BACTERIA OF ANTARCTICA

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Previous to the departure of the Byrd Antarctic Expedition II, which spent about eighteen months during 1933–34 in the south polar region, plans were made by the authors to collect materials for the study of microörganisms, as well as to do some investigations on this group at the expedition's headquarters in Little America. Having accompanied the Byrd Antarctic Expedition I, Siple was familiar with the conditions under which work of this character could be done.

Necessary equipment and supplies for this study were taken. These included a pressure cooker for sterilizing, glassware, culture media, incubator, microscope, jars and vials for collecting. At Little America the crowded conditions of the laboratory, together with limited amount of time for investigations of this character, permitted only a few tests to be made; enough was done, however, to demonstrate the presence of microörganisms in snow and ice and to isolate a few cultures which were brought back to the United States for further study. Collecting of various samples of snow, ice, plant debris, mud, and rock fragments, which were delivered to the laboratory at Allegheny College, constituted the more important phase of the work.

METHODS OF COLLECTING MATERIALS

Glass fruit jars, mostly of quart and pint capacities, with rubber gaskets and glass lids were used for collecting the snow samples. The jars were partially wrapped with cotton and placed in open cotton bags with the lids and gaskets on the jars, but unsealed; these were then sterilized. By experimentation it was found that glassware as well as culture media could be made

sterile in the pressure cooker by exposure to a pressure of twenty pounds for thirty minutes. The jars were allowed to cool in the sterilizer; upon removal the lids were clamped and the bags tied. The cotton served to absorb excess moisture and so prevent the lid from freezing onto the jar.

In taking snow samples the sterile jar was unpacked and the cover carefully removed; the jar, held at arm's length to windward, was pushed into an abruptly ending sastrugi, or irregular snow drift, until it was filled with snow. The cover, which was placed on the snow during the operation, was replaced and the jar rebagged and labeled. Excepting the few samples tested in Little America the jars were not removed from the bags until examined in the Allegheny laboratory.

Soil, mud, rock fragments, and plant debris from mosses, lichens and algae were collected in metal-capped glass jars which had been previously sterilized. These materials were picked up with metal forceps sterilized immediately before using by flaming over metaldehyde tablets. The jars were recapped at once and not opened until the contents were examined.

Exposures of sterile agar jars were made in regions not previously visited by man. The jars were carefully wedged in by rocks, the caps removed; no one visited the place until the jars were collected. Most of the samples were taken by Siple, although a few were collected by James M. Sterritt, Olin Stancliff, and Quin A. Blackburn.

Materials collected and delivered to the laboratory at Allegheny College were obtained from three general regions in the Antarctic. One was near the edge of the polar plateau on Thorne glacier in the Queen Maud Mountains, lat. 86° 58′ S., long. 152° 36′ W., at an elevation of about nine thousand feet; this region is within 180 miles of the south pole. The material consisted of three quart jars of snow taken by Blackburn in December, 1934. The jars, previously sterilized, were immediately sealed after the samples were taken and not opened until examined in the Allegheny laboratory.

The second region in which collections were made was in Marie Byrd Land, about the Edsel Ford Mountains; this land is about

three hundred miles northeast from Little America in lat. 77° 48′ S., long. 145° W. No human being had ever entered this region until Siple and his party began their explorations. The material collected consisted of (1) six pint jars of snow taken after a two-day blizzard from the east; (2) five jars of plant debris, one of which was taken near a rookery of squa gulls, the others in regions showing no evidence of bird visitation; (3) three jars of glacial alluvial soil; (4) four pint jars containing nutrient agar (0.5 per cent agar) which with lids removed were exposed on wind-swept mountain crags for several days, varying from seventeen to thirty-one; (5) five petri dishes of nutrient agar which were inoculated with water from pools in which algae were growing.

The third region of collection was about Little America, lat. 78° 34′ S., long. 163° 56′ W. The materials consisted of (1) four pint jars of snow samples taken in the vicinity of the Bay of Whales, about five miles from camp; (2) seven pint jars of broth which had been inoculated in the laboratory at Little America and from which platings were made; (3) two tubes of sea-floor ooze taken from the bottom of the Bay of Whales, about three hundred feet down; (4) five petri dishes inoculated by Siple from material taken from an enclosure called the non-magnetic house; (5) twelve test tube cultures isolated at Little America; (6) twenty-six petri dishes wrapped separately in paper, some of which were used in plating samples at Little America, others being air-exposed plates from Marie Byrd Land.

