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Microbiological Research in the Region of the North Pole

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To Soviet researchers belong the outstanding role in the microbiological investigations of Arctic seas. From our native work science has attained fundamental data concerning microbic populations of the Arctic Ocean and the significance of microorganisms in cycles of material emanating in the polar basin. All seas reaching the northern coast of the European-Asian continent were examined: Barent Sea, Kara Sea, Laptev Sea, East Siberian Sea, Chukot Sea. A large monograph by academician B. L. Isachenko "Research on Bacteria of the Arctic Ocean" (1908) was the first monograph about microorganisms of the Arctic.

However, microbiological research in the Arctic seas was carried out before the present time only adjoining continents or islands of the region--in the shelf part of these seas or on the continental slope. The same samples of northern water for microbiological examination were obtained by V. S. Butkevich (1935) from 82°42' north latitude, but they were taken from the upper layer of the ocean. In deep water areas of the central Arctic Ocean, there was no research in respect to microbiology.

Meanwhile fundamental questions of the productivity of the waters of the polar basin and dynamic life phenomena in this area of the world oceans cannot be settled without detailed characteristics of microbiological processes taking place in enormous water mass and in the bottom of the Arctic Ocean, under ice floe of several years standing, beyond the immediate influence of the continental slope.

Unprecedented possibility for microbiological research in the central Arctic occurred with the organization of drifting scientific stations. By the author's persistent purpose, two flights were achieved--in July and September 1954--to drifting scientific station "North Pole-3". In July the coordinates of the station for taking daily water and mud samples for microbiological study (13/vii) were: 88°04'3" north latitude and 151°16' west longitude. The ocean depth under the station was 3450 meters. After two months' drift the station was almost immediately over the North Pole and in September the daily collection of water samples and soil (9/ix) occurred at 89°29'5" north latitude and 65°43' west longitude. The depth of the ocean under the station equaled 4116 meters.

Translated from Kriss (1955) p. 30

In July the drifting station was located on the Pacific side of the submerged ridge of Lomonosov , and in September--on the Atlantic side of it, which introduced great interest for relative microbiological research. As is known, this submerged ridge, exposed by Soviet investigators, extends approximately from New Siberia islands across the region of the North Pole toward Greenland and Ellesmere. The height of the submerged mountain in some places in the central Arctic exceeds 3000 meters.

The microbiological laboratory on the drifting station was organized in a hydrologic tent. Samples of water and soil from the ocean were obtained through a hole in the ice (diameter almost 2 m) with the help of a special winch, constructed by the Arctic Institute. For water samples a bottle of the Arctic Institute was used and for extracting a column of mud--a tube of the system of Alekseeva (of the same Institute). All equipment necessary for the research was delivered by boat.

In July the water samples were taken from depths: 0 (surface layer of water next to the ice), 10, 25, 50, 75, 100, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1500, 2000, 2500, 3000, and 3400 m. In September to depths from 0 to 3000 were added depths of 3500 and 3700 m. In such a manner all strata of the water in the ocean from the surface to the bottom were examined in sufficient detail.

Before removing the water from the bottle the stopcock of it was flamed thoroughly, after this, subsequent to draining off a certain amount of water, sterile flasks were filled. From a given water sample 30 ml were filtered through an ultrafilter No. 3. After this the filter was superimposed on the surface of meat-peptone agar, prepared from Pacific Ocean water, in Petri dishes. Thanks to the diffusion of nutritious substances from the agar through the filter, bacteria settled on its surface were able to propagate and to produce colonies.

The Petri dishes with filters were put in sterile metal cans, which were then placed on a shelf in the top of the tent. With the help of a gas plate the temperature in the top layer of the air in the tent was sustained at a level between 25-30°C. After 4 days' incubation were counted a large number of colonies growing on every filter, and after this they were plated on meat agar slants of the same composition. From this bacteria producing characteristic colonies were obtained for microbiological study. All of this part of the research was conducted on the drifting station.

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Profiting from the opportunity to express profound thanks for assistance in conductiong these studies to the chief of the drifting station "North Pole-3", A. F. Treshnekov, and also to my immediate and energetic assistants in the work in the tent, to coworkers of the station, Dr. Volovich and hydrologist V. A. Shamontev.

