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XI.

DIATOMACEÆ

FROM THE ICE-FLOES AND PLANKTON OF THE ARCTIC OCEAN

BY

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(WITH 3 PLATES).

During the Norwegian Polar Expedition 1893—96, Dr. Nansen and Dr. Blessing collected a number of samples containing microscopic algæ, especially Diatomaceæ. Some of them are plankton samples, taken with fine silk nets, from various depths, some of them samples of algæ from the ice-floes or from the channels in the ice, where the algæ floated about in great lumps during the summer when the ice was melted. As the plankton samples differed not a little from the others, I shall specially describe them first.

I. THE PLANKTON OF THE POLAR SEA.

The plankton samples that have been collected on previous expeditions in the Polar Sea, contained a considerable quantity of algæ, especially diatoms. It has therefore been a generally accepted idea, that the Polar Sea possesses an abundant vegetable plankton, at any rate in the summer.

The series of samples that Nansen brought home shows, however, that the great, deep Polar Sea is very deficient in plankton algæ, deficient not only in species, but also in specimens. North of the New Siberian Islands, in a latitude rather above 78° N., large quantities of diatoms were indeed found as plankton in October, 1893. It was principally only one species, however — *Chætoceras boreale* —, that appeared in very large numbers; *Chætoceras decipiens* and *contortum* in very much smaller quantities, the latter with spores. *Chætoceras boreale* and *decipiens* are oceanic specimens, while *Ch. contortum* is neritic. The plankton therefore consisted principally of oceanic diatoms.

At the same time, Nansen observed some newly-formed ice that was brown in colour. When he melted some pieces, a brown sediment came from them, consisting of plankton diatoms. The sediment was preserved in spirit, and has retained perfectly all its cell-contents with cell-nuclei and chromatophores. Some of the plankton diatoms found in this way in the ice, were the same species that were living at the same time as plankton; but in addition to these, there were also several especially neritic forms (vide p. 11). These occurred in the ice as spores. There is therefore reason to believe that not long before, they had been living as plankton, but on the arrival of autumn, had formed spores, and disappeared from the plankton.

All the plankton samples taken later during the expedition, contain only a few specimens of algæ, while at the same time there is quite an abundant animal life. There seem to be comparatively most in the autumn, in the winter, none. All the species that occur are purely oceanic, and their distribution, moreover, is almost cosmopolitan. I have only been able to discover the following species:

Chætoceras boreale,
— *decipiens,*
Coscinodiscus oculus iridis.

The last-named seems to occur in the greatest quantities; in one sample of deposit from newly-formed brown ice (October 15th, 1894), no inconsiderable quantity of it was found.

Table I. will give an idea of the scarcity of algæ in the samples.

It is difficult to understand how all the crustaceans (*Calanus finmarchicus*, etc.) that swarm in the upper strata of the Polar Sea, can find the means of sustaining life; I did not succeed in finding any trace of diatoms in their intestinal canal, and the plankton contained very little of their excrements.

II. THE DIATOMS UPON THE ICE-FLOES.

The samples taken upon the drift-ice, partly upon the ice-floes and at their edge, partly in the channels in the ice, are of greater botanical interest.

Diatoms have also been found during previous expeditions on the ice-floes in the Polar Sea, and they have been examined so thoroughly that there is very little chance of finding new species in such localities. It will also be seen in the list of species that follows, that Nansen's samples contain comparatively few new forms, and the few new species that I have had to enter, differ from the most nearly allied forms only in characters that may easily escape observation.

Former investigations, on the other hand, have not shed light upon the conditions of life among these diatoms. The samples have in most cases been boiled with acid or heated without previous examination; and we have therefore not learned whether any of the species can live upon the ice, or whether they are to be regarded as more or less casual impurities, like the inorganic dust which often accompanies them.

The earliest information on the subject of diatoms on ice-floes that I have been able to find, is in *Cleve* and *Grunow's* paper [80][1] p. 3. Among the abundant material upon which the interesting work of these authors is based, there were also samples of mud and earth, which *Nordenskiöld* and *Stuxberg* had taken from ice in the Kara Sea in 1875—76, on the Swedish expedition to the Yenesei. But there were scarcely any diatoms in these samples, say the authors, and they contained only a few species. In the list that then follows, it is not stated which species were found on the ice.

During the Vega Expedition, *Kjellman* collected diatoms from ice-floes near Cape Wankarema in north-eastern Siberia. This collection has been examined by *Cleve* [83]. It consisted in a great measure of hitherto undescribed species. About half of the new species that Cleve describes in his report were from Cape Wankarema, most of the others being tropical forms. Some slides of this collection were distributed in Cleve and Möller's exsiccatæ, and attracted universal attention among students of diatoms, by their peculiar composition. Cleve says nothing as to how the diatoms occurred upon the ice-floes, nor yet whether they were alive when found. The majority of the species already known from other places were salt-water forms.

At about the same time, *Grunow* ([84] pp. 102, etc.) had an opportunity of examining a sample of diatoms, that was taken from the under surface

[1] The works cited, a list of which will be found at the end of this paper, are indicated by the date of their publication in parentheses [ ] following the name of the author.

of an ice-floe, in latitude 74° 48′ 4″ N., and longitude 54° 52′ 8″ E., on the west coast of Novaja Semlja. It consisted principally of small forms with thin cell-walls, that in all probability have lived where they were found. Many of the species were the same as those found at Cape Wankarema, but some of the most characteristic of those forms were missing, e. g. *Navicula superba* with all its varieties (*N. sibirica, N. obtusa*), *Navicula Baculus* (= *Stenoneis inconspicua* var. *Baculus*), *Pinnularia quadratarea* with varieties (only var. *Stuxbergii* found), *Gomphonema kamtschaticum* var. *grœnlandica, Navicula kryophila*, etc.

When *Nansen* came back in 1889 from his Greenland expedition, he brought with him 2 samples of mud from the drift-ice on the east coast of Greenland. The diatoms were determined by *Cleve*, who found 16 species and varieties, with all of which he was acquainted from Cape Wankarema, 12 of them not having hitherto been found anywhere else. I here give a list of them from Nansen's work [92], p. 107. The forms known only from Cape Wankarema are marked with an asterisk.

Navicula Stuxbergii, Cl.
* — *imperfecta*, Cl.
* — *transitans*, Cl.
* — *superba*, Cl.
* — — v. *elliptica*, Cl.
* — *sibirica*, Grun.
— *subinflata*, Grun.
* — *algida*, Grun.
— *œstiva*.
* — *kryophila*, Cl.
* — — v. *gelida*, Cl.
* — *Baculus*, Cl.
* *Amphiprora kryophila*, Cl.
* *Nitzschia gelida*, Cl. & Grun.
* *Coscinodiscus lacustris* v. *hyperborea*, Grun.
* — *polyacanthus* v. *intermedia*, Grun.

These diatoms were dead when Nansen found them; it is probable that they had drifted with the ice from north Siberia, as Nansen and Cleve supposed.

In 1891, during *Ryder*'s expedition, a very large collection of diatoms was made by *N. Hartz* upon ice-floes off the east coast of Greenland. The collection has been thoroughly and minutely examined by Östrup [95]. In these samples too, all the forms characteristic of the samples from Cape Wankarema were found. Östrup does not, however, venture to draw any conclusion as to a connection between the ice in the two places; for the Greenland samples also contain some other species that are not known from Cape Wankarema. Some of these, it is true, are fresh-water forms, whose occurrence on the ice must be dependent upon chance circumstances; but others are marine, and occur in such large quantities that they are characteristic forms of the ice-samples. Östrup names, for instance, *Stauroneis Hartzii,* Oestr., *Navicula perlucens,* Oestr. and *Chætoceras septentrionale,* Oestr.. all newly-described species.

In any case, Östrup's specimens have some of them been dead when taken; the extract that is given from Hartz's journal shows that they were found in lumps, were as a rule white outside, but of a brownish green inside. This indicates that in the interior of the lumps, at any rate, cells might be found that had vitality. In certain cases, Hartz specially mentions that they are living, as for instance:

"Ice 42. July 16, 1891. Large, light brownish green lumps of living diatoms, some floating upon a lake on the ice, some lying at the bottom of shallow cylindrical hollows on the bottom of the lake. 74° 45′ N. Lat., 11° 42′ W. Long.".

In a supplement (l. c. p. 467), Hartz states his view as to the origin of the diatoms. He supposes some to have been carried out on to the ice by the wind, others by the rivers; but most of them are marine forms that may have been washed up in stormy weather, or frozen into the ice when this formed. "Those lumps that had been enclosed in the ice for any length of time, were bleached and colourless all through; other lumps, which had not lain so long in the ice, had only lost their colour on the outside, while inside they had retained their brownish green hue."

In 1892—93, *Vanhöffen* carried out some investigations in Karajak Fjord in West Greenland, which are of the greatest importance for a comprehension of these conditions. Vanhöffen has made a provisional statement on the subject in "Verhandlungen d. Gesellschaft für Erdkunde zu Berlin" [93]; a full report has since been published [97], and I have myself elsewhere [97, 2] published a special description of the diatoms.

Karajak Fjord was covered with ice from the beginning of December until the beginning of June. During the months from November to February, there were very few diatoms in the plankton; but in March (March 24th, 1893), the quantity increased considerably, *Fragilaria* being the most abundant. At the same time, Vanhöffen found that the under surface of the ice was covered with a brown coating of diatoms, consisting of species that, for the most part, were also found on the ice-floes in the Polar Sea. *Nitzschia frigida, Fragilaria oceanica* and *Navicula septentrionalis,* Oestr. were the most numerous, the first two of these being also the predominating species in most of the samples from the Polar Sea. The specimens collected by Vanhöffen have undoubtedly been possessed of full vitality. They are preserved in alcohol, and their cell-contents are in a perfect state of preservation, so that the cell-nuclei and chromatophores can be studied in all their details.

These species were also found at the same time as plankton, and still more later on, in May. The chain-like species in particular increased to an extraordinary degree in the plankton *(Fragilaria, Achnanthes tæniata, Navicula septentrionalis* and *Vanhœffenii)* while the forms capable of motion, such as *Nitzschia, Pleurosigma* and the larger species of *Navicula (N. directa, N. transitans)* were only found in very small numbers.

Vanhöffen's investigations show that the diatom-flora of the ice consists of a community of algæ, which, for biological reasons, resort to the under surface of the ice, and are able to live there. It is probably the attraction of the light which makes them congregate under the ice. This algæ-community is composed partly of plankton forms *(Fragilaria, Melosira),* and partly of littoral forms, capable of movement, such as *Pleurosigma Stuxbergii* and *Navicula directa.*

The ice flora in the Karajak Fjord must be replenished every year by the neritic plankton of the fjord, and by the local littoral flora; in the Polar Sea, where the ice never disappears, algæ-communities of this kind may be frozen into the ice in the winter, and in the spring, if they have not in the mean time been killed, again develope.

Cleve, in an interesting treatise [96, 1] on diatoms from Baffin's Bay and Davis Strait, mentions that in a plankton sample from Cape Eglinton, he found a number of the forms that are characteristic of the ice-floes in the Polar Sea. He supposes, and with very good reason, that they come from melted ice-floes that have drifted along the coast of Greenland.

Lastly, *Cleve* [98] has examined a sample of ooze taken by the Jackson-Harmsworth Expedition from a drifting ice-floe, 48 miles south of Belle Isle. Most of the forms contained in this sample were fresh-water forms, but there were also 17 true salt-water forms, and a large proportion of these were the same as those found near Cape Wankarema. Several, however, of the most characteristic Wankarema forms are wanting. Cleve says (l. c. p. 25):

"These figures prove that the ice-floe derives from the mouth of some river, but the fresh-water species do not indicate the precise spot. Some of the marine species are identical with those found on the drifting ice at Cape Wankarema and along the east coast of Greenland, but on the whole there is a considerable difference, as many of the most characteristic of the latter were not found. On the other hand, there is nothing against the supposition that the mud was derived from the shore of the Kara Sea, which seems most probable." [1]

The majority of the diatom-samples taken from the drift-ice during Nansen's expedition, were collected in the summer of 1894 in about 81° N. Lat. and 125° E. Long. Three of the samples Nansen obtained by melting newly-formed sea-ice that was remarkable for its brown colour. The sediment left after melting, and which consisted solely of diatoms, was preserved in alcohol. Two of these samples were taken in October, 1893, north of the New Siberian Islands, the third in October, 1894.

One sample that differed considerably from the others, Nansen took on an ice-floe in the Barents Sea, between Franz Josef Land and Novaya Zemlya, on the 8th August, 1896. Further mention will be made of it later on.

The samples may be classed according to their occurrence, in the following manner:

(1) Free-floating lumps in the channels between the ice-floes.

(2) Diatoms 'on the ice-foot', a margin projecting from the ice-floes, a foot or two below the surface of the water, and formed by the

[1] Since this was written, Cleve has published a paper: Mikroskopisk undersökning af stoft, funnet på drifis i Ishafvet 1899. Öfversigt af Kgl. Vetenskaps-Akademiens Förhandlingar 1899, No. 3. In a sample taken during the Swedish expedition to Spitsbergen, 1898, in 78° 21' 48" N. Lat. and 2° 45' W. Long., he has found a great number of the species characteristic of the ice at Cape Wankarema.

more thorough melting of the ice on the surface of the sea, where the water is comparatively warm (see the surface-temperatures in Memoir IX, pp. 82—89).

(3) Diatoms in cylindrical holes on the ice-floes, on the bottom of fresh-water ponds not communicating with the open sea.

(4) Sediment obtained by melting newly-formed sea-ice.

1. The free-floating masses were of two kinds, (a) mucous greenish brown masses composed solely of *Melosira,* and often occurring in great abundance at a depth of about 1 metre, in the layer of fresh water formed by the melting of the ice. These mucous brownish masses very often formed almost continuous layers extending from floe to floe in the narrow water-channels. The *Melosira* evidently flourished here, and often grew very fast. (b) The other form of free-floating masses consisted of globular lumps, generally of a reddish colour, and with a diameter from quite small up to one or two inches, or even more. The bulk of each lump was generally formed of a large, globular alga with red cell-contents, which gave the lumps their reddish external colour. The latter were often living, but sometimes dead and colourless, and then the lumps looked quite white. Inside, the lumps have the more brownish green colour of the diatoms. These floating communities of algæ grew rapidly larger from day to day. They began as small floating lumps that were hardly visible, but could attain a considerable size. The lumps, as well as the mucous masses of *Melosira,* are generally found at the depth of about 1 metre below the surface, on the border between the fresh water formed during the melting of the ice, and the under-lying salt sea-water.

The lumps contain great quantities of diatoms, especially *Nitzschia* species *(N. frigida)* and *Fragilaria.* The cells of the diatoms have retained their contents, sometimes in a fairly good condition.

Others of them were dead, only empty cell-walls; probably the unfavourable hydrographic conditions, the great inequality in the salinity of the water, may have killed them.

2. The samples taken on the ice-foot exhibit, on the whole, the same composition as the lumps. *Melosira hyperborea,* however, generally predominates, while *Nitzschia frigida* occurred in the greatest numbers in most

of the free-floating lumps. As minor component parts in both kinds of samples, there are a great number of species, especially *Naviculaceæ,* that are identical with those Cleve has mentioned from Cape Wankarema.

3. The samples taken from holes in the ponds of fresh water on the surface of the ice-floes are, on the whole, poorer. They are all alike in containing numerous fragments and spores of plankton forms such as *Chætoceras boreale* and *decipiens* (fragments), *Coscinodiscus oculus iridis* (empty valves), *Chætoceras contortum, debile, diadema, teres, Thalassiosira gravida* (spores). But there are also species that have lived in these holes, as they appear in considerable quantities, and with their cell-contents; among these I would especially mention *Navicula subinflata* and *Caloneis kryophila.*[1]

4. The samples from the newly-formed sea-ice contain, for the most part, plankton forms, some of them vegetative cells, but more especially spores. There are also a certain number of species which are commonly regarded as bottom forms, as they are equipped for moving along the bottom, and are without the special requisites for floating (e. g. *Pleurosigma Stuxbergii, Navicula gelida*).

A detailed account of the contents of each sample will be found in a table at the end of this paper.

The species found in the samples from the Polar Sea may be classed under the following heads:

(1) True plankton forms.
(2) Species that are found living both in plankton and on ice.
(3) Species that are known from ice-floes only, or also as littoral forms.
(4) Fresh-water forms.

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[1] By the melting of the snow and ice on the surface of the floe-ice, ponds of fresh-water were formed on the floes everywhere in the neighbourhood of the Fram, during the summer of 1894. On the bottom of these ponds I soon observed small brownish spots or, as it were, accumulations of sediment. Upon examining this sediment I found, however, that it was composed partly of dead fragments of diatoms, *Chætoceras, Coscinodiscus,* etc., but to a still greater extent of living diatoms. By observing these brown spots in the ponds, I could now see how they rapidly grew larger from day to day, but by their absorption of the heat from the sun, the ice was melted away under them, so that they sank deeper and deeper into the ice, and small circular holes were formed often several inches deep and perhaps an inch or more in diameter. The bottom of these holes was gradually quite filled with a quantity of diatoms, which could easily be sucked up by a glass-tube. *F. N.*

(1) *True Plankton Forms.*

The number of true plankton forms is by no means small; the oceanic species occur as fragments, the neritic as spores. They are most numerous in a few samples taken in October, 1893, in latitude 78° 19′ N., longitude 136° 16′ E. The samples were obtained by melting ice that was of a brownish red colour. Plankton samples were taken at about the same time, that contained great quantities of *Chætoceras boreale,* but few diatoms besides *(Ch. decipiens, Ch. contortum).* The ice, on the other hand, besides cells of *Ch. boreale,* contained spores of the following species:

Chætoceras contortum,
— *debile,*
— *diadema,*
— *septentrionale,*
— *sociale,*
— *teres,*
— *Wighami,*
Thalassiosira gravida,
— *Nordenskiœldii,*
Actinocyclus alienus v. *arctica,*

as well as empty cell-walls of *Chætoceras decipiens* and *criophilum,* and cells of *Thalassiosira hyalina.* Some special ice-forms were also found, *Nitzschia, Fragilaria* and *Navicula* species. In some of the other ice samples, *Chætoceras Mitra* and *furcellatum* were found as well as the above-named plankton forms; and *Coscinodiscus oculus iridis* occurs rather frequently in the shape of fragments.

