1) Don will give some history of the LRL, its physical attributes, MSC management, outside advisers, conflicts, etc.

2) Gary will talk about the quarantine barrier, its function, how it operated, how persons came and went.

3) Don will talk about those sample studies dealing with the geological-chemical nature of the rocks.

4) Gary will talk about the biological testing, how it was done and the results.

APOLLO LUNAR QUARANTINE PROGRAM

SIGNIFICANT DATES

- 1963 – Special subcommittee of the Space Science Board of the NAS was convened to consider the general problem of handling material and personnel returned from flights to the moon. They recommended that NASA establish a quarantine program to ensure that Earth and its ecology would be protected from any possible hazard associated with the return of lunar material
- 1963 – Interagency on Back Contamination formed with representatives from public health, agriculture, & interior

SIGNIFICANT DATES (cont'd)

- 1964 – Approval of LRL design and continued adhoc studies prior to construction
- 1965 – NASA determined that Public Health Service should be responsible for the back contamination aspects of the LRL
- 1966 – LRL construction began
- 1968 – LRL construction completed
- 1969 – LRL simulations began prior to Apollo 11 & 12 mission support
- 1969 – ICBC met to evaluate the post Apollo 11 test results
- 1971 – Apollo 14 simulations & mission support
- 1971 – Apollo Lunar Quarantine Program ended

MR&OD PERSONNEL

- Quarantine Management – Dr. Charles Berry – Director
  - Richard Johnston – Special Assistant to MSC Director & LRL Back Contamination Operations Director
  - Bill Kemmerer, MD – Division Chief
    - Ben Wooley, PhD – Quarantine Branch Chief
      - Hal Eitzen, PhD – QCO
      - Howard Schneider, PhD – QCO
      - Richard Graves – QCO
      - Gary McCollum – QCO
    - Bill Carpentier, MD – MQF Medical Officer
    - John Hirosaki – MQF Engineer
    - Clarence Jernigan, MD – CRA Test Director

GEOLOGICAL PERSONNEL

- Wilmot Hess, PhD – Director of Science & Applications
  - Persa Bell – Lunar & Earth Sciences Division Chief
    - Gene Simmons, PhD – Chief Scientist
    - Jim McLane, PhD – Lead LRL Designer
    - Elbert King, PhD – LRL Designer
    - Don Bogard, PhD – Gas Analysis Lab Lead

CHARTER OF ICBC

- To protect the public's health, agriculture, and other living resources.
- To protect the integrity of the lunar samples and the scientific experiments.
- To ensure that the operational aspects of the program were least compromised.

QUARANTINE OBJECTIVES

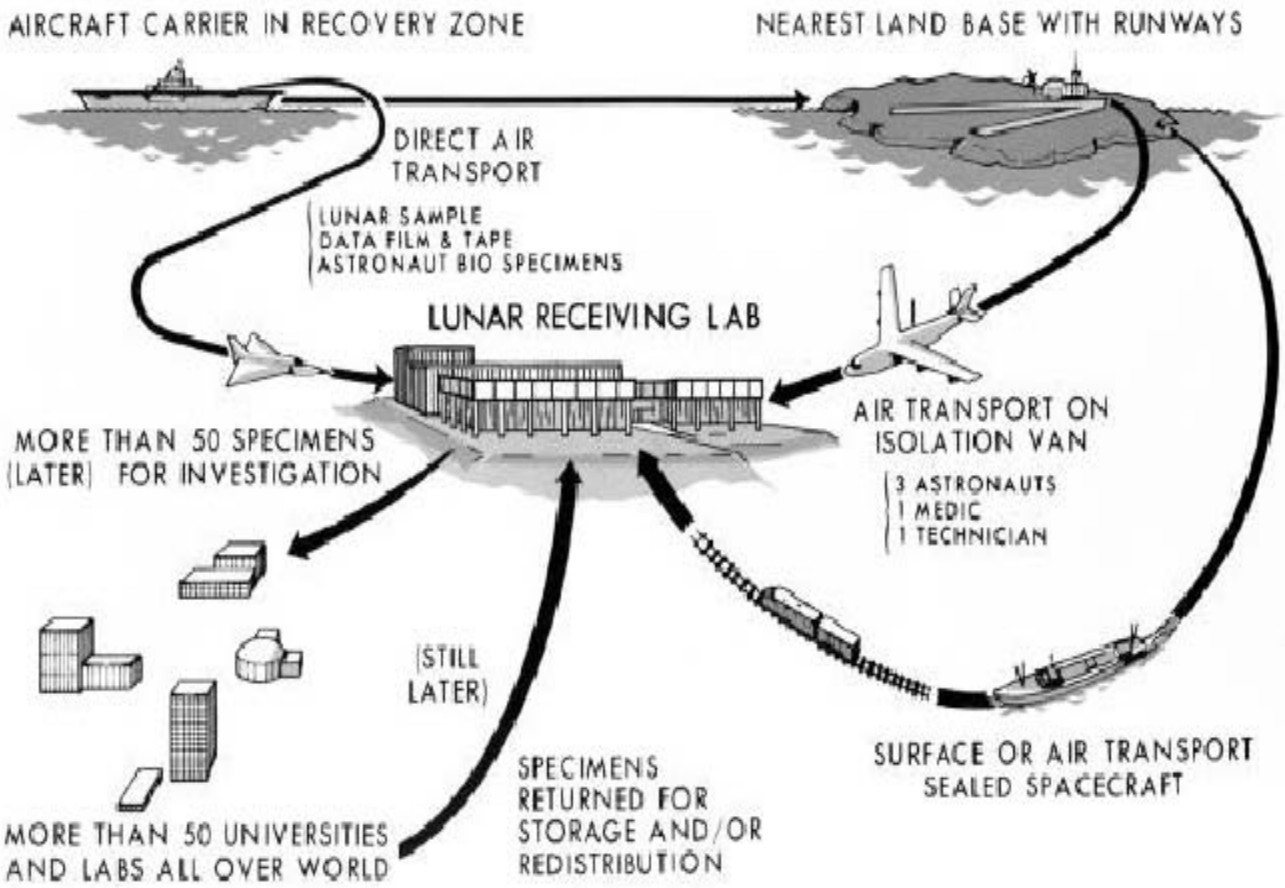
- Biological containment of the crewmen, lunar samples, and other lunar-exposed material until released from quarantine
- Biological assessment of the returned lunar materials to ensure that safe release could be effected.

