

Some *Nitzschia* and Related Diatom Species from Fast Ice Samples in the Arctic and Antarctic

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Summary. Some *Nitzschia* and closely related species have been examined in the light and electron microscopes from fast ice samples in the Arctic and Antarctic. *Nitzschia neofrigida*, forming arborescent colonies, and *Nitzschia promare*, forming loose ribbon colonies, are described as new species, both probably included in the distribution of other similar species. A new combination, *Auricula compacta*, represents the first report of this genus from ice samples. Colony formation is reported for the first time in *Nitzschia arctica* and *Nitzschia taeniiformis*. No biopolar species were found and several reports of Arctic species in Antarctic ice samples have been refuted.

Introduction

The history of ice algal investigations in the polar regions goes back to the middle of the 19th century (for review, see Horner 1985). As early as 1909 (his Appendix II) Van Heurck recognised that in both the Arctic and Antarctic most ice-associated as well as littoral diatoms differed from those in the plankton. There are now, however, reports from the pack ice region and the ice edge zone in the Weddell Sea documenting the similarity of ice and planktonic assemblages (Garrison and Buck 1985; Garrison et al. 1987). But, there are also recent reports supporting Van Heurck's statement (e.g. McConville and Wetherbee 1983; Grossi and Sullivan 1985) showing the existence of distinct algal assemblages in land-fast ice in Antarctic nearshore waters. The situation in the Arctic may be simpler in the way that one or two of the sea ice algal assemblages defined by Horner et al. (1988) are missing. There is, however, evidence that ice-associated diatoms play an unimportant role in the Arctic plankton (for review, see Horner 1984).

Taxonomic and floristic work with the plankton and the pack ice appears to be ahead of that with the fast ice and the benthos in the Antarctic (Hasle 1964, 1965a,b; Johansen and Fryxell 1985; Garrison et al. 1987), while the

reverse may be true in the Arctic (Horner and Schrader 1982; Hsiao 1983; Poulin in Medlin and Priddle, in press). This perhaps only reflects the research efforts of the last 10–15 years in both polar regions. More emphasis is now being placed on sea-ice communities and their contribution to the polar ecosystem. Moreover, it appears that the diatoms present in each of the sea-ice assemblages defined by Horner et al. (1988), can be used to describe a particular type and age of ice (Hasle and Syvertsen 1985), and thus, the need for correct species identification becomes essential as the assemblage delineation becomes more precise.

From some of the earliest reports of ice-associated and littoral diatoms (Cleve 1883; Peragallo 1921), pennate diatoms were noted to far outnumber centric ones. One such pennate genus, *Nitzschia*, is particularly well represented in the ice and littoral community (Cleve and Grunow 1880) and its species are difficult to identify because they have few characters that can be used with light microscopy (LM). In this paper we have studied species of that genus along with some closely related forms from both Arctic and Antarctic ice samples with light and electron microscopy (EM). Several of these species have been cited from both polar regions and we have tried to establish the accuracy of some of these reports. Colony formation or the absence of it has proven to be a very reliable character and we have illustrated it where applicable.

Materials and Methods

While most of our Antarctic samples came from nearshore waters, most of the Arctic material was sampled at a greater distance from land (Table 1). Each location is recorded where a particular species has been found as that species is described. For some species we have examined permanent mounts from the slide collections from the British Museum (Natural History), London (=BM), the Swedish Museum of Natural History, Stockholm (=S, P.T. Cleve slides), the University of Copenhagen, Botanical Museum (=C, Østrup and Grøntved slides), the Naturhistorisches Museum, Vienna (=W, the Grunow collection), the Friedrich-Hustedt-Arbeitsplatz für Diatomeenkunde, Bremerhaven, (=BRM, Heiden slides and the Hustedt types), the Muséum National d'Histoire Naturelle, Laboratoire

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Table 1. Locations of preserved samples examined from both polar regions

Number	Date	Location	Collector	Number	Date	Location	Collector
Arctic Samples				Antarctic Samples			
Eurasian Sector				Weddell Sea			
IMBB 568	11/8/73	80°18'N 28°30'E Svalbard Under 1 m ice	T. Benjaminsen IMR, Norway	IMBB 1592	Feb. 1977	77°45'S 41°44'W Broken shelf-ice	S. Fevolden NARE 1976/77
IMBB 1015/16	24/6/74	66°26'N 32°55'W Denmark Strait Ice	T. Ørtrand IMR, Norway	Ant II/4 Core 5	15/1/84	77°25.4'S 39°35.5'W	A. Bartsch AWI, W. Germany
IMBB 1615	24/8/77	79°03'N 27°40'E Svalbard Lump in ice pond	M. Schaanning Univ. of Oslo	Ant III/3 Core 6c Core 7	4/2/85 6/2/85	77°41.6'S 36°58.2'W 77°48'S 44°54'W	S.Z. El-Sayed TAMU
IMBB 2453 St.721	8/6/84	76°48'N 33°07'E Barents Sea	S. Kristiansen PRO MARE	IMBB 2596 St.11	12/3/86	65°39.5'S 48°12.3'W Brown lump in ice	E.E. Syvertsen AMERIEZ
IMBB 2548	2/5/85	76°48'N 24°37'E Barents Sea under 60 cm ice	E.E. Syvertsen PRO MARE	IMBB 2707 St.20	21/3/86	65°02.48'S 50°38.3'W Infiltration layer	
IMBB 2706 St.33	30/5/86	76°30.8'N 34°15'E Barents Sea Under 70 cm ice	E.E. Syvertsen PRO MARE	Ross Sea Quad 1 Quad 1-7	18/11/81	ca 78°S 166°E Cape Armitage	C.W. Sullivan USARP
IMBB 2675	12/7/88	ca. 79°N 12°E Kings Bay Svalbard	G.R. Hasle B.R. Heimdal	Site L	12/11 to 12/21/84	E. McMurdo Sound Sediment Trap, 37 m 77°51'S 166°36'E	A. Leventer USGS
IMBB 2472	1878	ca. 68°N 176°W	M.M. Kjellman Vega Exped.	IMBB 58(10)	23/11/76	60°42.5'S 45°36'W Signy Island Iceberg shelf	T.A. Whitaker BAS
North American Sector				East Antarctica			
IMBB 1012	16/4/74	51°36'N 54°16'W Newfoundland Ice	T. Ørtrand IMR, Norway	IMBB 2589	28/10/81	69°00'S 39°35'E Bottom of 60 cm sea-ice	K. Watanabe NIPR, Japan Syowa Station
Ice Core 1	15/5/79	Prudhoe Bay Alaska	Rita Horner OCSEAP	IMBB 2590	12/11/83	500 m west of Ongulkalven Sea-ice	
Ice Core 2	18/5/79	70°24'N 127°31.1'W Narwhal Island Beaufort Sea					

de Cryptogamie, Paris (= PC, Manguin slides), and the Department of Biology, Marine Botany, Oslo (= IMBB). The geographical origin of the particular mount is recorded the first time it is mentioned in the text.

Holotypes were not encircled by most of these earlier workers and we have had to search slides in these collections to find single specimens corresponding to published drawings. It seems that Cleve and Grunow split many of their samples because slides from the same location and expedition can be found in each collection. We were able to trace unprepared material of many of these slides in Stockholm and have used this unprepared material to make new permanent mounts and for electron microscopic examination. Where appropriate, lectotypes have been designated from this dried material.