It will be seen that all these plankton forms are also found alive on the shores of Greenland, which, as regards plankton, have been more carefully investigated than any other arctic region. These species have a very wide distribution; they are probably circumpolar. The oceanic plankton species, *Coscinodiscus oculus iridis, Chætoceras boreale, criophilum* and *decipiens* may be considered to be cosmopolitan. Among the neritic forms, some, such as *Chætoceras contortum, debile, diadema, teres* and the *Thalassiosira* species, extend pretty far south, at any rate as far as the North Sea and the Skagerak; others, such as *Thalassiosira hyalina, Chætoceras furcel-*

latum and *Mitra*, are exclusively arctic, the first two being found only in the winter on the Norwegian coast from Stadt northwards.

It is a remarkable fact that so many of the plankton forms that are distributed along the arctic shores, are found in and upon the ice in the form of spores. The contents of many of these are in so good a state of preservation, that in all probability they were alive when found. The formation of spores is such a general process among the neritic diatoms, that it must be important for the existence of the algæ. As I have pointed out in another work, (*Hjort* and *Gran* [99]), it is probable that these algæ exist, during the time that they are not found in the plankton, as spores. On more southern shores, they can only pass their period of rest at the bottom of the sea in the shallower places. In the Polar Sea, the spores may attach themselves to the ice-floes, and be frozen into them. The possibility of their retaining their power of germinating while drifting with the ice-floe, and again developing when they are brought into more favourable conditions, is not excluded.

In the Polar Sea itself, these species do not appear to occur as plankton; but on the east coast of Greenland they are all found again in the summer (cfr. Gran [97, 3]), often in great quantities. It is probable that they may develope from the spores that are found in the melting drift-ice; but it is also not impossible that they originate from the nearest coast. Even if the plankton flora that comes to life every summer on the east coast of Greenland is not periodically replenished by spores from the drift-ice, it is still probable that it is due to these spores that the plankton flora on the north coast of Siberia is so similar to that of the coasts of Greenland.

(2) *Species that are found living both in plankton and on ice.*

To this category belong all the species that occur in the greatest quantities on the ice-floes. *Melosira hyperborea, Nitzschia frigida, Fragilaria oceanica, Fr. cylindrus* are the prevailing species; they are all also found as plankton. *Nitzschia* generally occurs rather sparsely in the plankton, but the others may predominate. They all have a rather wide distribution, but they only occur in cold seas, and especially between ice-floes, or where the sea is covered with ice.

Upon the polar ice they live and multiply during the summer. In many cases, the cell-contents are in a good state of preservation; and the observations as to colour, etc. that *Nansen* and *Blessing* made during the expedition, also prove that the algæ were alive. In these species too, spores are to some extent known; in *Fragilaria oceanica* they have already been described by *Cleve* [73]; in *Melosira hyperborea* they have been up to the present unknown, but were found in considerable quantities in several of the Nansen expedition samples (*vide* p. 53).

To this class belong the following species:

Navicula septentrionalis,
— *gelida,*
Fragilaria oceanica,
— *cylindrus,*
Nitzschia frigida,
— *lævissima,*
— *acicularis,*
Chætoceras septentrionale,
Melosira hyperborea.

Most of these species were found wherever diatom-samples were collected upon the drift-ice. They form a biological community, which seems to exist wherever the conditions are favourable for their existence. Their occurrence cannot therefore throw any light upon the origin of the ice-floes where they live.

(3) *Species that are known from ice-floes only, or also as littoral forms.*

To this class belong most of the forms that occur. They are not found in particularly large numbers, but yet evenly distributed among most of the samples. A few of the samples may have more of them, others again fewer. In the samples taken from ponds of fresh water on the ice-floes, some predominate at the expense of the others; but they are, in the main, the same species that are found in all the samples. The preserved specimens of these species also, for the most part, still have their cell-contents, so that it is evident they were alive.

How these species have come upon the ice has not yet been clearly determined; but it is highly probable that they congregated upon the under surface of the ice somewhere near the land, in the manner observed by Vanhöffen in the Karajak Fjord. Most of these species are organisms with the power of self-motion; a few, such as the discoid forms, are not, indeed, actively motile, but they can probably ascend towards the light by the aid of air-bladders in or outside the cells. It is at any rate certain that these are also found *alive* on the under surface of the ice. The diatom samples from the west side of Novaya Semlya, examined by *Grunow*, were also found on the *under surface* of an ice-floe. They were evidently alive also, as there were many small and thin-walled forms among them, which otherwise could hardly have been preserved. It is, moreover, a phenomenon with which most arctic voyagers are acquainted, that the drift-ice is sometimes quite brown on the under surface (with living diatoms)[1]; when the ice has been turned upside down, the brown colour is visible from a great distance.

Some of those diatoms that are still upon the ice when autumn arrives, will possibly sink to the bottom, but others will certainly be frozen into the ice. Nansen, as already mentioned, observed that the ice in autumn is sometimes full of plankton forms that have been frozen in. If there are diatoms upon the under surface of the ice, these will also be frozen in when the ice increases in thickness[2]. The large masses that both Hartz and Nansen found, sometimes frozen into the ice, sometimes living at the bottom of the ponds on the surface of the ice, can only be formed of a thick community of diatoms, *that have been living on the ice.*

When the diatoms are frozen in, most of them will probably perish, but some of them, protected by the masses of mucilage, will probably be able to keep alive, so as to be capable of developing when the ice melts and the conditions for living are once more favorable. By the melting of the surface-

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[1] In 1892, I found that ice that was quite new, *perhaps not more than a week old,* was sometimes quite red-brown on the under surface; and it appeared under the microscope that this was algæ. It is affirmed that the seal shows a preference for being on such ice, perhaps because there are many crustaceans in the water, that live upon the algæ plankton. *F. N.*

[2] I often observed brown stripes and thin layers in the ice, which could only be formed by the diatoms having actually lived on the under surface of the ice, and having been frozen in. *F. N.*

ice, these diatoms are set free in the fresh-water ponds on the floes, and then begin to develope and form communities at the bottom of these ponds.

The authors who have previously discussed the subject of the diatom-flora of ice-floes, appear to start with the assumption that the diatoms have come on to the ice quite by chance, like the inorganic ooze and remains of fresh-water organisms that are found in similar circumstances. But if this were the case, the various samples would differ in their composition. Experience shows, however, that the same species, though varying in number, are found in all the samples, and that they are the same species that were found at Cape Wankarema and on the east coast of Greenland. This similarity can only be explained by the assumption that it is a certain community, that has lived, at any rate for a time, on the ice. Most of the species, moreover, are found in such large numbers, that on that account alone, it must be assumed that they have lived and multiplied on the ice.

In addition to this ice-flora, however, there are also a few specimens of other species that may have found their way on to the ice by chance. These are especially the fresh-water forms, which will be briefly described hereafter.

Can any conclusions be drawn from the composition of the ice-flora, as to the origin of the ice?

This question cannot be answered decisively, until further investigations have been made of the diatoms of the ice; but the results hitherto obtained indicate that in many cases the study of diatoms will prove of valuable assistance in studying the drift of the ice.

The first attempt in this direction was made by Nansen, whose diatoms from ice-floes on the east coast of Greenland were examined by *Cleve.* These diatoms were so similar to the samples collected at Cape Wankarema during the Vega Expedition, that Cleve considered it probable that the East Greenland ice-floes must have drifted with the ocean currents from some place or other in the neighhourhood of Cape Wankarema. This correspondence between the ice-diatoms on the east coast of Greenland and at Cape Wankarema, was one of the probabilities upon which Nansen built, when he put forward his theory of a continuous current across the Polar Sea from Siberia to East Greenland.

When Östrup subsequently examined the ice-diatoms collected on the east coast of Greenland during the Ryder Expedition, he found, it is true, in these samples, all the species and varieties that were characteristic of the collections from Cape Wankarema; but he did not venture to draw any conclusions as to a direct connection between the ice-flora at the two places; for he found in the Greenland collection 3 small species that appeared in comparatively large numbers, and which Cleve had not mentioned as coming from Cape Wankarema, viz. *Navicula Hartzii*, Oestr., *Navicula (Pinnularia) perlucens*, Oestr., and *Chætoceras septentrionale*, Oestr. There were also several forms which occurred, indeed, both on the east coast of Greenland and at Cape Wankarema, but which Östrup had no opportunity of identifying, as Cleve's drawings and descriptions were altogether inadequate, and the preparations published by Cleve and Möller were not accessible to him.

In 1896, Cleve was again able to demonstrate the great similarity between the ice-flora at Cape Wankarema, and the ice-diatoms that he found floating freely among the plankton at Cape Eglinton. By an examination of the original prepared specimens, he was able to correct some of Östrup's determinations, and show that what Östrup had collected had also the greatest possible resemblance to the Cape Wankarema samples.

But while so little is known concerning the distribution of ice-diatoms, it is possible to believe that the ice-flora may be uniform upon all the shores of the Polar Sea, like the neritic plankton flora. In other words, it is possible that the correspondence between the Siberian and the Greenland samples is due to the circumstance that the biological conditions were the same in both places. There are undoubtedly species that are distributed over the entire Polar Sea, especially such species as occur both as plankton and on the ice, like the above-mentioned *Nitzschia frigida, Melosira hyperborea, Fragilaria oceanica, Fr. cylindrus*, etc.

The facts hitherto obtained seem, however, to indicate that the ice-flora in other parts of the Polar Sea that are not in direct communication with the current from North Siberia to East Greenland, is essentially different from the algæ-community, which may be best designated the *Wankarema community*. The sample from the sea west of Novaya Semlya, examined by Grunow, and Vanhöffen's collection from the Karajak Fjord, agree with one another and with the Wankarema samples in those species that live all over the Polar Sea under similar conditions; but the characteristic Wankarema forms are missing, and instead of them there are a few special forms. The same may be said of the sample from the Barents Sea, examined by Cleve, which, in addition to the ice-flora, contains some fresh-water forms which will be briefly described later on.

The composition of the samples under discussion strengthens the probability of Nansen and Cleve's theory that the diatoms in North Siberia and East Greenland are directly connected with one another. The samples taken while the 'Fram' was drifting across the Polar Sea, contain almost exactly the same species that Cleve found at Cape Wankarema and Cape Eglinton, and that Östrup has pointed out from East Greenland. The peculiarly Greenland forms, *Navicula Hartzii* and *N. perlucens*, however, are missing. On the other hand, the sample that Nansen took in the Barents Sea on an ice-floe which, he supposed, had no connection with the polar current, has none of the Wankarema forms, and contains, besides some fresh-water forms and a few of the commonest ice forms, hardly any but the one species, *Coscinodiscus polyacanthus*, but this, it is true, in immense quantities,

In the following table, I have brought together all the species that are found in Nansen's samples, and which are only known from ice, or as littoral forms. The various species are placed in eight vertical columns, according to the locality in which they were found, viz.

<table>
<tr><td>1. Polar Sea, in lat. 81° N. and long. 125—127° E. N.
2. Wankarema (Kjellman—Cleve). W.
3. East Greenland (Östrup). R.
4. Cape Eglinton (Cleve). E.</td><td>Supposed to be connected with the drift-ice across the Polar Sea.</td></tr>
<tr><td>5. W. of Novaya Semlya (Grunow). G.
6. Karajak Fjord, West Greenland (Vanhöffen). K.
7. Barents Sea, Jackson (Cleve). J.
8. Barents Sea, Nansen. N.</td><td>Probably local ice-formations, which are not carried with the great polar current.</td></tr>
</table>

The species that are littoral, or found in bottom-samples as well as on the ice, are indicated by an asterisk. As earlier naturalists have not always distinguished between dead cell-walls and living organisms, some of their statements are of little value. The valves found in the Arctic Ocean and the North Atlantic, may easily have come from species that have lived on the drift-ice.

	N. Arctic Ocean Nansen	W. Wankarema Kjellman-Cleve	R. East Greenland Ryder-Östrup	E. Cape Eglinton Cleve.	G. Novaya Semlya Grunow	K. Karajak Fjord Vanhöffen	J. Barents Sea Jackson-Cleve	N. Barents Sea Nansen
Amphiprora paludosa v. *punctulata*	+	+	+	+	+			
— *Kjellmanii*	+	+		+			+	
— — var. *glacialis*	+		+	+	+			
— — „ *striolata*	+		+					
— — „ *kryophila*	+	+	+	+				
* — *gigantea* v. *septentrionalis*	+	+	+	+				
* *Tropidoneis maxima* v. *dubia*	+							
Pleurosigma Clevei v. *sibirica*	+	+		+				
* — *Stuxbergii*	+	+	+	+	+	+		
— — v. *rhomboides*	+	+	+					
Caloneis kryophila	+	+	+				+	
* *Diploneis didyma*	+		+					
— *litoralis* v. *arctica*	+	+	+	+			+	
* — *Smithii*	+		+					
Navicula lineola	+				+			
— *Oestrupi*	+		+	+				
— *kryokomites*	+	+	+	+				+
* — *Spicula*	+	+	+					
* — *vitrea*	+	+	+	+				
— *Kjellmanii*	+	+	+	+				
Stenoneis inconspicua v. *Baculus*	+	+	+	+				
* *Navicula subinflata*	+	+	+	+			+	
— *pellucida*	+	+	+					
* *Gomphonema exiguum* v. *pachyclada*	+	+	+	+				
— — v. *arctica*	+	+	+	+				
— *kamtschaticum* v. *grœnlandica*	+	+	+	+				
Navicula valida	+	+	+	+			+	
— *transitans*	+	+	+	+		+	+	
— v. *incudiformis*	+	+	+					
* — *directa*	+	+	+	+		+		

	N.	W.	R.	E.	G.	K.	J.	N.
	Arctic Ocean Nansen.	Wankarema Kjellman-Cleve	East Greenland Ryder-Östrup	Cape Eglinton Cleve	Novaya Semlya Grunow	Karajak Fjord Vanhöffen	Barents Sea Jackson-Cleve	Barents Sea Nansen
* *Navicula directa* v. *subtilis* . . .	+	+	+	+				
— — v. *remota* . . .	+		+					
— *gelida*	+	+	+		+			
— *derasa*	+	+	+	+				
— — v. *erosa*	+	+	+	+				
— *detersa*	+	+	+		+			
— *Blessingii*	+		?					
— *trigonocephala*	+	+	+	+				
— *recurvata*	+							
— *sibirica*	+	+	+	+				
— *superba*	+	+	+	+				
— — *subacuta*	+							
— — *elliptica*	+	+	+					
— — *crassa*	+		+					
— *obtusa*	+	+	+	+				
— *algida*	+	+	+	+	+		+	
* — *glacialis*	+		+					
* — *pygmæa*	+							
Pinnularia perlucens			+					+
* — *ambigua*	+	+	+	+				
* — *quadratarea*	+	+	+	+				
— — v. *Stuxbergii* .	+	+	+	+	+		+	
— — v. *bicontracta* .	+		+	+				
— — v. *constricta* .	+		+	+				
— *semiinflata*	+		+					
— — v. *decipiens* . .	+	+	+	+				
— — v. *inæqualis* .	+		+					
* *Amphora lævis* v. *lævissima* . .	+		+	+				
Surirella Oestrupi	+		+					
Hantschia Weyprechtii	+		+		+			+
* *Nitzschia hybrida*	+	+	+	+	+	+		
* — *distans*	+	+		+				
— *Brebissonii* v. *borealis* .	+	+	+	+				
— *gelida*	+	+	+					
— *polaris*	+	+	+	+	+			
— *lanceolata* v. *pygmæa* . .	+	+	+	+				
* — *Closterium*	+							

	N.	W.	R.	E.	G.	K.	J.	N.
	Arctic Ocean Nansen	Wankarema Kjellman-Cleve	East Greenland Ryder-Östrup	Cape Eglinton Cleve	Novaya Semlya Grunow	Karajak Fjord Vanhöffen	Barents Sea Jackson-Cleve	Barents Sea Nansen
Xanthiopyxis polaris	+							
Actinocyclus alienus v. *arctica*	+	+	+	+				
Coscinodiscus polyacanthus	+	+	+	+				+
— *curvatulus*	+	+	+	+	+		+	
— *Kützingii* v. *glacialis*	+							
— *bioculatus*	+	+		+	+			
— *septentrionalis*	+		+					

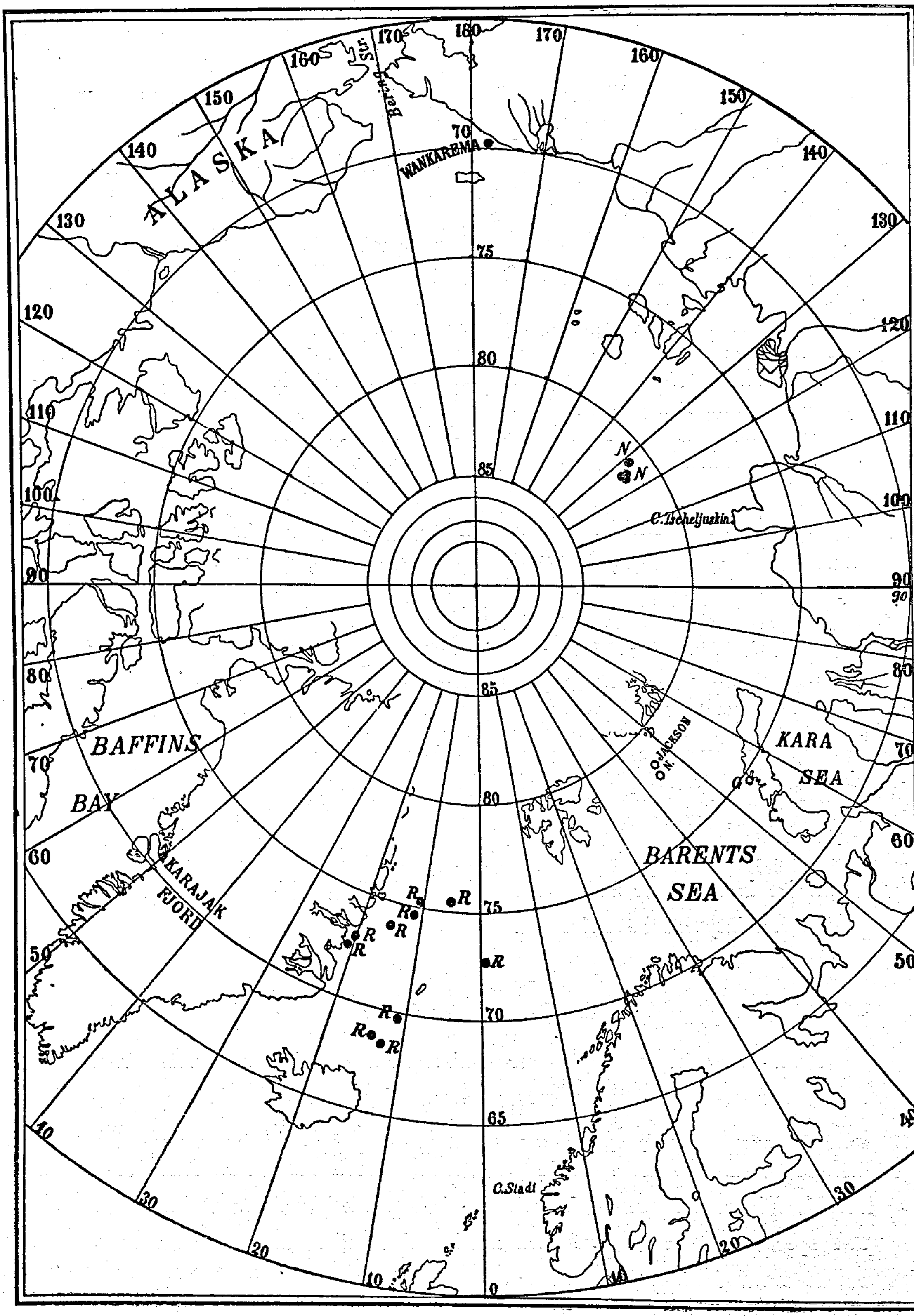
It will be immediately seen from the table, that the first four columns have almost all their species in common, while the last four have only a very small number of these typical Wankarema forms.

