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Surveyor III: Bacterium isolated from lunar-retrieved TV camera

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Abstract—Selected components of the unmanned Surveyor III spacecraft which had remained on the lunar surface for 2½ years were collected and returned to earth by the crew of Apollo 12. A bacterium, *Streptococcus mitis*, was isolated from a sample of foam taken from the interior of the retrieved TV camera. The available data suggests that the bacterium was deposited in the camera prior to the Surveyor III spacecraft launch. The authors suggest that lyophilizing conditions existing during prelaunch vacuum testing and later on the lunar surface may have been instrumental in the apparent survival of this microorganism.

INTRODUCTION

ON 20 APRIL 1967, the unmanned Surveyor III spacecraft successfully landed near the eastern shore of Oceanus Procellarum on the lunar surface. On 20 November 1969, two Apollo 12 crew members walked from their lunar module to inspect and photograph the Surveyor III spacecraft. The entire TV camera and other selected components were then retrieved for return to earth (Fig. 1). Upon return to earth, the TV camera and lunar soil samples were placed in quarantine in the Lunar Receiving Laboratory (LRL) at the NASA Manned Spacecraft Center (MSC) at Houston, Texas. The quarantine was lifted on 7 January 1970, and inspection and disassembly of the retrieved TV camera began the next day.

Microbial analysis was the first of several studies of the retrieved TV camera and was performed immediately after the camera was opened. A serious constraint placed upon this analysis was the need to obtain samples without compromising any planned subsequent studies. As a consequence, not all desired microbial samples could be obtained. The emphasis of the microbial analysis was placed, therefore, upon isolating microorganisms which might be potentially pathogenic for man.

Decontamination measures taken before the Surveyor III launch did not eliminate the possibility that the spacecraft carried microorganisms to the moon. The following statement reflects the decontamination guidelines which were current at the time of the Surveyor spacecraft launches (HALL, 1966): "The precautions against the contamination of the moon, once strict have now been relaxed in view of our developing

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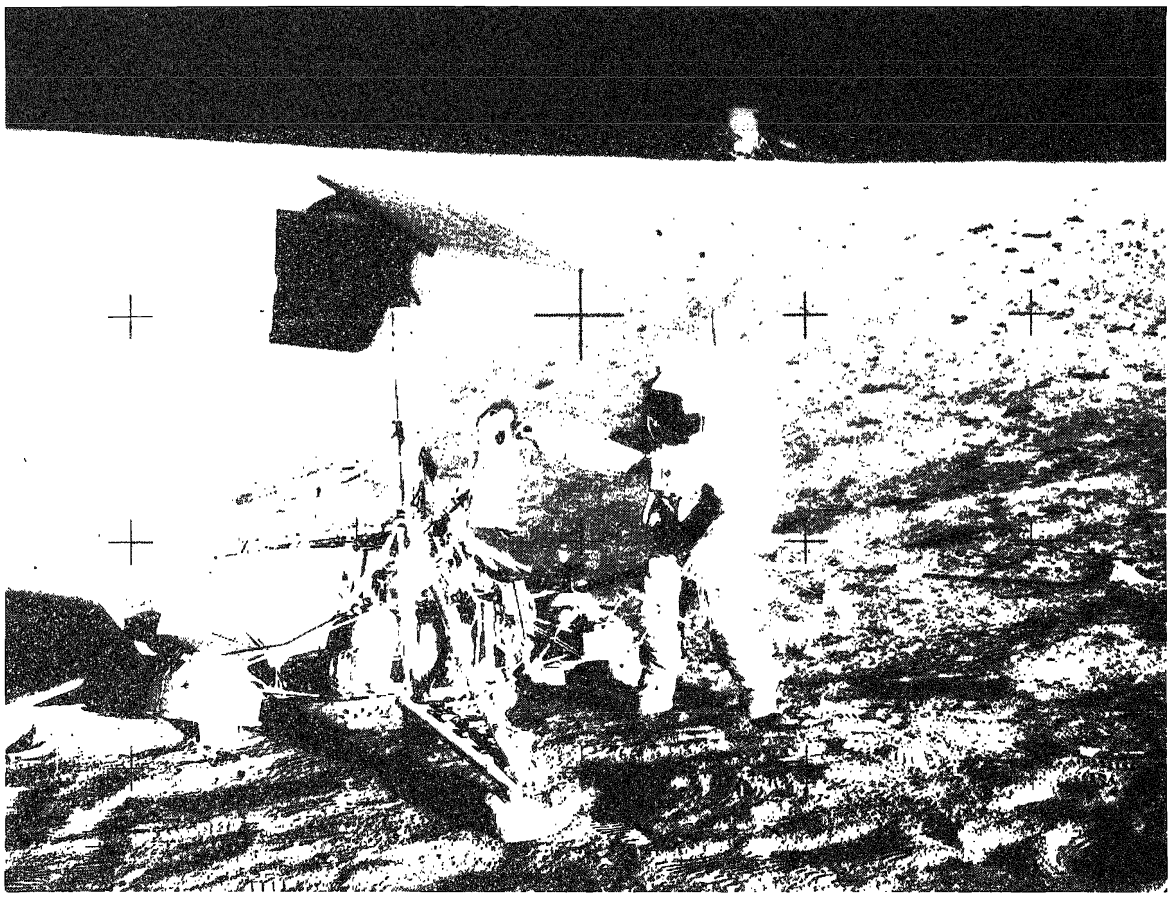