PHASES OF APOLLO BACK-CONTAMINATION PROGRAM

- The first phase was concerned with procedures to be followed by the crewmen while inflight to eliminate the return of lunar-surface contaminants in the Command Module (CM).
- The second phase included spacecraft and crew recovery and the provisions for isolation and transport of the crewmen, spacecraft, and lunar samples to the Lyndon B. Johnson Space Center (JSC).
- The third phase encompassed the quarantine operations in the Lunar Receiving Laboratory (LRL).

NASA-S-67-688

TRANSPORTATION TO AND FROM LRL



ICBC REQUIREMENTS

- NASA began to plan special quarantine facilities, equipment, and operational procedures. The facilities and procedures made necessary by the quarantine program were often well beyond the state of the art. Quarantine represented a major impact on the Apollo Program. It meant that the crew, the Command Module, and the lunar material had to be isolated from the moment of arrival back on Earth.

PHYSICAL SCIENCE & BIOMEDICAL REQUIREMENTS

- Collection, return, and examination of lunar samples were formulated. Whereas the primary concern of the physical science advisory groups was to ensure that procedures and equipment were developed that would minimize the possibility of the contamination of the lunar samples by terrestrial organic and inorganic material, the primary concern of the biomedical advisory groups was to ensure that equipment and procedures were developed that would minimize the possibility of introducing the lunar material into the biosphere. Although the possibility of discovering an existing life system was considered remote, it could not be ignored. Consequently, appropriate quarantine precautions were required for both the crewmen and the lunar samples.

PLANT & ANIMAL DISEASES

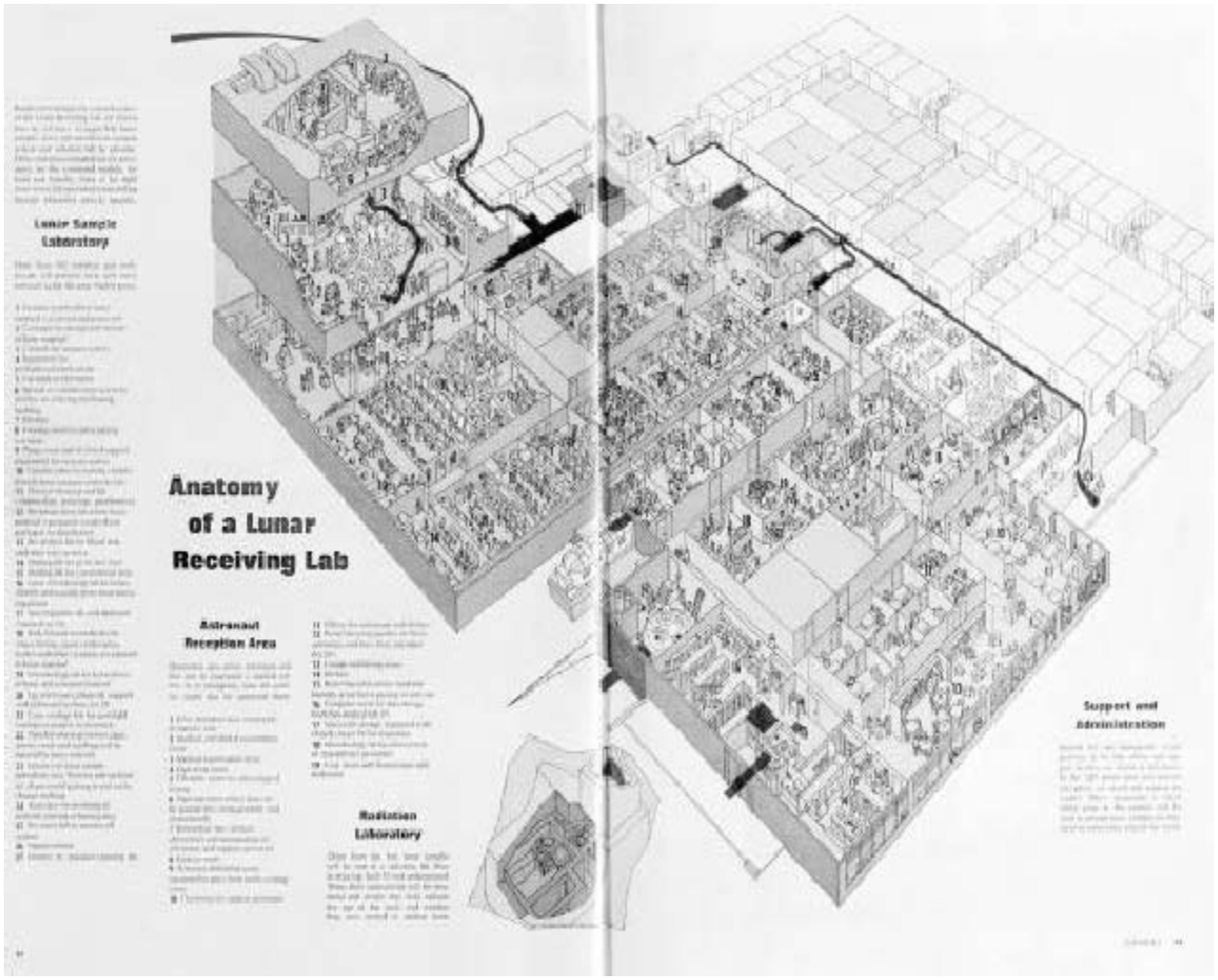
- It was determined that most terrestrial disease agents were capable of invading a host and causing evident disease symptoms within 21 days after exposure of the host. Most disease agents capable of causing epidemic or rapidly spreading diseases were sufficiently virulent to be transmitted in less than 21 days. The ICBC decided that a crew quarantine period of at least 21 days should be required after each Apollo mission.