In the accompanying map, (fig. 1, p. 21), the places are marked where ice-diatoms have hitherto been found; the stations where the Wankarema community was found are indicated by a black circular spot, the others by a circle. N indicates the samples collected by Nansen, R, Ryder's collections, and G, Grunow's samples from Novaya Semlya.

Both the table and the map go to show the possibility of ice-diatoms being employed as an assistance in investigating the currents and the drift of the ice in the Polar Sea; but many investigations will be required before perfect certainty can be arrived at.

4. *Fresh-water forms.*

Fresh-water forms play a very unimportant part in the samples from the Polar Sea. I have found only a few species, all of them in very small numbers, most of them represented by only a single specimen. I have not, therefore, been able to determine whether they have had cell-contents; they have probably not been living on the ice, or they would have multiplied. The species that occur have such a wide distribution, that no conclusions can be drawn from their occurrence.



ALASKA
Bering Str.
WANKAREMA
C.Tscheljuskin
BAFFINS BAY
KARAJAK FJORD
KARA SEA
BARENTS SEA
JACKSON
C.Stadt
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
65
75
85

Fig. 1.

I have found the following species:

Cymbella cuspidata,
Navicula rhynchocephala,
Pinnularia borealis,
Fragilaria Harrisonii,
Nitzschia denticula,
Melosira crenulata.

The sample taken by Nansen from the Barents Sea contains comparatively more fresh-water forms than the others, *Melosira crenulata* occurring rather plentifully.

The sample that Cleve has examined from the Barents Sea contains more fresh-water than salt-water forms, *Melosira crenulata* being common. Cleve infers from this that the ice has probably been formed in the neighbourhood of a river; but it is impossible to base any decisive conclusions upon the fresh-water diatoms.

Östrup's collection also contains a far greater number of fresh-water forms than the one under discussion. Östrup and Hartz suppose that the diatom valves have been carried on to the ice from the land by the wind.

SYSTEMATIC LIST OF THE SPECIES.

In the systematic arrangement of the naviculoid diatoms, I have followed Cleve's Synopsis. Cleve has rendered great service by giving in this work a survey of all known species. His system, indeed, appears to me to be somewhat one-sided, as he has made too much use of certain features for separating his main groups, especially of the striation of the valves; but at present it is scarcely possible to draw up a system that answers better to the genetic connection of the forms. For this purpose a more thorough knowledge is required of the structure of the entire cell, and the actual conformation of the cell-walls. The investigations of recent years, especially those of Otto Müller, have shown that the structure in the various forms may be so diversified that the terms generally used — "striæ", "punctæ", "areolæ" — give only a very inadequate idea of the actual circumstances. The form of the raphe must above all be taken into consideration in the division into large groups.

One fault in the form of Cleve's system is that sections with separate generic names, such as *Diploneis, Gyrosigma,* etc., are ranged side by side with others that are only entered as *Naviculæ fusiformes, orthostichæ,* etc. This gives the impression that Cleve looks upon all sections as equally good genera; but he has not wanted to give too many new generic names at the present stage of investigation. In other words he considers even his own classification as temporary.

The collection before us is a very limited one, a special feature being that it contains only a very small number of the large main groups, while some of these, e. g. *Naviculæ lineolatæ,* are represented in tolerable abundance. I have therefore been desirous of not giving expression to my own personal views by departing from the order of Cleve's Synopsis, the more so as from practical considerations, this vade-mecum of all students of diatoms should be followed as far as possible.

In other respects, the classification in Van Heurck's 'Traité des Diatomées' is followed. With regard to the designation of the morphological axes and the various parts of the cell, I have kept entirely to Otto Müller's [95] excellent system.

I. *PENNATÆ.*

A. RAPHIDEÆ.

AMPHIPRORA, (Ehb.) Cl.

1. *Amphiprora paludosa,* W. Sm. [53].
   Var. *punctulata,* Grun. [80] p. 62, Pl. IV, fig. 84.
   Grun. [84] p. 105, Pl. A, figs. 54, 55.
   Cl. Syn. I, p. 15.

Rather frequent, especially in masses in open channels.

Geographical Distribution. Cape Wankarema, Kara Sea, on the under surface of a piece of ice near Novaya Semlya, 74° 48′ 4″ N. Lat., 54° 52′ 8″ E. Long, Aug. 2, 1872 (Grunow [84] p. 105). On ice off the east coast of Greenland, and in latitude 72° 46′ N., longitude 0° 13′ E. (Östrup [95] p. 443). Floating freely off Cape Eglinton (Cleve [96] p. 14).

2. *Amphiprora Kjellmanii,* Cl. [80], pp. 15, 61, Pl. IV, fig. 83. Cl. Syn. I, p. 16.

The forms allied to this species are little known as yet, as they generally occur in small numbers, and as their cell-walls are so slightly silicated, that an opportunity is seldom afforded of observing entire cells. In the samples from the Polar Sea, I have been able to distinguish the following forms:

Var. *glacialis,* Cl. [83] p. 477, Pl. 35, fig. 12.

with f. *subtilis,* (Grun.) *A. kariana* v. *subtilis,* Grun. [84] p. 105, Pl. A, figs. 52, 53.

Dimensions. a = 29—62 μ, striæ, 13 or 14 per 10 μ[1].

Var. *striolata,* (Grun.) [80] p. 62, Pl. IV, fig. 81. *A. striolata,* Grun. l. c.

Var. *genuina.*

Dimensions. a = 90—168 μ, striæ on the keel, 11—13·5 per 10 μ.

Var. *kryophila,* Cl. [83] p. 477, Pl. 35, fig. 11. *A. kryophila* Cl. l. c.

Striæ about as close on the keel as on the valve, 13—16 per 10 μ.

Scarce in most of the samples, v. *glacialis* found especially in open channels, v. *kryophila* in pools on the ice.

Geographical Distribution. Arctic waters — Kara, Wankarema, East Greenland.

3. *Amphiprora gigantea,* Grun. [60] p. 568, Pl. IV, fig. 12.

Var. *septentrionalis,* (Grun.) [80] p. 63, Pl. V, fig. 87. Cl. Syn. I, p. 18. *A. decussata* v. *septentrionalis,* Grun. l. c. Östrup [95] p. 444, Pl. VII, fig. 79.

Scarce.

Geographical Distribution. Arctic waters — Finmark, Wankarema, East Greenland.

TROPIDONEIS, Cl.

4. *Tropidoneis maxima,* (Greg.) Cl. *Amphiprora maxima,* Greg. [57] p. 507, Pl. XII, figs. 61 & 61 b.

Var. *dubia,* Cl. & Grun. [80] p. 65, Pl. V, fig. 89. Cl. Syn. I, p. 26.

Dimensions. a = up to 120 μ, t = 12 μ, striæ, 17 per 10 μ.

Scarce.

Geographical Distribution. Finmark, 'nicht selten' (Cl. & Grun.).

---

[1] a = the apical axis, t = transapical axis, p = pervalvar axis. Cf. Otto Müller [95].

PLEUROSIGMA, W. Sm.

5. *Pleurosigma Clevei,* Grun. [80] p. 52, Pl. III, fig. 70 a, b.
   Var. *sibirica,* Grun. in Cl. Syn. I, p. 37.

Rare.

Geographical Distribution. Wankarema, Cape Eglinton.

6. *Pleurosigma Stuxbergii,* Cl. & Grun. [80], p. 54, Pl. IV, fig. 74. Cl. Syn. I. p. 41.

Singly in most of the samples.

Geographical Distribution. Arctic waters — Kara, Wankarema, Franz Josef Land, East Greenland.

Var. *rhomboides.* Cl. Syn. I, p. 41.
P. rhomboides, Cl. [80] pp. 14, 54, Pl. IV, fig. 73.

Together with the chief species, but less frequent.

Geographical Distribution. Arctic waters — Kara, Wankarema, East Greenland.

CALONEIS, Cl.

7. *Caloneis* (?) *kryophila.* Cl. Syn. I, p. 64.
   Navicula kryophila, Cl. [83] p. 473, Pl. 37, fig. 43.

Fairly plentiful in some of the samples, especially on the ice-foot. Size. a = 36—62 μ, t = 18—24 μ, striæ 8—10 per 10 μ. Cleve's doubt, when he refers this species to *Caloneis,* appears to me to be well founded. In my opinion, it is more closely connected with *Pinnularia quadratarea,* A. Schm.

Distribution. Arctic waters — North Siberia, Wankarema, East Greenland, West Greenland (Östrup [97]).

DIPLONEIS, Ehb.

8. *Diploneis didyma,* Ehb. [40], p. 75. Cl. Syn. I, p. 90.

Singly.

Distribution. Cosmopolitan.

9. *Diploneis litoralis* (Donk). Cl. Syn. I, p. 94.
Navicula litoralis, Donk [70], p. 5, Pl. I, fig. 2.

Occurs not infrequently in most of the samples, in various forms. The size varies considerably; a = 22—63 μ, t = 12—26 μ, $\frac{a}{t}$ = 1·9—4·0. Striæ, 12—16 per 10 μ. The most frequent forms are those of the following dimensions: a = 30—55 μ, t = 14—17 μ, $\frac{a}{t}$ = c. 2·5; striæ, 15 or 16 per 10 μ. These forms are thus most nearly related to var. *arctica*, Cl. [96], p. 18, Pl. I, fig. 7.

Distribution. Almost cosmopolitan; var. *arctica*, however, only in the Polar Sea (North Siberia, E. Greenland).

10. *Diploneis Smithii* (Bréb.). Cl. Syn. I, p. 96.
Navicula Smithii, Bréb. in W. Smith [56], p. 52.

Singly.

Distribution. Cosmopolitan in salt and brackish water.

NAVICULÆ FUSIFORMES, Cl.

11. *Navicula lineola*, Grun. [84], p. 104, Pl. A, figs. 45, 46. Cl. Syn. I, p. 107,

Scarce.

Distribution. Franz Josef Land.

12. *Navicula Oestrupi*, Cl. [96, 1], p. 20, Pl. I, fig. 10. *Amphiprora amphoroides*, Oestr. [95], p. 442, Pl. VI, fig. 70.

Scarce.

Distribution. East Greenland and Cape Eglinton, on ice.

NAVICULÆ ORTHOSTICHÆ, Cl.

13. *Navicula kryokonites*, Cl. [83], p. 473, Pl. 37, fig. 44. Cl. Syn. I, p. 109.

Pl. III, fig. 9.

Not uncommon, especially small forms (a = 25—41 μ, t = 6—9 μ).

Distribution. Wankarema, East Greenland.

14. *Navicula Spicula* (Hickie) [73], p. 290. Cl. Syn. I, p. 110.

Stauroneis Spicula, Hickie, l. c.

Not uncommon. Dimensions, a = 80—105 μ, t = 11 or 12 μ.

Distribution. Arctic America, Wankarema, Kara Sea, East Greenland, Northern Europe.

15. *Navicula vitrea,* Cl. Syn. I, p. 111.

Pleurosigma vitreum, Cl. [80], p. 15, Pl. IV, fig. 78.

Scarce.

Distribution. Arctic waters, Adria.

16. *Navicula Kjellmanii,* Cl. Syn. I, p. 111.

Pleurosigma Kjellmanii, Cl. [80], p. 14, Pl. IV, fig. 80.

Navicula Vegæ, Cl. [83], p. 474. Östr. [95], p. 439.

Scarce.

Distribution. Arctic waters — North Siberia, Kara, Wankarema, E. Greenland, on ice.

STENONEIS, Cl.

17. *Stenoneis inconspicua* (Greg.) Cl. var. *Baculus* Cl. Syn. I, p. 124.

Navicula Baculus, Cl. [83], p. 474, Pl. 37, fig. 51.

Not uncommon. Dimensions, a = 54—92 μ, t = 10 or 11 μ, Striæ, 18 per 10 μ.

Distribution. North Siberia, Wankarema, East Greenland, upon ice.

NAVICULÆ DECIPIENTES, Grun.

18. *Navicula subinflata,* Grun. in Cleve [83], p. 470, Pl. 37, fig. 50. Cl. Syn. I, p. 141.

Pl. II, figs. 16, 17.

Common, especially in pools on the ice.

Distribution. Arctic America, Wankarema, Greenland, Norway.

NAVICULÆ MICROSTIGMATICÆ, Cl.

19. *Navicula pellucida,* Cl. Syn. I, p. 144.
Stauroneis pellucida, Cl. [83], p. 475, Pl. 35, fig. 10.

Scarce.

Distribution. Wankarema, North Siberia, E. Greenland, on ice (Östrup).

20. *Navicula septentrionalis,* Östrup [95], p. 439, Pl. VIII, fig. 97. Cl. [96, 1], p. 11.

Not uncommon.

Distribution. Arctic Ocean, on ice, and on the coasts as plankton; Baffin's Bay, Karajak Fjord, E. Greenland.

CYMBELLA, Ag.

21. *Cymbella cuspidata,* Kütz. [44], p. 79, Pl. 3, fig. XL. Cl. Syn. I, p. 166.

Singly.

Distribution. Fresh water, circumpolar, especially in cold and temperate climates.

GOMPHONEMA, Ag.

22. *Gomphonema exiguum,* Kütz. [44], p. 84, Pl. 30, fig. 58. Cl. Syn. I, p. 188.

Var. *pachyclada,* Bréb. [38], p. 21. *G. pachycladum,* Bréb. l. c.
G. septentrionale, Oestr. [95], p. 414, Pl. III, figs. 9, 10.
Pl. II, figs. 18, 19.

Distribution. Shores of the Arctic Ocean — Wankarema, Bering Strait, E. Greenland; Normandy.

Var. *arctica* (Grun.) in V. H. Syn. Pl. XXV, figs. 31, 32.
G. arcticum, Grun. l. c. Grun. [84] p. 102, Pl. A, fig. 12.

Distribution. Shores of the Arctic Ocean — Franz Josef Land, Novaya Semlya, Wankarema, E. Greenland.

Both the varieties occur pretty frequently in most of the samples; var. *arctica* is the commonest. The valves are always asymmetrical in relation to the apical axis; the raphe lies almost entirely on one side of the mid-rib. The striæ extend on one side right up to the rib; but on the other side, where the raphe lies, there is a more or less distinct, unstriated region between the raphe and the striæ, a unilateral axial area.

Dimensions. Var. *pachyclada* — a = 22—40, t = 6·5—8·5, striæ, 10—12 per 10 μ.

— *arctica* — a = 25—36, t = 6·5—8, striæ, 14—17 per 10 μ.

23. *Gomphonema kamtschaticum,* Grun. [78], p. 109, Pl. III, fig. 4. Cl. Syn. I, p. 188. Cl. [96, 1], p. 19.

var. *grœnlandica* (Oestr.).

G. grœnlandicum, Oestr. [95], p. 414, Pl. III, figs. 8, 11, 12.

Pl. II, figs. 20, 21.

Common in most of the samples. This species also is always asymmetrical in relation to the apical axis, in the same manner as the preceding one, as Östrup also states.

Distribution. Wankarema, E. Greenland, upon ice.

NAVICULÆ LINEOLATÆ, Cl.

This group is abundantly represented in the polar ice. The species are to some extent very difficult to distinguish, as they vary to an extraordinary degree. Cleve, in his paper on the diatoms of the Vega Expedition [83], draws attention to the fact that on the ice-floes off Cape Wankarema, a number of forms were found that were nearly related to *Navicula directa,* but which differed so greatly from one another, that they might all have been considered good species, if every possible transition-form had not been found in the same samples. These forms differ from one another in the contour of the valves, and the closeness and direction of the striæ. In some forms the striæ are interrupted, in others they are entire; some are quite symmetrical in relation to the apical plane, when the usual curve of the mid-rib at the ends of the valve is left out of consideration; others are more or less asymmetrical. Some have almost flat valves, while in others they are curved as in *Achnanthes.* The latter species should belong to the genus *Rhoiconeis,* established by Grunow; but as, on the other hand, they are so nearly related to the regular forms of *Navicula Lineolatæ*, the genus *Rhoiconeis* cannot be retained. Cleve, in his above-mentioned paper [83], has arranged these difficult forms with delicate systematic discernment.

Östrup [95] has found the same series of forms in some samples collected by the Ryder Expedition on ice-floes off the east coast of Greenland and as far east as 72° 46′ N. Lat. and 0° 13′ E. Long. Östrup follows Cleve's classification, and also describes some peculiar forms.

Subsequently, Cleve also found these species off the east coast of Greenland, where they were drifting in small quantities among the plankton, 30 nautical miles to the east of Cape Eglinton. In his report of this [96, 1] and in his Synopsis, Cleve principally follows the same classification as before, although by placing several of the former species as varieties of others, he has considerably reduced their number.

In the samples collected by Nansen, this very series of species also belongs to the characteristic forms; all the variations described by Cleve and Östrup are also found there. I shall here try to give a systematic survey of them.

The valves in all these species are provided with a narrow median rib. It widens in the middle, sometimes rather unilaterally, into a central node; and at the ends it is bent into a hook, which lies in the valvular plane. Both ends are bent to the same side of the apical plane.