Rinsed and cleaned preparations (Simonsen 1974) from over 250 Arctic samples as well selected samples from the Antarctic were examined with a Zeiss Standard 16 microscope equipped with bright field (BF), phase contrast (PC), and Nomarski interference contrast (NIC) optics at the University of Bristol and with a Leitz Orthoplan and a Nikon Optiphot microscope equipped with the same type of

optics at the University of Oslo. Preparations for electron microscopy were made following Medlin and Fryxell (1984) and Hasle (1978) and examined on a Philips 501 scanning electron microscope (SEM) or a Jeol 1200 EX transmission electron microscope (TEM) at the University of Bristol, on a Jeol JFM 35C SEM or a Jeol JEM 100C TEM at the Electron Microscopical Unit for Biological Sciences, University of Oslo, or on a Jeol JSM 25 at Texas A&M University. Morphometric measurements for each species are presented in Table 2. Terminology follows that of Anonymous (1975), Mann (1981, 1986), and Ross et al. (1979).

Observations from Arctic Material

Nitzschia frigida Grunow in Cleve and Grunow 1880, p. 94, pl. 5, fig. 101, non *N. frigida* in Poulin and Cardinal 1983, p. 111, fig. 11.

Type Locality: Kara Sea.

Table 2. Morphometric measurements of species examined in this study

	Apical Axis in μm	Transapical Axis in μm	Fibula in $10 \mu\text{m}$	Striae in $10 \mu\text{m}$	CN
<i>Nitzschia frigida</i> Grun.	45–75	4.5–7.5	7–9	45–50 N	+
<i>Nitzschia neofrigida</i> Medl.	60–109	6–7	6–8	40 R	+
<i>Nitzschia polaris</i> Grun.	50–169	5–7	5–8	40 P	+
<i>Nitzschia stellata</i> Mang.	60–134	6.5–10	4–8	40 R	+
<i>Nitzschia taeniiformis</i> Sim.	110–150	5	6–10	24	+
<i>Nitzschia promare</i> Medl.	31–45	4–5.5	8–12	45–50 N	+
<i>Nitzschia scabra</i> Cleve	108–220	7–10	2–3	mottled	–
<i>Nitzschia arctica</i> Cleve	90–155	7–8	8–10	24–26	+
<i>Nitzschia brebissonii</i> var. <i>borealis</i> Cleve	120–170	6–8	7–8	12–18	–
<i>Nitzschia laevis</i> Grun.	115–170	6–6.5	6–8	40 V	+
<i>Nitzschia neglecta</i> Hust.	44–98	4–6	3–6	35–40 R	+
<i>Nitzschia lecontei</i> V.H.	27–112	2.5–5	5–14	51–55 N	+
<i>Hantzschia weyprechtii</i> Grun.	55–75	6–7	9–11	33–35	+
<i>Auricula compacta</i> (Hust.) Medl.	85–134	12	6–9	22–24	+

CN = central nodule

N = not resolvable with LM

R = just barely resolvable with LM, ~ 40 in $10 \mu\text{m}$

P = not present on valve face, face appears hyaline

V = striae appearance varies from hyaline to isolated puncta to ~ 40 in $10 \mu\text{m}$

Lectotype: Grunow slide 1933d W.

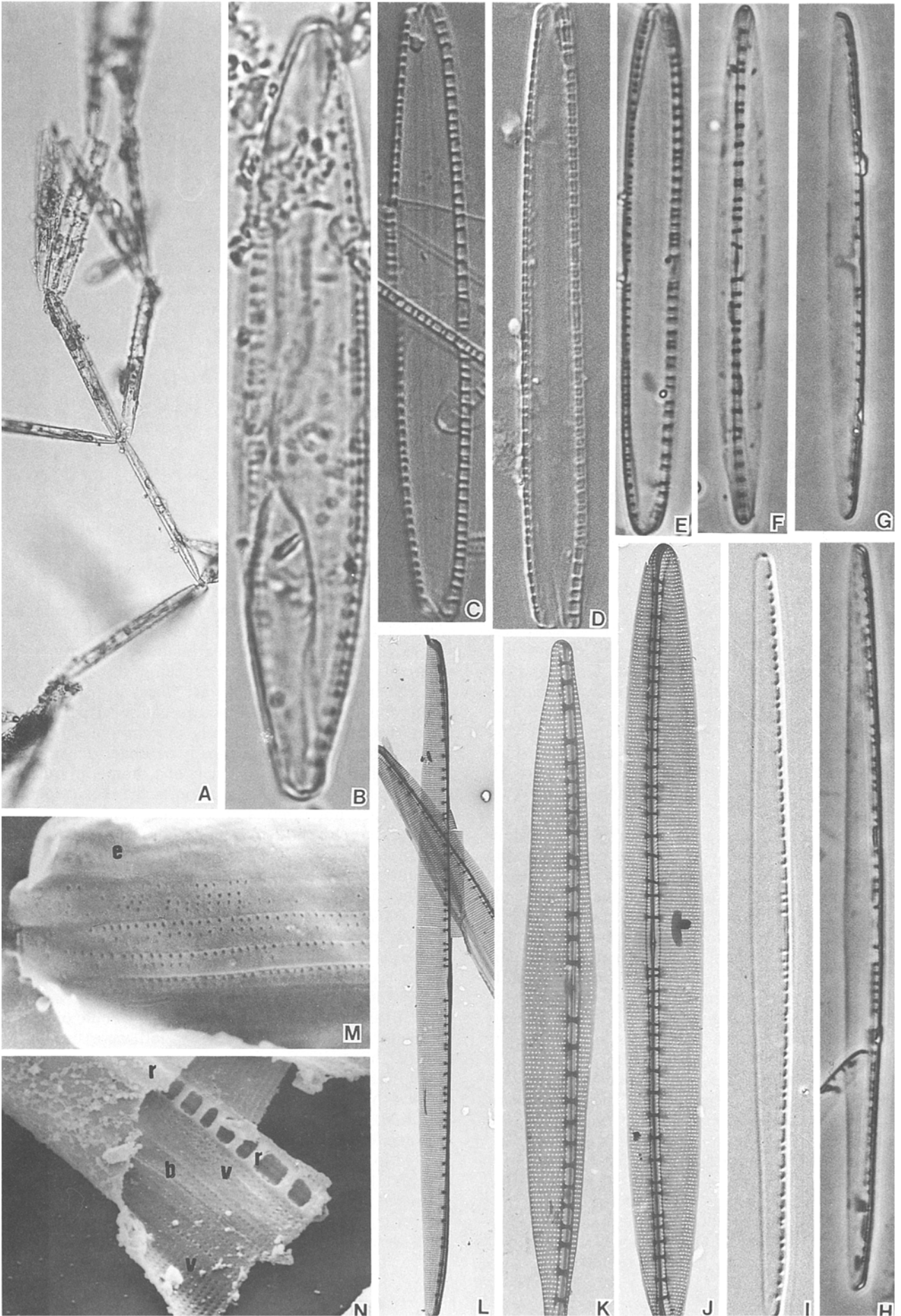
Material Examined: P.T. Cleve slides VI:1–7, Kara Sea, and V:4–76, Discovery Bay, Nares Exp.; Grunow slide 1933d, Kara Sea; Østrup slide 1475, NE Greenland; 14 Grøntved slides, Kalling-Vig, Denmark, glow (= incinerated on a hot plate) and cleaned prep., 5–3–47; Cleve and Möller slides 314, Franz Josef Land, Barents Sea, and 315–318, Mys Vankarem (= Cape Wankarema), East Siberian Sea, BM Coll.; IMBB samples 568, 1014, 1015, 1016, 1615, 2453 and 2706; Ice core samples 1 and 2.