MEDICAL EXAMINATIONS OF FLIGHT CREWMEMBERS

- Intensive medical examinations of the flight crewmembers during quarantine would determine if any medical problems existed as a result of exposure to lunar material. The returned lunar samples and equipment would be evaluated to ensure that release of these items to an investigation team did not represent a hazard.

LRL CONSTRUCTION

- As a quarantine facility for returning Apollo crewmembers, spacecraft, equipment, and lunar samples.
- As an isolation facility where specific biomedical evaluations of the lunar samples could be performed to determine whether the samples contained any hazardous replicating microorganisms.
- As an isolation facility where time-critical physical science investigations could be performed. (Time-critical investigations were those for which data would be lost or seriously degraded if the experiments were not initiated during the quarantine period.)
- As a facility for lunar sample preparation and distribution to outside principal investigators for detailed scientific analyses.


Anatomy of a Lunar Receiving Lab
Lunar Sample Laboratory
Astronaut Reception Area
Radiation Laboratory
Support and Administration

BASIC ASSUMPTIONS FOR LUNAR QUARANTINE PROGRAM

- The existence of hazardous, replicating microorganisms on the moon would be assumed.
- The preservation of human life should take precedence over the maintenance of quarantine.
- Biological containment requirements should be based on the most stringent means used for containment of infectious terrestrial agents.
- The sterilization requirement should be based on methods needed for the destruction of the most resistant terrestrial forms.
- Hazard detection procedures should be based on an alteration of the ecology and classical pathogenicity.
- The extent of the biological test protocol would be limited to facilities approved by the Congress, to well-defined systems, and to biological systems of known ecological importance.

LIMITATIONS FOR THE BIOLOGICAL TEST PROTOCOLS

- Test systems for which little or no baseline or background information was available were not considered.
- Systems of known ecological importance were stressed.
- Size of the facility and the scope of activities were determined for planning purposes.

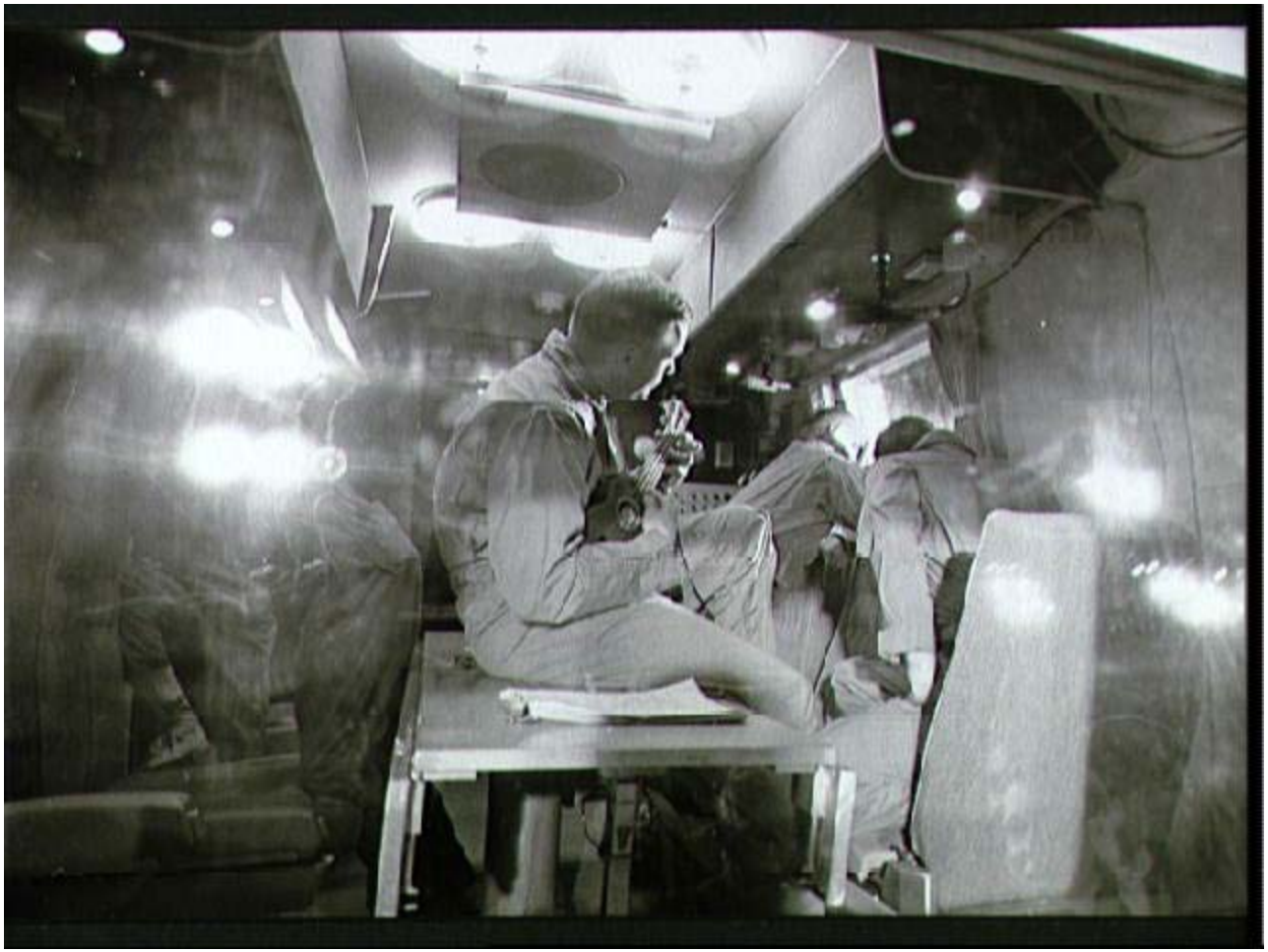
START OF QUARANTINE

- The period of quarantine for spacecraft, crew, and lunar samples was considered to have begun as soon as the Apollo crewmen left the moon. Isolation was accomplished by containing men and equipment first in the Mobile Quarantine Facility (MQF) located on the hangar deck of the recovery ship, and, later, the Lunar Receiving Laboratory at the Johnson Space Center. A crew surgeon and recovery engineer joined the crew in the MQF and remained with them throughout the period of quarantine.

