In reality, the values of the PIPA's are never exactly equal to 1 cm/sec. The exact value of a PIPA is determined by the scale factor, and it must be determined by calibrating the accelerometers. This calibration is performed before launch. In addition to the scale factor, each PIPA has a bias. The best place to determine the bias is in free fall. Fortunately, the lunar module is in free fall much of the time during a mission (that is, during translunar orbit and lunar orbit, except when the thrusters are firing). The PIPA's are read while in orbit (these readings should be zero). A reading of any magnitude, whether negative or positive, is an error or bias. In addition, the bias can change with time. The bias and scale factor are entered into the guidance computer memory of the lunar module before launch. During the mission, the bias can be changed in the guidance computer of the lunar module. The bias was redetermined after the flight of Apollo 11. After these values are determined, they must be applied to the original PIPA readings by means of the following equations:

$$\frac{XC}{\Delta T} = \frac{(1+SX)\,XI}{\Delta T} - BX \qquad (2)$$

$$\frac{YC}{\Delta T} = \frac{(1+SY)\,YI}{\Delta T} - BY \qquad (3)$$

$$\frac{ZC}{\Delta T} = \frac{(1+SZ)\,ZI}{\Delta T} - BZ \qquad (4)$$

where XC, YC, and ZC are the corrected values of the PIPAX, PIPAY, and PIPAZ readings, respectively; SX is the scale factor for X, SY is the scale factor for Y, and SZ is the scale factor for Z; BX is the bias for X, BY is the bias for Y, and BZ is the bias for Z. Values of the scale factor and bias for the PIPA during the lunar-landing mission were:

$$SX = -0.00027 \qquad BX = 0.66$$
$$SY = -0.00115 \qquad BY = 0.04$$
$$SZ = -0.00062 \qquad BZ = -0.029$$

To a second-order approximation, the gravity can be computed from Eq. 5

$$g = \left[\left(\frac{XC}{\Delta T}\right)^2 + \left(\frac{YC}{\Delta T}\right)^2 + \left(\frac{ZC}{\Delta T}\right)^2\right]^{1/2} \qquad (5)$$

The gravity observation from the PIPA's is an absolute observation. Values of g were computed from Eq. 5 for 16 time intervals from data obtained from the lunar module on the lunar surface. The mean of these 16 values of g was 162,821.680 mgal. The standard deviation was 13.098 mgal.

The gravity should be compared to a theoretical (normal) gravity γ_0 at the lunar-landing site. The normal gravity is computed as follows:

$$\gamma_0 = GM/R^2 \qquad (6)$$

where GM is the product of the gravitational constant and the mass of the moon and R is the radius at the observation point. According to Eq. 6, it is assumed that the moon is spherical and homogeneous. The effects of the lunar rotation and oblateness are neglected. It is assumed that the value of R is obtained from sources other than gravity measurements. In the Apollo 11 mission, the location of the touchdown point of the lunar module relative to the topographic features of the lunar surface was determined from 16-mm sequence-camera photographs taken during descent. The touchdown point was then located on Lunar Orbiter photographs. From Apollo 10 data, the radius at the touchdown point of the lunar module was determined to be 1,735,575 m. From the Lunar Orbiter data, the radius was determined to be 1,735,177 m.

The value adopted in the Apollo project for GM is 4902.778 ± 0.2 km^3 sec^{-2}. The value of GM is determined from the relation

$$GE/GM = M_e/M$$

where M_e/M is the earth/moon mass ratio and GE is the product of the gravitational constant and the mass of the earth. In the calculation of GM, a value for M_e/M of 81.3015 ± 0.0033 was determined by tracking Mariner 2 (*4*). The value of GE was determined by tracking satellites of the earth to be $398{,}603.2 \pm 3$ km^3 sec^{-2} (*5*).

Tracking data from a spacecraft near the moon can give a value for GM. There have been several flights near the moon, for example, the Ranger spacecraft. However, the former method still gives the best results for GM.