Frustules are united at their poles into arborescent colonies. (Fig. 1A). Several cells can be joined at one “branching point”. Mucilage adhering the cells to form this distinctive colony shape is secreted through the girdle bands at the poles. Within a single colony, cells can be oriented in either valve or girdle view. The colonies appear to preserve well because intact colonies were found in material 10 years old. The cells often lie in girdle view in rinsed or mildly cleaned preparations and the two valves are easily dislodged from their bands to give a distinct elliptic appearance to the frustule (Fig. 1B–E), such as that seen in the original drawings of *N. frigida* by Grunow (Cleve and Grunow 1880). Single valves are linear-lanceolate with tapered, rounded apices (Fig. 1F–L). The striae, composed of poroid areolae (puncta), run parallel across the valve and perforate the outer canal wall (Fig. 1J, K).

The raphe system is more or less eccentric (Fig. 1F, J, K). However, if the proximal mantle (that closest to the raphe) is flattened beside the valve face in cleaned preparations, then the appearance of a more central raphe system is given (Fig. 1F, J, K). One method we have used to

determine the position of the raphe is to compare the width of the valve distally and proximally to the raphe at the valve centre or at the central nodule (if resolvable externally) on complete frustules seen in the SEM. From Fig. 1N, these two widths (v) are unequal and thus the raphe must be eccentric. Fracture of this critical-point-dried frustule shows the cell to be quite rounded with the raphe systems of the two valves lying under one another and not offset to opposite corners of a rhomboid frustule. Grøntved (1950) noted that in colonies, the keels (raphe) of the cells are not rarely seen centrally. This is possibly because the cell is more rounded than rhomboid in cross section and possibly because the cells can be in various orientations in the colony.

This difficulty in determining the position of the raphe in *N. frigida* has led to conflicting interpretations of its position in the literature. Cleve and Grunow (1880) listed *N. frigida* under the Section *Lineares* implying that there was an eccentric raphe. We have examined a slide of this material from the Kara Sea in the Cleve collection (Fig. 1B) and in the Grunow collection and could only find complete frustules in girdle view and were unable to confirm the position of the raphe from the type material. Østrup (1895) drew a series of figures of *N. frigida* and decided that *N. frigida* possessed a central raphe. One of us (LKM) has examined his slides from northeast Greenland and found cells primarily with an eccentric raphe but also with a broad proximal mantle, which would lend interpretation of the raphe position as being central. Grøntved (1950) was convinced that the raphe position was eccentric and he did not believe that Østrup's figures b–d were of *N. frigida*.



The raphe slit is interrupted by a central nodule, which is easily seen with light microscopy (Fig. 1B–I). The polar raphe endings extend externally into terminal fissures, which are slightly curved around each valve apex (Fig. 1J, K). Internally a simple helictoglossa is formed. The raphe system is not elevated into a prominent keel (Fig. 1N) and is spanned internally by small irregularly spaced fibulae. These are joined to the valve at their bases by a thin ridge of silica (Fig. 1J–L). The central two fibulae are quite widely separated (up to 4 μm). The fibulae also stop some distance from the valve apex. These two characters are quite useful for identifying *N. frigida* in cleaned strewn mounts where the colonies have been disrupted.

The cingulum is composed of three to four open bands perforated with two to four rows of puncta (Fig. 1M, N). On the valvocopula, the first row of puncta is separated from the remaining irregular rows by a non-perforated space (Fig. 1M). The number of irregular rows beneath the non-perforated space is reduced in each subsequent band and on the fourth band there are only two rows of puncta.

Nitzschia neofrigida Medlin sp. nov.

Type Locality: Prudhoe Bay, Alaska.

Type Slides: BM 81531 – Holotype rinsed preparation and BM 81532 – Isotype cleaned preparation.

Material Examined: Ice core samples 1 and 2; IMBB sample 1014.

Diagnosis: Cellulae lineares, in coloniis arborescentibus ex minus quam 15 cellulis constantibus. Valvae lineares, apicibus rotundate obtusis, 60–190 μm longae, 6 μm latae. Striae punctatae, inaequaliter longae, 40 in 10 μm . Raphe centralis. Fibulae 6–8 in 10 μm . Cingulum ex 3 taeniis apertis constans, latitudine harem in directione abvalvari decrescenti, omnibus serie una pororum prope partem interiorem munitis.

Frustules are united into arborescent colonies by mucilage secreted through the girdle bands at the apices (Fig. 2A). The number of cells per colony is usually less than 15 with each individual having a perivalvar axis greater than 10 μm .

Valves are linear with rounded obtuse apices (Fig. 2B, C, E). The punctate striae are somewhat irregular in length, occasionally reaching the raphe canal (Fig. 2D, E). A single punctum (sometimes two) perforates the outer canal wall on each side of the raphe slit (one row of puncta arrowed on adjacent cell in Fig. 2E).

The raphe is centrally or slightly subcentrally placed on the valve on a low raised keel (Fig. 2G, H). Again, we used the same method mentioned above to determine the raphe position. The two widths of the valve in Fig. 2G (see

arrows) can be seen to be equal. The keel appears to have a ridge running alongside the raphe slit (Fig. 2H). The fibulae are more robust and more regularly spaced than those of *N. frigida* (Fig. 2B, C). A distinct central nodule is present (Fig. 2B, D).

The cingulum is composed of three open bands with each bearing a row of puncta along their advalvar margin adjacent to the pars interior (Fig. 2F, G). The bands decrease in width abvalvarly.

This species has probably been included in the distribution of *N. frigida*, although it could easily be distinguished from that species in the samples from Prudhoe Bay by its greater cell size and by its colonies, which have fewer but distinctly more robust cells. Identification of *N. neofrigida* in cleaned preparations is more of a problem because morphometric measurements of this species overlap with smaller specimens of *N. polaris* and with larger specimens of *N. frigida*. However, valves of *N. polaris* are always hyaline with LM (see discussion below), whereas the irregular, but numerous striae of *N. neofrigida* can be resolved under optimum conditions. *Nitzschia frigida*, by comparison, appears more fragile than *N. neofrigida*, is linear-lanceolate with an eccentric raphe. With EM, distinctions between *N. frigida* and *N. neofrigida* can be made on the structure of the valve and girdle bands. In *N. frigida*, the valve striae completely reach the eccentric raphe, while in *N. neofrigida*, the striae are irregular in length, occasionally meeting the centrally positioned raphe. The bands of *N. frigida* contain several rows of puncta, while those of *N. neofrigida* possess only a single row along their advalvar margin.

Nitzschia polaris Grunow in Cleve and Möller 1882, p. 4; Cleve 1883, p. 480, pl. 38, fig. 72 as *N. (recta var.?) polaris* Grun.

Type Locality: Mys Vankarem.

Lectotype: BM 81563 made from dried material in the Cleve collection from Mys Vankarem.

Material Examined: P.T. Cleve collection, dried material, Mys Vankarem; Cleve and Möller slides 315–318 not on 314, BM Coll.; Ice core samples 1 and 2.

Frustules are linear in girdle view and slightly indented at valve centre (Fig. 3D, E). As far as we are aware it does not form colonies. In valve view, the linear valve tapers gradually to rounded, slightly rostrate apices (Fig. 3A).