STUDIES AT LITTLE AMERICA

Conditions for carrying on bacteriological studies in the cramped quarters at Little America were such that comparatively little was accomplished; enough work was done by Siple and Sterrett, however, to demonstrate the presence of microörganisms in various materials.

At the beginning of the investigation on snow samples, from 1 to 2 ml. of melted show were introduced into sterile nutrient agar in petri dishes and incubated at about 37°C.; no growths were obtained from several samples. The next method was to place

from 50 to 200 ml. of melted snow in fruit jars with sterile nutrient broth of such high concentration that the added water diluted the broth to approximately standard proportions. The jars were then incubated; many of these inoculations contained bacteria.

Three snow samples were taken about one mile east of camp, a region not previously visited by members of the expedition, after a high wind from the east and at a temperature of 60°F. below zero. Of these three samples one showed no visible growth after three days of incubation, the other two became cloudy and produced a sediment. Petri dish isolations from these showed a gram-positive spore-producing rod in chains, one small gram-negative coccus and one larger gram-positive coccus. (At the Allegheny laboratory from these petri dishes were obtained *Bacillus mesentericus*, *Achromobacter delicatulum*, and one unidentified *Bacillus*.)

Other snow samples were taken near the Bay of Whales, three to five miles from Little America, at Amundsen's Arm and McKinley Plateau five miles southwest of camp, and at Echo Canyon sixteen miles southwest. On the main trail south to the hundred-mile depot, Poulter made a few collections. Most of these were examined in the laboratory at camp and showed growths in broth. (Later identifications from some of these plates showed *Bacillus mesentericus* and one unidentified *Bacillus*.)

On the Byrd Antarctic Expedition I a structure known as the non-magnetic house was built. On the second expedition, four years later, Siple entered the house first and secured some material; upon plating he found it contained a spore-forming rod. (From each of the three plates delivered to the Allegheny laboratory *Bacillus mesentericus* was identified.)

A sample of mud was obtained from the bottom of the Bay of Whales at a depth of about three thousand feet by using a metal tube about two inches in diameter. When plated, this material showed bacterial growth. A sample of ice taken about one foot below the surface on the Bay of Whales produced a growth in broth. (From each of these plates *Bacillus mesentericus* was secured.)

Siple's hand became infected from handling seal blubber. At

first the infection was limited to a deep cut on his finger but later spread to other abrasions on his hand. A cream-colored pus exuded from the sores; a culture made from the pus was found to be a spore-producing rod. (At the Allegheny laboratory this proved to be *Bacillus megatherium*.) It was observed that the wounds on seals caused by fighting were commonly infected. Seal hunters in the Arctic are reported to be fearful of infection from seal blubbering. Cuts and other abrasions of the skin on many members of the expedition became infected and were extremely slow to heal. A culture taken from Poulter's finger was grown in broth and on agar; it was a coccus form. Some of this culture was exposed at a temperature of 65°F. below zero for seventy-two hours; when thawed and inoculated into broth, it grew rapidly. Among the dogs, infection of wounds caused by fighting was common; several dogs died, seemingly as a result of wound infection, in spite of first aid treatment; no data were obtained concerning the infective organism.

Other evidences of the presence of microörganisms in the Antarctic consisted of food spoilage and of disintegration of fur clothing. At the Rockefeller Mountains a quantity of food and some clothing were abandoned by the first expedition; by the second expedition some of the furs were found to be disintegrated and to emit an offensive odor, some of the food was moldy.

METHODS OF STUDYING MATERIALS AT THE ALLEGHENY LABORATORY

All of the cultures and materials collected in the Antarctic were kept in a refrigerator until unloaded in Boston; since then, they have been at room temperature except when subjected to study. In examining the materials, no attempt has been made to make a quantitative study owing to the possibilities of increase or decrease of microörganisms in the materials. As yet no attempts have been made to study anaerobic forms or those which require special media or special conditions for growth.