Fig. 1. Surveyor III spacecraft on its lunar landing site with Astronaut Conrad inspecting the TV camera. The lunar module Intrepid appears in the background.

knowledge of the inhospitable environment for terrestrial life that exists on the lunar surface and the belief that landed contamination, if it survives, will remain localized. For these reasons, lunar landing spacecraft may have on board a low level of microbial life—they must be decontaminated, but not sterile."

The extensive experience gained from Apollo 11 and Apollo 12 indicated that extraterrestrial microorganisms would not be isolated from Surveyor III (OYAMA *et al.*, 1970, 1971; TAYLOR *et al.*, 1970, 1971). The recovery of terrestrial microorganisms originally present in the TV camera would be possible if these microorganisms had been able to survive in the lunar environment. However, verifying the origin of any isolate would be complicated by the possibility of postretrieval contamination.

It had not been anticipated at launch in 1967 that the TV camera would be returned to earth at some future time. Consequently, no prelaunch microbial analysis of the camera interior was performed, and therefore, no appropriate experimental control was available for comparison. However, substitute controls were available. Several identical backup Surveyor TV cameras had been held in bonded storage during the same time period that Surveyor III had remained on the lunar surface. One backup TV camera was used to refine techniques for disassembly and microbial sampling

prior to performing any definitive procedures on the retrieved Surveyor III camera. A second backup TV camera, designated the type approval test camera (TAT–1), was disassembled after the Surveyor III camera and sampled identically to the retrieved Surveyor III TV camera.

Disassembly and Sampling Procedures

The retrieved TV camera was placed in a laminar-outflow hood equipped with high-efficiency particulate air filters (Fig. 2) in the LRL astronaut debriefing room, which has an air-conditioning system separate from the system used by the rest of the LRL. Every surface of the laminar flow hood which would be exposed to the camera was thoroughly washed twice with isopropyl alcohol prior to the camera being placed into the hood. A sterile cloth was placed on the floor of the hood to retain any lunar material which might accumulate as a result of the disassembly procedures. Only those personnel directly responsible for disassembling and sampling the TV camera were permitted in the room. They were clothed in laboratory attire, including surgical caps, face masks, and sterile gloves. Other participating personnel observed and coordinated activities from behind a viewing window.

