Science, UCLA, Los Angeles, Calif. 90024	Time Zero Corp., 3530 Torrance Blvd., Torrance, Calif. 90503. Subcontractor to TRW Systems Group
Lunar Sounder	Dr. R. Phillips, Team Leader Mail Code 183-510, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103	North American Rockwell, Downey, Calif. 90242
SM Orbital Photographic Tasks 24-Inch Panoramic Camera	"Photo Team" Mr. F. J. Doyle, Chairman, Topographic Division, U.S. Geological Survey, 1340 Old Chainbridge Road, McLean, Va. 22101	Itek Corp., 10 Maguire Road, Lexington, Mass. 02173
SM Orbital Photographic Tasks, 3-Inch Mapping Camera, 3-Inch Stellar Camera	"Photo Team" Mr. F. J. Doyle, Chairman	Fairchild Camera and Instrument Corp., 300 Robbins Lane, Syosset, Long Island, N.Y. 11791
SM Orbital Photographic Tasks	"Photo Team" Data Analysis, Dr. W. M. Kaula, Institute of Geophysics & Planetary Physics, UCLA, Los Angeles, Calif. 90024	RCA Aerospace Systems Division, Post Office Box 588, Burlington, Mass. 01801
Apollo Window Meteoroid	Mr. B. G. Cour-Palais/TN61 NASA Manned Spacecraft Center, Houston, Tex. 77058	
UV Photography—Earth and Moon Uses CM electric Hasselblad camera with specified lens and filters	Dr. Tobias C. Owen Department of Earth and Space Sciences, The State University of New York, Stoney Brook, N.Y. 11790	
Gegenschein from Lunar Orbit Uses CM 35-mm Nikon camera	Mr. Lawrence Dunkelman Code 613. 3, Goddard Space Flight Center, Greenbelt, Md. 20771	
CM Photographic Tasks Uses standard CM facility cameras	CSM "Photo Team" Mr. F. J. Doyle, Chairman	

TABLE 6.—*Scientific Equipment Suppliers*

The companies that built scientific equipment for the Apollo program, including 17, are shown here. Clearly, I could not list every company that produced a small screw; there would be too many. So I have chosen to list those companies, or governmental agencies, that contributed significantly to the design, building, etc., of hardware.

Company	Address	Responsibility
Motorola, Inc., Govt. Elec. Div	Scottsdale, Ariz	Command Receiver, ALSEP Control Data System
U.S. Geological Survey	Flagstaff, Ariz	Lunar Geology Investigation
Murdock Engineering	Los Angeles, Calif.	Penetrometer
Ames Research Center	Moffett Field, Calif	Lunar Portable Magnetometer and Lunar Surface Magnetometer
Analog Technology Corporation	Pasadena, Calif	Particle Shadows/Boundary Layer (Subsatellite), Particles Experiment Subsystem, and Gamma Ray Spectrometer
California Institute of Technology	Pasadena, Calif	Neutron Flux Gradient Experiment
Electro-Optical Systems, Inc	Pasadena, Calif	Design and fabrication of electronics and packaging, ALSEP Solar Wind Spectrometer
Jet Propulsion Laboratory	Pasadena, Calif	Gamma Ray Spectrometer, and Medium Energy Solar Wind
North American Rockwell	Downey, Calif	Lunar Sounder
Philco	Palo Alto, Calif	Lunar Tri-Axis Magnetometer
Space Ordnance Systems, Inc	Saugus, Calif	Grenade Launcher, Subsystem of ASE
Stanford Electronic Laboratory, Stanford University	Stanford, Calif	Bistatic Radar
Time Zero Corporation	Torrance, Calif	Magnetometer (Subsatellite), Suprathermal Ion Detector, and Electronics Subsystem of LEAM
TRW Systems Group	Redondo Beach, Calif	S-Band Transponder (Subsatellite and CSM/LM), and SS Particle Boundary Layer
University of California at Berkeley	Berkeley, Calif	Cosmic Ray PI Support
Velonex, Inc	Santa Clara, Calif	High Voltage Power Supply, Lunar Surface Ultraviolet Camera/Spectrograph
Martin Marietta Corporation	Denver, Colo	Apollo Lunar Surface Drill (ALSD)
Barnes Engineering Co	Stamford, Conn	IR Scanning Radiometer
Chicago-Latrobe Co	Chicago, Ill	Core stems, core and bore bits, Apollo Lunar Surface Drill
Applied Physics Laboratory	Silver Spring, Md	FAR UV Spectrometer
Black and Decker Manufacturing Co	Towson, Md	Powerhead, Apollo Lunar Surface Drill
Westinghouse Electric Corp	Baltimore, Md	CM Color TV Camera
American Science & Engineering, Inc	Cambridge, Mass	Alpha Particle Spectrometer, and X-Ray Fluorescence
ITEK Corp	Lexington, Mass	24-Inch Panoramic Camera
Arthur D. Little, Inc	Cambridge, Mass	Heat Flow Probes, Surface Electrical Properties, Boron Filament/Glass Epoxy-bore stems, Apollo Lunar Surface Drill, and LSG Thermal Subsystem
Littleton Research & Engineering Corp	Littleton, Mass	Assist in structural verification of hardware
Massachusetts Institute of Technology—Draper Laboratory	Cambridge, Mass	Lunar Gravity Traverse
Massachusetts Institute of Technology—Center for Space Research Geophysics	Cambridge, Mass	Surface Electrical Properties
RCA Aerospace Systems Division	Burlington, Mass	Laser Altimeter
David Clark Co	Worcester, Mass	Communication Carriers (Com-caps)
Raytheon Co	Sudbury, Mass	Surface Electrical Properties
Bendix Corp	Ann Arbor, Mich	ALSEP
Rosemont Engineering Co	Minneapolis, Minn	Platinum Sensors
Eagle-Picher Ind., Electric Division	Joplin, Mo	Battery housing and attachment design
Washington University at St. Louis	St. Louis, Mo	Cosmic Ray PI Support
The Singer Co., Kearfott Division	Little Falls, N.J	Pendulous Vertical Sensors
Paillard	Sinden, N.J	Hasselblad Cameras and Equipment