The valve face curves up from a shallow but distinct mantle towards a central raphe lying atop a prominent keel (Fig. 3E, G–K). The cells tend to lie on one valve face (i.e. in girdle view) giving the impression that the raphe is

Fig. 1. *Nitzschia frigida*. A Arborescent colony, BF, IMBB 1012, $\times 300$. B Lectotype specimen, girdle view, DIC, Grunow slide 1933d W, Kara Sea, $\times 3000$. C Girdle view, NIC, Cleve slide V:4–76, Discovery Bay, Nares Exp., $\times 2000$. D Girdle view, NIC, IMBB 1012, $\times 2000$. E Girdle view, PC, IMBB 1015/16 $\times 2000$. F Valve view showing collapsed proximal mantle, PC, culture isolated from IMBB 2453, Pro Mare Exp. $\times 2000$. G Valve view, but proximal mantle is not collapsed, as for F, $\times 2000$. H Valve view, PC, as for F, $\times 2000$. I

Valve view, NIC, as for F, $\times 2000$. J Valve view showing wide proximal mantle, TEM, as for F, $\times 3200$. K Valve view with narrow proximal mantle, which is not collapsed at the apices, TEM, IMBB 560, $\times 4000$. L Valve view of two specimens showing various degrees of mantle exposure, TEM, as for F, $\times 2000$. M Detail of four bands associated with the epivalve (e), SEM, IMBB 2706, ProMare, $\times 5600$. N Fracture of critical point dried cell, note position of raphe (r) and bands (b) on the two valves (v), SEM, IMBB 1012, $\times 8000$.

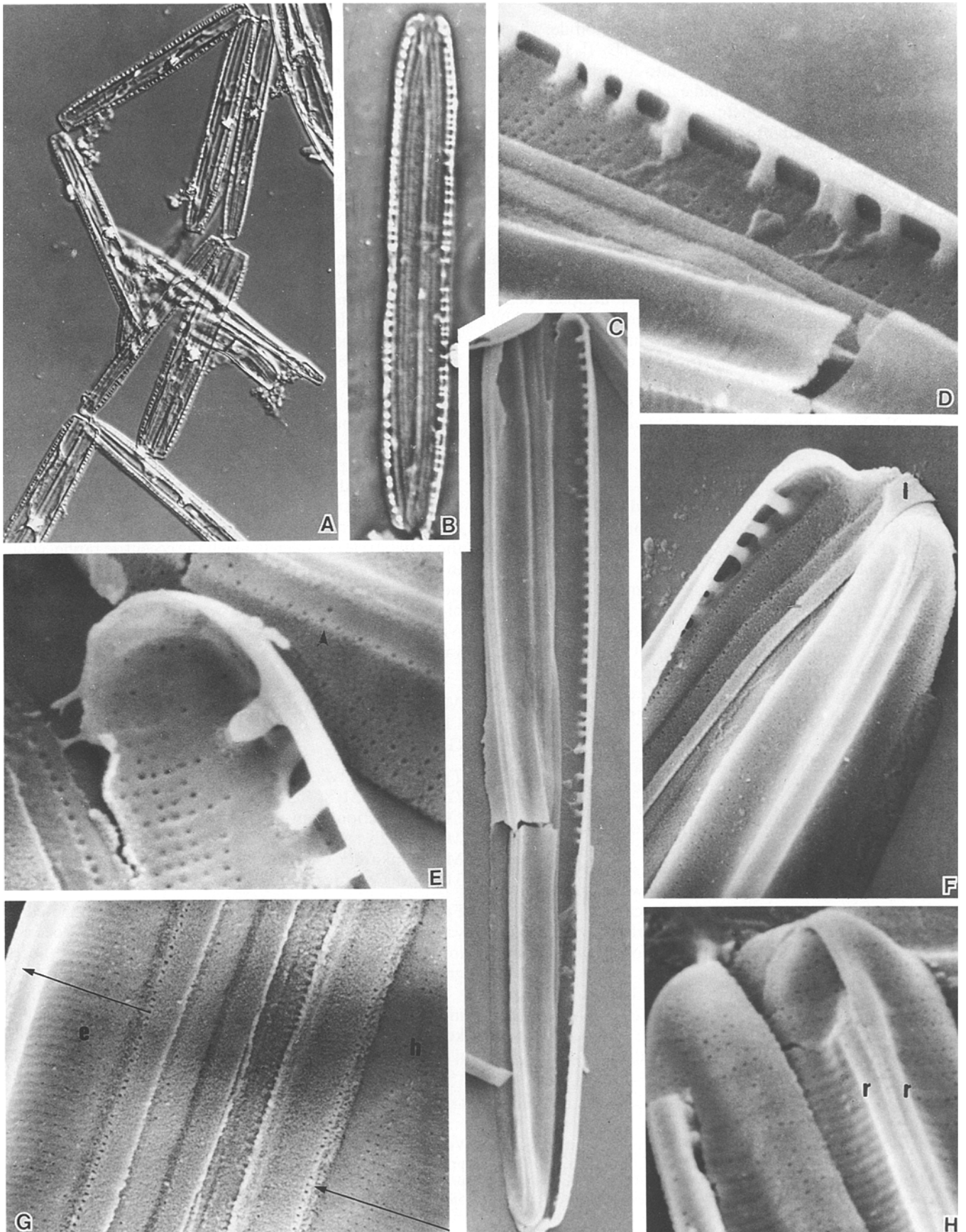


Fig. 2. *Nitzschia neofrigida* all figures type material from Prudhoe Bay. *A* Arborescent colony, NIC, $\times 500$. *B* Cleaned girdle view, PC, $\times 1000$. *C* Valves dislodged showing internal and external views, SEM, $\times 2300$. *D* Detail of central nodule of *C*, SEM, $\times 9400$. *E* Detail of apex of *C*, note row of puncta (arrow) along one side of raphe slit of adjacent cell, SEM, $\times 13300$. *F* External view of valve apex with

girdle bands, note ligulae of third band (*l*) and central position of the raphe, SEM, $\times 6300$. *G* Detail of bands at mid valve, epivalve (*e*) with three bands to the left and hypovalve (*h*) with two bands to the right, note equal width of valve face (shown by arrows), SEM, $\times 8200$. *H* Detail of valve apex and ribs (*r*) beside raphe, SEM, $\times 7700$