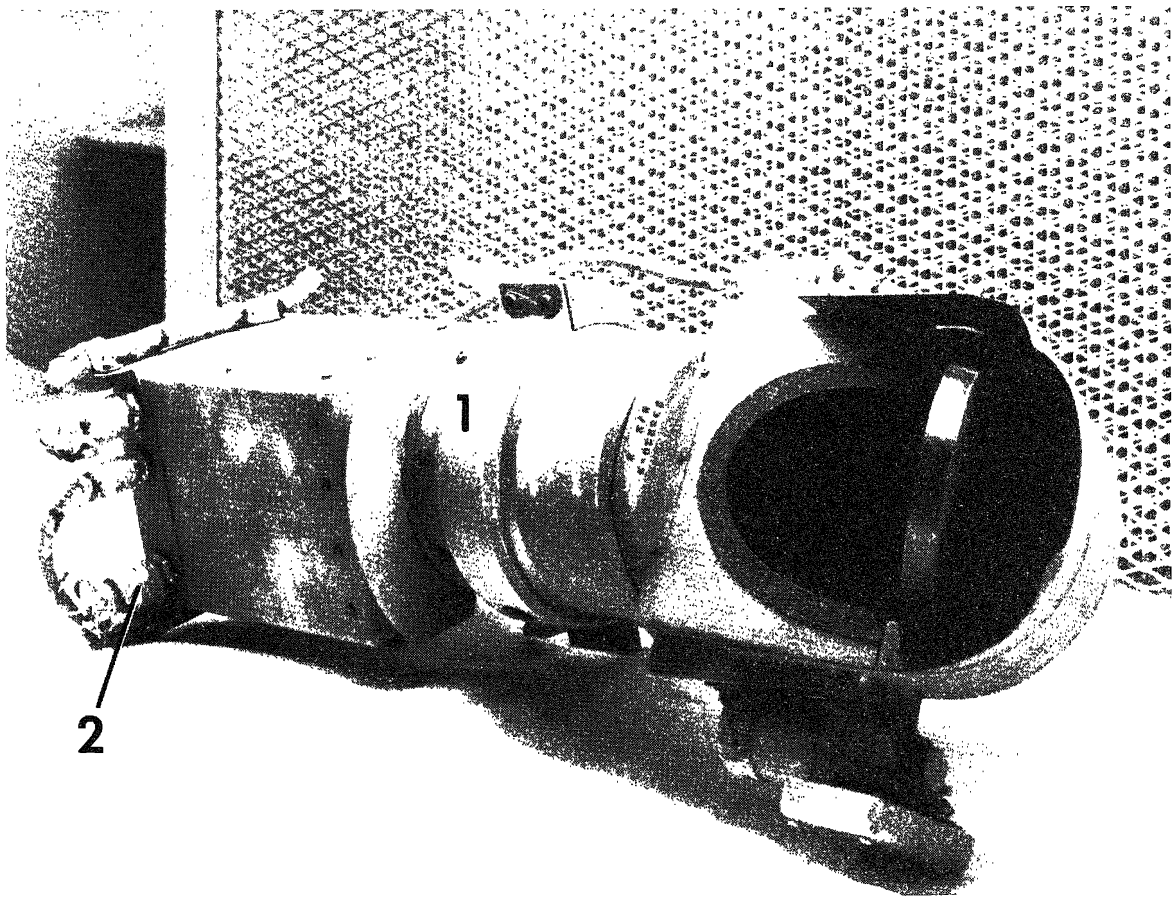

Fig. 2. The retrieved Surveyor III TV camera, complete with shroud, original collar, and cables, as it appeared in the laminar-flow hood of the Lunar Receiving Laboratory. Sampling sites are numbered.

To prepare the TV camera for disassembly, the original collar of the camera was removed and replaced with a special tripod permitting easy manipulation of the camera in the laminar-flow hood. To remove the camera shroud, the outer aluminized and inner clear Teflon wrappings were removed from the cable connectors. The cable connectors were sampled and then washed with isopropyl alcohol. Retaining screws on the shroud were removed and the cable connectors pushed inside the shroud. The shroud was then removed from the bottom of the camera and the biological samples were immediately taken. The shroud fit very tightly on the camera, and although the camera was not hermetically sealed the interior of the camera was extremely clean. No evidence of lunar material was observed within the TV camera when the shroud was removed (Fig. 3). The only evidence that the camera had been launched to the moon and retrieved was a small number of particles (no larger than 1 mm^3) which had accumulated in the bottom of the shroud. These particles were determined to be bits of ceramic insulation which had shaken loose during the flight to the moon or during the return flight (RIGLIN, CARROL, private communication, 1970).

Identical procedures were used for sampling the Surveyor III and the TAT-1 TV cameras. Three sterile calcium alginate swabs were arranged with the swab heads in tandem, moistened with sterile phosphate-buffered saline (0.0003 M PO_4^{3-},