MOBILE QUARANTINE FACILITY

- A Mobile Quarantine Facility (MQF) was designed and fabricated to house and transport the Apollo crewmen from the recovery ship to the LRL. The MQF was equipped to house six people for a period of ten days and provided a lounge, galley, and sleeping and toilet facilities. It was powered through several systems to interface with various ships, aircraft, and transportation vehicles. Quarantine was assured in the MQF through the maintenance of negative internal pressure and by filtration of effluent air.


Enterprise



MQF (cont'd)

- Waste water from washing and showers was chemically treated and stored in special containers. Body wastes (urine and feces) were stored in special tanks. Items were passed in or out through a submersible transfer lock. The MQF could be serviced with utilities (power, communications, alarm system) from shipboard, aircraft, and/or trucks. Redundant power systems and fans assured maintenance of a negative pressure. Specially packaged and controlled meals could be passed into the facility to be prepared in a microwave oven. Medical equipment was also provided for use in immediate postlanding crew examinations and tests.

MQF (cont'd)

- Biological isolation garments were used in Apollo 11 to isolate the crew from the Earth's environment and from contact with recovery personnel. These garments were constructed from a fabric which effectively isolated microorganisms from the crewman's body. The garment was donned in the spacecraft before the helicopter hoist operation and was worn until the crew entered the MQF aboard the primary recovery ship. The suit was fabricated of nylon. A respirator was worn with the garment. It featured an air-inlet flapper valve and high efficiency air-outlet filter to biologically filter expired gas. The Apollo 11 crew used a heavier biological isolation garment, but this was discarded as an unnecessary precaution after the initial lunar landing flight. On later missions, a lightweight overgarment was used when transferring from the Command Module to the MQF.

APOLLO LUNAR SAMPLE RETURN CONTAINERS

- Boxes containing samples of lunar rocks and soil from early missions were opened at the LRL in a unique vacuum chamber. The chamber was designed to ensure sample sterility and to provide a method for preliminary examination without compromising sample integrity by exposure to air. The vacuum simulated lunar pressure.

SPECIAL CONTAINERS

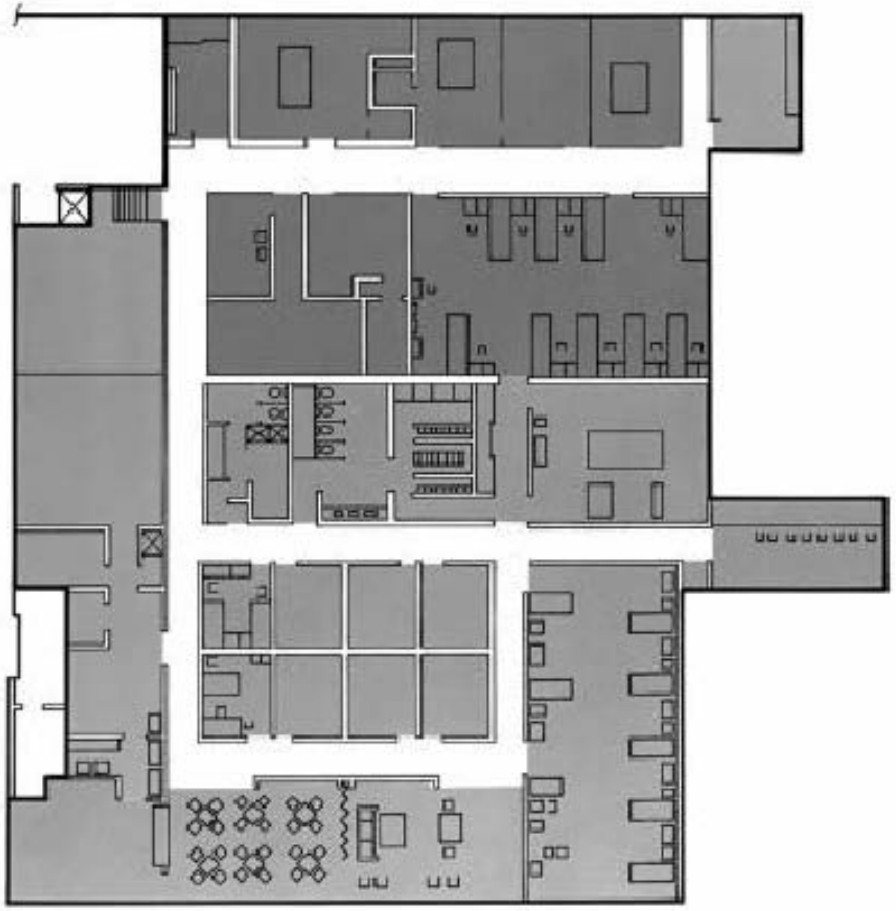
- Special containers were fabricated for return of the medical and lunar samples, films, and data tapes from the recovery area to the LRL.

LRL

- Physical description:
  - Housed in Building 37 at JSC
  - 7700 m^2 (83 000 ft^2) of floor space and included the Crew Reception Area (CRA), Vacuum Laboratory, Sample Laboratories (Physical and Bio-Science), and an administrative and support area
  - Special building systems were employed to maintain airflow into sample-handling areas and the Crew Reception Area to sterilize liquid waste and to incinerate contaminated air from the primary containment systems.