Final analyses of the collected materials was carried out in Moscow by coworkers in the branch of Marine Microbiology, Institute of Microbiology of the Academy of Science SSSR, V. I. Biruzova, A. S. Techoninko and V. A. Lambina.

Table 1 presents data of the number of bacterial colonies, propagated from water samples which were obtained from given depths of the Arctic Ocean in the region of the North Pole, and of the composition of these colonies. From the number of colonies it is possible to estimate the quantity of heterotrophic microorganisms living in the water of the ocean and capable of growing in albuminous media under laboratory conditions of culture.

From the table, heterotrophic bacteria appear to occur in almost all depths of the polar basin in the region of the North Pole. The fact that in separate occurrences bacteria were not found (at depth 75 m in September and 3400 m in July) is indicative, by no means of sterility of the layers of water, but only, as shown in our studies in the Pacific Ocean, of small content of bacteria in a known quantity of water. By filtering sufficiently large volumes of water, heterotrophic bacteria appear in all depths of the ocean.

Characteristically, July and September water samples from the same surface layer of the ocean in separation near the ice were distinguished by the contents of heterotrophic bacteria. In July, when life is richer even in the icy scope of the central Arctic, continuous growth of bacteria utilizing easily assimilable organic material for their activity appeared on the surface of filters from zero depth.

Attention is directed to the same circumstance, that comparatively large numbers of heterotrophs were found at depth 100 m in July and at depth 150 and 200 m in September. As is known, by studies on drifting stations also while at high latitudes, aerial expeditions for data on depths disclosed layers of water distinctive from Arctic water. Possibly there is direct connection between these hydrologic features and the increased content of heterotrophic bacteria at depths 100-200 m. At the junction of water masses, even with low difference in the density of abutting waters, conditions are created for relative concentration of organic materials, and, as a result of this, for large growth of bacterial life. Experience shows that bacteria respond even to extremely low variations of contents of easily assimilable organic matter. Consequently it is very essential to combine microbiological

Table 1

Number and kinds of heterotrophic microorganisms which grew on albuminous media inoculated with Arctic Ocean water collected near the North Pole

Water depth Meters	Water collected July 1954 Cells/liter	Morphology	Water collected Sept. 1954 Cells/liter	Morphology
0	Overgrown	Bacilli	525	S & N rods*
10	1120	N rods, yeast	1995	N rods, yeast, cocci
25	35	Yeast	2485	S rods
50	315	S rods	350	S & N rods
75	490	N rods	735	S rods
100	2660	N rods	140	S rods
150	210	N rods	2660	N rods
200	35	N rods, yeast	3045	N rods
250	455	N rods, yeast	665	N rods
300	Overgrown	S rods	980	N rods
400	280	N rods	150	S rods
500	455	N rods	245	S rods
600	490	N rods		
750	70	N rods	0	
1000	420	S rods	175	N rods
1500	70	N rods	105	N rods
2000	175	S rods	210	S & N rods
2500	280	N rods	245	N rods
3000	210	N rods	35	S rods
3500			350	S rods
3700			140	N rods

*S = Sporeforming rods; N = Nonsporeforming rods
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studies with hydrology. Already first observations show that microorganisms can be used in a series of cases as indicators for the characteristic origin and dynamics of water masses.

In the microbiological laboratory on the drifting station water samples, taken from almost all depths from top to bottom, were put into glass stoppered sterile flasks (capacity 250 ml) in which were earlier put narrow pieces of glass. Then the flasks were closed with ground glass stoppers and in such condition were kept approximately a week at temperatures 5-7°C and later (in Moscow) at temperatures 18-22°.

As is known, in sea water, taken from different depths and poured into sterile flasks with ground glass stoppers, usually according to the lapse of time, the quantity of heterotrophic microorganisms increases 10, 100,000, and even a million times. Since not any food materials are added to the flask, it is obvious that reproduction of heterotrophs results at the expense of organic matter occurring in the water. In natural conditions it is represented chiefly by persistant, not easily assimilable by microorganisms, so-called water humus. Consequently in water of the open regions of the sea and ocean, even in its superficial layer, is a column of insignificant content of heterotrophs, growing in albuminous medium in laboratory conditions. In sea water poured into flasks a transformation of this organic material into a form accessible to microorganisms results. On the surface portion of the glass the water performs adsorption phenomenon, which reduces by accumulation and quantitative conversion the aqueous organic matter into a form easily available to microorganisms. As a consequence of this appears activated reproduction of heterotrophs, utilizing the container for their adsorption of organic material.