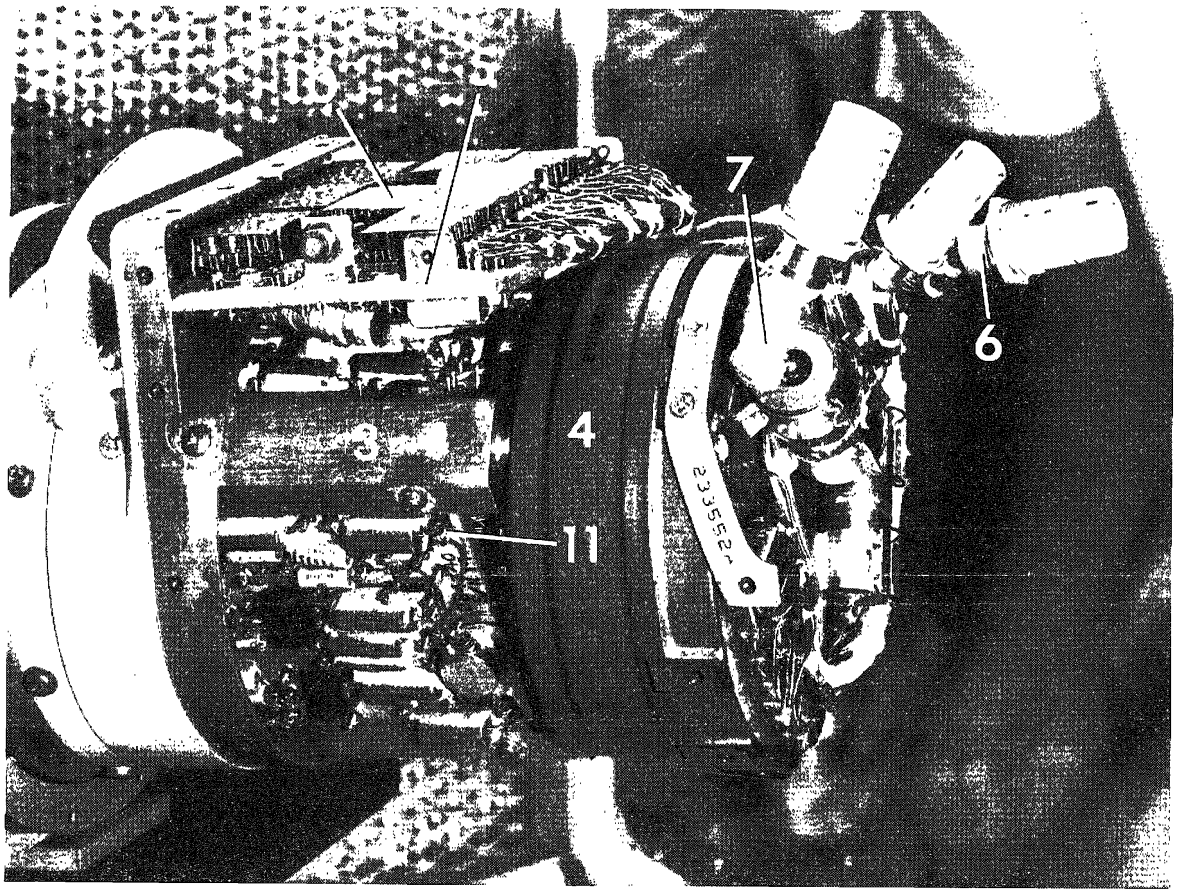

Fig. 3. Surveyor III camera interior with shroud and cables removed. Sampling sites are numbered.

Table 1. Microbial sampling sites of the Surveyor III and TAT-1 TV cameras. Sampling sites 1 and 2 are exterior camera samples pertaining to the Surveyor III TV camera only. The TAT-1 camera had no collar or cables; consequently, no sample of site 1 was taken. Site 2 included all three exterior metal cable connector surfaces.

Sampling site	Tube number		
	TSB	THIO	YMB
1. Metal surface under front half of collar	1	11	21
2. Nylon ties, Teflon wrapping, cable connector suface	2	12	22
3. Surface area on support studs	3	13	23
4. Surface are on electronic conversion unit	4	14	24
5. Circuit board support-plate edges and screw studs	5	15	25
6. Surface area of all three cable connectors inside camera	6	16	26
7. Nylon ties and cable wrappings	7	17	27
8. Debris in bottom of shroud	8	18	28
9. Large area on inside of shroud	9	19	29
10. Top surface of exposed circuit boards	10	20	30
11. Foam samples from between circuit boards	31	32	33

0.147 M NaCl), and used to swab the maximum surface area of each site (Table 1). The swabs were then separated. One each was placed into 5 ml of trypticase soy broth (TSB) for aerobic analysis, 5 ml of thioglycollate broth (THIO) for anaerobic analysis, and 5 ml of yeast malt broth (YMB) containing 33 units/ml of penicillin G and 62 μg/ml of streptomycin for mycological analysis. In confined areas where this method of swabbing could not be used, three sequential samples were taken and placed in the appropriate media. The first such sample was always placed into TSB, the second into THIO, and the third into YMB.

Dry swabs, arranged as described previously, were employed at three sampling sites because of the nature of the material to be sampled or the requirements of prescribed followup studies. These samples included the bits of ceramic debris in the camera shroud base, the cable surfaces in the camera interior, and the top surface of the circuit boards. Samples numbered 31, 32, and 33 consisted of bits of polyurethane foam. This foam had been used as insulation between the two aluminum plates of the circuit boards. The space between the aluminum plates was approximately 4 mm. This thin layer of foam was accessible only where holes had been cut into the plates for the placement of electronic components. Only by using long, curved, needle-nosed forceps could one reach through the hole and into the space between the aluminum plates to obtain bits of the foam. The largest bit of foam that was extracted was approximately 1 mm^3. Samples obtained with forceps or with dry swabs were cultured according to the same procedures and in the same media as prescribed for wet-swab samples.

The protocol established for the aerobic and anaerobic analyses (Fig. 4) maximized the possibility of detecting and quantitating low numbers of microorganisms in a sample while at the same time yielding valuable clues as to the source of any microorganism detected. The protocol inherently contained a system of redundancy and cross-checks designed to identify suspected laboratory contamination. For example, growth on any BA plate from the 10^2 dilution tube without simultaneous growth in the original tube, the two dilution tubes, and on the BA plates from the 10^1 dilution