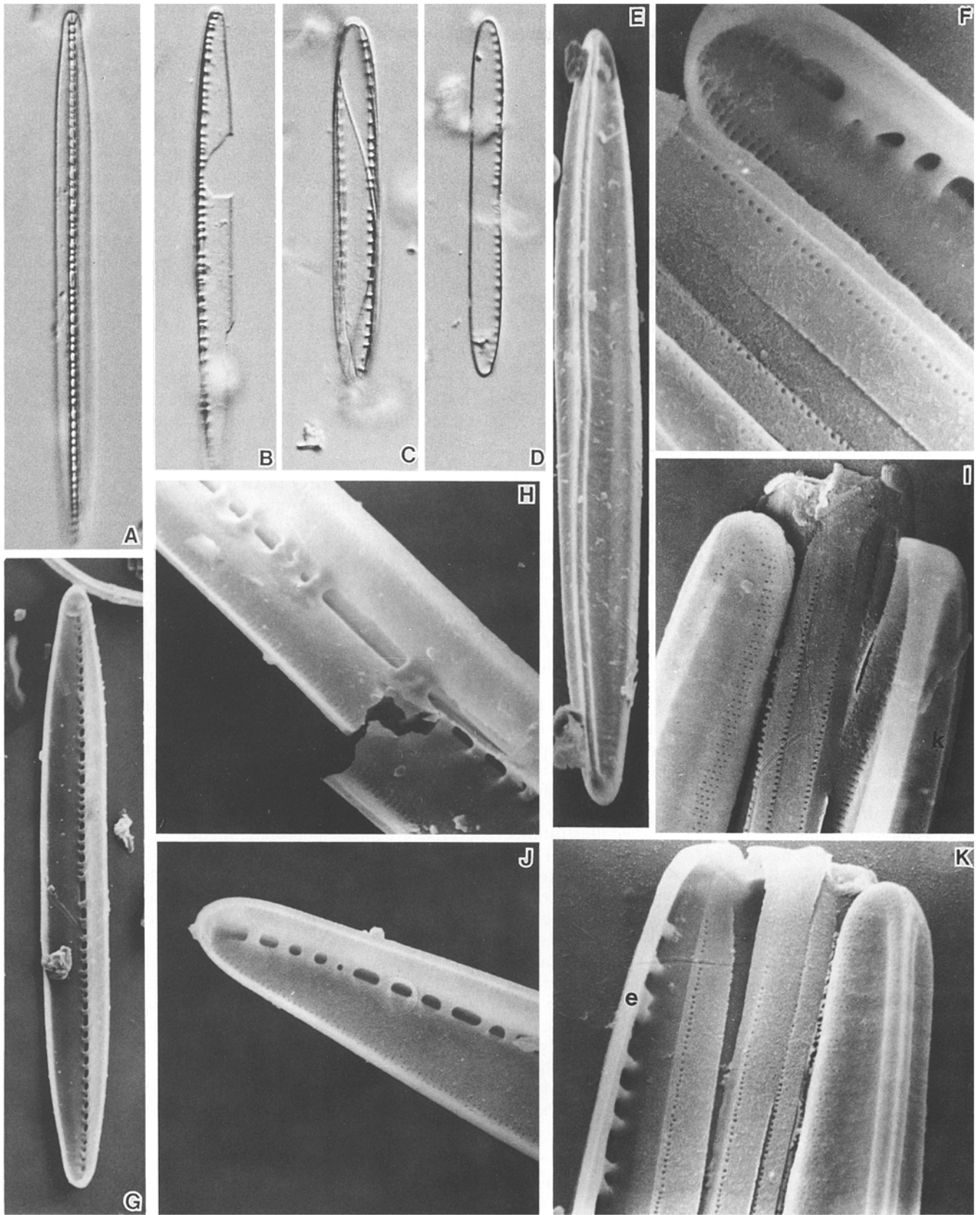


Fig. 3. *Nitzschia polaris*. *A* Valve view, NIC, type material, Vega Expedition, Mys Vankarem, $\times 1000$. *B* Girdle view, note thickened valve edge, as for *A*, $\times 1000$. *C* Girdle view, as for *A*, $\times 1000$. *D* Girdle view, as for *A*, $\times 1000$. *E* External valve view, SEM, as for *A*, $\times 1950$. *F* Internal view of valve apex, note areolae curving around apex and into outer canal raphe wall, SEM, Prudhoe Bay, $\times 4000$. *G* Internal

valve view, SEM, as for *A*, $\times 1200$. *H* Detail of central nodule, SEM, as for *A*, $\times 4500$. *I* External view of valve apex and bands, note prominent keel (*k*), SEM, as for *F*, $\times 8600$. *J* Internal view of apex, SEM, as for *F*, $\times 4100$. *K* Detail of bands, epivalve (*e*) and three bands to the left, SEM, as for *F*, $\times 5000$

eccentric (Fig. 3B–D). Positive determination of raphe position can be established by rolling the cells in fluid mounts (compare Fig. 3A with B and D).

The valve appears hyaline with light microscopy (Fig. 3A–D), but with SEM short but regular punctate striae can be found along both valve margins (Fig. 3F, H, J). The face itself is non-perforate and the marginal striae continue around the apices and into the outer raphe canal wall (Fig. 3F, I). The valves of this species are so robust that the thickened margin of the valve can easily be seen with LM as can the concavity of the valve (Fig. 3A).

The raphe system is interrupted by a central nodule with central raphe endings meeting coaxially. The raphe fissure lies within a ridged groove of the keel (Fig. 3K). The fibulae spanning the raphe system are robust, more or less flush with the internal valve surface and unequally spaced along its length (Fig. 3F).

The cingulum is composed of three (four?) bands decreasing in width abvalvarly. Each band has a single row of puncta adjacent to the pars interior of the band (Fig. 3I, K).

Cleaned valves lying on one face can easily be confused with *N. neofrigida*; however *N. polaris* is more heavily silicified with more robust fibulae than *N. neofrigida*. The close morphological relationship between these two species can easily be seen when the two are compared in the SEM with the main difference being the more regular striae and the more convex and arched valve in *N. polaris*.

The first published description and illustration of *N. polaris* is that of Cleve (1883). Although both Franz Josef Land and Mys Vankarem are listed as sites where Cleve (1883) and Grunow (1884) had found *N. polaris*, the illustration of *N. polaris* in Cleve (1883) is from Mys Vankarem. We have examined some of this material from the Cleve collection in the SEM and it has formed the basis of our description of *N. polaris*. The later Latin description of *N. polaris* published by Grunow (1884) appears to be based primarily on the material seen in Cleve and Möller slide 314 from Franz Josef Land, although specimens from Mys Vankarem are included in the published illustrations. Grunow gives a striae measurement of 40 in 10 μm . From our SEM observations and also from our examination of Cleve and Möller slides 314–318, it appears that two taxa are present. The specimens on Cleve and Möller slide 314, which could be assigned to *N. polaris*, have resolvable striae, while those in slides 315–318 do not. Lange-Bertalot and Krammer (1987) have also illustrated this same discrepancy between *N. polaris* from these two locations. Their fig. 7 and 7A (Plate 7) from Cleve and Möller slide 314 clearly depicts a specimen with resolvable striae, while a more robust and hyaline specimen is shown in their fig. 4 on the same plate from Cleve and Möller slide 315. Our SEM observations indicate that the striae in

the specimens from Mys Vankarem are restricted to the mantle edge and would therefore not be resolved in the light microscope. Thus, it would appear that those specimens resembling *N. polaris* in Cleve and Möller slide 314 belong to a different taxon. As the Mys Vankarem material was described and illustrated first, it must take priority over the later publication by Grunow in which the Latin description and the designation of Cleve and Möller slide 314 as a reference slide appear (R. Ross and P. Sims, personal communication). We have also considered the possibility that specimens on slide 314 are of *N. neofrigida* but cannot confirm this without SEM observations. Peragallo (1921) described *N. polaris* var. *antarctica* associated with green algae from the Argentine Islands, but we cannot tell, without EM observations, if this variety is related to *N. polaris*. Undoubtedly it is a littoral rather than ice-associated form.

Nitzschia promare Medlin sp. nov.

Type Locality: 76°48'N, 34°15'E, Barents Sea.

Type Slides: BM 81533 – Holotype rinsed preparation and BM 81534 – Isotype cleaned preparation.

Material Examined: IMBB samples 2706, 2548.

Origin of Name: PRO MARE (Norwegian Research Program for Marine Arctic Research), to be used as an indeclinable word.

Diagnosis: Cellulae lineares, in coloniis longis, laxe affixis et ad instar taeniae; cellulae ad apices liberae. Valvae lineari-lanceolatae, ad centrum constrictae, apicibus paullo rostratis, 31–45 μm longae, 4–5.5 μm latae. Striae punctatae, parallelae, 45–50 in 10 μm . Fibulae irregulares, 8–12 in 10 μm . Cingulum ex taeniis numerosis, omnibus seriebus 1–2 pororum munitis, constans.

Cells occur in long ribbon colonies attached along the mid-region of the frustule with the apices remaining free (Fig. 4B). The cells appear to be loosely held in this type of formation because the colonies can easily be disrupted by rinsing.