It was interesting to show if organic material from the ocean depths in the region of the North Pole is capable of being changed so much that the structure is available for nourishment of heterotrophic microorganisms. It appeared that after 2-4 months of storing the number of heterotrophs increased to thousands and ten thousand times in the bottles over water taken not only at the surface layer but also from depths 1000, 1500, 2000, 2500, 3000, and more meters. For instance, in recently collected water samples from depth of 1000 m 175 heterotrophic bacteria (calculated in 1 liter of water) were detected, but after 2 months in the same bottles more than 2,600,000 bacteria were counted. In bottles of water taken from depth 2000 m, the number of heterotrophs for the same time grew from 210 to 11,300,000 and from depth 3500 m-- from 350 to 5,000,000 bacteria.

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Thus during the storage of water even from great depths, where, as it is the custom to assume, is accumulated organic compounds most resistant to the action of bacteria, the conversion of water humus to a form utilizable by microorganisms is possible. Similar processes result in all water masses at the boundaries of contact of suspended particles from water.

Heterotrophic microorganisms isolated from samples of water from different depths, multiplying in artificial media of albuminous compounds, appear mainly as rod-like form. Among them are observed short and long bacilli, thin and thick, homogeneous and with granular content, motile and non-motile. Most of them do not form spores, but sporeforming bacteria do occur in different depths. Cocci were detected only in certain layers of the ocean.

Interesting yeast organisms were found. Colonies of white and red colored yeast grew from water samples taken from depths 0, 10, 25, 100, 250 m and from mud from depth 3450 m. Discovering yeast in the region of the North Pole attests that they, like bacteria, do not have north boundaries or occurrence.

In order to compile a description of the general number of microorganisms and of their morphological composition from different depths of the Arctic Ocean in the region of the North Pole, direct microbiological isolations were conducted. In microbiological laboratory on the drifting station, 15 ml from each water sample was passed through a filter membrane by the method of E. A. Rukina and V. N. Biruzov. The filter with the sediment of bacterial cells on its surface was placed in fumes of formalin for fixation of the microbial cells, after which they were stained with 1% erythrosine in 5% phenol for 24 hours, and were cleared in cedar oil. A survey of the filter was made under the microscope with the immersion objective for high magnification. In 100 visual fields, that in 10,000 square ocular grids, the number of microbial cells were counted and their morphologic composition was determined. By known area of the filter and the volume of water filtered through, it is possible (by correlated formula) to determine the quantitative contents of microorganisms in 1 ml of water from a given sample.

In Table 2 is reduced data of the general number of microorganisms in 1 ml of water from all depths of the ocean in the region of the North Pole in July and September and, for comparison, on a series of stations in the north-west part of the Pacific Ocean. As seen from the table, direct microscopic determination of the cells on a membrane ultrafilter provides for getting more complete representation of the quantity of microbic population in different layers of the Arctic Ocean than the method of culture. For example, at about 150-250 m the number

Table 2

Microbial cells per ml of water found at different depths in the Arctic Ocean near the North Pole and in the northwestern part of the Pacific Ocean

Water depth	Arctic Ocean		Northwest Pacific Ocean, May-July 1953				
	July '54	Sept. '54	Stat. 1	Stat. 2	Stat. 3	Stat. 4	Stat. 5
meters							
0	39,379	5,229	57,239		86,788	140,673	
10	7,934	8,596	41,580		94,893	35,042	
25		8,935	34,554		116,597	13,007	
50	2,645	12,084	16,828		82,686	7,267	
75	2,636	8,735	14,261		29,776	8,346	
100	6,177	4,367	12,141		21,482	1,742	
150	4,428	1,418	15,216		11,797	2,184	
200	1,879	679	6,318		8,515	7,157	
250	1,966	305	2,463		10,699	1,651	
300	722	218	2,931		2,294	1,086	
400	574	305			507	410	
500	757	209	2,080		240	1,183	
600	99		1,605		234	780	
750	228	174	2,405	18,421	143	637	
1000	853	818	1,735	6,981	117	306	1,651
1500	235	635	1,514	14,690	507	468	
2000	252	479	962	435	201	176	943
2500	96	87	1,150	299	91	111	813
3000	52	44	760	331	46	59	494
3400	35						
3500		44					
4000			572	208	39		494
5000				91	20		397