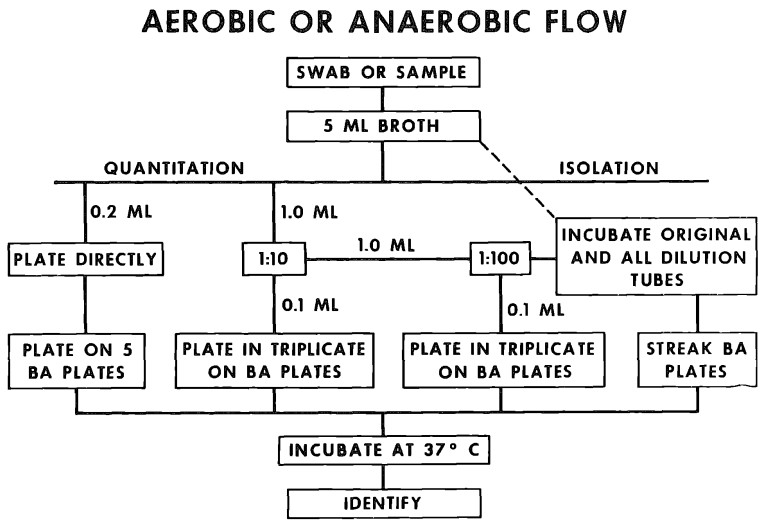

Fig. 4. Protocol established for the aerobic and anaerobic samples. This protocol was followed for both the retrieved Surveyor III TV camera and the backup TAT-1 TV camera.

tube and from the original tube containing the foam sample would be suspect. Growth on any BA plate without growth in the tube from which aliquots were taken to place on the BA plate would require extreme care in interpretation, and in this case one would probably suspect contaminated BA plates. Growth in either the 10^1 or the 10^2 dilution tube without growth in the original tube would require some logical reason why growth did not occur in the undiluted tube. The replicate BA plates provide the requirement for consistent results, within experimental error, on each plate and provide a check on techniques used in making dilutions. Streaking fresh BA plates with aliquots from each tube after 24 hours of incubation was intended to provide an opportunity for early isolation and separation in case the sample contained more than one microorganism with the result that one specie might overgrow another specie if the tube was allowed to incubate to full turbidity without examination. Again this operation provided another opportunity to cross-check with the results from the previous dilutions and plating. With growth on the 10^2 dilution BA streak plate one would also expect growth on the 10^1 dilution BA streak plate and on the BA streak plate from the original undiluted tube. Whatever the results, any observed growth would have to be consistent and logical in view of the redundancy and cross checks built into the protocol. Obvious cases of laboratory contamination could easily be identified and reported as such.

The swab or sample was placed into 5 ml of the selected broth and vortexed. One ml of this broth was spread in 0.2 ml aliquots onto five blood agar (BA) plates. Aliquots of 0.1 ml were taken from 10^1 and 10^2 dilutions of the broth containing the selected sample and spread on BA plates in replicates of three. The tubes containing the original samples, the two dilution tubes, and all plates were incubated for 24 hours. The TSB tubes and a set of BA plates containing 5% sheep (lamb) blood were incubated aerobically. The THIO tubes and a second set of BA plates were incubated anaerobically, using GasPak (BBL) systems in stainless steel jars. Aliquots from each tube were streaked onto fresh BA plates, and all plates and tubes were returned for

incubation at 37°C for 30 days. Any observed growth on the plates was quantitated and identified. Growth in the incubated tubes was also identified. The YMB tubes were handled according to the established LRL procedures for mycological analysis.

Surveyor III Camera Results

The only sample to produce visible microbial growth was sample number 32, a 1 mm^3 piece of foam incubated in undiluted thioglycollate broth. The initial growth was observed on the fourth day of incubation as a white "tail" of growth 2–3 mm in length, hanging from the piece of foam which was floating in the middle of the tube. No other growth was observed on that day. The next day this tube was turbid with growth and the 10^1 dilution tube exhibited approximately 100 foci of growth scattered predominantly at the top of the tube. No growth was observed in the 10^2 dilution tube or on any BA plate or BA streak plate for the remainder of the study.

In both tubes containing growth, only a single cellular morphology was observed, that of a Gram positive coccus in chains. Since the initially observed growth had required 4 days of incubation in THIO and since no growth was observed on the initial five anaerobic BA plates, these media were again inoculated with the isolate. In addition, TSB and aerobic BA plates were inoculated with the isolate. Growth was observed in both THIO and TSB within 24 hours. Growth was observed on the aerobic BA plates within 24 hours and on the anaerobic BA plates within 72 hours (first examination). As a precaution, 1 ml aliquots containing respectively 10^3, 10^4, 10^5, and 10^6 viable cells of the isolate were injected intraperitoneally (in replicates of five) into 5-week-old white male CD–1 mice, with no observed effect.

The isolate was identified, with confirmation from the U.S. Public Health Service Center for Disease Control in Atlanta, Georgia, as alpha hemolytic *Streptococcus mitis* (Facklam, private communication, 1970).