Of the melted snow samples, ten platings of both diluted and undiluted material were made of each sample on standard nutrient agar; these were incubated at 35°C. for two days followed by

room temperature for five additional days. Some of the samples contained several organisms, others only a few or none. Agar slant cultures were made from various colonies. Of the plant debris and soil samples, varying amounts were placed in sterile water and allowed to stand for a few hours; the water was then thoroughly shaken and varying amounts plated. From the petri dishes containing dried cultures from Little America, inoculations were made directly onto agar; in addition, sterile broth was introduced into the dish and incubated; one or more cultures were recovered from each of the dishes.

After isolation and purification of the cultures they were subjected to a careful study to determine their various characteristics. Standard methods of study were followed throughout the work. Tests were repeated from four to eight times on each culture. All of the work of isolating, culturing, classifying was done by Darling. The fifth edition of Bergey's *Manual of Determinative Bacteriology* was used for classifying; all subsequent reference to *Manual* refers to this work.

RESULTS OF STUDY

Thus far 178 cultures of bacteria have been studied and all but six have been classified. Besides bacteria, three cultures of yeasts and several of molds have been secured; these have not yet been identified. Of the bacteria isolated 117 cultures are rods which produce spores, 45 are non-sporing rods, and 16 are coccus forms. Of the spore formers nine different species have been identified: 51 cultures are *Bacillus mesentericus* DeBary; 20 *Bacillus subtilis* Cohn; 5 *Bacillus cereus* Frankland and Frankland; 5 *Bacillus fusiformis* Gottheil; 12 *Bacillus tumescens* Zopf; 10 *Bacillus malabarensis* Lohnis and Pillai; 4 *Bacillus megatherium* DeBary; 3 *Bacillus consolidus* Bredemann and Stuhrk; 1 *Bacillus albolactis* Migula. Of the non-spore-forming rods nine species have been identified: 15 *Achromobacter liquidum* (Frankland and Frankland) Bergey et al.; 8 *Achromobacter delicatulum* (Jordan) Bergey et al.; 11 *Flavobacterium* including species *devorans* (Zimmermann) Bergey et al., *flavescens* (Pohl) Bergey et al., *solare* (Lehmann and Neumann) Bergey et al.,

sulfureum Bergey et al., *turcosum* (Zimmermann) Bergey et al.; 11 *Proactinomyces agrestis* Jensen, 1 *Serratia marcescens* Bizio (obtained by Siple from a pool on Easter Island). Of the coccus forms, 11 are *Micrococcus* including species *caseolyticus* Evans, *flavus* Lehmann and Neumann, *freudenreichii* Guillebeau, *halopilus* Bergey et al.

Observations on variations of several of the cultures may be worthy of record. Of the cultures of *Bacillus mesentericus* De-Bary, five are decidedly tan colored when grown on nutrient agar in contrast to the white or cream color of most cultures of this species; this variation in color has been noted by other workers and is referred to in Bergey's *Manual.* The most distinctive characteristic of the species is its appearance on potato; this growth is thin, spreading, wrinkled, changing from cream color to tan or light brown. Reactions in milk are variable; about half of the cultures studied produce acid and all but one produce a soft curd which becomes peptonized in all but three of the cultures. In nitrate broth no nitrites are found but ammonia is produced in all. Urea is used by most cultures; blood serum is liquefied in five days.

Bacillus subtilis Cohn cultures give a characteristic growth on potato—thick and wrinkled, at first cream colored then changing to pink, especially along the edges of growth. About half of the cultures become dull pink on nutrient agar after a few days. In milk, the changes produced are variable; acid is formed in most cultures within ten days, a curd is formed in all.

Cultures of *Bacillus tumescens* Zopf differ from the description in the *Manual* by producing both nitrites and ammonia in peptone broth and by liquefying gelatin within 48 hours. *Bacillus malabarensis* Lohnis and Pillai is of interest because of the variation in morphology of the cells; under normal conditions of growth most of the cells are straight rods but some are spindle shaped, some curved, some nearly coccoid; sporangia are swollen, the spore usually excentric in the cell; spores form rather slowly, often requiring ten days as compared with two days in cultures of *Bacillus mesentericus.* This species is reported from southern India; we have found no reference to its occurrence in America.

The cultures of *Bacillus cereus* Frankland and Frankland differ from the description in the *Manual* only in that they produce curd in milk. The single culture of *Bacillus albolactis* Migula differs from *Bacillus cereus* in producing acid from lactose, hydrolyzing starch, liquefying blood serum, and in not peptonizing milk. The distinctive morphological characteristics of *Bacillus fusiformis* Gottheil are the spherical spores and the swollen sporangia; the spores are formed at the end of the cell; they form rather slowly, in from seven to ten days. In milk, curd is produced.