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Table 2 (continued)

Water depth	Northwest Pacific Ocean, May-July 1953					
	Stat. 6	Stat. 9	Stat. 14	Stat. 17	Stat. 22	Stat. 26
meters						
0	96,200	233,669	406,146	165,347	165,321	95,413
10	87,308	149,708	375,915	171,802	216,599	380,263
25	176,300					
50	60,294					
75	55,718					
100	25,649					
150	3,283					
200	2,821					
250	1,417					
300	1,671					
400	1,339					
500	1,274					
600	709					
750	624					
1000		1,684	1,333	728	266	767
1500		3,075	169	559	182	702
2000		1,268	182	423	104	397
2500		1,205	111	156	208	195
3000		429	65	266	247	163
4000		176	46	156	117	39
5000						39
6000						91
7000						98
8000						65
9000						33

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of microorganisms is determined in the thousands in 1 ml of water. Ten thousand were disclosed in the same surface of the ocean, in water layers near the ice, but only in July, as in September the concentration of microbial cells diminished.

A noticable increase in the contents of the total number of microorganisms was observed at depths 100-150 in July and at 50-100 m in September. Nevertheless they are significantly less than at 82° north latitude, according to data of V. S. Butkevich. The concentration of microbial cells sharply increased at depth of 1000 m. Here the number of microorganisms both in July and in September increased several times in comparison with upper and lower lying layers.

Apparently, there are hydrological reasons for the vertical stratification of the microbial population in the ocean in the region of the North Pole. In connection with this it is reiterated that a study of the distribution of the number of microorganisms in the Arctic Ocean according to the vertical and horizontal must yield valuable material for the hydrology of the polar basin.

In the layer of water from 200-300 to 2000 m the general number of microorganisms is calculated in hundreds per ml of water. Deeper they are counted in tens per ml.

The comparison of the density of microbial population in the Arctic Ocean in the region of the North Pole and in corresponding depth at a position in the Pacific Ocean, in the north west part of it, at a distance of 180-200 miles from the Kurile Islands and Kamchatka, seems very interesting. In the surface layer of water of the Pacific Ocean (at almost every station) the quantity of microorganisms is several times, and in several cases 10 times, greater than in the upper layer of the Arctic Ocean in the central Arctic. With depth the differences continue to exist, but become less sharp. It is characteristic in the Kurile-Kamchatka depression of the contents of microbial cells in depths exceeding 5000 m as compared to a given depth in the Arctic Ocean in the region of the North Pole, as an example of such. The density of the microbial population in a given case may be employed as indicator of the general productivity of the ocean. The life in the waters of the polar basin near the North Pole is comparatively less rich than in the waters examined in the locality of the Pacific Ocean.

The problem is a subject for further microbiological study to obtain comparative data on the number of microorganisms in different regions of the Arctic Ocean and adjacent areas of the Pacific and Atlantic Oceans for characteristic productivity of waters of the polar basin.

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In the region of the North Pole the biomass of microbial cells in the upper layer of the ocean is in terms of milligrams in 1 m^3 of water, but according to the depth of the depression rather quickly decreases to ten, after this to a hundredth of a milligram and in the greatest depths amounts to a thousandth of a milligram per 1 m^3 of water (Table 3).[1]

A schematic dispersion in layers of the microbial biomass in this region is characterized in the reduced drawing below. In a 1 m^2 column of water from the surface of the ocean reaching to the bottom the total biomass of microorganisms amounted to 417 mg in July and 437 mg in September.