TAT–1 TV Camera Results

The results from the backup TAT–1 camera, sampled identically as the retrieved Surveyor III camera, provide observations on microbial survival at ambient atmospheric pressure and room temperature for the same period of time that the Surveyor III camera rested on the lunar surface. The TAT–1 camera was held undisturbed in bonded storage in its original shipping container for this time period. Terrestrial microorganisms were isolated in very low numbers from one exterior and five interior locations. One bacterial isolation and five mycological isolations were made after long incubation periods varying from 6 to 27 days. All six isolations were made from accessible metallic and nonmetallic sampling sites.

From a Teflon-covered cable within the TAT–1 camera, a *Bacillus* species was isolated in THIO after 6 days of incubation. Growth appeared only in the tube containing the undiluted sample. An *Aureobasidium* species was isolated after a sampling of the TAT–1 exterior metal cable connectors was incubated in YMB for 14 days. The same species was also isolated after a sampling of the metal electronic conversion unit within the TAT–1 camera was incubated in THIO for 27 days. *Aspergillus pulvinus* was isolated from three sites in the interior of the camera. This

isolate was detected after a sampling taken from the top surface of the nonmetallic circuit board was incubated in THIO for 12 days. A second isolation was made from a sampling of the metal cable connectors after 14 days of incubation in TSB. The third isolation was made from a sampling of the metal electronic conversion unit after 21 days of incubation in YMB.

In the five fungal isolations, growth appeared only in the tube containing the undiluted sample, indicating very low numbers of microorganisms originally present on the sampled surfaces. To illustrate, when three swabs were used in tandem to sample one of the selected sites, *Aspergillus pulvinus* was isolated from only one of the swabs; an *Aureobasidium* species was isolated from a second swab; and the third swab was negative.

DISCUSSION

Every step in the retrieval of the Surveyor III TV camera was analyzed for possible contamination sources, including camera contact by the astronauts; ingassing in the lunar module and command module during the mission or at "splashdown"; and handling during quarantine, disassembly, and analysis at the LRL.

Contact by the astronauts during retrieval on the moon was not considered a probable source of contamination. Microorganisms were undoubtedly present on exterior surfaces of the astronauts' space suits during each lunar landing and selenological sample collection excursion. However, no viable terrestrial microorganism has ever been detected in the selenological samples collected by the astronauts (OYAMA *et al.*, 1970, 1971; TAYLOR *et al.*, 1970, 1971).

After the TV camera was removed from the Surveyor III spacecraft, it was placed into a back pack carried by one of the astronauts. The pack was zipper-closed although there was no capability for sealing it. The pack was placed in storage first aboard the lunar module and then the command module, and finally was flown to the LRL by jet aircraft. At the LRL, the TV camera was removed from the pack and placed in a Teflon bag. The bag was heat sealed and then the camera and first bag were placed into a second Teflon bag which was also heat sealed. The double-bagged camera was then placed in bonded storage at room temperature until the lunar sample was released on 7 January 1970.

When the Apollo 12 lunar module landed on the moon, lunar dust was disturbed with such force that it traveled approximately 155 m with a reported velocity of at least 70 m/sec and "sandblasted" the Surveyor III spacecraft (JAFFE, 1971). Shadows in the exterior paint of the Surveyor III TV camera were clearly visible wherever a strut or other part had shielded the camera from this hail of lunar particles caused by the lunar module rocket exhaust.

While the TV camera was being disassembled it was observed that barely visible particles of lunar dust had accumulated underneath the camera collar. The presence of this fine dust in this protected area is a reflection of the minute size of some lunar particles and the "sandblasting" force which caused the penetration. It has already been noted that no such presence or accumulation of lunar particles was found in the interior of the camera protected by the shroud despite the "sandblasting." This suggests that the camera shroud may have provided a formidable barrier to ingassing

carrying fine particles, perhaps even the size of a bacterium, from the environment into the camera interior.

The lunar material under the camera collar was sampled for viable microorganisms. None was recovered. Further, as the two layers of Teflon wrappings were removed from the exterior of the metal cable connector, a sampling was made of both layers of the Teflon wrappings as well as the metal surface of the cable connector. Again, no viable microorganisms were detected. This was a deliberate attempt to detect any microorganisms which might have been available in the external environment and which might have entered the camera interior during ingassing.

The Apollo 12 astronauts, spacecraft, and space suits were sampled prior to launch and after recovery. All three astronauts carried species of a number of genera of microorganisms, including *S. mitis* (FERGUSON, private communication, 1970). As a result, the cabin air of both the lunar and command modules undoubtedly contained a number of different bacteria as an aerosol load.

Assuming that microorganisms had entered the camera interior during ingassing, a representation of the entire microbial population available would be expected rather than a single species. This representative population of microorganisms would be expected to be randomly distributed in the camera. Therefore, if large surface areas of the camera interior were sampled, microbial contamination due to ingassing should be detected. Even if *S. mitis* was the only one of the population carried in by ingassing to survive, it should have been found randomly distributed over large surface areas instead of in the only relatively inaccessible location that was sampled.