Finding *Bacillus megatherium* DeBary in pus from Siple's finger suggests the possibility of its being pathogenic; of course it may have been a contaminant and not the cause of pus formation. It is of interest to note that Lehmann and Neumann state in their text-book that Wollstein produced lobar pneumonia in dogs with broth cultures of the organism.

Three cultures classified as *Bacillus consolidus* Bredemann and Stuhrk were found in snow samples taken in the vicinity of Little America; the *Manual* reports it only from Cuban soil. Supplementing the characteristics as given in the *Manual* for this species: spore is central, does not enlarge the cell; spores form slowly, about seven days. Agar slant growth is echinulate, smooth to rough, cream colored, sticky; agar colonies circular, 2 to 6 mm. in diameter, lobed or fringed, flat, smooth. Broth turbid; growth on potato is scant, filiform, cream to yellow. Acid is produced from glucose, sucrose, and lactose; starch is hydrolyzed. No changes produced in milk.

Cultures of *Achromobacter delicatulum* (Jordan) Bergey et al. conform to the description in the *Manual* excepting that the growth on potato is flesh-colored instead of light gray, and in milk a curd is formed. The fourteen cultures of *Achromobacter liquidum* (Frankland and Frankland) Bergey et al. show one or two polar flagella; ammonia is formed in nitrate broth but no nitrites; in milk a soft curd is formed in five days followed by peptonization in about ten days.

Cultures of *Flavobacterium devorans* (Zimmermann) Bergey et al. are lemon-yellow rather than yellowish-gray; acid is produced

in sucrose but not in glucose or lactose; starch is hydrolyzed. The characteristics of *F. flavescens* (Pohl) Bergey et al., *F. solare* (Lehmann and Neumann) Bergey et al., *F. sulphureum* Bergey et al., and *F. turcosum* (Zimmermann) Bergey et al. as given in the *Manual* were found in these cultures, except that *F. solare* produced a turbid instead of a clear broth. Additional characteristics show that no acid is produced from glucose, sucrose, or lactose by any of the cultures except that of *F. turcosum* in which glucose and sucrose are changed. Starch is hydrolyzed by cultures of *F. flavescens* and *F. solare* but not by those of *F. sulphureum* or *F. turcosum.*

Proactinomyces agrestis Jensen has not been reported from America so far as we know. The characteristics of the eleven cultures obtained conform to those given in the *Manual*; the short branches on short filaments and the pinkish growth on agar are both distinctive.

Of the four species of *Micrococcus* obtained, *M. caseolyticus* Evans conforms to the *Manual* description; *M. flavus* Lehmann and Neumann differs in that no acid is formed from glucose and starch is not hydrolyzed. Cultures of *M. freudenreichii* Guillebeau show cells from 0.7 to 1 micron in diameter instead of 2; otherwise the characteristics are the same. *M. halophilus* Bergey et al. produces no acid in glucose, sucrose, or lactose, nor is starch hydrolyzed—these are additional characteristics not given in the *Manual.*

DISTRIBUTION OF BACTERIA IN ANTARCTICA

Several species were obtained from each of the three general regions from which materials for bacteriological studies were secured. Each of the three snow samples collected by Blackburn in the Queen Maud Mountains, the region nearest the pole, yielded *Bacillus mesentericus.* In addition to this species, from sample I were isolated *B. subtilis, Achromobacter delicatulum, Micrococcus freudenreichii;* from sample II, *B. tumescens, A. delicatulum, A. liquidum, Flavobacterium devorans;* from sample III, *B. subtilis, A. liquidum.* Altogether seven different species were secured from this region.