NASA-S-67-2349

CREW RECEPTION AREA



OFFICE AND LIVING SPACE

MEDICAL FACILITIES

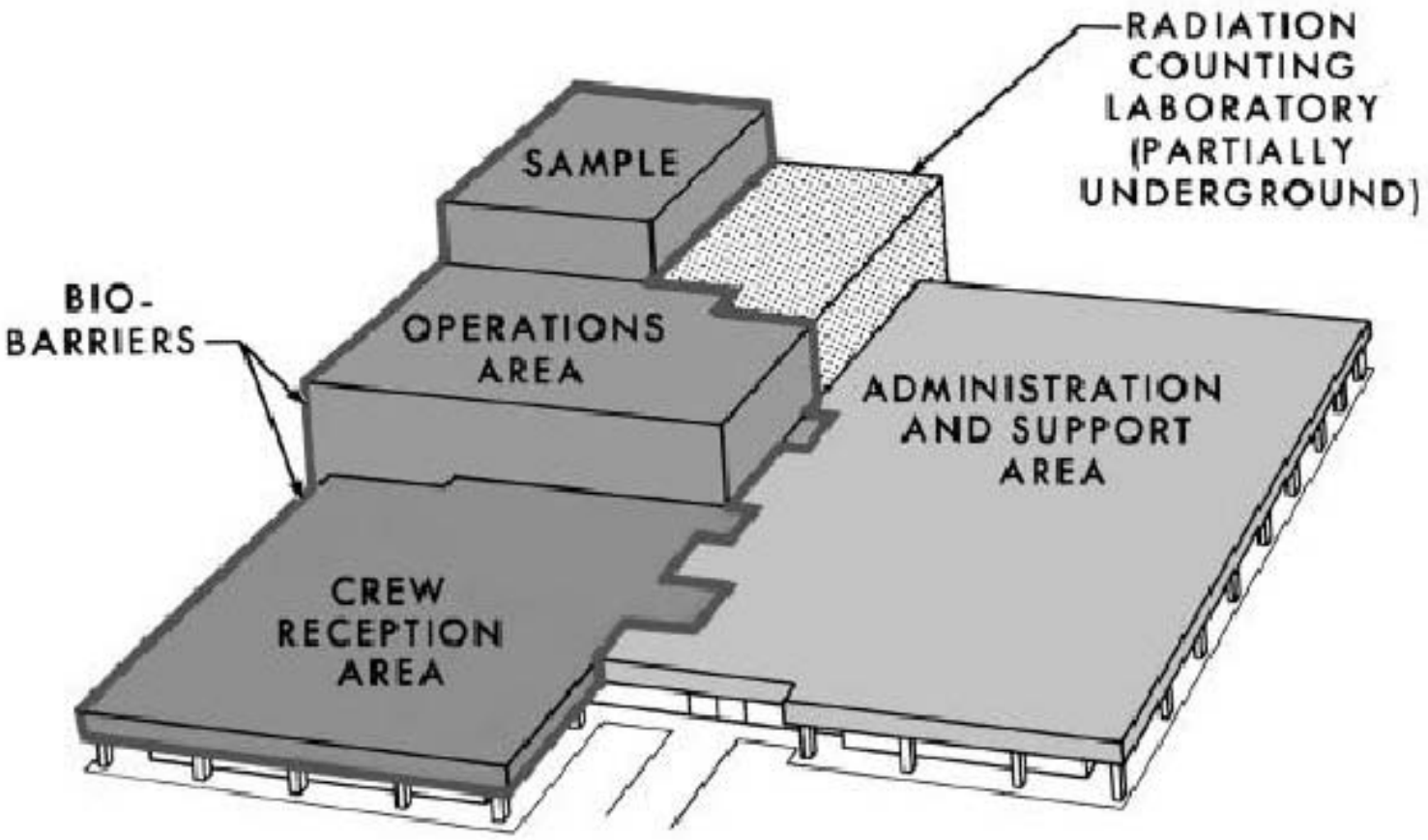
STORAGE AND SUPPORT FACILITIES

CORRIDORS

BIOLOGICAL BARRIER

NASA-S-67-696

LRL FUNCTIONAL AREAS



BIOLOGICAL CONTAINMENT

- Relied on a primary and secondary barrier system. The primary biological barrier consisted of the vacuum complex and Class III biological cabinets. A secondary barrier was maintained in the Crew Reception Area and the sample laboratory by maintaining the areas at negative pressure with respect to the atmospheric pressure external to the building. Within these two barriers the postmission work on returned lunar samples was performed. The design and operational features for the primary and secondary barriers are described as follows:

BIOLOGICAL CONTAINMENT (cont'd)

- The LRL was built to meet the most stringent biological containment requirements of the U.S. Army Biological Laboratories, Fort Detrick, MD. This was a unique facility in many respects. It contained a vacuum chamber which permitted scientists to manipulate and examine lunar samples without breaking the vacuum or risking contamination of the samples or themselves. It had a low-level radiation counting facility and could safely accommodate a large variety of biological specimens.

BIOLOGICAL CONTAINMENT (cont'd)

- The vacuum complex was the area in which sample containers were opened and processing of the lunar material was initiated. This system was sterilized before return of the containers to ensure lunar samples would not be contaminated with terrestrial microorganisms. All materials entering the vacuum complex after premission sterilization were sterilized using peracetic acid. All items leaving the complex during the quarantine period were either placed in vacuum-tight containers, the exteriors of which were sterilized with peracetic acid, or were directly sterilized with the acid. Effluent gases from the vacuum chamber pumps were passed through absolute biological filters, incinerated, and filtered again prior to venting to the outside environment. All lunar samples left the vacuum complex in sterilized vacuum-tight containers. The containers were placed in sealed plastic bags for handling within the sample laboratory.

BIOLOGICAL CONTAINMENT (cont'd)

- Biological and physical/chemical testing of the lunar samples was performed within biological cabinets. These cabinets were gastight enclosures through which all manipulations were performed using neoprene gloves. Air or nitrogen entered the cabinets through absolute biological filters, was incinerated, and was filtered again before being vented to the outside. All material entering the cabinets was sterilized. The cabinets were operated at a pressure negative with respect to the laboratory to ensure that any leak that developed would be directed into the cabinets rather than into the laboratory.

BIOLOGICAL CONTAINMENT (cont'd)

- The rooms in which the cabinets were housed were also maintained at a pressure negative with respect to the adjacent corridors. This guaranteed that any escaping lunar material would be contained. The secondary biological barrier which surrounded the sample laboratory included facility systems and operational procedures. Tight building construction was used and all penetrations were sealed. The sample laboratory had a single-pass air conditioning supply and exhaust system which maintained the area at a pressure negative with respect to the outside air. Inlet air was filtered, and air exited through absolute biological filters. All liquid waste coming from the sample laboratory area was sterilized with steam before being transported to the JSC sewage treatment plant. All solid materials including waste, clothing, and trash were sterilized. The sample laboratory area received supplies during quarantine operations through ultraviolet-lighted airlocks.

