in harmonic content of the curves with geography and, in addition, some shifts of phase. But the effect is sufficiently widespread in the land masses of the Southern Hemisphere to warrant further investigation.

It is not yet possible to advance a physical explanation of the phenomenon, but it is clearly not incompatible with the meteor hypothesis. Meteoritic dust reaching the earth is known to be distributed in orbits, the majority of which are in the plane of the ecliptic. The moon's orbit is also close to the ecliptic and, as the moon revolves around the earth, it could impose a lunar modulation on the amount of dust reaching the earth. However, a calculation of the magnitude of such an effect shows that it is unlikely that gravitational forces alone could produce a variation in rainfall as large as that shown by the accompanying curves. It may therefore be necessary to look for some other explanation for the phenomenon.

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25 June 1962

Alveolar Epithelial Cell Mitochondria as Source of the Surface-Active Lung Lining

Abstract. We propose that the surface-active lining of the mammalian lung is formed in the mitochondria of the alveolar epithelial cells. Findings supporting this hypothesis are the presence of strong surfactant uniquely in the washed mitochondrial fraction of mammalian lung, almost complete loss of mitochondrial lamellar forms accompanying loss of lung surface activity after vagotomy, and the absence of strong surface activity from the lung extracts of animals whose alveolar lining cells show no lamellar forms.

Several investigations have suggested that a substance possessing characteristic surface activity (surfactant) lines the internal surface of the lungs (*1, 2*) and helps to stabilize the air spaces. There is some evidence that a lipoprotein containing phospholipid as a major component may be the stabilizing factor (*3*).

In 1954, Macklin (*4*) suggested that the alveolar epithelial cell (sometimes called septal cell, epicyte, or pneumonocyte) secretes substances into the fluid film that lines the alveoli. He observed osmiophilic granules in the alveolar epithelial cell and on the air-liquid interface and recovered these granules from washings of the respiratory tract. Low (*5*) and Schlipköter (*6*), by means of the electron microscope, have observed mitochondria and unusual inclusion bodies in the alveolar epithelial cells. The presence of forms intermediate between mitochondria and these inclusions has led several investigators (*7, 8*) to suggest that the mitochondria of the alveolar epithelial cell can be transformed into inclusion bodies. These inclusion bodies have been called mitochondrial transformations, lamellar transformations, and lamellar forms. In changing into the lamellar form, the mitochondria appear to swell and lose their homogeneous interior, and their cristae coalesce into densely osmiophilic structures (Fig. 1).

We have noted similar structures in surface active material prepared from beef lung, fixed with osmic acid and examined with the electron microscope. Further, Buckingham and Avery (*9*) have found that the surfactant first appears in the lungs of fetal mice on the 17th to 18th day of gestation; they related this finding to the work of Woodside and Dalton (*10*), who had observed the first appearance of lamellar forms in the fetal mouse lung on the 17th to 18th day. All of these observations suggested to us that the alveolar cell mitochondria may contain the lung surfactant or its precursor and that they release this material during the process of lamellar transformation. Our report presents three experiments which attempt to locate the subcellular site of such material in the lung.

The first experiment correlates the gross occurrence of mitochondrial transformation in different species with the surface activity of extracts of the lungs in these species. Lamellar forms and characteristic surface activity have been found in the lungs of the dog, cat, rat, mouse, rabbit, and man. Toad and pigeon lungs do not have lamellar forms (*8*). To test for surface active material in these two groups, we made surface tension-area measurements on saline extracts of the lungs. Fifty milliliters of 0.9 percent NaCl was added to 3 g of minced lung, and the mixture was stirred for 30 min-

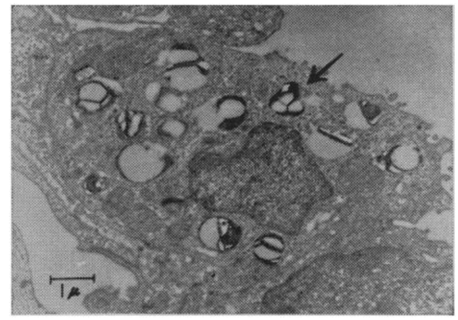

Fig. 1. Alveolar epithelial cell from a normal guinea pig, showing normal mitochondria and many lamellar forms (arrow). Osmic fixed, methacrylate embedded. (RCA EMU 3 electron microscope, × 5080)

utes. Debris was removed by filtration through four layers of cotton gauze, and surface tension measurements were made on the filtrate with a modified Langmuir-Wilhelmy trough (*11*). The area of the extract surface was reduced to one-fifth and reexpanded over a period of ½ hour. The tension-area measurements were recorded automatically and repeated until two successive tracings were duplicated. On compression of the surface of the mammalian lung extracts, surface tension characteristically drops below 10 dyne/cm (*2, 11*). Extracts prepared from 30 toad and 6 pigeon lungs, however, did not reduce surface tension below 18 dyne/cm. Miller and Bondurant (*12*) found that extracts from the chicken and frog did not reduce surface tension below 20 dyne/cm.