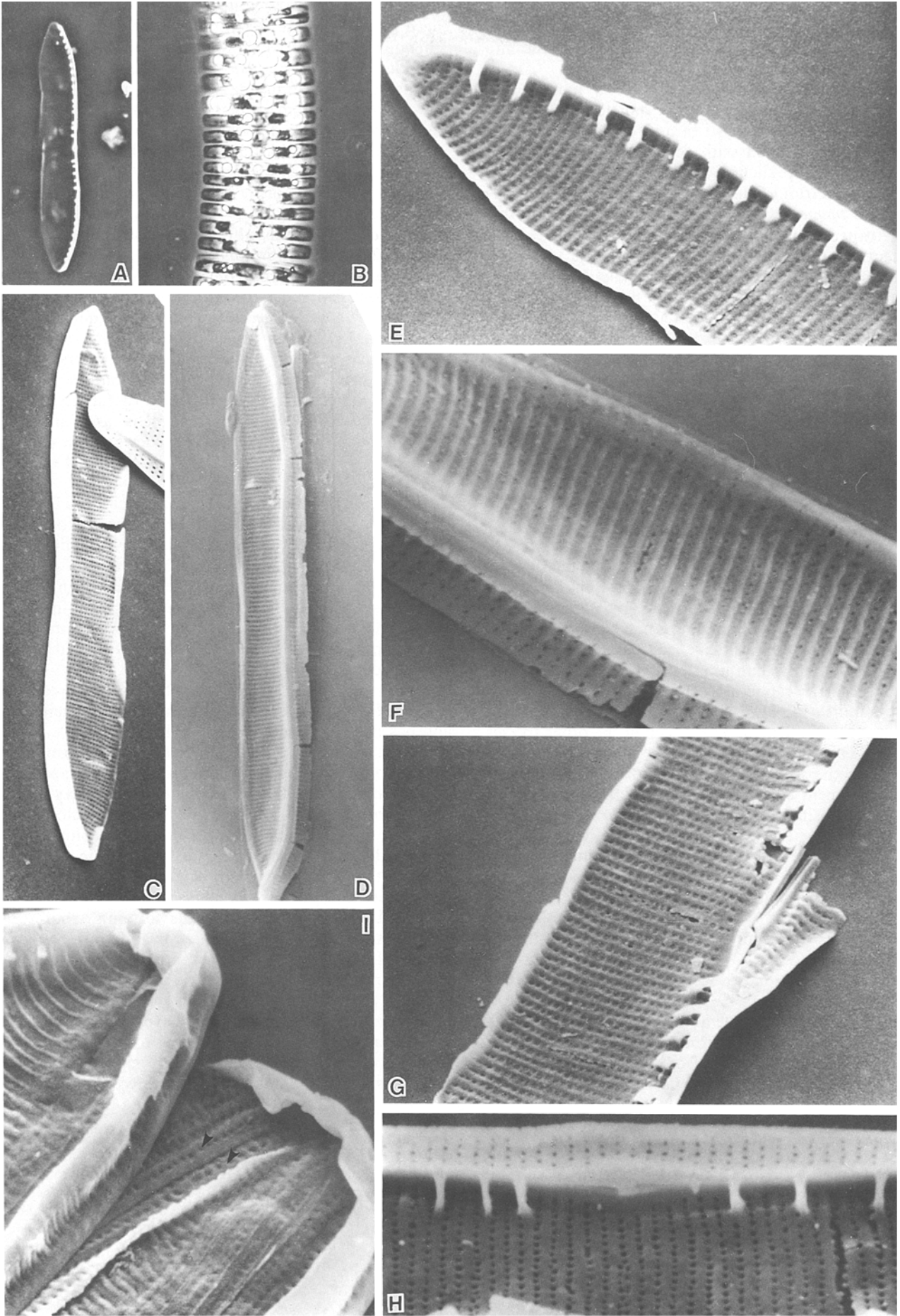
The frustules are narrow and linear in girdle view. Valves are linear-lanceolate, slightly waisted at the centre and taper more sharply towards slightly rostrate apices (Fig. 4A, C, D). The proximal mantle (that adjacent to the raphe system) is well developed, while no clear distinction between face and mantle occurs on the other side of the valve (Fig. 4E, F).

The striae are composed of small poroid areolae (puncta), which are closed at the external valve surface (Fig. 4F). Externally, the interstriae are narrow but distinct ridges. Internally the areolae have small rounded openings with some vertical development of the interstriae separating them (Fig. 4E, G, H).

The eccentric raphe system lies at the junction of the valve face and mantle where it is elevated into a distinct

Fig. 4. *Nitzschia promare* all figures from type material, IMBB 2706, Pro Mare Exp. *A* Valve view, note waisted cell, PC, $\times 1000$. *B* Portion of long ribbon colony, note cell apices free, PC, $\times 500$. *C* Internal valve view, SEM, $\times 3500$. *D* External valve view, SEM, $\times 3500$. *E* Detail of internal valve apex and fibulae, note distal valve mantle weakly developed, SEM, $\times 9300$. *F* Detail of external valve

surface near centre, note distinct proximal valve mantle, SEM, $\times 12100$. *G* Detail of internal valve surface at central nodule, SEM, $\times 8700$. *H* Detail of central nodule and proximal valve mantle, note thin fibulae SEM, $\times 11300$. *I* Rinsed colony, detail of bands (arrows show bands with one or two rows of puncta), SEM, $\times 11300$



keel (Fig. 4D). The central nodule, interrupting the raphe slit, is easily seen with LM (Fig. 4A) and the middle two fibulae are quite widely spaced. The striae continue into the outer raphe canal wall (Fig. 4H).

The cingulum is composed of several bands, each perforated with one or two rows of puncta (Fig. 4I).

We suspect that the distribution of this species has probably been included with reports of species of the *Fragilariopsis* group, such as *Nitzschia grunowii* Hasle and *N. cylindrus* (Grun.) Hasle as well as with chains of *Achnanthes taeniata* Grun. As the chains are easily disrupted by rinsing, these would probably be missed in permanent mounts of rinsed material. Cleaned valves are easily confused with smaller cells of *N. frigida* but can be distinguished from that taxon by its waisted centre, slightly greater width near the cell apices, more numerous fibulae, and rostrate apices.

Nitzschia arctica Cleve 1896, p. 21, pl. 1, figs. 21, 22.

Synonym: *Nitzschia vitrea* var. Cleve 1883, p. 316.

Type Locality: *N. vitrea* var. from Bessels Bay.

Neotype: BM 81532 Prudhoe Bay, Ice Core 1.

Material Examined: Cleve and Möller slides 315 and 318 BM Coll., BM 23350 of *Nitzschia tenuis*, Lewes, England; Ice core samples 1 and 2.

Cells occur solitary or in short ribbon chains of up to five cells unattached at their apices (Fig. 5A–C). The frustules are linear and broad in girdle view (Fig. 5B). The valves are lanceolate and taper to small rostrate apices (Fig. 5A, D). The striae, composed of small rounded poroid areolae (puncta), are separated by interstriae that are slightly more developed externally than internally (Fig. 5F, H, I).

The eccentric raphe (Fig. 5H) is interrupted by a central nodule (Fig. 5D–F). The number of fibulae in 10 μm is much smaller than that seen in the other species discussed here (Fig. 5A). Towards the apices the last two fibulae span the valve from margin to margin (Fig. 5G). This arrangement causes the raphe canal to twist at the apex. At this position the apex lies in girdle view while the remainder of the valve lies in valve view (Fig. 5A, D). There are no flanges external to the raphe to facilitate colony formation and we presume that mucilage secreted from adjacent valve faces must be involved in forming the short ribbon colonies.