On a unit area basis at least 10,000 times the area in which the isolate was detected was sampled, and this area represents large exposed surface areas of different types of materials throughout the camera interior. That *S. mitis* cells (alone from all the microorganisms available in the external environment) could enter the camera and find their way to the least accessible sampling site without being detected in 10,000 times that area of readily exposed surface area is difficult to envision. In the absence of any other microorganisms isolated and in view of the large sampling area it is considered improbable that ingassing at any point in the retrieval could be responsible for depositing *S. mitis* in the relatively inaccessible location where it was isolated.

Extreme precautions were taken at all times during the analysis to prevent any handling errors which might have caused contamination. Experimental controls of the implements and media used in the analysis did not initiate microbial growth.

To determine whether low numbers of organisms alone could cause the delay in initial growth, a dilution series of THIO containing the isolate was prepared. From each dilution tube, 0.1 ml was transferred to a THIO tube and to 5 aerobic BA plates. Visible growth appeared within 24 hours, even in the dilution tube initially containing less than 10 viable cells as determined by the colony count on the 5 BA plates. Furthermore, the presence of the foam sample did not account for the initial delay in growth, since growth was not delayed when the isolate was cultured in a dilution series of THIO containing foam sections the same size and composition as the original samples.

The fact that no growth was observed until the fourth day of incubation in liquid broth indicated that the isolated bacterium required an adaptation period. Growth

delays are not uncommon in bacteria recovering from lyophilization (SINSKY and SILVERMAN, 1970). No colonies were found on the first set of five anaerobic BA plates, indicating either that no viable cells were placed on the BA plates, or that the cells could not adapt and replicate on the solid agar surface as they had in the liquid broth media.

The "tail" of growth which streamed from the underside of the foam on the fourth day of incubation indicates a direct relationship between the organism and the foam sample and is an important observation. When a control dilution series of the broth containing the isolate was made with similarly sized foam sections, no such relationship (no "tail") was observed in any of the dilution tubes indicating no spontaneous association of the bacteria with the foam.

The initial delay in growth of the isolate, the direct association of the bacterium with the foam sample from which it was isolated, the relatively inaccessible location from which the isolate was obtained, and the absence of any other isolates in the large sampling area are, in our opinion, not consistent with the hypothesis that the Surveyor III TV camera was contaminated with the isolate during or after its retrieval.

It is inadequate to simply imply that the foam sample or the thioglycollate tube became contaminated and that this readily explains the growth in the original undiluted tube and the 10^1 dilution tube. That would not be examining all the data and it would require unsupported assumptions; for example, the assumption that somehow the contaminant came into intimate contact with and remained in association with the foam sample despite vortexing so that it eventually grew as a "tail" to the foam. It would have to assume that for some reason the *S. mitis* cells were damaged and growth was delayed 4 days, that of all the tubes in the experiment contamination occurred only in this particular tube despite the control data, or that contamination occurred in the sample taken from the most inaccessible of all the sampling sites. Still other such assumptions would be required for such a simple explanation. No one single observation is adequate. Every bit of data must be considered. In the opinion of the authors, the total data is consistent with the hypothesis that the isolated bacterium was in intimate association with and isolated from the piece of foam sample which was taken from the camera interior and processed in an asceptic manner under controlled conditions.

The isolated bacterium, *S. mitis*, is a spherical microorganism measuring from 0.5 to 1.0 μ in diameter and is a frequent, normal, benign inhabitant of the respiratory tract. Man constantly sheds microorganisms into the air, a large portion of which comes from the respiratory tract. Although normal talking drives out considerable numbers of organisms a good healthy sneeze may dispense as many as 20,000 aerosol droplets, which may vary in diameter from 10 μ to 2 mm and the larger of which may travel 15 feet before reaching the ground. These larger droplets settle rapidly, adhering to particles of dirt, and dry leaving organisms attached to the particles (SMITH, CONANT, and OVERMAN, 1964).

A single aerosol droplet could contain large numbers of organisms. It has been estimated that saliva contains an average of 750 millions of organisms/ml (ROSEBURY, 1962). In addition saliva contains many organic constituents, the major portion of which is protein and the principal salivary protein of which is mucin. "It seems that

mucin exerts much of its effect on the oral microbiota by physical localization of bacterial growth. Mucin probably protects bacteria primarily by a coating effect with the formation of a temporary artificial capsule about the cell; this has been demonstrated with such oral microorganisms as staphylococci, streptococci, and lactobacilli" (BURNET and SCHERP, 1968).

Other organic constituents of saliva are carbohydrates, including hexosamine, methyl pentose, galactose, mannose, deoxyribose, and glucose (BURNET and SCHERP, 1968). "The synthesis of intracellular glycogen in the presence of excess carbohydrate, and its rapid catabolism to lactate in the absence of exogenous carbohydrate, has been observed in *S. mitis*. The polysaccharide appears to function as the sole reserve of energy of this organism and may provide the cell with energy in a utilizable form. The conclusion seems to be justified that the possession of glycogen by *S. mitis* favors its survival during starvation" (VAN HOUTE and JANSEN, 1970). In addition, when drying bacteria the presence of glucose in the suspending fluid in concentrations of between 5 and 10% greatly increased the survival rate both immediately and after storage (FRY and GREAVES, 1951).