From Marie Byrd Land sixty-nine cultures were obtained representing eighteen species from sixteen different samples of collected materials. The six snow samples contained the following: sample M3—*B. malabarensis, B. mesentericus, A. liquidum;* sample M4—*B. mesentericus, B. subtilis, M. halopilus;* sample M5—*B. mesentericus, B. subtilis, A. liquidum;* sample M7—*B. tumescens, A. liquidum, P. agrestis;* sample M8—*B. mesentericus, A. delicatulum, A. liquidum, F. devorans, M. caseolyticus;* sample M10—*B. malabarensis, A. delicatulum, F. sulphureum.* Out of the five jars of plant debris were obtained: from sample 26 *F. solare, M. freudenreichii, P. agrestis;* from sample 27 *B. mesentericus, P. agrestis;* from sample 28 *A. delicatulum;* from sample 72 *A. delicatulum, F. flavescens, P. agrestis;* from sample 113 *B. mesentericus, F. solare, P. agrestis.* The four pint jars of nutrient agar exposed for several days on windy mountain peaks yielded five species: sample A20—*B. tumescens, A. delicatulum;* sample A21—*A. liquidum;* sample A22—*B. albolactis, B. mesentericus, A. liquidum;* sample A23—*A. liquidum.* From only one of the three jars of alluvial soil were cultures secured; from sample 112, *B. fusiformis, B. mesentericus, B. subtilis.*

Several petri dishes with sterile nutrient agar were inoculated or exposed by Siple in different regions of Marie Byrd Land. Two were inoculated with a few drops of water from a small pool on a large rock formed by melting snow; from P9 were isolated *B. megatherium, B. mesentericus;* from P13 *B. mesentericus.* Two dishes were inoculated with water from a pond visited by squa gulls and snowy petrels; P18 contained *B. fusiformis;* P25 contained *B. cereus* and *B. malabarensis.* One petri dish, P20, was inoculated by introducing some plant debris; from this was isolated *B. megatherium.* Seven dishes were exposed for several days along the trail; *B. mesentericus* was obtained from four, *B. subtilis* from one, *B. fusiformis* from one, no bacteria from the other.

From collections made about Little America seventy cultures were obtained, including seventeen species from eleven different samples. In the vicinity of the Bay of Whales Sterrett collected four jars of snow which were brought back to the Allegheny

laboratory; from these the following cultures were isolated: sample D1—*B. cereus, B. malabarensis, B. subtilis, B. tumescens,* one unidentified *Bacillus;* sample D3—*B. mesentericus, B subtilis, B. tumescens, F. devorans, F. turcosum, M. halopilus;* sample D4—*B. malabarensis, B. mesentericus,* sample D5—*B. consolidus, B. mesentericus, B. subtilis.* Seven pint jars of broth inoculated with snow at Little America were found to contain the following: sample 1A—*B. tumescens, M. flavescens, M. halopilus;* sample 2A—*B. tumescens, M. caseolyticus, M. flavus, M. freudenreichii, P. agrestis;* sample 3A—*B. consolidus, B. mesentericus;* sample 4A—*B. mesentericus, B. tumescens;* sample 5A—*B. malabarensis, B. tumescens;* sample 6A—*B. subtilis, M. freudenreichii;* sample 7A—*B. malabarensis, B. subtilis, M. freudenreichii, P. agrestis.* From the two samples of ooze taken from the bottom of the Bay of Whales only one culture was been obtained; this is unidentified.

Thirteen inoculated petri dishes which were used in the laboratory at Little America were included in the collection. Five of these were from material taken by Siple in the non-magnetic house; from four of these dishes *B. mesentericus* was isolated, from the other one, *B. tumescens.* Five dishes were inoculated in the study of snow samples; three of these contained *B. mesentericus,* the other two contained two types of organisms which have resisted identification. One dish from sea-bottom ooze contained *B. mesentericus;* one from pus of Siple's finger yielded *B. megatherium;* one from ice taken one foot below the surface contained *B. mesentericus.*

Twelve test tube cultures were delivered to the Allegheny laboratory. Tube 3, isolated from pus from Siple's finger, contained *B. megatherium,* as did the petri dish from the same source. Tube 1 from the non-magnetic house inoculations contained *B. mesentericus,* as did three of the inoculated petri dishes. Six tubes were isolations from snow samples taken in the vicinity of the Bay of Whales; two contained *B. malabarensis,* one *B. subtilis,* one *M. freudenreichii,* one *M. halopilus,* and one an unidentified yeast. Of two tubes from sea ice isolations one contained *B. cereus,* the other an unidentified *Bacillus.* One tube contained inoculated material taken by Siple from a small pond on Easter

Island where the expedition stopped en route back to America; from this tube were obtained *Serratia marcescens* and *M. caseolyticus*.