There are two to four open bands in the cingulum. Each is perforated by a single row of puncta at the advalvar edge of the band. Scattered puncta also occur beneath this row on each band (Fig. 5G–I).

We were unable to locate any slides from Cape Eglinton in the Cleve collection (the site from which Cleve (1896) described *Nitzschia arctica*) but specimens matching our taxon are present in the Cleve and Möller slides

315 and 318 from Mys Vankarem, which is also listed by Cleve as a site where *N. arctica* can be found. The only other taxon that might be confused with this species is *Nitzschia linearis* var. *tenuis*, which Cleve (1896) cites as also being present in his material from the Davis Strait as well as being present in material from Greenland, Mys Vankarem, and outside polar seas.

Nitzschia tenuis was considered to be a variety of *N. linearis* by Grunow in Cleve and Grunow (1880). However, Kobayashi and Kobori (1988) have convincingly shown that these two taxa are distinct and should be kept as separate entities. One of us (LKM) has examined the type slide of *N. tenuis* Wm. Smith from Lewes, England and has found that our specimens from sea-ice samples bear only a superficial resemblance to that taxon. *Nitzschia tenuis*, a later synonym of *N. tergestina* Kütz. according to Van-Landingham (1973), is linear for most of its length and then just before the end of the cell, the valve tapers to small rostrate apices. This abrupt tapering can be seen in fig. 222 of the type material illustrated by Lange-Bertalot and Simonsen (1978). Our specimens are lanceolate throughout. They are wider and have fewer striae (25–26) and fibulae (8–10) in 10 μm than *N. tenuis* and must be regarded as *N. arctica*.

Jørgensen (1905) has reported this species as a frequent member of the coastal plankton or northern Norwegian fjords. He includes five figures of *N. arctica*, the first three of which seem to fit well with the specimens we have, although he was unable to see the striae on any of his specimens. His figs. 15e, f are of a more sigmoid form and he considered the possibility that these two figures were straighter forms of *N. laevissima*. They may instead be very large specimens of *N. hybrida*.

Nitzschia arctica might also be confused with *N. hudsonii* Poulin and Cardinal but that species is narrower and has finely punctate striae visible with LM.

Nitzschia promare and *N. arctica* both form loose ribbon colonies, apparently attached by the juxtaposition of sister valves. What role the eccentric raphe may play in colony formation is not known. Specimens closely resembling *N. arctica* also form arborescent colonies (unpublished observation). We must be certain that two different taxa are not involved before we can safely report two different types of colony formation for the same species. Long, thin, aciculate cells forming arborescent colonies in samples from the Barents and Kara Sea were described by Meunier (1910) as *Nitzschia divaricata*, but we have not, as yet, examined this material.

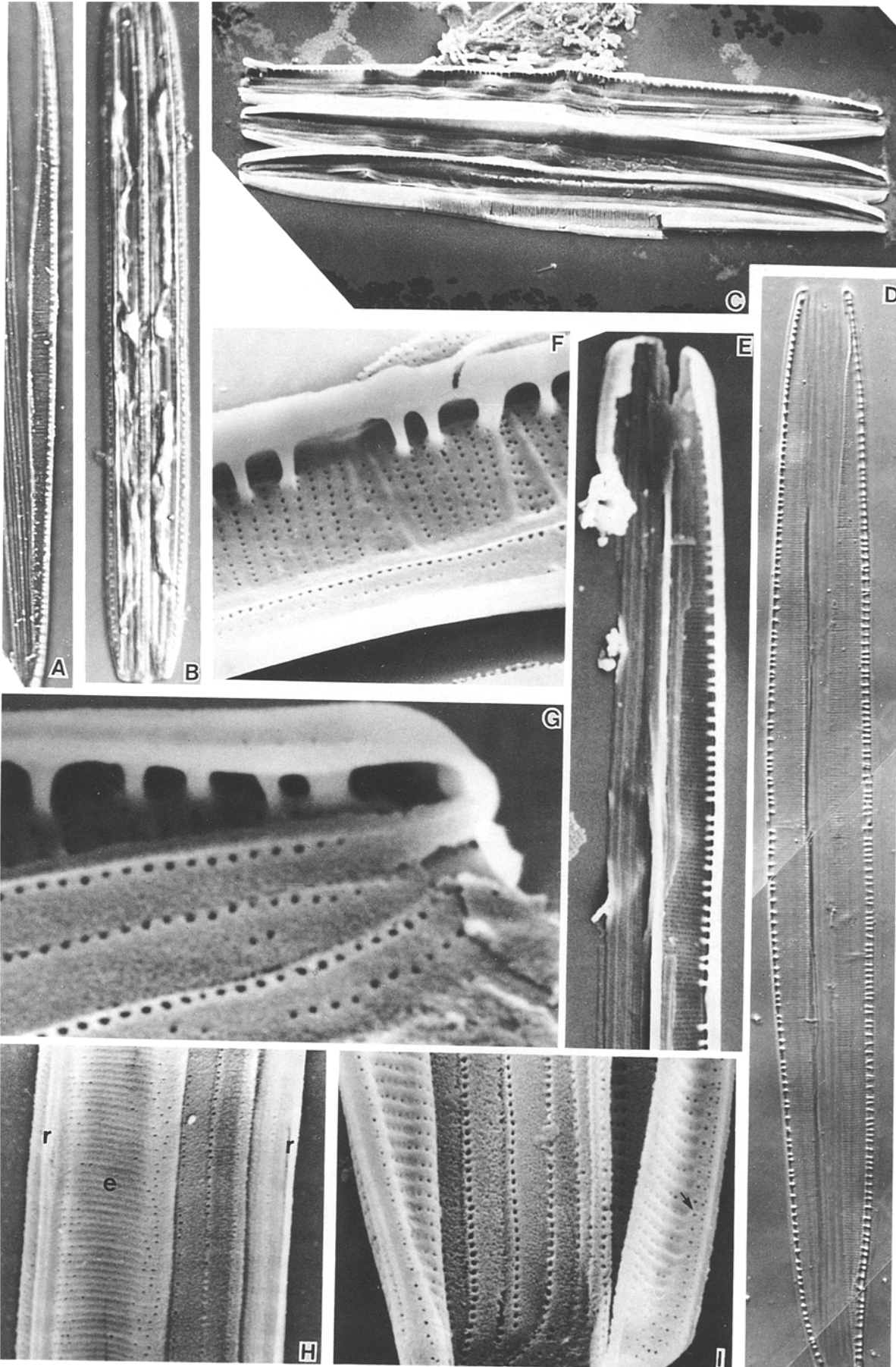
Nitzschia laevissima Grunow in Cleve and Möller 1882, p. 4; Grunow 1884, p. 106, pl. 1, figs. 65, 66.

Type Localities: Franz Josef Land, Mys Vankarem.