These observations pertain to the vertical distribution of bacilli and cocci forms of bacteria of conventional shape (in the picture characterized with diagonal lines). But side by side with them in the water mass of the ocean from the surface to the bottom occurs unique cocci form with thickened capsule. In the deep water area of the Okhotsk Sea and the part of the Pacific Ocean adjoining it, where these forms were discovered previously (A. E. Kriss and E. A. Rukina), they, in contrast to the conventional shape of bacteria, either were not observed at all in the surface layer, or were observed in small quantities. The greater concentrations of them were found in the deep layers of water; in considerable quantity they were also in deep water slime deposits. In the vicinity of the North Pole cocci forms with thickened capsule are relatively uniformly distributed through the vertical profile of the ocean (in the drawing shown by dots), while on the Pacific side of the submerged crest of Lomonosov the concentration of them is greater than on the Atlantic side. The average size of these forms is half (0.1 μ^3) the average size of marine bacterial forms generally seen. However, owing to a relatively large concentration, the biomass of them through all profiles of the ocean in the vicinity of the North Pole on the Pacific side of the ridge of Lomonosov amounted to 10 milligrams in 1 m^3 of water (on the Atlantic side the order of a hundredth of a milligram in the same volume of water).

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[1]Biomass was estimated as follows: By the method of multiplying the number of microorganisms in 1 ml of water by 10^6 the number in 1 m^3 at a given depth was determined. After this, for quantitative characteristic of a given stratum, the numbers of microorganisms in 1 m^3 at the levels restricting the stratum were added up and multiplied by half of its width. The resulting value expressed the mean number of microbic cells in a given stratum--the mean number in 1 m^3 of the stratum. Multiplying the mean number of microorganisms in 1 m^3 of the layer by the estimated mean volume of marine bacillus and cocci forms of bacteria at 0.2 μ^3 (the specific gravity of microbial cells was taken as unity), we get the quantity expressed in terms of biomass of microorganisms in 1 m^3 of this stratum.

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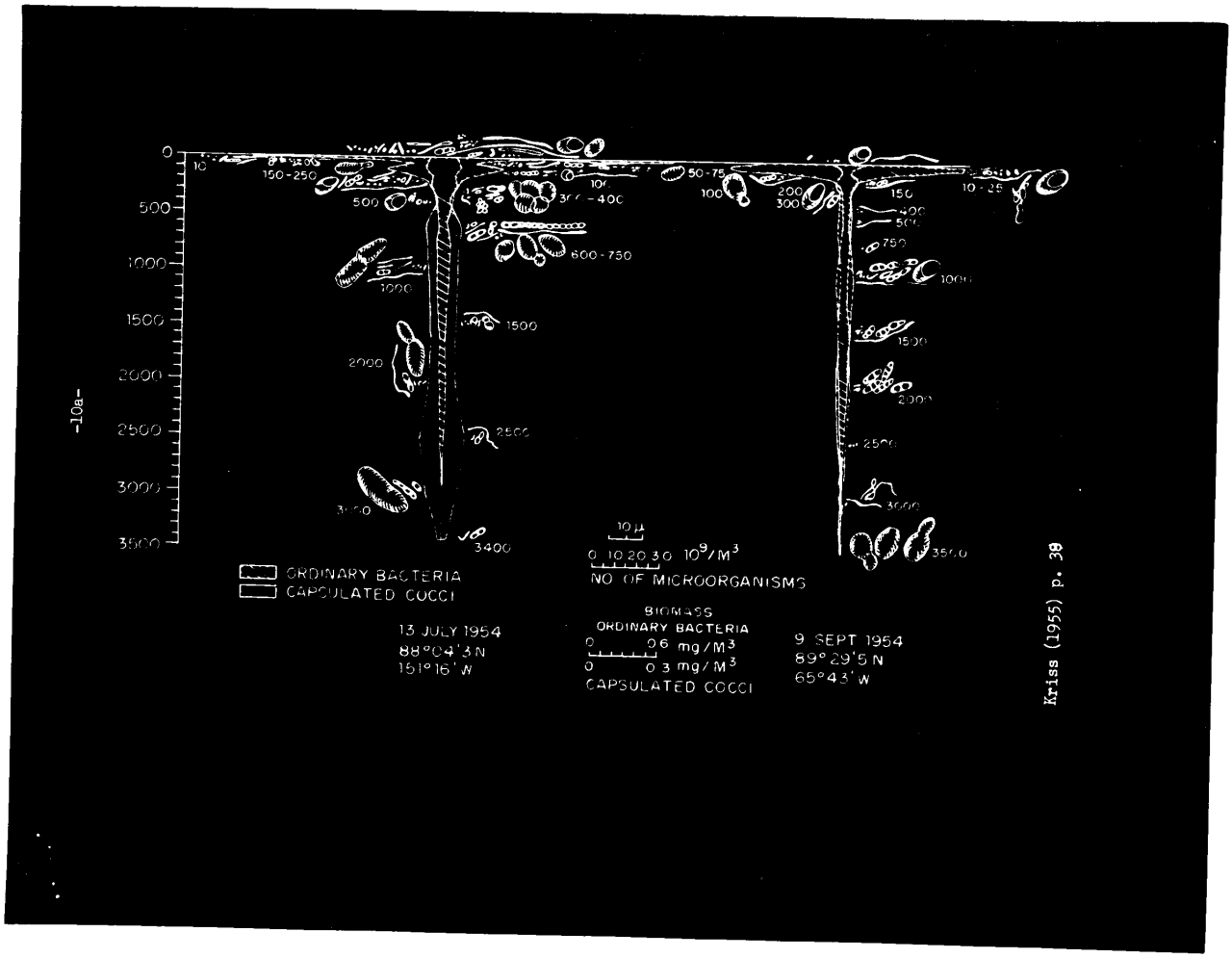