A new value for M_e/M of 81.301 ± 0.001 was determined by tracking Mariner 5 (*6*), and a new value for GE of $398{,}601.2 \pm 0.7$ km^3 sec^{-2} was determined by tracking the Ranger spacecraft (*7*). This changed the value of GM to 4902.78 ± 0.06 km^3 sec^{-2}; however, there was a large improvement in the standard deviation.

If we use $GM = 4902.778 \pm 0.2$ km^3 sec^{-2} and $R = 1{,}735{,}575$ m, $\gamma_0 = 162{,}762.914$ mgal; if we use the same value of GM and $R = 1{,}735{,}177$ m, $\gamma_0 = 162{,}837.589$ mgal.

If the gravity anomaly Δg is defined as the difference between the observed gravity and the normal gravity (that is, $\Delta g = g - \gamma_0$), then $\Delta g = 58.766$ mgal if $R = 1{,}735{,}575$ m, and $\Delta g = -15.909$ mgal if $R = 1{,}735{,}177$ m.

The radius at the observation point can be computed from GM, which was determined from tracking data, and g, which was measured with the lunar module accelerometers. From Eq. 6, we have

$$R = (GM/g)^{1/2} \qquad (7)$$

Equation 7 can be used to compute R independently of other measurements of R

$$R = \left(\frac{4.902778 \times 10^{18}\ \text{cm}^3\ \text{sec}^{-2}}{1.62821680 \times 10^{2}\ \text{cm sec}^{-2}}\right)^{1/2} = 1{,}735{,}261.76\ \text{m}$$

$$R = \left(\frac{4.90278 \times 10^{18}\ \text{cm}^3\ \text{sec}^{-2}}{1.62821680 \times 10^{2}\ \text{cm sec}^{-2}}\right)^{1/2} = 1{,}735{,}262.12\ \text{m}$$

These radii are in good agreement with the radius computed from Apollo and Lunar Orbiter data.

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19 September 1969

Fungi Associated with Stalactite Growth

Abstract. *A fungus,* Cephalosporium lamellaecola, *was found to be regularly associated with the active tip of stalactites; crystallization of* $CaCO_3$ *occurred on hyphae suspended from the stalactite wall in the terminal drop.*

During an aerological and ecological survey of Lehman Caves, in the Wheeler Peak area of Eastern Nevada (*1*), fungal hyphae were found to be regular inhabitants of all walls, stalac-

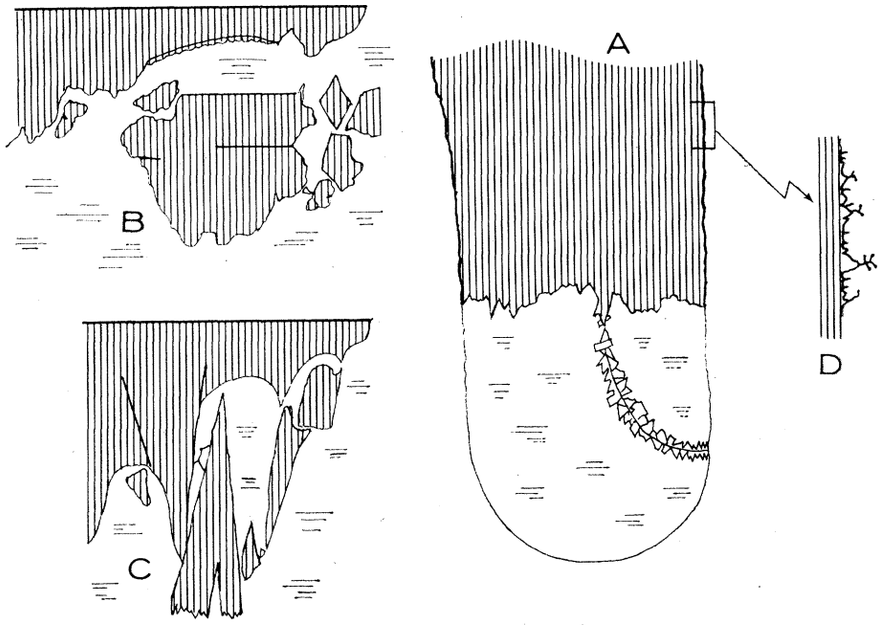

Fig. 1. Enlargements of active stalactite tips. (A) Drop on stalactite tip (diameter 11 mm). (B), (C), and (D) Enlargements of (A) (× 6). Striped areas indicate calcium carbonate.

tites, and other limestone structures. With a special microscope, mounted horizontally on an adjustable bracket, sliding along a vertical steel bar, stalactites were observed *in situ*. As in telescopes, the eye piece on the horizontal microscope was attached at a right angle by means of a prism, making it possible to observe even in tight spots. A flashlight was mounted near the microscope to illuminate the stalactites.