As a rule, only the two central pores of *the raphe* are visible; the rest is so narrow that it vanishes in the median rib. In a few of the forms, the central pores are very close together, only separated by a cylindrical isthmus (e. g. *Navicula detersa*), in others they may be rather farther apart. In the latter case, they are bent a little outwards, both to the same side as the ends of the median rib. The course of the raphe may be best followed in fragments. In certain species, it divides the median rib into two almost symmetrical halves; in others it lies almost entirely on one side of the rib, and always on the side towards which the ends of the rib curve. This is often the case in *Navicula valida*, and to a still greater extent in the above-mentioned species, *Gomphonema kamtschaticum* var. *grœnlandica*, which does not, however, belong to this group of forms.

The striation of the valves is closely connected with the course of the raphe. The striation is due to the strengthening interiorly of the cell-wall by ribs. Between the ribs there are grooves of the same width as the ribs, and closed outwards with a very thin membrane. Inwards, towards the inner chamber of the cell, they are probably open; but this I have not been able to decide with certainty.

In cases where the raphe lies in the middle of the median rib, the grooves run right up to the latter; but in the middle, where the valve will not bear any weakening, on account of the large central pores, they do not reach quite up. In this way, a larger or smaller *central area* is formed.

When the course of the raphe is not median, it is bounded by a strong rib only on one side; on the other side the margin is much thinner, and in the most asymmetrical forms, the cell-wall here may be quite without anything to strengthen it. The grooves then run right up to the rib on one side; but on the other, they do not reach so far. An axial area is left, which, however, is generally rather narrow. If the grooves were to run right up to the raphe on this side where the margin is already so weak, the wall would probably not have the necessary strength.

The striæ may also be interrupted in one place or several places between the median rib and the margin of the valve, as well as in the centre and along the raphe. Most frequently there is only one, rather large interruption, which occurs in all the striæ on the same side, with the exception of the outermost, which is quite short. This then, in agreement with Cleve, I consider to be the *lateral area*. In symmetrical forms which, like *Navicula detersa* and *derasa,* have no axial area, there is a lateral area on each side of the median rib. In asymmetrical forms such as *Navicula transitans* var. *incudiformis,* there is a lateral area only on the side of the median rib where the raphe and the axial area are not found.

Other forms, such as *Navicula trigonocephala,* have their striæ divided into several portions.

The unstriated areas of the cell-wall are thicker than the membranes that close the grooves at their outer extremity; but they are somewhat thinner than the transverse ribs that separate the grooves.

The system of grooves and ribs, which forms the striation, has a twofold biological significance. The membrane must be strengthened for mechanical reasons, and when the material is limited, a greater firmness can be attained by a strong network than by an even thickening of the cell-wall.

On the other hand, an even thickening would check the osmotic connection with the outside world, whereas diffusion is not essentially hindered if only a part of the wall remains unthickened.

Very thin-walled diatom cells generally have a very fine and inconspicuous striation. Apart from a few spores, on the other hand, no instances are known of thick, highly silicified walls that have not a strong and distinct system of ribs or network, at any rate on part of the cell-wall. The curved forms of this group are very interesting, in as much as their two valves differ from one another in structure. The one valve, which is curved outwards, has a strong system of ribs, occupying nearly the entire surface of the valve; while the other, which curves inwards towards the interior of the cell, has its striæ broken by a large lateral area (*Navicula superba*, etc.), or, as in the symmetrical forms, by two such, one on each side of the median rib (*N. recurvata*). This also indicates that the rib system generally occurs where the greatest strengthening is required.

It is difficult to decide which of the characteristics in this group are to have the greatest importance attached to them. The dimensions vary extremely here as in all diatoms, and with them the outward form also varies. In the series of developments that each species goes through from one auxospore formation to another, there are already great variations in size. These variations have therefore no systematic significance whatever. In elongated forms, it is especially the length of the apical axis (a), that is subject to such variations, while the transapical axis (t) is far more constant. The proportion a : t is therefore also very variable. The striæ also vary to a certain extent with the size, the larger forms always having a somewhat coarser striation than the smaller developmental forms of the same species. Among these species also, however, there are probably variations in size, that really have a systematic significance; but as long as living subjects are unobtainable, in which the development may be followed, no decisive results can be arrived at. In many particulars, therefore, it must depend upon the subjective judgement, how much consideration is to be paid to the various characters.

In his last treatise (Synopsis II, p. 10, seq.), *Cleve*, in my opinion, has attached too little importance to symmetrical proportions; but in other respects, my detailed investigations and numerous measurements have led me to the conviction that Cleve's grouping in species and varieties is in the main the most natural that can be made at present.

I have succeeded in distinguishing the following forms:

I. Fresh-water forms:

24. *Navicula rhynchocephala,* Kütz. [44], Pl. 30, fig. 35. Cl. Syn. II, p. 15.

One specimen.

Distribution. In fresh water, circumpolar.

II. Salt-water forms:

A. Valves uniform in construction, almost flat, with only a low curvature at the margin.

25. *Navicula valida,* Cl. & Grun. [80], p. 32, Pl. II, fig. 29. Cl. Syn. II, p. 25.
Pl. I, figs. 11, 12.

Valves flat, broadly lanceolate; a = 50—131 μ, t = 18—31 μ, striæ, 6—8 per 10 μ. Very unsymmetrical; the raphe lies almost entirely on one side of the median rib, the central pores rather far apart. The unilateral axial area very conspicuous.

The f. *minuta,* described by Cleve [83], p. 466, is also in Nansen's samples.

Not uncommon.

Distribution. Polar Sea — Kara, Wankarema, East Greenland.

26. *Navicula transitans,* Cl. [83], p. 467, Pl. 36, fig. 31. Cl. Syn. II, p. 27.
Pl. I, figs. 4, 5.

A very variable species, closely allied to the broadest forms of *N. directa.* Valves lanceolate; $\frac{a}{t} = 4—6$. The typical form is conspicuously asymmetrical, with central pores rather far apart, and a distinct, unilateral axial area. The striæ are continuous and rather coarse. The following forms of the principal species may be distinguished:

f. *genuina;* a = 56—86 μ, t = 15—19 μ, striæ, 7—9 per 10 μ, $\frac{a}{t} = 3{\cdot}7—5{\cdot}1$.

f. *robusta;* a = 67—130 μ, t = 20—21 μ, striæ, 6 per 10 μ, $\frac{a}{t} = 4{\cdot}4—6{\cdot}3$.

Pl. I, fig. 4.

Var. *incudiformis,* Grun. in Cl. [83], p. 467, Pl. 36, figs. 26, 30. Cl. Syn. II, p. 28. *Navicula incudiformis,* Grun. l. c.

Pl. I, fig. 5.

Like the principal species, but the valves have a distinct lateral area upon the side of the median rib that is turned away from the raphe.

Dimensions. a = 56—101 μ, t = 17—20 μ, striæ, 7 or 8 per 10 μ, $\frac{a}{t} = 3{\cdot}3$—$5{\cdot}5$.

27. *Navicula directa,* W. Sm. [53], p. 56, Pl. XVIII, fig. 172. Cl. Syn. II, p. 27.

Pl. I, figs. 1—3.

Valves narrow lanceolate, narrower than in the preceding species, almost symmetrical, with the central pores close together. The striæ at right angles to the median rib, and thus parallel with the transapical axis. Like Cleve, I can distinguish 3 varieties:

Var. *genuina,* Cl. Syn. II, p. 27. Pl. I, figs. 2, 3.

Dimensions. a = 54—112 μ, t = 9—11 μ, striæ, 8 or 9 per 10 μ, $\frac{a}{t} = 5$—11.

Var. *subtilis* (Greg.) Cl. *Pinnularia subtilis,* Greg. [57], p. 488, Pl. IX, fig. 19.

Dimensions. a = 84—93 μ, t = 7 μ, striæ, 9 per 10 μ, $\frac{a}{t} = 11$—13.

Var. *remota,* Grun. [80], p. 39. Pl. I, fig. 1.

Dimensions. a = 112—145 μ, t = 12—14 μ, striæ, 6 or 7 pr. 10 μ, $\frac{a}{t} = 9$—12.

All three varieties fairly frequent, var. *genuina* common.

Distribution. Northern shores, var. *remota* also in warmer seas.

28. *Navicula gelida,* Grun. [84], p. 103, Pl. A, figs. 27, 28. Cl. Syn. II, p. 28.

Pl. I, figs. 8, 9.

Under this species I have classed all the small forms that are nearly allied to *N. transitans* and *N. directa,* and have entire, slightly radiating striæ, and a narrow, but visible axial area.

Dimensions. a = 32—67 μ, t = 9.5—14 μ, striæ, 10—13 per 10 μ, $\frac{a}{t}$ = 2·4—5.

Common in most of the samples.

Distribution. Arctic waters.

29. *Navicula derasa,* Grun. [80], p. 39, Pl. II, fig. 46.

N. transitans v. *derasa,* Cl. Syn. II, p. 28.

Pl. I, fig. 6.

Like *N. transitans,* but symmetrical, without axial area, but with a distinct lateral area on each side of the rib. The central pores close together.

Dimensions. a = 56—96 μ, t = 16—21 μ, striæ, 6—9 per 10 μ, $\frac{a}{t}$ = 3·5—5·5.

Rather common.

Distribution. Polar Sea — Kara, Cape Deschneff, Wankarema, East Greenland.

Var. *erosa* (Cl.) [83], p. 468, Pl. 36, fig. 28. *Navicula erosa,* Cl. l. c.

N. transitans v. *erosa,* Cl. Syn. II, p. 28.

Is distinguished from the principal species by its greater breadth, and by the striation, which is interrupted by 2 or 3 areas on each side of the median rib.

Uncommon.

Distribution. The same as the principal species.

30. *Navicula detersa,* (Grun.) in Cl. [83], p. 469, Pl. 36, fig. 36.

Pl. I, fig. 7.

Navicula kariana v. *detersa,* Grun. l. c. Cl. Syn. II, p. 28.

Resembles the principal species of *N. derasa* in its striation and symmetrical proportions, but is broader in comparison to its length, the walls are thinner, and the striation is finer and fainter.

As the true *N. kariana* does not occur in the samples, I have preferred to enter this form under a special specific name.

Dimensions. a = 60—114 μ, t = 22—27 μ, $\frac{a}{t}$ = 2·7—4·2, striæ, 9—11 per 10 μ.

Common in most of the samples.

Distribution. Arctic waters.

31. *Navicula Blessingii,* n. sp.

Pl. I, fig. 10.

Valves flat, with parallel margins which curve together towards the obtusely triangular ends. Median rib and raphe as in *Navicula derasa;* axial area absent, but on both sides of the median rib there is a large lateral area. The fragments of striæ by the median rib are always visible on both sides of the rib near the middle of the valve; but near the extremities they often disappear on one side. Here, then, the lateral area goes right up to the raphe. It may probably be concluded from this that near the centre, the raphe keeps almost in the middle of the median rib, but near the extremities runs closer to the inner side of the rib.

This species resembles *Navicula trigonocephala* in the outline of the valves; but its valves are slightly curved, and the symmetry and striation are different. I have not succeeded in discovering transition-forms. It is probably identical with the form that Östrup has named *N. trigonocephala* v. *depressa,* Oestr. [95], p. 430, Pl. IV, fig. 44. The name *depressa,* however, cannot be used as the specific name, as it is already employed for another *Navicula.*

Dimensions. a = 41—69 μ, t = 13 or 14 μ, striæ, 8 or 9 per 10 μ, $\frac{a}{t}$ = 3—5.

Not uncommon in several of the samples.

B. *Rhoiconeis,* Grun. Valves unequal, more or less curved in the same direction, so that the one is convex, and the other concave, as in *Achnanthes.*

32. *Navicula trigonocephala,* Cl. [83], p. 468, Pl. 36, fig. 29. Östrup [95], p. 429, Pl. IV, figs. 45, 46. Cl. Syn. II, p. 27.

Pl. I, figs. 13, 14.

The valves are very slightly curved, somewhat unequal, as the striæ on the convex[1] valve are generally more entire than on the concave side. The median rib is somewhat unsymmetrical, the axial area distinct.

Dimensions. a = 32—72 μ, t = 12—14 μ, $\frac{a}{t}$ = 2·3—5·3, striæ 8—10 per 10 μ.

Fairly common in most of the samples.

Distribution. Arctic waters — Wankarema, East Greenland.

33. *Navicula recurvata,* n. sp.

Pl. II, figs. 12—15.

Valves bluntly lanceolate in outline, evenly arcuate, but not vaulted. The median rib symmetrical as in *N. derasa* and *N. detersa.* The valves are unequal, the convex valve having entire striæ, while the concave has a large lateral area on each side of the median rib.

The pleuræ in this species form such narrow bands, that the distance of the valves from one another is not great.

The concave valve of this species strongly resembles diminutive forms of *Navicula derasa;* but its curvature distinguishes it decidedly from that species. It also resembles *Navicula finmarchica,* Cl. & Grun., *Stauroneis finmarchica,* Cl. & Grun. [80], p. 47, Pl. III, fig. 63; but Cleve states that the valves in that species are uniform (Syn. II, p. 28).

Dimensions. a = 27—62 μ, t = 8—12 μ, striæ, 9 or 10 per 10 μ, $\frac{a}{t}$ = 3—5.

Fairly common.

34. *Navicula superba,* s. l.

Valves unequal, considerably vaulted, with coarse, strongly marked striation. The keel on the convex valve is fairly evenly curved; on the concave valve it is straighter, but with a break inwards in the middle. Both valves are asymmetrical in build, with a distinct, unilateral axial area. On the opposite side, the concave valve has a lateral area, which is poorly

[1] Considered from the outside.

developed in the narrower forms, well developed in the broader forms. The central pores of the raphe are at a considerable distance from one another. The pleuræ of the cells form a comparatively broad band, and the length of the pervalvar axis is still further increased by the high vaulting of the valve.

The contour of the valves varies exceedingly, in the same manner as in the series of forms that are grouped about *Pinnularia quadratarea* (A. Schm.) Cl. The following principal types may be distinguished:

Sub-sp. 1. *Navicula sibirica* (Grun.) Cl.

Pl. II, figs. 7—11.

N. Bolleana var. ? *sibirica*, Grun. in Cl. [83] p. 469, Pl. 37, fig. 38.
N. sibirica, Cl. Syn. II, p. 29.
Syn. *N. Bolleana* var. *asymmetrica*, Cl. [83], p. 469, Pl. 37, fig. 39.
N. Bolleana v. *intermedia*, Oestr. [95], p. 431, Pl. V, fig. 51.
N. sibirica v. *asymmetrica*, Cl. Syn. II, p. 29.

Contour of the valves of a narrow rhombic or lanceolate form, sometimes with pointed extremities. Var. *asymmetrica* corresponds with the concave valve, while the convex one looks like the typical *N. sibirica*, (Grun.).

Dimensions. $a = 33—67\ \mu$, $t = 8—12\ \mu$, $\frac{a}{t} = 3—6.6$, striæ, 8 or 9 per $10\ \mu$.

Common in most of the samples.

Distribution. Arctic waters, on ice — Wankarema, East Greenland.

Sub-sp. 2. *Navicula superba*, Cl. s. s.

Pl. II, figs. 1—3.

Cl. [83], p. 468, Pl. 36, fig. 23. Cl. Syn. II, p. 29.

Contour of the valves broadly rhombic or elliptical (var. *elliptica*, Cl.).

Dimensions. $a = 34—95\ \mu$, $t = 18—22\ \mu$, $\frac{a}{t} = 1{\cdot}9—4{\cdot}4$, striæ, 7—9 per $10\ \mu$.

Var. *subacuta*, n. var.

Pl. II, fig. 4.

Valves somewhat pointed, otherwise like the principal species.

Var. *elliptica,* Cl. [83], p. 469, Pl. 36, fig. 23.

Valves elliptical in contour, otherwise like the principal species.

Var. *crassa* (Oestr.). *N. erosa* v. *crassa,* Oestr. [95], p. 429, Pl. VIII, fig. 94.

Pl. II, fig. 5.

Contour as in var. *elliptica;* striæ somewhat closer together than in the principal species, divided into several portions, with narrow, longitudinal lateral areas.

Dimensions. a = 50—90 μ, t = 21—27 μ, $\frac{a}{t}$ = 2·1—3·3, striæ, 8 or 9 per 10 μ.

Fairly common, especially the principal species.

Distribution. Arctic waters, on ice — Wankarema, East Greenland.

Sub-sp. 3. *Navicula obtusa,* Cl. [83], p. 469, Pl. 36, fig. 25. Cl. Syn. II, p. 29.

Pl. II, fig. 6.

Contour of the valves linear, sometimes constricted in the middle (f. *amphiglottis,* Oestr.), with bluntly rounded ends.

Dimensions. a = 50—106 μ, t = 15 μ, striæ, 9 or 10 per 10 μ, $\frac{a}{t}$ = 3·5—7·3.

Not uncommon.

Distribution. Arctic waters, on ice — Wankarema, E. Greenland.

NAVICULÆ PUNCTATÆ, Cl.

35. *Navicula algida,* Grun. [84], p. 56, Pl. A, fig. 31. Cl. Syn. II, p. 40.

Dimensions. a = 45—91 μ, t = 21—55 μ.

Not uncommon.

Distribution. North Siberia; E. Greenland, on ice.

36. *Navicula glacialis,* (Cl.) Grun.

Cocconeis glacialis, Cl. [73], p. 14, Pl. III, fig. 12.

Navicula glacialis, Grun. [84], p. 55. Cl. Syn. II, p. 40.

Not uncommon.

Distribution. Arctic and Antarctic Oceans.

NAVICULÆ LYRATÆ, Cl.

37. *Navicula forcipata*, Grev. [59], p. 83, Pl. VI, figs. 10, 11. Cl. Syn. II, p. 65.

Dimensions. a = 39—46 μ, t = 15 or 16 μ, striæ, 17—19 per 10 μ.
Rather uncommon.

Distribution. In brackish water, especially on northern coasts.

PINNULARIA, Ehb.

38. *Pinnularia borealis*, Ehb. [43], Pl. I, 2, fig. 6. Cl. Syn. II, p. 80.
Occurs singly.

Distribution. In fresh water, especially in cold climates and on mountains.

39. *Pinnularia perlucens*, Oestr. [95], p. 421, Pl. III, fig. 14.
Navicula perlucens, Oestr. l. c.

On ice in the Barents Sea; not in the other samples.

Distribution. On ice off E. Greenland.