As noted in the Hughes Aircraft Company Report, dated 22 January 1971, *Surveyor III Parts and Materials/Evaluation of Lunar Effects Returned from the Moon by Apollo XII*, "There were opportunities for contaminants to deposit on the camera prior to launch." A number of these opportunities came while the shroud of the camera was removed for prelaunch inspections or repairs. In addition, the prelaunch thermal vacuum testing of the camera provided conditions conducive to lyophilization. The Surveyor III and TAT–1 TV cameras were subjected to a series of thermal vacuum tests following inspections and repairs. Information provided by personnel of the Hughes Aircraft Company, El Segundo, California, where the Surveyor III TV camera was tested before launch indicates that prior to launch the Surveyor III TV camera was exposed, under a 10^5 torr vacuum, at least 12 times to temperatures of −29°C and at least three times each to temperatures of −45°C and −118°C. Exposure at these temperatures was for at least one hour, and in many cases longer. The highest temperature attained during any testing cycle was 52°C. The last thermal vacuum test of the camera before it was placed on the spacecraft occurred late in January 1967 leaving approximately 90 days before launch. After the Surveyor III TV camera was attached to the Surveyor III spacecraft, it was again exposed to extreme temperature and vacuum conditions in the course of spacecraft thermal vacuum testing.

If the bacterium was deposited in the camera prior to launch one can only speculate as to how many of these lyophilizing cycles the bacterium experienced. In one report a paracolon bacillus culture was subjected to repeated lyophilization and reconstitution without allowing for further growth. Approximately the same percentage of cells survived each cycle of lyophilization and reconstitution (FRY and GREAVES, 1951). It is certain that, if deposited in the camera, the bacterium would have experienced at least one cycle when the TV camera was attached to the Surveyor III spacecraft and the spacecraft underwent its thermal vacuum testing. In addition, since the TV camera was not maintained under a continuous vacuum, ambient pressure returned to the camera for approximately 90 days while the spacecraft awaited its launch to the moon. The survival of the bacteria inside an aerosol droplet in the foam

would depend, it would seem, on the amount of protective substances which might surround the bacteria and the effect the lyophilizing conditions had on the dried droplet. Considering the fact that tubercule bacilli can survive in dried sputum for at least 8 months (SMITH, CONANT, and OVERMAN, 1964) it would seem possible that if the bacteria were encapsulated in a protective coating and dried they might survive until they experienced the continuous vacuum of space after launch. "The haemolytic streptococcus group B is very resistant to drying, and one strain, which shows a survival rate of 100% even in serum water, was, in another experiment, not entirely killed 18 months after drying in distilled water. It seems impossible to kill this strain by drying" (FRY and GREAVES, 1951).

It has been reported that when bacteria and viruses are dry they require, like isolated enzymes, a higher temperature for irreversible damage (DAVIS *et al.*, 1968). Engineering estimates at the MSC suggest the maximum temperature experienced inside the TV camera while on the lunar surface at 70°C (ERB, private communication, 1970). Perhaps in such a dried state and under the high continuous vacuum of space, survival of lyophilized bacteria is possible. It has been shown that several *Streptococcus* species have remained viable for at least 20 years after lyophilization under routine laboratory conditions (RHOADES, 1970). Finally, in dealing with large numbers of microorganisms, even the loss of 99.9+% of the original population can still leave considerable numbers of survivors. It is estimated that between 2 and 50 cells or clumps of cells (chains) of *S. mitis* were isolated from the foam sample.

It would be very desirable to be able to define the exact conditions under which the isolated bacterium may have been deposited on the foam, the amount of protection which may have been provided by its source in the respiratory tract, the tolerance of bacteria contained in an aerosol droplet to heat and high vacuum, and the initial concentration of bacteria. Although the literature contains many reports of experiments which at first appear to be applicable, they all seem to suffer from the same shortcomings: the test species were different, the vacuum or temperature was not high enough, and most common of all, the experiment did not last long enough.

The isolated bacterium was lyophilized upon its initial isolation and is available for further testing as time, money, and facilities are available. The bacterium will be submitted for addition to the American Type Culture Collection.

The available data indicates that *Streptococcus mitis* was isolated from the foam sample and suggest that the bacterium was deposited in the Surveyor III TV camera before spacecraft launch. It is suggested that the bacterium may have been provided some protection from its source in the respiratory tract, and that lyophilizing conditions to which the TV camera was subjected before launch and later on the lunar surface may have been instrumental in the apparent survival of this terrestrial microorganism.

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