Table 3

Average biomass of ordinary bacteria and capsulated cocci found in different strata of the Arctic Ocean water near the North Pole (mg biomass per 1 m^3 of water)

Water depth Meters	Ordinary bacteria July 1954	Ordinary bacteria Sept. 1954	Capsulated cocci July 1954	Capsulated cocci Sept. 1954
0-10	4.74	1.38	0.12	0.12
10-25		1.7		0.06
25-50		2.1		0.05
10-50	1.06		0.12	
50-75	0.52	2.08	0.14	0.03
75-100	0.8	1.3	0.17	0.03
100-200	0.6	0.2	0.1	0.1
200-250	0.38	0.1	0.09	0.08
250-300	0.2	0.05	0.12	0.06
300-400	0.13	0.05	0.08	0.06
400-500	0.134	0.05	0.04	0.06
500-600	0.086		0.11	
500-750		0.03		0.6
600-750	0.03		0.16	
750-1000	0.1	0.09	0.13	0.05
1000-1500	0.1	0.14	0.13	0.03
1500-2000	0.04	0.1	0.11	0.05
2000-2500	0.03	0.05	0.1	0.06
2500-3000	0.014	0.01	0.2	0.02
3000-3400	0.007		0.13	
3400-3700	0.005		0.04	
3000-3500		0.008		0.02

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As shown, the direct microscopic examination of water samples from different depths of the ocean in the region of the North Pole, the greatest variety of microbial forms in morphological regard are distinguished in the upper layer of water (see drawing). Here are found spherical and oval cells, small and large, appearing singly or in small accumulations. Side by side with cocci are observed bacilli of a variety of lengths, thin and thick, straight and curved, with homogeneous plasma and with granular contents, with vacuoles, and also non-branching filamentous form, and yeast cells often budding. As a rule, rod-shaped bacteria predominated.

It follows to note, that in July the qualitative composition of the microbial population in the surface layer was richer than in September. Thus the Arctic summer influences not only the quantity but also the morphological variety of microorganisms in the upper levels.

With depth the morphology of the microbial cells becomes yet more uniform (the chief form rod-shaped cells), that indicates relative poverty of microbial species dwelling in greater depths. It is interesting that budding yeast cells, i.e. multiplying, appear at different depths (to the same number beyond 3000 m).

A peculiarity of the composition of the microbial population of the ocean in the vicinity of the North Pole in comparison with explored regions of the north-western part of the Pacific Ocean is the presence of large vacuoled cells at all depths, from the surface to the bottom, on both sides of the ridge of Lomonosov. Often these cells occur in heaps or in short chains. Judging from the relative number being observed in the stage of division, they are propagating in the depths of the ocean.

Accumulations of microbial cells of a design of microcolonies were found chiefly in the upper layers of the ocean. In the majority of cases less than 10 cells entered in their formation, but they were observed in colonies composed of 10, 20, and more cells.