40. *Pinnularia ambigua*, Cl. Syn. II, p. 94.
Pl. III, figs. 1 & 2.
Navicula retusa, Grun. [80], p. 38. Cl. [83], p. 470, Pl. 36, fig. 35. Östrup [95], p. 432.

Valves highly vaulted, keel bent in in the middle, out at the extremities.

Dimensions. a = 23—87 μ, t = 7 or 8 μ, striæ, 9 or 10 per 10 μ.

Distribution. Northern coasts; on ice at Wankarema, East Greenland, Cape Eglinton.

41. *Pinnularia quadratarea*, (A. Schm.) Cleve. Syn. II, p. 95.
Navicula quadratarea, A. Schm. [74], Pl. II, fig. 26.
Navicula Pinnularia, Cl. [68], p. 224, Pl. IV, figs. 1, 2.
Pl. III, figs. 3—6.

Occurs, as in the collection from Wankarema and from the ice-floes off East Greenland, in a large number of forms, which would each have been considered a good species, if every possible transition-form had not existed.

The typical form with linear valves is rather rare; the others can be most conveniently arranged under the following principal types:

Var. β. *Stuxbergii*, Cl. [80], p. 13, Pl. I, fig. 15. Cl. Syn. II, p. 96. Pl. III, fig. 3.

Contour of the valves elliptical lanceolate, broadest in the middle.

Dimensions. a = 43—104 μ, t = 15—20 μ, striæ, 8—10 per 10 μ.

Certain dwarf forms (e. g. f. *minima*, Oestr.) may be even smaller. In the collection under discussion, there are forms that are altogether identical with the above-mentioned form.

Dimensions. a = 22 μ, t = 8 μ, striæ, 10 per 10 μ.

Under this type are classed the following forms:

f. *leptostauron*, Grun. [84], p. 103, Pl. A, fig. 32.

f. *subcontinua*, Grun. [84], p. 103, Pl. A, fig. 33.

f. *Theelii*, Cl. [80], Pl. I, fig. 22. *Navicula Theelii*, Cl. l. c. p. 13.

f. *subglabra*, Oestr. [95], p. 421, Pl. IV, fig. 27. *Navicula Stuxbergii* var. *subglabra*, Oestr. l. c.

f. *cuneata*, Oestr. [95] p. 421, Pl. IV, fig. 37. *Navicula Stuxbergii* var. *cuneata*, Oestr. l. c.

f. *minima*, Oestr. [95], p. 420, Pl. IV, fig. 29. *Navicula Pinnularia* var. *minima*, Oestr. l. c.

Common under various forms in most of the samples.

Distribution. Arctic waters, on ice.

Var. γ. *bicontracta*, Oestr. [95], p. 419, Pl. IV, fig. 34. Pl. III, fig. 5.

The valves widen in the middle, thence tapering, and often again slightly wider near the extremities.

Dimensions. a = 46—113 μ, t = 10—17 μ, striæ, 8—11 per 10 μ.

f. *gibbosa*, Oestr. (a = 27 μ, t = 9 μ) is a dwarf form belonging to this variety.

The following forms also come under the above variety:

f. *maxima*, Oestr. [95], p. 418, Pl. IV, fig. 22. *N. Pinnularia* v. *maxima*, Oestr. l. c.

f. *gibbosa*, Oestr. [95], p. 420, Pl. IV, fig. 28. *N. Pinnularia* v. *gibbosa*, Oestr. l. c.

f. *densestriata,* Cl. [96, 1], p. 22, Pl. I, fig. 8. *P. quadratarea* v. *densestriata,* Cl. l. c.

Not uncommon, both large and small forms.

Var. δ. *constricta,* Oestr. [95], p. 419, Pl. IV, figs. 23, 24.

Pl. III, fig. 4.

The valves more or less constricted in the middle, with the ends tapering to a blunt triangle.

Dimensions. a = 42—80 μ, t = 13—17 μ (greatest width), striæ, 9 or 10 per 10 μ.

The following form comes under this variety:

f. *subconstricta,* Oestr. [95], p. 419, Pl. IV, fig. 25.

Fairly frequent.

Distribution. East Greenland, upon ice.

42. *Pinnularia semiinflata,* (Oestr.) [95], p. 422, Pl. IV, fig. 39.

Navicula semiinflata, Oestr. l. c.

As Cleve remarks ([96, 1], p. 19), this species is very nearly allied to *P. quadratarea.* It is especially distinguished from that species by the circumstance that the raphe does not reach quite to the ends of the valve, so that a radiating striation is visible round the apical areas. In most of its forms, moreover, this species exhibits a peculiar tendency towards unsymmetrical development.

The following principal types may be distinguished:

Var. α. *genuina.* *Navicula semiinflata,* Oestr. l. c.

Pl. III, fig. 7.

Striæ unbroken, valves linear in outline, with rounded extremities and a protuberance on one side, where the central area goes quite up to the margin.

Dimensions. a = 21—60 μ, t = 10 or 11 μ, striæ, 12—14 per 10 μ.

Fairly common.

Distribution. East Greenland, on ice.

Var. β. *decipiens*, (Cl.). *Navicula decipiens*, Cl. [96, 1], p. 19, Pl. I, fig. 3 (not fig. 4).

Navicula latefasciata var. *angusta*, Oestr. [95], p. 422, Pl. IV, fig. 35.

Navicula glacialis var. Cl. [83], Pl. 37, fig. 41.

Pl. III, fig. 8.

The striæ on both sides of the raphe are divided into two by a linear lateral area, which does not, however, reach to the end of the valves. The valves are almost symmetrical; the central area is somewhat unilaterally expanded, but does not always reach the margin of the valves.

Dimensions. a = 41—62 μ, t = 11 or 12 μ, striæ, 13 or 14 per 10 μ.

Scarce.

Distribution. North Siberia (Wankarema) and E. Greenland, on ice.

Var. γ. *inæqualis*, Oestr. [95], p. 433, Pl. V, fig. 53.

Navicula glacialis var. *inæqualis*, Oestr. l. c.

Navicula decipiens var. Cl. [96, 1], p. 19, Pl. I, fig. 4.

The striæ divided into several portions. The valves more or less asymmetrical, but not protruding in the middle; the central area goes right to the margin on one side.

Dimensions. a = 36—42 μ, t = 15—17 μ, striæ, 14—17 per 10 μ.

Scarce.

Distribution. East Greenland, on ice.

AMPHORA, Ehb.

43. *Amphora lævis*, Greg. [57], p. 514, Pl. XII, fig. 74 a, b, c.

Var. *lævissima*, (Greg.), Cl. Syn. II, p. 130.

A. lævissima, Greg. [57], p. 513, Pl. XII, fig. 72.

Not uncommon.

Distribution. Northern coasts, North Siberia and East Greenland, upon ice.

B. PSEUDORAPHIDEÆ.

FRAGILARIA, Lyngbye.

44. *Fragilaria oceanica,* Cl. [73], p. 22, Pl. IV, fig. 25. Grun. [84], p. 107, Pl. B, fig. 14 a, b.

F. arctica, Grun. [80], p. 110, Pl. 7, fig. 124. De Toni Sylloge [92], p. 685.

Common in most of the samples, sometimes the predominating species.

Distribution. Northern coasts, in the neritic plankton, and on ice.

45. *Fragilaria cylindrus,* Grun. [84], p. 107, Pl. B, fig. 13. De Toni [92], p. 684. Gran [97, 2], p. 8, Pl. I, figs. 4, 5.

Common in most of the samples.

Distribution. Like the preceding species, but only on the shores of the Arctic Ocean.

46. *Fragilaria Harrisonii,* (W. Sm.) Grun.

Odontidium Harrisonii, W. Sm. [56], p. 18, Pl. 60, fig. 373. De Toni [92], p. 639.

Occurs singly.

Distribution. Fresh water, Northern Europe.

SURIRELLA, Turpin.

47. *Surirella Oestrupii,* nov. nom.

Surirella splendida var.? *minima,* Oestr. [95], p. 449, Pl. VI, fig. 68.

This species, which is characteristic of the flora on the ice, ought to have a specific name of its own, at any rate as long as its systematic position is so little known. It differs not a little from the typical *Surirella splendida.* As the variety name, *minima,* is not very appropriate as a specific name, I have preferred to name it after its discoverer.

Dimensions. $a = 20–36\ \mu$, $t = 11–17\ \mu$, $\frac{a}{t} = 1{\cdot}75–2{\cdot}2$.

Not uncommon.

Distribution. East Greenland, on ice-floes.

HANTSCHIA, Grun.

48. *Hantschia Weyprechtii*, Grun. [80], p. 104, [84], p. 107, Pl. A, fig. 60.
Not uncommon.
Distribution. North Siberia (Grunow), E. Greenland (Östrup), both places on ice.

NITZSCHIA, (Hassall) Grun.

49. *Nitzschia denticula*, Grun. 80, p. 82.
Occurs singly.
Distribution. In fresh water in Europe, Siberia, etc.

50. *Nitzschia hybrida*, Grun. [80], p. 79, Pl. V, fig. 95.
Grun. [84], p. 107, Pl. A, fig. 61. De Toni [92], p. 513.
Fairly common.
Distribution. The shores of the N. Atlantic and Arctic Oceans.

51. *Nitzschia distans*, Greg. [57], p. 530, Pl. VI, fig. 103. De Toni [92], p. 524.
Fairly common.
Distribution. Scattered along various coasts.

52. *Nitzschia Brebissonii*, W. Sm.
Var. *borealis*, Grun. in Cl. & Möll. Diat., Nos. 315—318 seq. Cl. [96, 1], p. 21).
N. socialis var. *septentrionalis*, Oestr. [95], p. 445, Pl. VII, fig. 80.
Not uncommon.
Distribution. Wankarema, East Greenland, upon ice.

53. *Nitzschia lævissima*, Grun. [84], p. 106, Pl. A, figs. 65, 66. De Toni [92], p. 533.
Common.
Distribution. North Siberia, Wankarema, E. Greenland, always on ice.

54. *Nitzschia gelida,* Cl. & Grun. in Cl. [83], p. 480, Pl. 38, fig. 70.

Fairly common.

Distribution. Wankarema, E. Greenland, at both places on ice.

55. *Nitzschia polaris,* Grun. in Cl. & Möll. Diat., No. 314. Grun. [84], p. 106, Pl. A, figs. 62, 63.

Common.

Distribution. Wankarema, near Franz Josef Land, E. Greenland, always on ice.

56. *Nitzschia frigida,* Grun. [80], p. 94, Pl. V, fig. 101. De Toni [92], p. 537. Gran. [97, 2], p. 22, Pl. I, fig. 11.

Very common, predominating in several of the samples. Occurs generally in whole colonies, as figured by Gran, l. c.

Distribution. Shores of the Arctic Ocean, on ice and as plankton; widely distributed.

57. *Nitzschia lanceolata,* W. Sm.

Var. *pygmæa,* Cl. [84], p. 481. [96, 1], p. 22, Pl. I, figs. 19, 20.

Not uncommon.

Distribution. Wankarema, on ice; Cape Eglinton, floating freely.

58. *Nitzschia acicularis,* Kütz.

To this species I have referred some acicular cells that occur in great quantities in several of the samples. Cleve found it in the plankton in the Barents Sea, together with *Melosira hyperborea, Nitzschia frigida,* and others (Cl. [98], p. 26).

59. *Nitzschia Closterium,* (Ehr.) W. Sm. De Toni [92], p. 548.

Rather scarce.

Distribution. Shores of the Atlantic and Arctic Oceans. Lives especially in masses of mucilage.

C. CENTRICÆ.

CHÆTOCERAS, Ehr.

Sub-genus I. *Phæoceras,* Gran.

60. *Chætoceras criophilum,* Castr. [86], p. 78.

As plankton rare, as fragments on the ice scarce.

Distribution. Oceanic plankton organisms, especially in northern seas.

61. *Chætoceras boreale,* Bail.

In immense quantities in a few plankton samples, frequently in the shape of fragments on the ice. The form occurring is the typical one which, for instance, is figured in Cleve [97], Pl. I, figs. 1, 2 (incl. f. *Brightwellii,* Cl.).

Distribution. In all seas in the oceanic plankton.

Sub-genus II. *Hyalochæte,* Gran.

62. *Chætoceras decipiens,* Cl. [73], p. 11, Pl. I, fig. 5.

Not uncommon in plankton samples and as fragments on the ice.

Distribution. Oceanic, especially in northern seas.

63. *Chætoceras Mitra,* (Bail.) Cl. [96, 1], p. 8, Pl. II, figs. 1, 2. *Dicladia Mitra,* Bail.

Spores *(Dicladia)* on the ice; rare.

Distribution. Shores of the Arctic Ocean, neritic.

64. *Chætoceras teres,* Cl. [96, 2], p. 30, Pl. I, fig. 7.

f. *spinulosa,* n. f.

Pl. III, fig. 10.

Spores on the ice; not uncommon. The secondary valve of the spores is more strongly armed than in the form that occurs on the coasts of Northern Europe. The secondary valve in the European form is smooth or furnished with fine hairs (*Ch. commutatus,* ? Cl. [96, 2], Pl. I, fig. 11).

Distribution. Principal form neritic on the coasts of Northern Europe.

65. *Chætoceras contortum,* Schütt [95], p. 44. Gran [97, 1], p. 14, Pl. II, fig. 32.

In plankton samples with spores. Isolated spores on the ice not uncommon.

Distribution. Coasts of Northern Europe and Greenland, neritic.

66. *Chætoceras diadema,* (Ehr.) Gran [97, 1], p. 20, Pl. 2, figs. 16—18.

Spores on the ice fairly common.

Distribution. Neritic on the coasts of Europe and Greenland, probably almost cosmopolitan.

67. *Chætoceras debile,* Cl. [94], p. 13, Pl. I, fig. 2. Gran [97, 1], p. 23, Pl. 2, figs. 14, 15.

Spores in and on the ice not uncommon.

Distribution. Neritic on the coasts of Northern Europe and Greenland.

68. *Chætoceras sociale,* Lauder [64], p. 77, Pl. 8, fig. 1.

A few smooth little spores belong in all probability to this species.

Distribution. Northern Europe, Greenland, Hongkong.

69. *Chætoceras Wighami,* Brightw. [56], p. 108, Pl. VII, figs. 19—36.

Syn. *Ch. bottnicum,* Cl. in Aurivillius [96], p. 14, Pl. 1.

Ch. biconcavum, Gran [97, 1], p. 27, Pl. 3, fig. 46.

Spores and whole chains frozen into the ice.

Distribution. Northern Europe, East Greenland.

70. *Chætoceras furcellatum,* Bail. [56], Pl. I, fig. 4. Gran [97, 2], p. 19, Pl. I, figs. 15, 16.

Spores on the ice, rather rare.

Distribution. Shores of the Arctic Ocean and most northerly parts of Europe, neritic.

71. *Chætoceras septentrionale,* Oestr. [95], p. 457, Pl. VII, fig. 88. Cl. [96, 1], p. 9, Pl. II, fig. 8.

Fairly common on the ice, sometimes with spores. Perhaps identical with *Ch. gracile,* Schütt, occurring on the coasts of Northern Europe.

Distribution. East Greenland, Baffin's Bay, on ice and in plankton.

XANTHIOPYXIS, Ehr.

Only fossil specimens of this peculiar genus have been found hitherto. In the samples from the polar ice, one species was found, sometimes in considerable quantities; but nevertheless, it is unfortunately impossible to clear up the systematic position of the genus. The cell-wall is silicified, and it easily divides into two when treated with acid, one part larger than the other. It is therefore probable that the genus belongs to the Bacillariaceæ; but it differs from all other Bacillariaceæ in having no connecting zone (pleura) between the valves. Cell-division, notwithstanding my diligent searching, I have been unable to find; nor is it easy to imagine how it takes place, if it is to be like the the cell-division of the other diatoms.

It is more probable that *Xanthiopyxis* represents a quiescent stage of some diatom. In such a case too, it would differ from all other known spores, as these always have a smooth, cylindrical portion, leaning directly against the wall of the mother-cell. *Xanthiopyxis* has long spines projecting in all directions; and if it is a spore that is formed inside another cell, it must necessarily be freely suspended in that cell. I once thought I saw a half decomposed cell-wall which resembled that of a *Chætoceras,* outside a *Xanthiopyxis* cell; but is was impossible to determine it with certainty.

The form found on the ice-floes is not unlike several of the fossil species described by Ehrenberg. I cannot, however, with certainty indentify it with any of these, but consider it advisable in the mean time to give it a name of its own.

72. *Xanthiopyxis polaris,* n. sp.

Pl. III, figs. 16—19.

The cells irregularly elliptoid with an almost cylindrical median part; armed all over with pointed, narrowly conical spines, projecting at right angles to the surface. The cell-wall consists of two valves, one of which forms a flat spherical calotte, the other being larger and almost cylindrical, with a hemispherical bottom.

THALASSIOSIRA, Cl.

73. *Thalassiosira Nordenskiœldii,* Cl. [73], p. 7, Pl. I, fig. 1.

Fairly frequent in some of the samples.

Distribution. Neritic on the coasts of Northern Europe and Greenland.

74. *Thalassiosira gravida,* Cl. [96, 1], p. 12, Pl. II, figs. 14—16.

Spores (*Coscinodiscus subglobosus,* Grun.) sometimes free, sometimes in their mother-cells on the ice and frozen into it. Diam. = 20—36 μ.

Distribution. Neritic on the coasts of Greenland and Northern Europe.

MELOSIRA, Agardh.

75. *Melosira hyperborea,* (Grun.) in V. Heurck Syn. Pl. 85, figs. 3, 4.

Melosira nummuloides var.? *hyperborea,* Grun. l. c.

Gallionella nummuloides var. *hyperborea,* De Toni [94], p. 1331.

Pl. III, figs. 11—15.

This species seems to be very characteristic of the ice-floes in the Polar Sea. It may also develope in great quantities as plankton among the ice. It represents one of the most simply constructed types of the genus *Melosira.* The valves are hemispherical with an annular rim outside near the top, to which the cells hang in chains. The edges of the valves are strengthened internally by a narrow fillet. The pleura consists of a tolerably broad band, which forms a cylinder; the younger of the valves, however, only forms its band immediately before a cell-division. Until this takes place, it leans with its margin against the fillet of the outer valve, while the band of the outer valve envelopes it like a mantle. The form of the cell is thus spherical or elliptoid, being surrounded on one side, from the greatest circumference to the pole, with a hollow, empty cylinder. When the cell-division is to take place, the pleura of the inner valve gradually grows, and thus forces the valve out, the edge always being supported by the fillet of the outer valve.