BIOLOGICAL CONTAINMENT (cont'd)

- The Apollo crewmembers represented the prime source of contamination to the lunar surface.
  - Three other sources of contamination were:
    - 1 Waste products such as feces, urine, and residual food
    - 2 Viable terrestrial microorganisms released during Lunar Module depressurization
    - 3 Microorganisms present in the LM waste water system.
  - Procedures were defined to eliminate massive contamination of the lunar surface from these three sources. Of the three, waste products were the chief source of potential contamination. To minimize the thrust required for lift-off from the lunar surface, waste products had to be removed from the ascent stage of the LM. All waste products were stored in the equipment bays of the descent stage. Even if the storage bags had leaked or the integrity of the containers had been violated, microbial contamination would have been contained within the descent stage of the LM and not deposited on the lunar surface.

CONCERNS

- The primary quarantine-related concern in collecting lunar samples was to minimize their contamination with viable terrestrial microorganisms. Such contamination would have complicated interpretation of biological findings. Lunar samples were collected with sterile tools and returned to the Lunar Receiving Laboratory in a sterile environment. The types of materials used for fabricating tools and other items that came in contact with lunar material were severely limited by the physical scientific contamination requirements and by weight restrictions. A high-temperature bakeout under vacuum conditions was considered the best method for removing volatile terrestrial contaminants from the hardware. This treatment, at a sufficient temperature for a sufficient period of time, also satisfied the sterilization requirements for the hardware.

CONCERNS (cont'd)

- The procedures and the hardware necessary for the stowage of collected lunar samples were considered next. Because the lunar material had existed for millions of years in an almost perfect vacuum, the physical scientists decided that the lunar samples should be transported to Earth under environmental conditions as near to those on the moon as technically feasible. This decision necessitated the design and fabrication of a pressure vessel that could be filled with lunar samples and sealed on the lunar surface, and in which the internal environment could be maintained throughout the sample transfer from the lunar surface to the LRL. Because the pressure vessel had to be an ultraclean, gastight container, no additional requirements were necessary in terms of quarantine control.

CONCERNS (cont'd)

- The Lunar Module was designed to include a bacterial filter system to prevent contamination of the lunar surface when the cabin atmosphere was released at the start of lunar exploration. Before reentering the LM, the crewmen brushed any lunar surface dust or dirt from their space suits. They scraped their feet on the LM footpad and kicked the ladder while ascending to dislodge any particles on their boots.

PRIMARY CONTACTS

- To safeguard the health of LRL personnel, every worker was subjected to extensive medical examinations before each Apollo lunar mission. Because of the potential hazard of working with lunar material, a requirement was established that pregnant employees, all persons taking medication, and those requiring medical aids such as crutches, braces, or hearing aids would not be permitted to enter the secondary biological barrier. In addition, serum pools were collected from each individual who might be exposed to lunar material. The stored samples would serve as a baseline for analysis of any medical complications that might arise in the years following the exposure.

REQUIREMENTS OF THE RECOVERY QUARANTINE OPERATION

- ***Crew Safety.*** To provide a safe method for the retrieval and return of crew and spacecraft.
- ***Biological Isolation.*** To provide isolation during the recovery operation and during the movement of the crew and equipment from the recovery area to the LRL.
- ***Sustenance Provisioning.*** To provide eating, sleeping, and hygienic facilities for the crew and technical personnel during the return phase.
- ***Medical and Debriefing Provisioning.*** To provide some limited medical facilities and interfaces during the recovery and transportation phases.
- ***Transportation.*** To provide suitable hardware for the transportation of the crew, CM, and hardware by ship, aircraft, and truck.

FINAL PHASE OF APOLLO BACK-CONTAMINATION PROGRAM

- The crewmen and spacecraft were quarantined for a minimum of 21 days and were released from the LRL after the completion of certain prescribed tests. The lunar samples were quarantined for a period of 50 to 80 days, depending on the results of extensive biological tests. In addition to the three Apollo crewmembers, other personnel quarantined in the LRL were two crew surgeons, a recovery engineer, medical laboratory technicians, cooks, and stewards.

QUARANTINE PERIOD

- During the quarantine period, the crew and their immediate contacts underwent daily medical examinations. Basic observations consisted of recording oral temperature and pulse rate, and a brief interview by the crew surgeon. Biological specimens were obtained from the crew on the twelfth and eighteenth days after lunar departure, and the crew underwent another complete physical examination on the twenty-first day. Selected microbiologic and immunologic examinations were also conducted at several points in the quarantine. The purpose of the latter examinations was to provide diagnostic information in the event of clinical illness.

QUARANTINE PERIOD (cont'd)

- Provisions were made to treat routine illness and minor injuries within the Crew Reception Area. Equipment and a small working pharmacy were available. Serious illness and injury were also to be treated onsite so far as possible. But, had any of the Apollo crewmen or support personnel become critically ill or injured, the quarantine would have been broken and the individual transported to the nearest appropriate medical facility.In the event of a serious crew illness, a quarantine Medical Advisory Panel was available for consultation. This panel consisted of experts in various aspects of infectious disease empowered to provide diagnostic information pertinent to any release recommendation.

SPILLS

- There were a few instances in the LRL operations when technicians had to be quarantined because of leaks in vacuum chamber gloves while personnel were handling the lunar material or when similar faults in the other protective devices occurred. These instances were infrequent. In no instance was the biological containment of the crewmen, lunar samples, and/or any other exposed material compromised.

RELEASE RECOMMENDATIONS

- Release recommendations for the crew and support staff were developed by the medical staff. The medical status of both the crew and the support personnel exposed to the crew and/or to the lunar mission equipment was taken into consideration. Technically, release of the Apollo crews might have been delayed because of illness among the support staff. This, however, never occurred.