Included in the collection were several unmarked test tubes; from five of these which showed growth *B. mesentericus* was identified; from one *F. devorans* and from another an unidentified *Bacillus*.

In summary of distribution of species: *B. mesentericus* was found in melted snow samples from each of the three regions in which collections were made; two-thirds or more of all samples contained the organism. From the snow taken in the nonmagnetic house four of the five petri dishes contained this species. It was isolated from plant debris, soil, pool water, and from exposed petri dishes and jars of agar from Marie Byrd Land; it was the most widely distributed of all the species obtained. *B. subtilis* was present in melted snow from each of the regions; in soil and in one of the exposed petri dishes from Marie Byrd Land. *B. tumescens* was found in melted snow from each region but less frequently than *B. subtilis;* it was present in the nonmagnetic house and in one exposed jar of agar from Marie Byrd Land. *B. malabarensis* and *B. cereus* were in melted snow from Little America and Marie Byrd Land and in pool water from the later region. *B. fusiformis* was isolated only from materials from Marie Byrd Land—from soil, pool water, and exposed petri dishes. *B. megatherium* came from Siple's finger, pool water, and plant debris from Marie Byrd Land. *B. consolidus* came only from melted snow from Little America. The single culture of *B. albolactis* was secured from a jar of agar exposed in Marie Byrd Land.

Of the two species of *Achromobacter* both *A. delicatulum* and *A. liquidum* were present in melted snow from Marie Byrd Land and Queen Maud Mountains and from agar jars from the former region; *A. delicatulum* was secured from plant debris from Marie Byrd Land. Of the four species of *Flavobacterium*, *F. solare* was isolated from plant debris from Marie Byrd Land; the other three species came from melted snow—*F. devorans* from each of the three regions, *F. sulphureum* from Marie Byrd Land, *F.*

turcosum from Little America. *Proactinomyces agrestis* was secured from snow samples in Marie Byrd Land and Little America and from plant debris from the former region.

The five species of *Micrococcus* were all found in melted snow from Little America; in addition from Marie Byrd Land *M. caseolyticus, M. freudenreichii,* and *M. halopilus* were secured from snow samples, and *M. freudenreichii* and *M. flavescens* from plant debris.

DISCUSSION

Previous to the Byrd Antarctic Expedition II some observations had been made relative to microörganisms on this southernmost continent. Ekelof (1908) of the Swedish Southpolar Expedition exposed petri dishes for two hours and more on Snow Hill Island near Graham Land. He obtained growths on at least half of the exposures. He believed that these growths were due to organisms on soil dust carried into the dishes by air currents. He also found that some of the animals which he examined contained bacteria.

Pirie (1912) on the English Expedition of the Scotia exposed petri dishes in the crow's nest at the top of the mainmast for twenty hours but obtained no growths. At Scotia Bay he secured negative results from plate exposures; in the Weddell Sea he exposed plates on the ship's deck and secured *Staphyloccus* and *Bacillus;* he considered that these probably came from the ship. In western Wilkes Land he found that three of four seals contained bacteria in the feces as did ten of fifteen birds examined. Of ten different samples of surface sea water he found seven contained bacteria.

Atkinson (1913) on the Scott Expedition claims to have isolated motile rods from snow. McLean (1918) on the Australasian Antarctic Expedition in 1911–14 did the most extensive work in studying microörganisms of the Antarctic up to the time of the present investigation. His observations were made for the most part in Adelie Land. He found in frozen algae at least four types of bacteria: a gram-positive coccus which produced small, white colonies and liquefied gelatin slowly; a gram-positive,

spore-producing rod which formed pale, wrinkled, adherent colonies; a gram-positive spore-producing rod in chains which formed a profuse, white growth; a gram-positive short rod which produced milky-white colonies that changed to pale yellow. McLean inoculated nine culture tubes with melted snow taken some distance from their hut; three tubes remained sterile, from the others he obtained three yeasts and two gram-positive cocci; two of the yeasts gave a pinkish growth on agar, the other a cream-yellow growth. From snow taken one-third mile from their camp he secured gram-positive cocci and a gram-negative spore-producing rod. On three occasions when snow was gathered in a sterile basin he obtained diplococci, cocci, and motile rods; on a glucose agar slant he inoculated falling snow and obtained grayish colonies. About fifty miles from the hut at an elevation of four thousand feet he found cocci and rods in surface névé. In the vicinity of Aladdin's cave, five miles south of the hut, he obtained gram-positive cocci, yeast, and protozoa from surface ice. In ice secured at a depth of four feet, as well as some at seven feet, he found cocci and rods. We have found no published report of any of the organisms discovered by McLean as having been identified.