In the cell-division, the new valves are formed centrifugally. First the central part of the valves is formed, by which they immediately become connected; but the young valves, from the first, lie unattached in the central protoplasm.

The spores are formed under very peculiar circumstances. As a rule, the spore-formation begins like an ordinary cell-division, except that the newly-formed valves are thicker than the ordinary vegetative ones. They are furnished with a network of ribs outside, wherever the wall is not in close contact with other cell-walls, either the valve of the sister-cell, or the pleura of the mother-cell. This first-formed valve (primary valve) thus consists of 3 parts, viz. (1) a circular disc which is hollowed out a little inside, flat outside, and covered with fine puncta, (2) a spherical zone which is strengthened outside with strong ribs, and (3) a cylindrical mantle, which is smooth, and lies close to the pleura of the mother-cell.

After this process, the protoplasm generally draws away from the older, thin valve of the mother-cell, and collects about the newly-formed spore valve. A hemispherical secondary valve is then formed, which resembles the primary valve, but is without the flat, smooth part on the top; and thus the spore is complete. In this way the spores come to lie in pairs, in the same manner, for instance, as in *Chætoceras furcellatum.*

Figs. 12, 13, Pl. III, represent chains with spore formation, which in one respect, differs from the normal formation. After the primary valves of the spores are formed, the new cells have taken the first steps towards yet another cell-division. This has advanced so far, that two new rudiments of valves have appeared; but only one of these has grown fully. It has become the secondary valve of the spore; the other is lying unattached in the cell, and the protoplasm has wandered almost completely into the spore.

The occurrence of such divisions shows that the spore-formation is in reality a special, reduced form of ordinary cell-division, just as Karsten [99] has found to be the case with the auxospore-formation.

Yet another form of spore-formation may occur in *Melosira hyperborea.* A single spore may be formed right inside a cell, in the same manner, for instance, as in *Chætoceras diadema* and *Thalassiosira gravida.* This however, only occurs in rare instances. While the spore-formation of the more highly organised species is determined, so that it occurs either in one way or the other, *Melosira* has kept both the principal forms. I have also found similar conditions in *Thalassiosira Nordenskiœldii*,

The auxospore-formation is figured by Vanhöffen [97], Pl. III, fig. 18.

Common in all the samples, sometimes in great quantities, predominating.

Distribution. The Polar Sea and its shores, on ice and as plankton.

76. *Melosira crenulata* (Ehr.) Kütz. [44], p. 55, Pl. 2, fig. VIII.

Occurs singly, rather more frequently in the sample from Franz Josef Land.

Distribution. In fresh water, Northern Europe, N. America.

ACTINOCYCLUS, Ehr.

77. *Actinocyclus alienus*, Grun.

Var. *arctica*, Grun. in V. H.'s Syn. Pl. 125, fig. 12. Cl. [96, 1], Pl. II, figs. 11, 12.

Diameter = 57—74 μ.

This form, whose systematic position on the whole is doubtful, is found rather plentifully in several of the samples. In pools on the ice and in water melted from ice, it is not infrequently found with spores, a new valve being formed within each of the old ones, and somewhat thicker than they; but they are of the same structure.

The species has been, to some extent at any rate, confused with *Podosira glacialis*, Grun. So little has as yet been done towards the systematisation of these forms, that in a revision it is probable that altogether different characters would be employed for the division of the genera from those now in use; the genera *Coscinodiscus, Podosira, Lauderia, Thalassiosira,* and to some extent *Actinocyclus*, would have to be defined in a very different manner to that which is at present in use.

Distribution. Arctic Ocean, on ice (and in plankton?).

COSCINODISCUS, Ehr.

78. *Coscinodiscus oculus iridis*, Ehr. [39], p. 147. De Toni [94], p. 1275.

Not uncommon on the ice, solitary occurrences in plankton.

Distribution. In the plankton of all oceans.

79. *Coscinodiscus polyacanthus*, Grun. [80], p. 112, Pl. VII, fig. 127. De Toni [94], p. 1234.

In large quantities on ice-floes off Franz Josef Land, otherwise rare. Diameter = 16—42 μ. Rows of puncta, 14—16 per 10 μ.

Distribution. The northern Polar Sea.

80. *Coscinodiscus curvatulus*, Grun. in A. Schmidt Atlas, Pl. 57, fig. 33. Grun. [84], p. 83, Pl. D, figs. 11—14. De Toni [94], p. 1226.

Scarce. Diameter = 37—72 μ.

Distribution. Shores of various oceans.

81. *Coscinodiscus Kützingii*, A. Schm. Atl. Pl. 57, figs. 17, 18. Var. *glacialis*, Grun. [84], p. 84, Pl. D, fig. 18. De Toni [94], p. 1222.

Not uncommon. Diameter = 38—73 μ.

Distribution. Arctic Ocean (Wankarema, Franz Josef Land, Greenland), especially on ice.

82. *Coscinodiscus bioculatus*, Grun. [84], p. 107, Pl. C, fig. 30. De Toni [94], p. 1225.

Not uncommon. As Cleve remarks [96, 1], the cells form rather high cylinders, as there are several annular intermediate ribbons (copulæ) between the valves and the pleuræ. In this respect, the species resembles the genus *Lauderia*.

Distribution. Arctic Ocean, especially on ice-floes.

83. *Coscinodiscus septentrionalis,* Grun. [84], p. 85, Pl. D, figs. 28—33.

C. lacustris var.? *septentrionalis,* Grun. l. c. De Toni [94], p. 1290.

Fairly common.

Distribution. Shores of the Arctic and Atlantic Oceans.

TABLE I. CONTENTS OF THE PLANKTON SAMPLES.

Year.	1893			1894			1896
Date	12th Oct.	13th Oct.	24th Oct.	22nd May	22nd June	20th Oct.	4th Feb.
Latitude, N.	78° 13′	78° 14′	78° 20	81° 24′	81° 45′	82°	84° 40′
Longitude, E.	135° 55′	136°	c. 136°	125° 20	121° 20′	115°	24° 38′
Depth	0—50 m.	0—50 m.	0—20 m.	0—100 m.		0—50 m.	0—100 m.
Chætoceras boreale, Bail.	*cc*	*cc*	*cc*				*r*
— *contortum,* Schütt.	*r*						
— *criophilum,* Castr.		*r*					
— *decipiens,* Cl.	+	+	+				
Coscinodiscus oculus iridis, Ehr.		*r*		*r*		*r*	
Fragilaria oceanica, Cl.					*r*		

cc = abundant, + = rather common, *r* = scarce.

In the following samples, no traces of diatoms could be found:

Year.	Month.	Date.	N. Latitude.	E. Longitude.	Depth.
1894	February	21	80° 4′	134°	0—100 m.
—	March	17	79° 37′	135° 15′	0—100 m.
—	—	20	79° 40′	135° 15′	0—8 m.
—	—	24	80° 1′	135° 40′	0—c. 270 m.
—	April	11	80° 17′	134°	0—300 m.
—	—	13	80° 17′	134°	0—40 m.
—	—	19	80° 27′	132°	0—40 m.
—	—	21	80° 28′	131° 8′	0—250 m.
—	—	25	80° 30′	131° 30′	0—250 m.
—	May	1	80° 44′	131° 30′	0—75 m.

TABLE II. **CONTENTS OF THE MOST**

	Water melted from new ice.		Ponds on the ice, not communicating with the sea.				Diatoms on					
Date.	Oct. 18, 1893.	Oct. 20, 1893.	July 22, 1894.	July 24, 1894.			July 20, 1894.		July 24, 1894.			
Locality.	N. 78° 19′ E. 136° 16′		N. 81° 28′ E. 125° 1′	N. 81° 24′ E. 125° 1′			N. 81° 30′ E. 125° 10′		N. 81° 24′ E. 125° 1′			
No. of the sample.	8	6	7	2	5	17	4	11	14	15	16	18
1. *Amphiprora paludosa* v. *punctulata*	..	..	..	..	..	..	..	..	..	..	..	..
2. — *Kjellmanii*	..	..	..	+	..	..	..	..	..	..	..	..
— — v. *glacialis* .	..	..	..	..	..	..	..	..	..	..	..	..
— — v. *striolata* .	..	..	..	..	..	..	..	..	..	..	..	..
— — v. *kryophila*	..	..	..	+	+	+	..	+	..	..	..	..
3. — *gigantea* v. *septentrionalis*	..	..	..	..	+	..	..	..	..	..	..	..
4. *Tropidoneis maxima* v. *dubia*	..	..	..	..	..	..	..	..	..	..	..	..
5. *Pleurosigma Clevei* v. *sibirica*	..	..	..	..	..	..	..	..	..	..	..	..
6. — *Stuxbergii*	+	+	+	..	..	..	..	..	..	..	..	+
— — v. *rhomboides*	..	..	..	..	..	..	+	..	..	..	..	+
7. *Caloneis kryophila*	..	..	+	+	..	..	..	..	..	..	..	+
8. *Diploneis didyma*	..	..	..	..	..	..	..	..	..	..	..	..
9. — *litoralis* v. *arctica*	..	..	..	+	+	..	..	+	..	..	..	+
10. — *Smithii*	..	..	..	..	..	..	+	..	..	..	..	..
11. *Navicula lineola*	..	..	..	..	..	..	..	..	..	..	..	..
12. — *Oestrupii*	..	..	..	+	..	..	..	..	..	..	..	..
13. — *kryokonites* . . .	..	..	..	+	+	..	..	..	..	..	+	..
14. — *Spicula*	..	..	..	..	..	..	..	+	..	..	..	+
15. — *vitrea*	..	..	..	..	..	..	..	..	..	..	..	+
16. — *Kjellmanii* . . .	..	..	..	..	..	..	..	..	..	..	..	..
17. *Stenoneis inconspicua* v. *Baculus*	..	..	..	..	..	..	+	..	..	..	+	+
18. *Navicula subinflata* . . .	..	..	+	+	+	+	..	+	..	..	..	+
19. — *pellucida*	..	..	..	..	..	..	..	..	..	..	..	..
20. — *septentrionalis* .	..	..	..	..	..	..	..	..	+	..	..	..

IMPORTANT SAMPLES FROM THE ICE.

the ice-foot.				Lumps in open channels.									Green ice and snow, Aug. 5, 1894.	Dirt on the ice.	Barents Sea, Aug. 8, 1896.
July 27, 1894.		Aug. 5, 1894.		July 18, 1894.	July 20, 1894.	July 24, 1894.			Aug. 3, 1894.	Aug. 5, 1894.					
N. 81° 15′ E. 125° 25′		N. 81° 7′ E. 127° 30′		N. 81° 26′ E. 125° 10′	N. 81° 30′ E. 125° 10′	N. 81° 24′ E. 125° 1′			N. 81° 5′ E. 127° 19′	N. 81° 7′ E. 127° 30′					
21	22	24	25	1	10	9	19	20	3	23	28	29	26	27	30
..	..	..	..	+	..	..	+	+	..	+	..	..	..	..	..
..	+	..	..	..	..	+	..	..	..	..	..	+	..	..	..
..	..	..	..	+	..	..	..	+	+	+	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
+	..	..	+	..	..	..	..	..	..	..	..	+	..	..	..
..	+	..	..	..	..	..	..	..	+	..	..	..	..	..	..
..	+	..	..	..	+	..	..	..	..	+	..	..	..	..	..
..	+	..	..	..	..	..	..	..	..	+	..	..	..	..	..
+	+	+	+	+	+	..	..	+	..	+	..	+	..	..	..
..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..
+	+	..	..	..	..	..	..	..	..	..	..	+	..	..	..
..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..
+	+	..	+	+	+	+	..	+	+	+	+	+	..	+	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	+	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	+	+	..	..	..	+	..	+	..	..	..	..	..
..	+	..	+	+	..	..	..	..	..	+	+	+	+	..	+
..	+	..	+	+	+	+	..	+	..	+	+	..	..	..	..
+	+	..	+	..	..	..	..	..	..	..	..	..	..	..	..
..	+	..	..	..	..	+	..	..	..	..	..	..	..	..	..
..	+	..	+	+	+	..	..	+	+	+	..	..	..	..	..
+	+	+	+	..	+	..	..	..	+	..	+	+	+	+	..
..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	+	+	..	+	..	..	..	..	..	..	..	..	..	..	..

TABLE II (continued). **CONTENTS OF THE MOST**

	Water melted from new ice.		Ponds on the ice, not communicating with the sea.				Diatoms on					
Date.	Oct. 18, 1893.	Oct. 20, 1893.	July 22, 1894.	July 24, 1894.			July 20, 1894.		July 24, 1894.			
Locality.	N. 78° 19′ E. 136° 16′		N. 81° 28′ E. 125° 1′	N. 81° 24′ E. 125° 1′			N. 81° 30′ E. 125° 10′		N. 81° 24′ E. 125° 1′			
No. of the sample.	8	6	7	2	5	17	4	11	14	15	16	18
21. *Cymbella cuspidata*	..	..	..	+	..	..	..	..	..	..	..	..
22. *Gomphonema exiguum* v. *pachyclada*	..	..	..	+	..	..	..	..	..	..	..	..
— *exiguum* v. *arctica*	..	..	..	+	+	..	+	+	+	+	+	+
23. — *kamtschaticum* v. *grœnlandica*	..	..	..	+	..	+	+	+	+	+	+	+
24. *Navicula rhynchocephala*	..	..	..	+	..	..	..	..	..	..	..	..
25. — *valida*	..	..	..	+	..	..	+	..	..	..	..	..
26. — *transitans*	..	..	..	+	+	..	+	+	+	+	+	+
— — v. *incudiformis*	..	..	..	..	..	..	..	..	..	..	+	..
27. — *directa*	..	+	..	+	+	+	+	+	+	..	+	+
— — v. *subtilis*	..	..	..	..	..	..	..	..	..	..	..	..
— — v. *remota*	..	..	..	..	..	..	..	..	..	..	..	..
28. — *gelida*	+	+	+	+	..	..	..	+	+	..	+	..
29. — *derasa*	..	..	..	..	+	..	..	+	..	..	..	..
— — v. *erosa*	..	..	..	..	..	..	..	..	..	..	..	..
30. — *detersa*	..	..	..	+	..	..	+	+	+	+	..	+
31. — *Blessingii*	..	..	..	..	..	..	..	..	..	..	..	+
32. — *trigonocephala*	..	..	..	..	..	..	+	+	..	..	..	+
33. — *recurvata*	..	..	..	..	..	..	+	..	..	..	..	+
34. — *superba*	..	..	..	+	..	..	+	+	+	..	..	..
— — subsp. *sibirica*	..	..	..	..	..	..	+	+	+	+	+	..
— — — *obtusa*	..	..	..	+	..	..	..	..	..	..	..	..
35. — *algida*	..	..	..	+	..	+	..	..	..	..	..	..
36. — *glacialis*	..	..	+	+	..	+	..	+	..	..	..	..
37. — *forcipata*	..	..	..	..	..	..	..	..	..	..	..	..

IMPORTANT SAMPLES FROM THE ICE.

the ice-foot.				Lumps in open channels.									Green ice and snow, Aug. 5, 1894.	Dirt on the ice.	Barents Sea, Aug. 8, 1896.
July 27, 1894.		Aug. 5, 1894.		July 18, 1894.	July 20, 1894.	July 24, 1894.			Aug. 3, 1894.	Aug. 5, 1894.					
N. 81° 15′ E. 125° 25′		N. 81° 7′ E. 127° 30′		N. 81° 26′ E. 125° 10′	N. 81° 30′ E. 125° 10′	N. 81° 24′ E. 125° 1′			N. 81° 5′ E. 127° 19′	N. 81° 7′ E. 127° 30′					
21	22	24	25	1	10	9	19	20	3	23	28	29	26	27	30
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TABLE II (continued).

CONTENTS OF THE M

	Water melted from new ice.		Ponds on the ice, not communicating with the sea.				Diato				
Date.	Oct. 18, 1893.	Oct. 20, 1893.	July 22, 1894.	July 24, 1894.			July 20, 1894.		July 24, 1894.		
Locality.	N. 78° 19′ E. 136° 16′		N. 81° 28′ E. 125° 1′	N. 81° 24′ E. 125° 1′			N. 81° 30′ E. 125° 10′		N. 81° 2 E. 125°		
No. of the sample.	8	6	7	2	5	17	4	11	14	15	16
38. *Pinnularia borealis* . . .	..	..	..	..	..	..	..	..	..	..	..
39. — *perlucens*. . . .	..	..	..	..	..	..	..	..	..	..	..
40. — *ambigua*	..	..	..	+	..	..	..	..	..	..	..
41. — *quadratarea* . .	..	..	..	..	..	..	..	..	..	..	..
— — v. *Stuxbergii*	..	+	..	+	+	..	+	+	..	+	+
— — v. *bicontracta*	..	..	..	+	..	..	..	..	..	..	+
— — v. *constricta* .	..	..	..	..	..	..	..	..	..	..	..
42. — *semiinflata*. . .	..	..	..	..	..	..	+	..	..	..	..
— — v. *decipiens* .	..	..	..	..	..	..	..	..	..	+	..
— — v. *inæqualis*	..	..	..	..	..	..	..	..	..	..	..
43. *Amphora lævis* v. *lævissima*	..	..	..	..	..	..	..	..	..	..	..
44. *Fragilaria oceanica* . . .	+	+	+	..	..	..	..	+	..	+	..
45. — *cylindrus* . .	+	+	+	+	+	+	..	+	+	+	+
46. — *Harrisonii* . .	..	..	..	..	..	..	..	..	..	..	..
47. *Surirella Oestrupii*. . . .	..	..	..	+	+	..	..	..	..	..	..
48. *Hantzschia Weyprechtii* .	..	..	..	..	..	..	..	..	..	..	..
49. *Nitzschia denticula*. . . .	..	..	..	..	..	..	..	..	..	..	..
50. — *hybrida*	..	..	..	+	+	..	..	+	..	..	..
51. — *distans*	..	..	+	+	..	..	+	+	..	..	+
52. — *Brebissonii* v. *borealis*	..	..	..	..	..	..	..	..	..	..	..
53. — *lævissima*	..	..	..	..	..	..	+	+	+	+	+
54. — *gelida*	..	..	..	+	..	+	..	..	+	..	+
55. — *polaris*	+	..	+	+	..	..	+	+	+	+	+
56. — *frigida*	..	+	..	..	+	..	+	..	+	+	c
57. — *lanceolata* v. *pygmæa*	..	..	..	..	..	..	..	..	..	..	..
58. — *acicularis*	..	..	..	..	..	..	..	..	..	..	+
59. — *Closterium*	..	..	..	..	..	..	..	..	..	..	..