As indicated above, in the course of microbiological work on drifting station "North Pole-3" in July and September 1954, not only the water mass of the ocean was studied, but also the bottom. The topmost layer of mud from depth 0-2 cm, was extracted with every essential precaution and put in sterile test tubes. On the drifting station there were now prepared a series of dilutions of weighed mud in sterile water, increasing by multiples of 10. From 0.1-0.5 ml of every dilution was plated on meat-peptone agar prepared from Pacific Ocean water, and up to 1 ml in meat-peptone broth, Giltner medium for denitrifying microorganisms, Winogradsky medium and medium with magnesium ammonium phosphate salt for nitrifiers, Tauson medium for

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desulfurizing organisms, and Nanson and Beijerinck medium for denitrifying sulfur microorganisms.[2] Also prepared from weighed mud were suspensions 1:10, 1:100, and 1:200 in 0.0004 N NaOH, which were distributed for direct microscopy by the method of Winogradsky in 6 cm^2 on the surface of slides, and accordingly processed for microbial content.

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[2] Differential media as follows were employed:

Giltner Medium:

Dist. water	1000 ml	$CaCl_2$	0.2 gm
KNO_3	2 gm	$FeCl_3$	trace
K_2HPO_4	2 gm	NaCl	2.0 gm
$MgSO_4$	2 gm	Asparagin	1.0 gm
Potassium citrate	5		

Winogradsky Medium:

Dist. water	1000 ml	$MgSO_4$	0.5 gm
$(NH_4)_2SO_4$	2 gm	NaCl	2.0 gm
K_2HPO_4	1 gm	$FeSO_4$	0.4 gm

Magnesium ammonium phosphate Medium:

Pacific Ocean water	100 ml
$Mg(NH_4)_2PO_4$	10 gm

Tauson Medium:

Tap water	1000 ml	$CaSO_4$	0.5 gm
$(NH_4)_2SO_4$	4.0 gm	NaCl	30.0 gm
K_2HPO_4	0.5 gm	Ca lactate	5.0 gm
$MgSO_4$	1.0 gm	$MgCO_3$	trace

Beijerinck Medium:

Dist. water	1000 ml
Sulfur	10.0 gm
KNO_3	0.5 gm
K_2HPO_4	0.2 gm
Na_2CO_3	0.2 gm
Chalk	20.0 gm

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In meat-peptone agar several colonies grew equivalent per gram of mud to 100 heterotrophic microorganisms able to propagate in laboratory medium of albuminous composition. Colonies of sporeforming and non-sporeforming rods, cocci and yeast developed. In meat-peptone broth the increase was observed only in the first dilution of the suspension of mud--1:20 for July samples and 1:70 for September. An analogous picture in Giltner medium, but reduction of nitrate was not noted. Marked denitrification with the formation of nitrite occurred in Beijerinck medium dilutions of mud 1:200 in July samples and 1:70 in September.

Nitrite and nitrate appeared in the magnesium ammonium phosphate and in Winogradsky media in the first dilution of mud. From the same dilution came the evolution of sulfates in Nanson and Beijerinck medium. No reduction of sulfate was noted in Tauson medium. It is necessary to indicate that inspection after inoculating muds into media for all of these physiological groups of microorganisms was conducted in the course of 3-5 months.

For direct microscopic examination of the mud are counted (calculated per 1 g weighed mud) from 4 to 304 million microbial cells of conventional appearance and 170-400 cocci forms with thickened capsule. In the main the microflora consists of rod-shaped bacteria, minute and large, straight or slightly curved. Coarse vacuoled appearing cells occurred in different depths of the water mass of the ocean. Side by side with rod-shaped forms are found yeast-like cells and among them budding yeast.

Thanks to the microbiological studies in the Arctic Ocean in the region of the North Pole populations of microorganisms were shown under long-lived pack ice in all masses of water of the ocean to depths of several thousand meters, and also in the bottom. Taking into account the high biochemical activity of microbial cells and the rapid rate of their reproduction, it is possible to affirm that in the region of the North Pole in all water masses of the ocean occur microbiological processes for the mineralization of organic matter and the transforma tion of biological compounds which make conditions possible for the existance of another link of life--plant and animal--in the high latitude of the central Arctic.

Besides the role of microorganisms in the biological productivity of high latitude regions of the Arctic Ocean, microorganisms appear also to be of possible importance as hydrologic indicators. Every case during the detailed study of the vertical stratification of the density of microbial population of the ocean in the region of the North Pole clearly shows layers of water of different origin.

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Necessary and completely feasible is extensive microbiological examination of all the Arctic Ocean. The data of such examination appear an essential investment in oceanographic study of the polar basin--of its biology, hydrochemistry, and hydrology.

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