Along the limestone surface of all active stalactites, short very thin hyphae extended perpendicularly (Fig. 1D). Some were branched and had conidiophores. On dissolving the limestone with dilute acetic acid, the mycelium was found only in the surface layer of the stalactites, and only sparingly. Some hyphae extended into the surface of the water drop hanging from the stalactite.

Whereas some of the growth of the stalactite surface was obviously by extension of the existing surface crystals downward into the drop surface, a large number of smaller and larger crystals and crystal aggregates were dispersed in the drop surface, having no continuity with the crystals of the stalactite (Fig. 1, B and C). Yet in some way the crystals were attached: When individual stalactites were observed over a 24-hour period, the unattached crystals retained the same relative position (1 to 20 μ distance) to the stalactite tube. In a number of cases hyphae were seen to connect these crystals to the body of the stalactite, and in other cases strings of crystals formed in a long arc, along hyphae which connected at both ends with the stalactite (Fig. 1A). Thus the hyphae function both as crystallization nuclei and as attachment, without which individual crystals would be eliminated by the falling drop. In one case a cotton fiber was attached to the tip of a stalactite, and all along its length, as far as it was coiled up and immersed in the drop, a row of crystals covered the fiber. From it, secondary strings of crystals emerged, apparently along hyphae.

It is conceivable that the presence of these hyphae allows the orderly growth of stalactites, which, if entirely dependent upon accretionary growth of preexisting crystals, do not grow straight down, as found in the case of helictites.

Cultures were made on nutrient agar of the microorganisms living in and on active and inactive stalactites. Cultures from the terminal drop and the active rim of the stalactite gave, in five out of six cases, pure cultures of *Cephalosporium lamellaecola* F. E. Smith, a slow-growing fungus with very fine white mycelium; in one case bacterial colonies developed in addition to the fungus. In another test, 42 out of 46 cultures from stalactite tips produced *Cephalosporium*. Of the 100 microorganisms developing on helictites, not a single one was *Cephalosporium*. In the active stalactites investigated in Lehman Caves the same fungus was associated with them, and no other microorganisms, and certainly no bacteria, can be involved in their growth. The nutrition of these fungi must depend on organic materials that are leached from soil and move down with the calcium bicarbonate solution seeping into the cave. All calcium carbonate deposits of known biological origin in oceans (corals, algae, and molluscs) are attributed to the activity of an enzyme, carbonic anhydrase, produced by these organisms.

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Note

1. Supported by National Park Service.

13 May 1969; revised 26 June 1969

Brain Lesions in an Infant Rhesus Monkey Treated with Monosodium Glutamate

Abstract. *In an infant rhesus monkey brain damage resulted from subcutaneously administered monosodium glutamate. Although a relatively high dose of monosodium glutamate was used, the infant was asymptomatic for a 3-hour observation period during which time hypothalamic neurons were undergoing a process of acute cell death. With the electron microscope it was observed that dendrites and cell bodies of neurons are the tissue components primarily affected in brain damage induced by monosodium glutamate.*

Susceptibility of the developing central nervous system to damage from subcutaneously administered monosodium glutamate (MSG) has been observed in every species of experimental animal tested thus far—mice (*1, 2*), rats (*2, 3*), and rabbits (*4*). In mice, which have been studied more extensively for MSG-induced brain damage than other species, the lowest effective dose for the baby animal (0.5 g/kg) was approximately one-tenth that for the adult (5 g/kg) (*2*). Additional studies are needed to clarify mecha-