IMPORTANT SAMPLES FROM THE ICE.

the ice-foot.				Lumps in open channels.									Green ice and snow, Aug. 5, 1894.	Dirt on the ice.	Barents Sea, Aug. 8, 1896.
July 27, 1894.		Aug. 5, 1894.		July 18, 1894.	July 20, 1894.	July 24, 1894.			Aug. 3, 1894.	Aug. 5, 1894.					
N. 81° 15′ E. 125° 25′		N. 81° 7′ E. 127° 30′		N. 81° 26′ E. 125° 10′	N. 81° 30′ E. 125° 10′	N. 81° 24′ E. 125° 1′			N. 81° 5′ E. 127° 19′	N. 81° 7′ E. 127° 30′					
21	22	24	25	1	10	9	19	20	3	23	28	29	26	27	30
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TABLE II (continued).

CONTENTS OF THE M

	Water melted from new ice.		Ponds on the ice, not communicating with the sea.				Diator				
Date.	Oct. 18, 1893.	Oct. 20, 1893.	July 22, 1894.	July 24, 1894.			July 20, 1894.		July 24, 1894.		
Locality.	N. 78° 19′ E. 136° 16′		N. 81° 28′ E. 125° 1′	N. 81° 24′ E. 125° 1′			N. 81° 30′ E. 125° 10′		N. 81° 2 E. 125°		
No. of the sample.	8	6	7	2	5	17	4	11	14	15	16
60. *Chætoceras criophilum* . .	..	+	..	+	..	..	..	..	..	..	..
61. — *boreale*	+	+	+	+	+	+	+	..	+	..	..
62. — *decipiens* . . .	+	+	+	+	..	+	+	..	..	..	..
63. — *Mitra*.	..	.	..	..	..	..	..	..	..	..	..
64. — *teres*	..	+	+	+	+	..	..	..	..	..	..
65. — *contortum*. . .	+	+	+	+	..	+	..	..	..	..	..
66. — *diadema* . . .	+	+	+	+	..	..	..	..	..	..	..
67. — *debile*.	..	+	+	+	+	..	..	..	..	..	..
68. — *sociale*	..	+	..	..	..	..	..	..	..	..	..
69. — *Wighami*. . .	+	+	..	..	..	..	..	..	..	..	..
70. — *furcellatum* . .	..	..	..	..	..	..	..	..	..	..	..
71. — *septentrionale*	..	+	..	..	..	..	+	..	..	+	..
72. *Xanthiopyxis polaris* . .	..	..	+	+	+	..	+	..	..	..	..
73. *Thalassiosira Nordenskiöldii*	+	+	+	+	+	..	..	..	..	..	..
74. — *gravida* . . .	+	+	+	+	+	+	..	..	..	..	..
75. — *hyalina* . . .	+	+	..	..	..	..	..	..	..	..	..
76. *Melosira hyperborea* . . .	..	..	..	+	..	..	*cc*	*cc*	*c*	*cc*	+
77. — *crenulata*. . . .	..	..	..	+	..	..	..	..	..	..	..
78. *Actinocyclus alienus* v. *arctica*	+	+	+	+	..	+	+	..	+	..	+
79. *Coscinodiscus oculus iridis*	..	..	+	..	..	+	..	..	..	..	..
80. — *polyacanthus* . .	..	..	..	..	..	..	..	..	..	..	..
81. — *curvatulus* . . .	..	..	..	..	..	+	..	..	..	..	..
82. — *Kützingii* v. *glacialis*	..	..	..	..	..	+	..	..	..	..	..
83. — *bioculatus* . . .	..	+	+	..	..	..	..	+	..	+	+
84. — *septentrionalis* .	..	..	..	+	+	+	..	+	..	..	+

IMPORTANT SAMPLES FROM THE ICE.

the ice-foot.				Lumps in open channels.									Green ice and snow, Aug. 5, 1894.	Dirt on the ice.	Barents Sea, Aug. 8, 1896.
July 27, 1894.		Aug. 5, 1894.		July 18, 1894.	July 20, 1894.	July 24, 1894.			Aug. 3, 1894.	Aug. 5, 1894.					
N. 81° 15′ E. 125° 25′		N. 81° 7′ E. 127° 30′		N. 81° 26′ E. 125° 10′	N. 81° 30′ E. 125° 10′	N. 81° 24′ E. 125° 1′			N. 81° 5′ E. 127° 19′	N. 81° 7′ E. 127° 30′					
21	22	24	25	1	10	9	19	20	3	23	28	29	26	27	30
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APPENDIX.

EXTRACTS FROM Dr. H. G. BLESSING'S JOURNAL,

WITH REMARKS BY THE AUTHOR.[1]

June 26th, 1894. "Out on the ice this afternoon to look for algæ. For a long time we sought in vain, but at last on the way back found some green confervæ in a little pool. It proved to be an alga that was growing out of the underlying ice, and reached up to the surface of the water, where the greater part of it was floating. *The part of the alga lying upon the surface of the water* was of a dark green colour, and had air-bladders, while the masses of *tough, slimy threads* that attached it to the underlying ice-foot were of a paler green. When I broke off a piece of the edge on one side of the pool, where it was deeply undermined by the water, there proved to be abundant algæ vegetation here too. There were also some *whitish, translucent algæ*, though few. These seemed to be growing on the under side of quite thin, probably only a few nights old, ice. At any rate they were partly attached to such pieces of ice. During the excursion, I noticed that wherever there were algæ in ponds and channels, there was also a quantity of 'dirty' ice. The idea then occurred to me to experiment with a little of the earth I have gathered upon the ice, to see whether algæ would grow from it. I was confirmed in this idea by finding in places, under

[1] Dr. *Blessing* has kindly allowed me to make use of the botanical notes that he made on board the *Fram* during the time of the collection of the samples. He has made many interesting observations, especially with regard to the occurrence and colour of the ice-flora, and has drawn a number of forms under the microscope. Those parts of the journal that treat of the occurrence on the ice, are here translated verbatim.

H. H. G.

the water, ice in which there were holes containing algæ mixed with particles of earth. In other places I saw similar holes containing only earth or clayey soil, under the water."

In his entry for the 27th June, Dr. Blessing states that he has examined under the microscope some prepared specimens of the samples that he had collected on the 26th. From the descriptions and drawings, it appears that he has observed the following forms, all with their cell-contents:

Melosira hyperborea, Grun., *Chætoceras septentrionale*, Oestr., *Fragilaria sp.*, *Nitzschia Closterium*, *Nitzschia sp.*, probably *N. lævissima*. *H. H. G.*

July 7th. "Out today with the drag-net after algæ. This time I did not need to go far. In the first pack-ice, I found a place like a well in the middle of the ice, going right down to the sea. Here there were chains of algæ[1] in quantities. I at once recognised the previously observed alga, and here as in the former place, it was the predominant one. It shot up from the underlying ice with masses of greenish red threads. The ice was just discernible far down in the water (about 20 or 25 feet below the surface). In several places this alga had grown right through the ice, which was like a coarse sieve. Earth and such like has probably been lying on the projecting ice-foot. I also saw today some white, floating lumps. Differentiating as well as possible the various kinds of this vegetation, I took 7 samples in envelopes, which I numbered and entered in my note-book on the spot, so as not to confuse them."

On examining them under the microscope, Dr. Blessing found, besides *Melosira hyperborea* which predominated, several other species of the genera *Navicula* and *Nitzschia*. They cannot, however, be identified with certainty from his drawings.

One sample contained almost exclusively *Fragilaria oceanica*. It was "taken from the fine, mobile, disconnected, rust-coloured film, lying in tufts, sometimes in hollows. The place communicates with the sea". Judging from the drawings and from the colour observed, this diatom has also undoubtedly been alive. *H. H. G.*

July 11th. "Was at a place yesterday close to where I found algæ last time. There was an eddy with saltish water, and salt ice formed the bottom of the eddy. It was connected with a piece of open channel beyond. There were numerous dark dots of various sizes on the blue-green ice at the bottom of the eddy. It looked as if clay or earth had melted its way into the ice and formed holes. With a syringe and an india-rubber tube, I took up some of the contents of the holes, and filtered it. In the matter thus gathered,

[1] *Melosira hyperborea.*

the organic life consisted of only a few diatoms and one animal, probably belonging to the Infusoria.

When the summer was so far advanced that there was some plant-life in the water, the sun had already melted so much of the snow and ice, that there was a stratum of brackish water about 1 metre in depth, above the usual sea-water. This water was rather fresh than salt. I am of opinion that this is especially important for the growth of diatoms, as I nearly always (I might say always) saw them floating about in this brackish water, and generally almost exactly at the boundary between the salt and the brackish water. The already-mentioned chain-algæ, on the other hand, which sometimes grew free in the water, from ice lying far below, or hung like a film of cobweb to the ice-walls, evidently throve best in the salt water.

While I think of it, I will mention that both the ordinary algæ and the silicious algæ that I have found, have been as it were enveloped and saturated with mucilage, quite transparent, tough, but not pulling out into threads, so that the whole mass came away as soon as a small piece came beyond the edge. This was especially the case, however, with the algæ that are far more cohesive than the masses of diatoms. When, for instance, I bring up a lump of these diatoms in the net, it is spread over a large portion of the surface of the net when it comes up, while it has kept its globular form fairly well during the careful drawing up of the net through the water. I then generally scrape the net gently with a flat knife, when I cannot turn the mass out of the net."

July 18th. "Out today with Dr. Nansen — I to collect algæ, he to take photographs. The thing was to find a good place with the 'brown snow', or rather 'brown ice'. I have been thinking about this for some time, for all over the ice we can see these more or less dark patches. I have taken samples from numerous places, and found that it is clay, or earth, which, according to its quantity, imparts this colour to the ice. Dr. Nansen says that he has examined a patch of this kind, and found that the colour is due to diatoms. Today again we found one of these places, which Dr. Nansen calls a 'diatom-place'. I have now just examined the sample under the microscope, and found it to consist chiefly of clay, or at any rate inorganic matter, with only here and there a diatom, not nearly enough to give it a colour. When the ice with this matter in it was melted, I saw at once that it had a tendency to deposit sediment in two layers, and I examined each one separately. In the lower layer there were a number of rather large, irregular grains of felspar."

July 21st. "Was also out today with Hansen to collect algæ. He helped me, with great interest, in the often difficult work of getting up particular accumulations of diatoms, that are often found in holes and cracks far down in the water. On these occasions I use a very long — more than $3^1/_2$ metres — slender rod to the end of which is attached a glass point with a reservoir behind. A long india-rubber tube is fastened to this and along the rod, and at the upper end of the rod is connected with a syringe. I can thus suck up any particular substance that I have caught sight of under the water. For the ordinary lumps of diatoms and algæ that float about in the water, or grow upon an ice-wall, etc., I use the frequently-mentioned drag-net. This also has a very long handle, and is as light and easily manipulated as possible. The net itself is only about 2 decimetres in diameter, and consists of a thick ring of steel wire, to which a very shallow bag of ordinary white gauze is attached. The net can be adjusted in relation to the handle both horizontally (continuing the direction of the handle) and perpendicularly."

Bottle 4 (No. 17). "Earth and diatoms? Lay like grayish yellow lumps in holes at the bottom of a little pool in the ice, which could not be supposed to communicate with the open sea. I expressly mention this, as it is the first time I have observed such a substance in confined ponds. (It is of course not impossible that the place may formerly have communicated with the sea). The water in these ponds is fairly fresh, containing, when tested by Dr. Nansen with Tornöe's apparatus, only a few tenths per cent of salt. It gives, however, a distinct precipitate — though appearing only as a cloudiness — with $AgNO_3$. Are these then fresh-water diatoms that can stand the salinity, or are they salt-water diatoms that can thrive in brackish water? As I found these upon an ice-surface that betrayed, by the abundance of earth (clay) on it, its former association with land (or river-water), and as, notwithstanding diligent search, I have never found such a substance in the ponds on the pure — not earthy — greenish blue sea-ice, I am inclined to suppose these diatoms to be fresh-water diatoms which have been brought out into the sea by river-water, or blown out on to the ice, together with earth-particles, etc."

The botanical observations that Dr. Blessing has noted in his journal during the remainder of the summer of 1894, refer especially to the results of his microscopic investigations, while nothing more is communicated about their occurrence than what he has written upon the labels of the bottles.

From his drawings in the journal, I can recognise the following species: *Chætoceras boreale*, (fragments), *Pleurosigma Stuxbergii*, *Thalassiosira gravida* with spores, *Diploneis didyma*, *Nitzschia hybrida* (?), *Amphiprora kryophila* with cell-contents, *Fragilaria oceanica* with spores, *Nitzschia frigida* and another *Nitzschia sp.*

He gives drawings, moreover, of some fungus-threads, and in several places mentions an infusorium and motile bacteria. *H. H. G.*

July 16th, 1895. "Was out yesterday afternoon in the boat, in order, among other things, to see whether algæ-vegetation and diatoms were beginning to come in the channels and on the under-water ice. For this purpose, I let the boat drift along the margin of the channel, and carefully examined all small holes, corners, cracks and enclosed pools; for I knew from last year's experience that this rare flora flourished in such places. But I saw only very little, though I persevered for a long time, and examined a very extensive area. I saw here and there signs of the yellowish red, or yellowish brown growth that appeared last summer, like a light, dusty cobweb, upon pretty well every ice-foot, or ice-wall, that was a little old, and which I know to be diatom growths. There was also a small, detached piece of the 'large chain-alga'[1] of last year, floating in the channel.

Aug. 7th. "Was out yesterday to look for algæ, but in spite of long searching, could not find even a trace of botanical substance. (I found however, the same evening, a beautiful *Medusa*)."

Sept. 2nd. "Have been out repeatedly during the past month, for the special purpose of looking for algæ, etc., and I am always telling my companions to keep their eyes open; but I have not yet succeeded in getting hold of a single sample.

[1] *Melosira hyperborea.*

I cannot understand the cause of this. There has been a great deal of water on the ice this summer as compared with last; but even if I imagine the spores (?) to have been washed away by the streams of water, the growths should surely still be found in the channels? It is not possible to imagine that the winter has been too cold."

Thus the results of the second summer were almost nil, and in the summer of 1896, we began our homeward voyage long before there could be any question of finding fully-developed algæ-vegetation on the ice.

H. G. Blessing.

BIBLIOGRAPHY.

96. **Aurivillius, C. W. S.** Das Plankton des Baltischen Meeres. 1896. *Bihang till K. Svenska Vet.-Ak. Handl. Bd. 21, Afd. IV No. 8.*

56. **Bailey, J. W.** Notice of Microscopic Forms found in the Soundings of the Sea of Kamtschatka. 1856. *The American Journal of Science and Arts. Ser. 2, Vol. 22.*

39. **Brébisson, A. de.** Considérations sur les Diatomées et classification des genres et des espèces. Falaise, 1838.

56. **Brightwell, Th.** On the filamentous, long-horned Diatomaceæ, with a description of two new species. 1856. *Quarterly Journal of Microscopical Science. Vol. IV.*

86. **Castracane degli Antelminelli, A. F.** Report on the Diatomaceæ collected by H. M. S. Challenger during the years 1873—76. 1886. *Report on the scientific results of the voyage of H. M. S. Challenger. Botany. Vol. II.*

68. **Cleve, P. T.** Svenska och Norska Diatomaceer. 1868. *Öfversikt af Kongl. Vetenskaps-Akademiens Förhandlingar 1868. No. 3.*

73. — On Diatoms from the Arctic Sea. 1873. *Bihang till K. Svenska Vet.-Akad. Handlingar Bd. 1, No. 13.*

83. — Diatoms, collected during the Expedition of the Vega. 1883. *Vega-Expeditionens vetenskapliga iakttagelser. B. III.*

94. — Planktonundersökningar, Cilioflagellater och Diatomaceer. 1894. *Bihang til K. Svenska Vet.-Akad. Handlingar Bd. 20, Afd. III, No. 2.*

94—95. — Synopsis of the Naviculoid Diatoms. I. *K. Svenska Vet.-Akad. Handl. Bd. 26, No. 2.* II. 1895. *Ibidem Bd. 27, No. 3.*

96, 1. — Diatoms from Baffin's Bay and Davis Strait. 1896. *Bihang till K. Sv. Vet.-Akad. Handl. Bd. 22, Afd. III, No. 4.*

96, 2. — Planktonundersökningar. Vegetabiliskt Plankton, 1896. *Ibidem Bd. 22, Afd. III, No. 5.*

97. — A Treatise on the Phytoplankton of the Atlantic and its Tributaries, and on the Periodical Changes of the Plankton of Skagerak. Upsala, 1897.

98. — Diatoms from Franz Josef Land collected by the Jackson-Harmsworth Expedition. 1898. *Bihang till K. Svenska Vet.-Akad. Handl. Bd. 24, Afd. III, No. 2.*

80. **Cleve, P. T.** und **Grunow, A.** Beiträge zur Kenntniss der arctischen Diatomeen. 1880. *K. Sv. Vet. Ak. Handl. B. 17, No. 2.*

91–94. **De Toni, J. B.** Sylloge Algarum omnium hucusque cognitarum. Vol. II, Bacillarieæ. Sectio I, 1891. II, 1895. III, 1894.

70–73. **Donkin, A. S.** The Natural History of the British Diatomaceæ. London, 1870–73.