TABLE 6.—*Scientific Equipment Suppliers*—Continued

Company	Address	Responsibility
RCA—Astro Electronics Div	Princeton, N.J	Ground Commanded Color TV
RCA—Government Systems	Camden, N.J	EVA Communications Systems and Lunar Communications Relay Unit (LCRU)
Atomic Energy Commission	Albuquerque, N. Mex	Radioisotope Thermoelectric Generator (RTG)
Bulova Watch Co., Inc., Systems & Instrument Division	Valley Stream, N.Y	LSP Timers
Fairchild Camera and Instrument Corp	Syosset, Long Island, N.Y	3-Inch Mapping Camera
General Electric R. & D. Center	Schenectady, N.Y	Cosmic Ray Detector (Sheets)
Norton Research Corp	Merrick, N.Y	Cold Cathode Gauge
Yardney Electric Corp	New York, N.Y	Silver Zinc Battery Apollo Lunar Surface Drill
Maurer	Long Island, N.Y	16 mm Camera System
Research Foundation of NY	Albany, N.Y	PI Support for UV Photography
Naval Research Laboratory	Washington, D.C	FAR UV Camera/Spectroscope
Hershaw Chemical Co	Solon, Ohio	Inorganic scintillator assembly—Gamma Ray Spectrometer
General Electric	Valley Forge, Pa	Equipment design—Cosmic Ray Detector (Sheets)
Radio Corporation of America	Lancaster, Pa	Photomultiplier tubes—Gamma Ray Spectrometer
Three-B Optical Co	Gibsonia, Pa	Schmidt optics for Lunar Surface Ultraviolet Camera
Union Carbide Corp	Oak Ridge, Tenn	Sample Return Containers (SRC's)
LaCoste & Romberg	Austin, Tex	Sensor for LSG
Manned Spacecraft Center	Houston, Tex	Lunar Dust Detector, Cold Cathode Ionization Gauge, and Soil Mechanics
Rice University	Houston, Tex	Suprathermal Ion Detector
Teledyne Industries Geotech Division	Garland, Tex	Seismic Detection Subsystem of ASE
University of Texas at Dallas	Dallas, Tex	Mass Spectrometer and Atmospheric Composition
University of Berne	Berne, Switzerland	Solar Wind Composition

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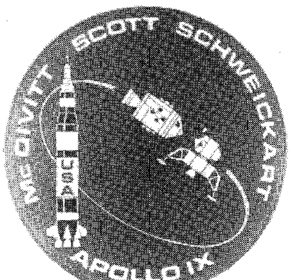
VII
SCHIRRA · EISELE · CUNNINGHAM


BORMAN LOVELL ANDERS


McDIVITT SCOTT SCHWEICKART
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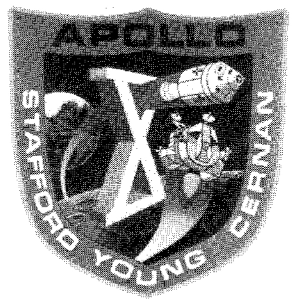
APOLLO IX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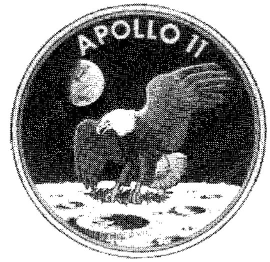
STAFFORD YOUNG CERNAN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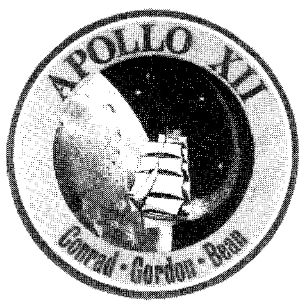
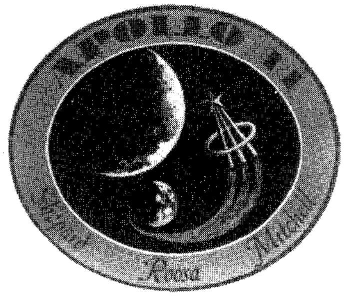

APOLLO XII
Conrad · Gordon · Bean


APOLLO XIII
EX LUNA SCIENTIA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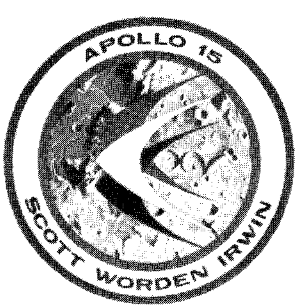
APOLLO 15
SCOTT WORDEN IRWIN


APOLLO 16
YOUNG · MATTINGLY · DUKE