SPACECRAFT ROOM

- The spacecraft room contained all equipment required for decontamination of the Command Module. There were also communications and closed circuit television for monitoring and supporting cleanup and decontamination activities. Personnel from the Crew Reception Area were trained to open the Command Module hatch and remove the double-bag stowed equipment, including lithium hydroxide canisters, fecal bags, food bags, and space suits. The individual working inside the CM doffed shoe covers upon egress. All persons then reentered the CRA and showered. Thus the likelihood of contaminating the Crew Reception Area and space suit room was minimal.
- Formaldehyde decontamination of the Command Module cabin and suit circuit was accomplished without reopening the hatch. Following a minimum 24-hour kill period, the hatch was opened and the cabin exhausted through the room air conditioning system. The water and waste management systems were also decontaminated with aqueous formaldehyde (formalin) for 24 hours. Spore strips were placed at random locations in the CM to verify decontamination effectiveness.

LUNAR SAMPLE ANALYSES STEPS

- Data upon which to base a release decision.
- Preliminary scientific data upon which to base a sample distribution plan.
- Portions of the lunar sample packaged for distribution to principal investigators.
- Portions of the lunar sample sealed and protected for future experiments.
- Time-critical experiments.

PROCESS FOR LUNAR ANALYSES

- On arrival at the LRL, sample boxes were moved through an airlock and through three decontamination chambers to sterilize the outside of the containers. They were then sent into a vacuum chamber where a technician punctured a diaphragm to draw off any gases. The sample was then passed on to a mass spectrometer to determine (1) if the interior of the boxes had been contaminated by the Earth's atmosphere, and (2) if any gases could be identified as being of lunar origin.
- The boxes were opened in an environment free of terrestrial organisms. The nominal mode of operation called for opening the sample boxes in the special chamber described earlier which operated at a vacuum of 1.33×10^{-4} N/m^2 (10^{-6} mm Hg). An alternate mode employed the same chamber but with an atmosphere of sterile nitrogen at a pressure slightly below atmospheric. A contingency mode was to open the containers in a Class III biological cabinet. Each lunar rock and portion of fine material was examined, photographed from six different angles, and observed visually through glass ports and through microscopes. A representative sample was committed to quarantine testing. Small chips of each rock were examined for physical and chemical properties. Selected specimens were subjected to special tests, radioactivity determination. The balance of the material was sealed and protected for later use.

PRINCIPAL INVESTIGATORS

- Scientific work on the lunar sample was done by some 150 to 200 PI's throughout the world. Each investigator received a type and amount of lunar material suitable for his work and returned the residues to the LRL for further use by other researchers. A few of the PI's performed their experiments in the LRL during quarantine because of the time-critical nature of the data being sought.

CRITERIA FOR RELEASE OF LUNAR SAMPLES

- Biological safety tests upon representative portions of the samples. These tests included: bacteriology, mycology, virology-mycoplasma, mammalian animals, botanical systems, invertebrate/lower vertebrate systems.
- Sterilization of the sample by the use of dry heat during the quarantine period.
- All protocols were designed to be completed within 30 days from the introduction of the sample to the laboratories. This was to be increased to 60 days in the event significant numbers of microbial contaminants were found in the sample. By 60 days, sufficient data would have been available to evaluate the requirement for second order testing.

CRITERIA FOR RELEASE OF FLIGHT EQUIPMENT

- All flight equipment exposed to lunar surface materials was placed under quarantine restrictions. The equipment included films, data tapes, logs, and other flight equipment.
- Procedures for quarantine and release of the equipment were as follows:
  - Flight film was received in the Crew Reception Area and, after appropriate preparation, was passed out for processing. Film from the Apollo 11 mission was sterilized with ethylene oxide. After the Apollo 11 mission, sterilization of flight film was not required.
  - Data tapes were received in the CRA and, after appropriate preparation, were sterilized using ethylene oxide gas and passed through the biological barrier. The tapes were then handled using normal procedures.
  - All other items were either held in approved biological containers until the release of lunar samples. Requirements for early release were kept to a minimum

RESULTS OF APOLLO LUNAR BIOMEDICAL EXPERIMENTATION

- Objective - to test appropriate representative lunar samples for the possible presence of agents that might be infectious or toxic for plants, man, and other animals. The goal of the laboratory was to provide safety clearance for lunar samples within a period of approximately 30 days. Lunar materials were analyzed in an isolated environment. These analyses were performed immediately after the lunar samples were unpacked in the LRL at JSC. Small but representative samples of lunar material were used to assess whether they contained microorganisms, and to ensure that the lunar materials were nonhazardous to the selected test species.

BREAK

BOTANICAL INVESTIGATIONS

Table 1
Plant Species Challenged With Lunar Materials
in Apollo 11 or 12 Quarantine Studies

Species	Common Name	Challenge System*
Allium cepa L.	Onion	SG
Anacystis nidulans (Richt) Drouet	Blue-green alga	A
Brassica oleracea L.	Cabbage	SG, S
Capsicum frutescens L.	Pepper	SG, S
Chenopodium amaranticolor Coste and Reyn.	Weed	S
Chlorella pyrenoidosa Chick	Green alga	A
Citrullus vulgaris Schrad.	Watermelon	S
Citrus limonia L.	Lime	S
Cucumis melo L.	Cantaloupe	S
Cucumis sativus L.	Cucumber	S
Glycine soja (L.) Sieb and Zucc.	Soybean	TC
Haplopappus gracilis (Nutt.) Gray	Weed	TC
Helianthus annuus L.	Sunflower	TC
Lactuca sativa L.	Lettuce	SG
Lycopersicum esculentum Mill.	Tomato	S
Lycopodium cernuum L.	Clubmoss	G
Marchantia polymorpha L.	Liverwort	G
Nicotiana tabacum L. (albino)	Tobacco	TC
Nicotiana tabacum L. (habituated)	Tobacco	TC
Nicotiana tabacum L. var. Samson	Tobacco	SG
Nicotiana tabacum L. var. Xanthi NC	Tobacco	S
Onoclea sensibilis L.	Sensitive fern	SPG
Oryza sativa L.	Rice	TC
Phaeodactylum tricornutum Bohlin	Diatom	A
Phaseolus aureus L.	Mung bean	SG
Phaseolus vulgaris L.	Common bean	S
Pinus elliottii Engelm.	Slash pine	S
Pinus lambertiana Dougl.	Sugar pine	TC
Pinus palustris Mill.	Longleaf pine	TC
Prophyridium cruentum (Ag.) Naeg.	Red alga	A
Raphanus sativus L.	Radish	SG, S
Saccharum officinarum L.	Sugarcane	S
Solanum tuberosum L.	Potato	S
Sorghum vulgare Pers.	Sorghum	S
Spinacia oleracea L.	Spinach	SG
Todea barbara (L.) Moore	Fern	G
Triticum vulgare Vill.	Wheat	S
Zea mays L.	Corn	TC
Zea mays L. var. *everta*	Popcorn	S