39. **Ehrenberg.** Ueber noch jetzt zahlreich lebenden Thierarten der Kreidebildung und den Organismus der Polythalamien. *Abhandlungen der K. Akademie der Wissenschaften zu Berlin 1839.*

97, 1. **Gran, H. H.** Protophyta: Diatomaceæ, Silicoflagellata and Cilioflagellata. 1897. *Den Norske Nordhavs-Expedition 1876—78. Hefte XXIV.*

97, 2. — Bacillariaceæ vom kleinen Karajakfjord. 1897. *Bibliotheca Botanica, Heft. 42.*

97, 3. — Bemerkungen über das Plankton des Arktischen Meeres. 1897. *Berichte der deutschen Botanischen Gesellschaft, B. XV, Heft. 2.*

99. —, see **Hjort** and **Gran.**

57. **Gregory, W.** On New Forms of Marine Diatomaceæ, found in the Firth of Clyde and in Loch Fyne. 1857. *Transactions of the Royal Society of Edinburgh. Vol. XXI.*

59. **Greville, R. K.** Descriptions of New Species of British Diatomaceæ, chiefly observed by the late Professor Gregory. 1859. *Quarterly Journal of Microscopical Science. Vol. VII.*

60. **Grunow, A.** Ueber neue oder ungenügend gekannte Algen I. 1860. *Verh. d. kais. königl. zool. bot. Ges. in Wien, B. X.*

78. — Algen und Diatomeen aus dem Kaspischen Meere. 1878. Dr. *O. Schneider's Naturw. Beitr. z. Kennt. d. Kaukasusländer.*

80. — see **Cleve & Grunow.**

84. — Die Diatomeen von Franz Josephs Land. 1884. *Denkschr. d. kaiserl. Ak. d. Wissensch. Wien. Math. Naturw. Classe B. 48.*

74. **Hickie, W. J.** Description of a new species of *Stauroneis (S. spicula).* 1874. *Monthly Microscopical Journal, Vol. XII.*

99. **Hjort, Johan** and **Gran, H. H.** Currents and pelagic life in the Northern Ocean. 1899. *Report on Norwegian Marine Investigations 1895—97, by Dr. Johan Hjort, O. Nordgaard and H. H. Gran.*

99. **Karsten, George.** Die Diatomeen der Kieler Bucht. 1899. *Wissenschaftliche Meeresuntersuchungen, herausgegeben von der Kommission zur Untersuchung der deutschen Meere in Kiel und der Biologischen Anstalt auf Helgoland. Abtg. Kiel. Neue Folge, B. 4.*

44. **Kützing, F. T.** Die kieselschaligen Bacillarien oder Diatomeen. Nordhausen 1844 (Zweiter Abdruck 1865).

64. **Lauder, H. S.** Remarks on the Marine Diatomaceæ found at Hong-Kong, with Descriptions of new Species. 1864. *Transact. Micr. Soc. Lond. New Ser. Vol. XII.*

92. **Mohn, H.** und **Nansen, Fridtjof.** Wissenschaftliche Ergebnisse von Dr. F. Nansens Durchquerung von Grönland 1888. 1892. *Ergänzungsheft No. 105 zu Petermanns Mitteilungen.*

95. **Müller, Otto.** Ueber Achsen, Orientirungs- und Symmetrieebenen bei den Bacillariaceen. 1895. *Bericht. d. deutsch. bot. Ges. B. XIII.*

95. **Oestrup, E.** Marine Diatomeer fra Østgrønland. 1895. *Meddelelser om Grønland XVIII.*

97. — Kyst-Diatomeer fra Grønland. 1897. *Meddelelser om Grønland XV.*

74. **Schmidt, A.** Die in den Grundproben der Nordseefahrt vom 21 Juli bis 9 Sept. 1872 enthaltenen Diatomaceen. 1874. *Zweiter Jahresbericht d. Kommission zur Untersuchung d. deutschen Meere in Kiel.*

73. — Atlas der Diatomaceenkunde in Verbindung mit den Herren Gründler, Grunow, Janisch, Weissflog und Witt. Aschersleben 1873.

95. **Schütt, Fr.** Arten von Chætoceras und Peragallia, Ein Beitrag zur Hochseeflora. 1895. *Ber. d. deutsch. bot. Ges. B. XIII.*

53. 56. **Smith, W.** Synopsis of the British Diatomaceæ &c. Vol. I. 1853. Vol. II. 1856.

80–85. **Van Heurck, H.** Synopsis des Diatomées de Belgique. Antwerp, 1880–85.

99. **Van Heurck, H.** Traité des Diatomées. Antwerp, 1899.

93. **Vanhöffen, E.** Frühlingsleben in Nordgrönland. *Verhandl. d. Ges. f. Erdkunde zu Berlin 1893.*

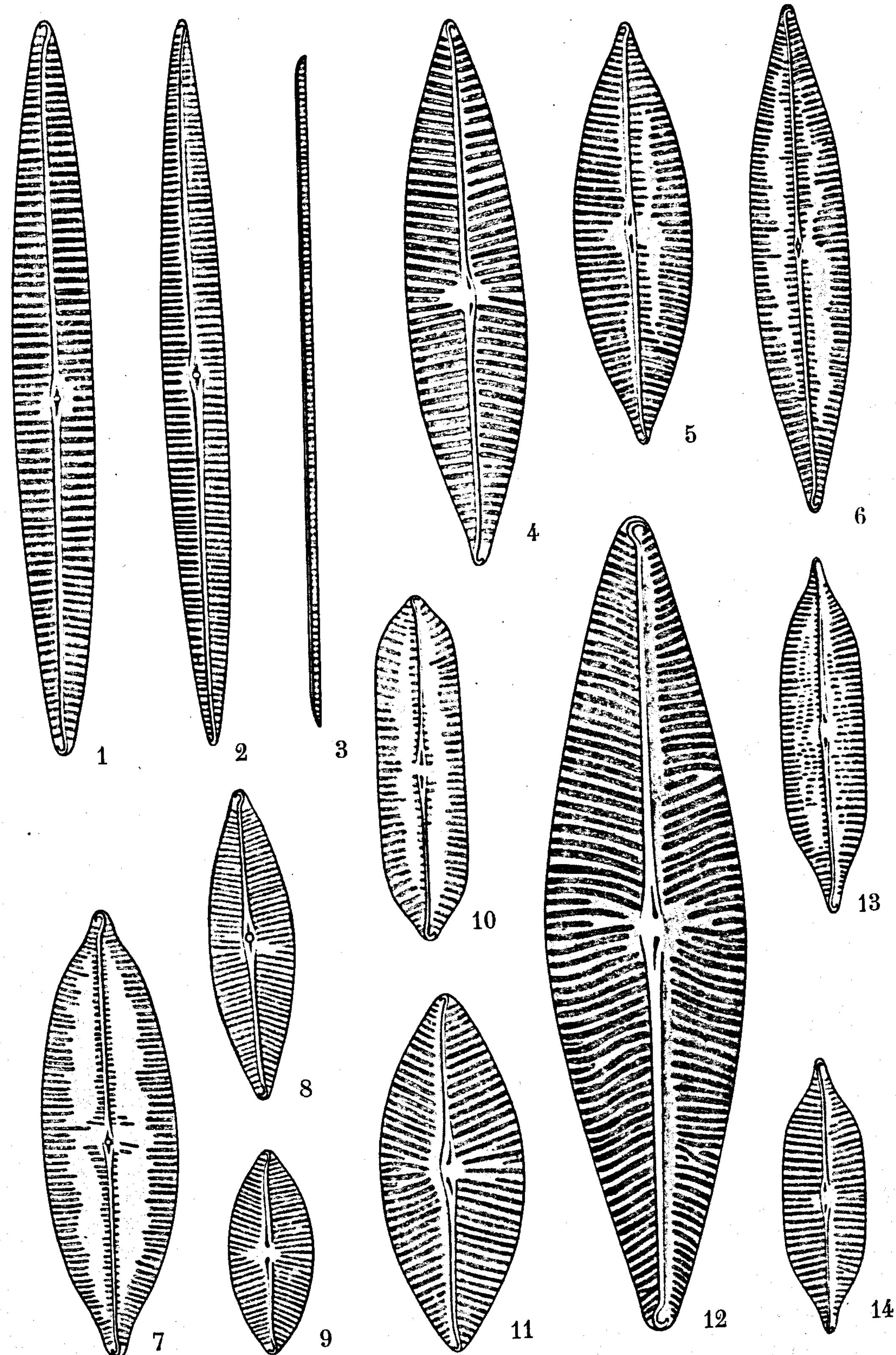
97. — Die Fauna und Flora Grönlands. 1897. *Grönland-Expedition der Gesellschaft für Erdkunde zu Berlin, B. II.*

PLATE I.

PLATE I.

(Magnification $\frac{1000}{1}$).

				Page
Fig. 1.	*Navicula*	*directa,* W. Sm. var. *remota,* Grun.		36
— 2.	—	—	var. *genuina,* Cl., valvar view	36
— 3.	—	— — —	- , valve in pleural view	36
— 4.	—	*transitans,* Cl. f. *robusta* n. f.		35
— 5.	—	—	var. *incudiformis,* Grun.	36
— 6.	—	*derasa,* Grun.		37
— 7.	—	*detersa,* Grun.		37
— 8–9.	—	*gelida,* Grun.; fig. 9, an asymmetrical form		36
— 10.	—	*Blessingii,* n. sp.		38
— 11–12.	—	*valida,* Cl. & Grun.		35
— 13–14.	—	*trigonocephala,* Cl.		38



PACHT & CRONE PHOTOT.

H. H. GRAN DEL.

PLATE II.

(Magnification $\frac{1000}{1}$).

			Page
Fig.	1.	*Navicula superba,* s. str., small form, concave valve	40
—	2.	— — — , typical specimens, concave valve	40
—	3.	— — — , convex valve	40
—	4.	— — var. *subacuta,* n. var., concave valve	40
—	5.	— — — *crassa,* (Oestr.)	41
—	6.	— *obtusa,* Cl., concave valve	41
—	7.	— *sibirica,* Grun., two sister-cells, pleural view	40
—	8.	— — , typical form, concave valve	40
—	9.	— — , — — , convex valve	40
—	10.	— — , apiculate form, concave valve	40
—	11.	— — , — — , convex valve	40
—	12.	— *recurvata,* n. sp., two sister-cells, pleural view	39
—	13.	— — , convex valve	39
—	14—15.	— — , concave valves	39
—	16.	— *subinflata,* Grun., valve	29
—	17.	— — — , cell, pleural view	29
—	18.	*Gomphonema exiguum,* Kütz. v. *pachyclada* Bréb., valve	30
—	19.	— — — , cell, pleural view	30
—	20.	— *kamtschaticum,* Grun. v. *grœnlandica,* Oestr., valvar view	31
—	21.	— — , pleural view	31

PLATE II

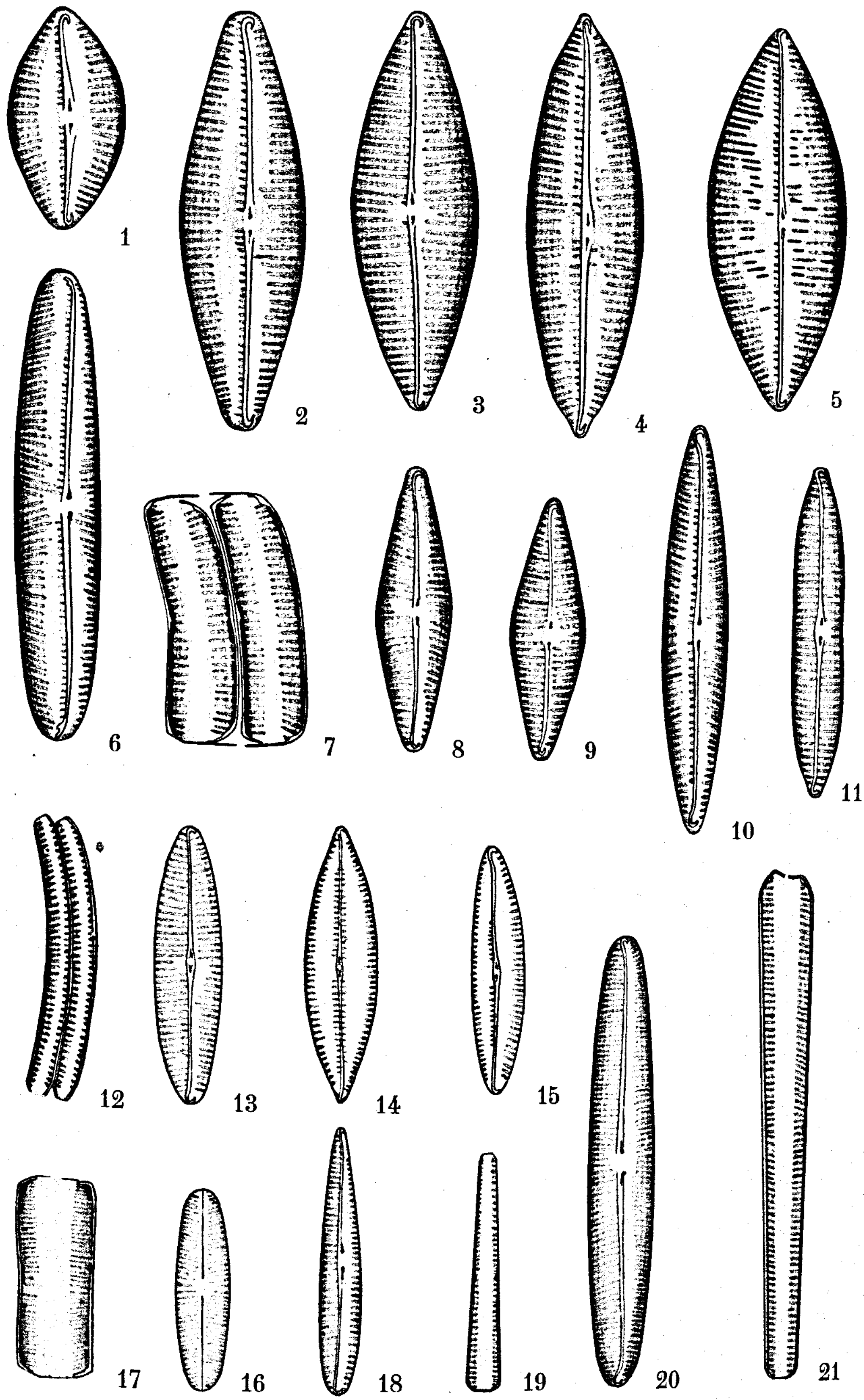


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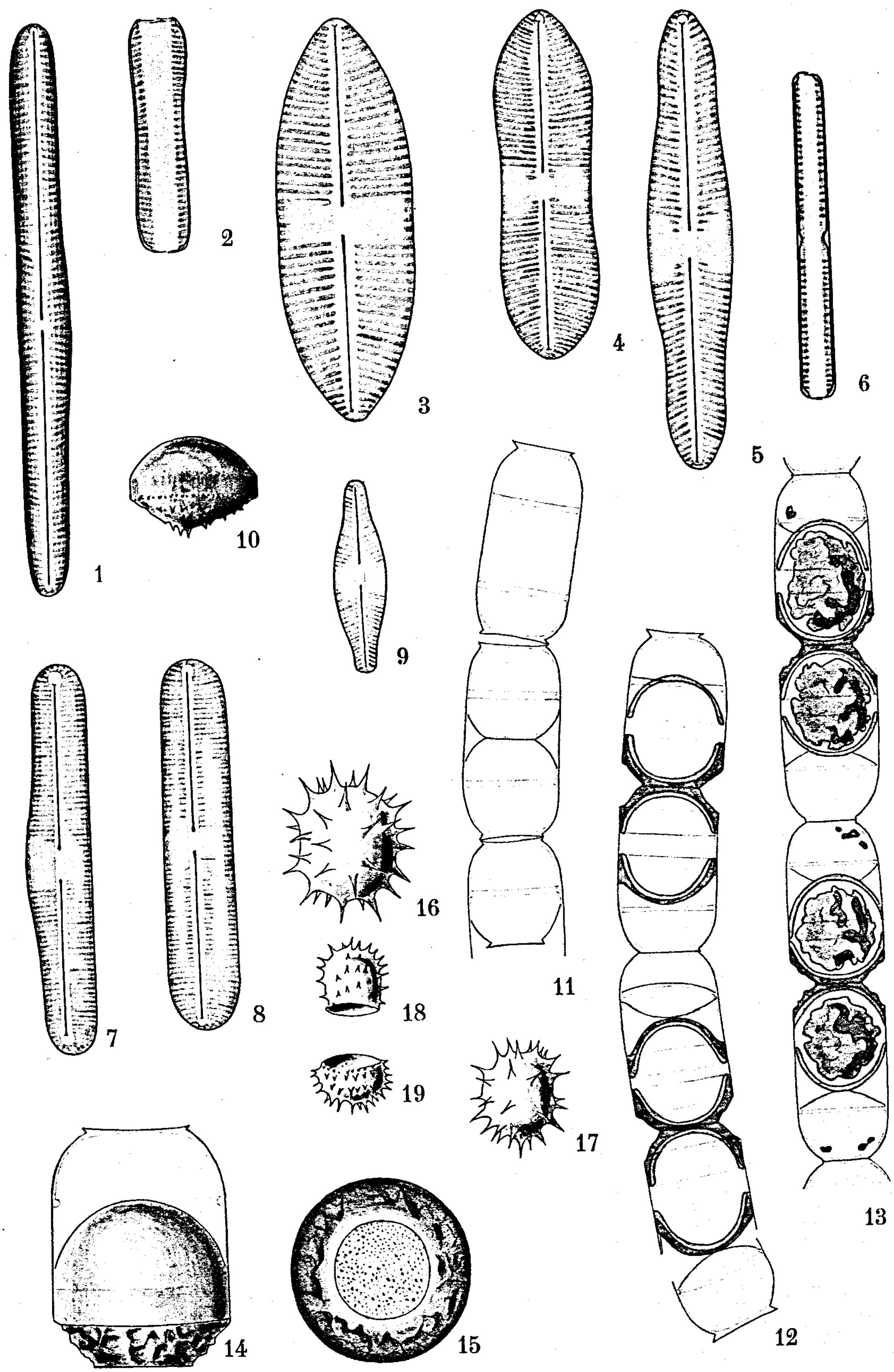
PLATE III.

(Where not otherwise stated, the magnification is $\frac{1000}{1}$).

			Page
Fig.	1.	*Pinnularia ambigua,* Cl., valvar view	42
—	2.	— — , pleural view of a smaller specimen	42
—	3.	— *quadratarea,* (A. Schm.) Cl. var. *Stuxbergii,* Cl.	43
—	4.	— — var. *constricta,* Oestr.	44
—	5.	— — — *bicontracta,* Oestr.	43
—	6.	— — — *Stuxbergii,* Cl., pleural view	43
—	7.	— *semiinflata,* Oestr., var. *genuina*	44
—	8.	— — — — *decipiens,* Cl.	45
—	9.	*Navicula kryokonites,* Cl.	28
—	10.	*Chætoceras teres,* Cl. var. *spinulosa* n. var., spore	49
—	11.	*Melosira hyperborea,* Grun., vegetative filament; $\frac{600}{1}$	52
—	12–13.	— — — , with spores; $\frac{600}{1}$	53
—	14.	— — — , spore in its mother cell, pleural view	53
—	15.	— — — , spore, primary valve, valvar view	53
—	16–19.	*Xanthiopyxis polaris,* n sp. 16–17. Cells. 18–19. Isolated valves	51



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