In the second experiment we tested whether the abundance of lamellar forms correlates with the surface activity of lung extracts in guinea pig lungs before and after bilateral cervical vagotomy, a procedure which is followed by loss of surface activity (*13*). Figure 1 is a section of a normal

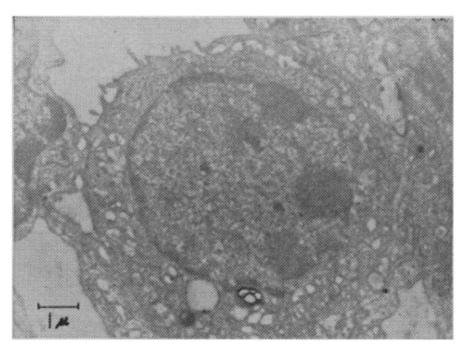

Fig. 2. Alveolar epithelial cell from a vagotomized guinea pig, showing vesiculation of the cytoplasm and only one lamellar form. (× 5250)

guinea pig lung, showing many lamellar forms in an alveolar epithelial cell. To estimate their number in the normal animal, we counted only the cells containing six or more lamellar forms. This method markedly underestimates the number of lamellar forms in the normal lung. In 11 sections from two normal guinea pigs there were 26.2 ($\pm$ 9.1) lamellar forms per grid division of the electron microscope. Figure 2 shows a characteristic section of lung from a vagotomized guinea pig. The amount of lung tissue in sections from normal and vagotomized animals was similar. The alveolar epithelial cells of the vagotomized animals show vesiculation of the cytoplasm and only rare mitochondria. Because there were so few lamellar forms in the tissue from the vagotomized animal they could be fully counted. In 29 sections from three vagotomized animals the count per grid division was 3.9 ($\pm$ 3.1). This difference suggests a relationship between surfactant and mitochondrial transformation.

The third experiment further explored the origin of the surfactant. We prepared subcellular fractions from 12 rabbit lungs in 1-percent crystalline bovine serum albumin, 0.18*M* KCl and 0.01*M* ethylenediaminetetraacetic acid, *p*H 7.2, by homogenization and centrifugation (*14*). After isolation, the mitochondrial fractions and microsomal fractions were washed twice with the medium. Each subcellular fraction and the final mitochondrial wash were layered on saline or 1-percent albumin solution, and the surface tension of each was measured as described above. The minimum surface tension of the washed mitochondrial fraction of lung was 11.5 ($\pm$ 7.2), of the microsomal fraction 24.8 ($\pm$ 2.6), and of the last mitochondrial wash 24.3 ($\pm$ 3.7) dyne/cm. Surface tension of the last four mitochondrial fractions measured on 1-percent albumin was 6.2 ($\pm$ 4.9) dyne/cm. Albumin did not lower the surface tension of the microsomal fraction or the last mitochondrial wash. Washed mitochondrial fractions prepared in the bovine albumin and KCl medium from rabbit liver, heart, brain, and kidney did not reduce surface tension below 24.0 dyne/cm in any preparation. The washed mitochondrial fraction prepared from lung had surface activity characteristic of the whole lung extract.

The above evidence supports the hypothesis that the surface active lining of the lung develops during the process of lamellar transformation of mitochondria in the alveolar epithelial cell. Direct evidence of secretion onto the surface has not yet been obtained (*15*).

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1 June 1962

Bedrock Geology of the Thiel Mountains, Antarctica

Abstract. Cordierite-bearing, hypersthene-quartz monzonite porphyry, the most widespread rock unit, is intruded by biotite granite and porphyritic biotite granite. Sedimentary and metasedimentary rocks, mainly quartzites and argillites, have been metamorphosed locally to hornfels and have been involved in high-angle faulting. Shear zones are common in the plutonic rocks.

The Thiel Mountains, which have previously been referred to informally as the "eastern Horlick Mountains," are located in western Antarctica about 330 miles from the South Pole (Fig. 1). Their elevations range between 7000 and 10,000 feet, their relief between 3000 and 4000 feet. They were studied by U.S. Geological Survey mapping parties (*1*) in the austral summers of 1960–61 and 1961–62, and the area between latitudes 85°45′S and longitudes 86°00′ and 95°00′W was mapped.

In 1958 and 1959 two parties concerned primarily with geophysical and glaciological studies approached these mountains, which, it was then believed, formed the eastern end of the Horlick Mountains. W. H. Chapman of the U.S. Geological Survey, a member of the 1958–59 U.S. Horlick Mountains oversnow traverse from Byrd Station, determined the geographic location of the north end of the Thiel Mountains in December 1958 from a point about 30 miles away. These and later geodetic studies showed that the Thiel Mountains are a distinct mountain group. In the 1959–60 season, the late Edward Thiel and a small party visited (by plane from Byrd Station) the ice plateau near the southern end (*2*).

The Thiel Mountains consist of a large, nearly flat-topped massif joined to a group of high nunataks by a southeast-trending ice escarpment 20 miles long. Numerous small nunataks lie along the escarpment, and others are present at distances ranging from a few miles to about 40 miles from the main massif. The mountains form part of the great chain of ranges that crosses the continent from the Ross Sea to the Weddell Sea. Prior to investigations during the International Geophysical Year the more isolated interior portions of this transantarctic mountain system were unknown geologically as well as geographically. Even at present, except for a few small areas where detailed work has been done, geologic data are limited. In general structure, the transantarctic ranges have been considered for a long time to be a large horst system (*3*), but more recently Hamilton (*4*) found evidence of broad domical structure defined by sedimentary rocks—Beacon sandstone—in the McMurdo Sound region. Because of the absence of such rocks in place in the Thiel Mountains, a possible domical structure cannot be demonstrated. On the other hand, the mesa-like topographic form of the mountains and the presence of numerous shear zones and faults suggest fault-block structure.

Medium-gray quartz monzonite porphyry is the most widespread rock. The