*A = algal culture, G = gametophyte culture, S = seedling, SG = seed germination unit, SPG = spore germination unit, TC = tissue culture.

(Walkinshaw et al., 1970).

VIROGICAL INVESTIGATIONS

Table 2

Systems Challenged in the Virological Analyses of Lunar Material Obtained During the Apollo Missions

Apollo Mission	Number of Samples Tested	Tissue Cultures	Systems Challenged		
			Embryonated Eggs	Suckling Mice	Mycoplasma Media
11	3	GMK, HEK, WI-38, BEK, PEK, DEF, RTG-2, FHM, GF	X	–	X
12	2	GMK, HEK, WI-38, MDBK, PK_{15}, DEF, RTG-2, FHM, GF	X	–	X
14	6	GMK, HEK, WI-38, MDBK, PK_{15}, DEF, RTG-2, FHM, GF	X	X	X
15	1	GMK, HEK, WI-38	X	X	X
16	1	GMK, HEK, WI-38	X	X	X
17	1	GMK, HEK, WI-38	X	X	X

GMK = African green monkey kidney
HEK = Primary human embryonic kidney
WI-38 = Diploid human embryonic lung
BEK = Primary bovine embryonic kidney
PEK = Primary porcine embryonic kidney
DEF = Primary duck embryonic fibroblast
RTG-2 = Rainbow trout gonadal tissue, *Salmo gairdneri*
FHM = Fathead minnow, *Pimephales promelas*
GF = Grunt fin, *Haemulon sciuras*
MDBK = Heteroploid bovine kidney
PK_{15} = Heteroploid porcine kidney

ZOOLOGICAL INVESTIGATIONS

Table 3

Summary of Species Conditions and Procedures Used in Quarantine Testing and Biocharacterization of Lunar Materials

Genus and Species (Common Name)	Lunar Material from Apollo Mission	Results
Euglena gracilis (euglena)	11	Slight reduction in locomotive ability after exposure and a return to normal activity by the fourth day. All groups had normal morphologic features.
Paramecium aurelia (paramecium)	11, 12, 14	Initial reduction in fission rates after exposure, rapidly increasing to normal after 4 to 5 days. All groups had normal morphologic features.
Dugesia dorotocephala (planaria)	11, 12, 14	No significant gross or histopathologic changes.
Crassostrea virginica (commercial oyster)	11, 12, 14	During Apollo 11 and 14 missions, large numbers of deaths were encountered in all groups but correlation could not be shown between the deaths and exposure to lunar material. During Apollo 12 mission, all oysters remained in excellent health.
Penaeus aztecus (brown shrimp)	11, 14	No abnormal behavior or significant gross or histopathologic changes.
Penaeus duorarum (pink shrimp)	12	Considerable fighting in all groups early in test. No significant gross or histopathologic changes.
Blattella germanica [German cockroach (gnotobiotic)]	11, 12, 14	No unaccountable gross or histopathologic changes.
Musca domestica (house fly)	11, 12, 14	No unaccountable gross or histopathologic changes.
Galleria mellonella (greater wax moth)	11, 12, 14	No unaccountable gross or histopathologic changes.
Lebistes reticulatus (guppy)	12, 14	No unaccountable gross or histopathologic changes.
Pimephales promelas (fathead minnow)	11	Sporadic deaths in all groups because of sodium hypochlorite spill. No unaccountable gross or histopathologic changes.
Fundulus heteroclitus (mummichog minnow)	11, 12, 14	With the exception of a few fish in each group during Apollo 12 mission (lost because of gill congestion from exposure to sodium hypochlorite), all mummichogs remained in excellent health, and no unaccountable gross or histopathologic changes were found.
Coturnix coturnix (Japanese quail)	11, 12	No unaccountable gross or histopathologic changes. Several deaths attributed to inoculation, laceration of internal organs or self-inflicted trauma.
Mus musculus [motobiotic CD-1 mouse (Charles River)]	11, 12, 14, 15	No indication of any infectious-disease-producing agent or acute toxic component in lunar material. Some evidence of long-term irritative effect; however, resolution of this point must await complete analysis of data obtained from long-term test groups.
Cavia porcellus (guinea pig)	14	No unaccountable gross or histopathologic changes.

RESULTS OF APOLLO LUNAR QUARANTINE PROGRAM

- The crews of Apollo 11, 12, and 14 experienced no health problems as a result of their exposure to lunar material.
- The test species, plant and animal, which were exposed to and injected with lunar material showed no adverse alterations or ill effects from exposure.
- Since exhaustive studies of the astronauts and returned lunar samples from Apollo 11 and 12 indicated there was no hazard to Earth's biosphere, the Interagency Committee on Back-Contamination, in January of 1970, concurred in NASA's recommendation that stringent quarantine rules be abandoned for future Apollo missions to the moon.
- To ensure that lunar material represented absolutely no danger to the Earth's environment, the quarantine program remained in effect for the Apollo 14 flight and was then abandoned.
- Although the formal quarantine for the crew, spacecraft, and lunar samples was over, procedures for handling lunar material and protecting it from contamination remained in effect for the Apollo 15, 16, and 17 missions. This guaranteed that scientists performing tests on the material would have uncontaminated samples.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