From the foregoing observations it seems evident that microorganisms are commonly present in the Antarctic; how they came to be there is not so clear. Without doubt some were transported by man and his equipment on the various expeditions. Migrating birds, especially the tern and to some extent gulls and petrels, may carry bacteria both on the outside and on the inside of the body; likewise seals, whales, and fish may be responsible for some of the microörganisms found. It is probable, however, that air currents are the most common cause of transfer of dust along with bacteria from one region of the world to another. It is a well established observation that in regions of the equator the air is continually rising and that in the upper atmosphere air currents move toward the polar regions where the air becomes chilled and gradually settles. Falling snow may collect dust and bacteria from the atmosphere and carry such to the earth.

Observations have shown that various objects including dust and microörganisms are carried in the upper atmosphere. Proc-

tor (1935) secured bacteria and molds at elevations of from ten to twenty thousand feet; from his collections he identified *Bacillus*, *Achromobacter*, *Kurthia*, *Staphylococcus*, *Micrococcus*, yeast, *Aspergillus* and *Penicillium*. Meier and Lindbergh (1935) made exposures of twenty-six petrolatum-coated glass slides in an aeroplane while flying at an elevation of three thousand feet over the coast of Greenland north of lat. 70° N.; by microscopical examination one hundred ninety-three different objects were observed, fifty-three on one slide. These included fungus spores, hyphal fragments, pollen grains, diatoms, algal fragments, insect wings, and volcanic ash.

Reports on the distribution of volcanic dust from the famous eruption of Krakatoa in 1883 indicate that some of the material was carried nearly around the world before settling to the earth. Dust storms in the United States not infrequently carry dust from the southwestern states into the eastern ones, a distance of over two thousand miles. Explorer Nansen (1897) reports having seen large areas of snow in the Arctic regions covered with dust; he believed that this dust was carried in the upper atmosphere from southern lands and brought to the surface of the earth by falling snow. McLean (1918) from his observations in the Antarctic believed that microörganisms were carried to the polar regions by air currents.

As to the kinds of microörganisms found in the Antarctic, it seems evident from this study as well as from those of other investigators that molds, yeasts, spore-producing rods, non-spore-producing rods, and coccus forms exist. Whether or not such forms grow and reproduce there except as they are associated with animals is not so evident; however, in the case of the chocolate and furs which were left by the first Byrd Antarctic expedition and found by Siple on the second expedition to be spoiled it seems evident that this spoilage was due to molds and probably bacteria.

The low temperature is a limiting factor for growth of microorganisms, as is also the food supply. Hill (1937) gives a table of the temperature of the warmest and coldest days for each month during 1934 at Little America. He reports that the warmest day of the year was in December with a registered tem-

perature of 37°F., the next warmest day was in January, 33°F.; throughout the remaining months on no day did the thermometer register above 29°F. In August the warmest day was zero; in both July and August the coldest days were 71°F. below zero. In Marie Byrd Land, although no accurate records are available, the absence of snow on the rocky peaks allowed more absorption and radiation of heat during sunshine than at snow-covered Little America. It was not uncommon for the members of the Marie Byrd Land party to strip to the waist and become comfortably tanned during the hours of sunshine. Siple collected and studied several species of mosses, lichens, algae, and protozoa which were living and growing in that region. It seems probable that bacteria might also secure sufficient food and warmth to grow and reproduce, at least during the summer in Marie Byrd Land.

SUMMARY

From materials collected in the Antarctic by Paul A. Siple, one hundred seventy-eight cultures of bacteria have been isolated and studied. One hundred seventeen are spore-forming rods included in nine species; *Bacillus mesentericus* and *Bacillus subtilis* are the most common. Forty-five cultures are non-spore-forming rods included in nine species. Sixteen cultures are cocci representing five species. Six cultures have not yet been determined. Bacteria seem to be widely distributed in the Antarctic and are probably carried there largely by air currents.

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