Lectotype: BM 81563 made from the dried material in the

Fig. 5. *Nitzschia arctica* all figures lectotype material from Prudhoe Bay. A Lectotype specimen, Valve view, note the small densely located fibulae, PC, $\times 500$. B Girdle view of recently divided cell, NIC, $\times 500$. C Ribbon colony of three cells, SEM, $\times 1100$. D Girdle view, cleaned frustules, NIC, $\times 1000$. E Internal valve view, SEM, $\times 2000$. F Detail of central nodule, SEM, $\times 7300$. G Detail of valve apex and girdle bands of E, note last fibula spans both margins such

that the apex twists on itself, SEM, $\times 12000$. H Detail of external valve surface, girdle view, raphe (r) to the left on the epivalve (e) with two bands, raphe (r) to the right on the hypovalve (h), note unequal width of proximal and distal mantles, SEM, $\times 4500$. I Detail of bands at valve apex, note perforation pattern of raphe canal (arrow), SEM, $\times 7400$



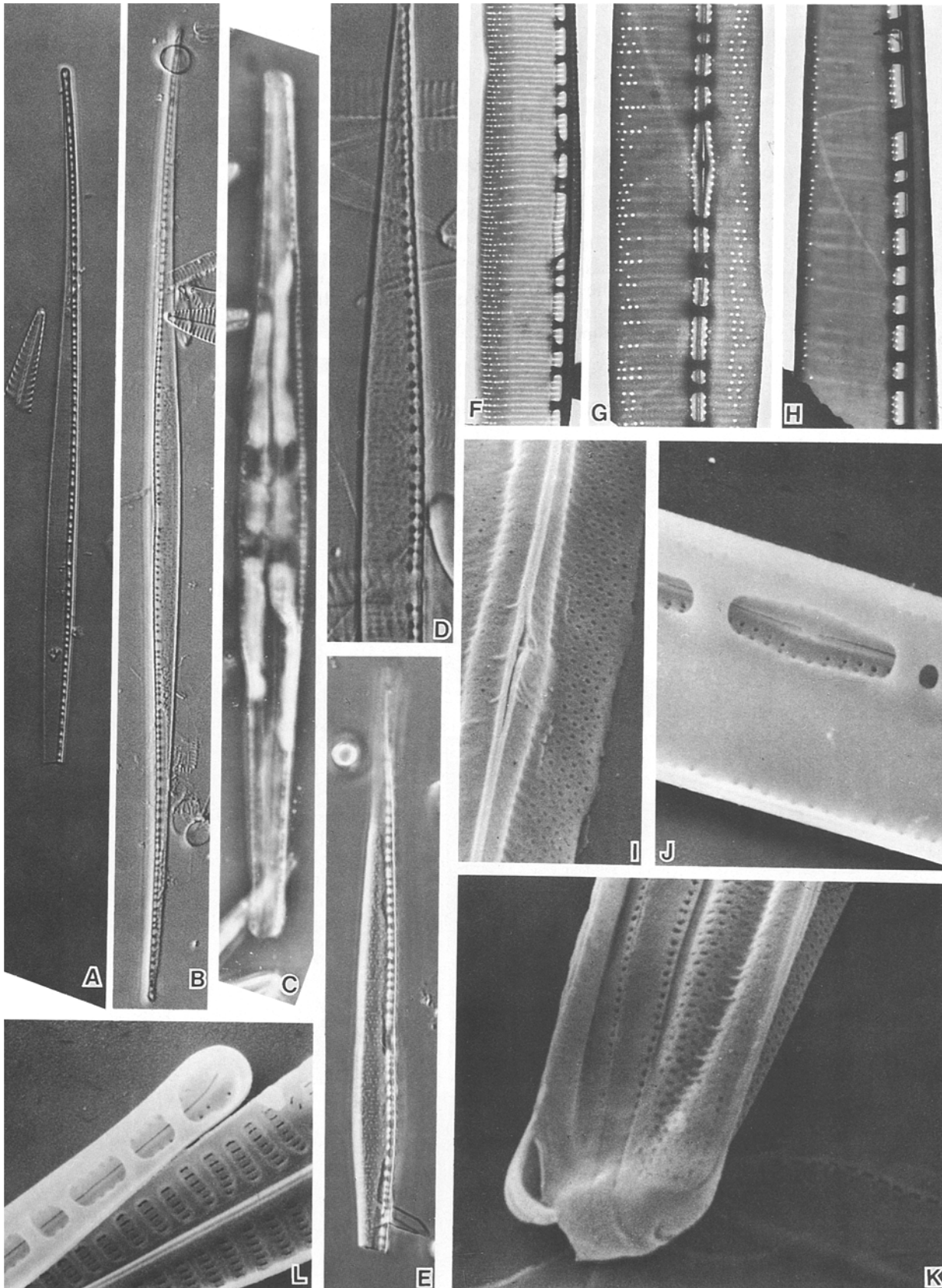


Fig. 6. *Nitzschia laevisissima*. **A** Fragment of valve, lectotype material, NIC, Mys Vankarem, $\times 1000$. **B** Valve view, note isolated areolae, PC, IMBB 1615, $\times 1000$. **C** Girdle view, note cell swollen in middle but not sigmoid, PC, IMBB 1615, $\times 850$. **D** Valve view, note distinct striae, PC, IMBB 1615, $\times 2000$. **E** Fragment of valve, PC, Franz Josef Land, Cleve and Möller Slide 312, $\times 1000$. **F** Detail of valve with perforate striae, TEM, IMBB 1615, $\times 4000$. **G** Detail of central nodule, note occasionally perforated striae on valve face and wide mantle, TEM, IMBB 1615, $\times 3800$. **H** Detail of valve with non-

perforated striae, TEM, IMBB 1615, $\times 4000$. **I** Detail of valve at central nodule, external view, note proximal mantle below the eccentric raphe, SEM, IMBB 1615, $\times 10800$. **J** Detail of internal view of central nodule, SEM, IMBB 1615, $\times 9100$. **K** Detail of one apex of specimen shown in **I**, note central position of raphe and curved terminal fissures, epivalve with 2 bands, SEM, IMBB 1615, $\times 10800$. **L** Detail of internal valve apex showing slightly curved helictoglossa and central position of raphe, SEM, IMBB 1615, $\times 7200$

Cleve collection from Mys Vankarem.

Material Examined: Cleve and Möller slide 314 BM Coll.; P.T. Cleve collection, dried material, Mys Vankarem; IMBB samples 1615 and 2706.

Frustules are sigmoid in valve but not girdle view (Fig. 6A–C) and occur as single cells. A displacement of the raphe system from an eccentric position near the middle of the frustule to an almost central position at the apices is related to the curvature of the valve (Fig. 6J, K).

The valves are sigmoid-lanceolate with slender drawn out rostrate apices (Fig. 6A, B, D, E). The proximal mantle decreases in depth from its widest point near the central nodule (Fig. 6I) to the apices (Fig. 6L). The striae are composed of poroid areolae (puncta); however some striae may be incompletely perforated, i.e. composed only of isolated puncta (Fig. 6B, E, G). The variability in perforation can change the appearance of the valve when seen with LM from completely hyaline (Fig. 6A) to isolated puncta (Fig. 6B) to complete striae (Fig. 6D). Those specimens on the Cleve and Möller slide 314 possess only isolated puncta randomly scattered over the valve face (Fig. 6E).

The raphe lies atop a prominent keel. A conopeum or canopy is not present (Fig. 6I). A central nodule, interrupting the raphe slit is easily seen with light microscopy (Fig. 6A–E), but the central raphe endings terminate coaxially, without any deflection to the ventral margin of the valve. The terminal fissures are slightly curved around the valve apex (Fig. 6K). Internally the helictoglossa is also slightly deflected (Fig. 6L). The outer canal raphe wall is perforated by a row of puncta on either side of the raphe slit (Fig. 6F–H, J). These puncta, which can be continuous with the completely perforated valve striae, lie close to a junction line where the fibulae join the valve. The fibulae vary in thickness (Fig. 6F) and also in their spacing along the raphe system (Fig. 6H). Towards the apices, they span both valve margins (Fig. 6L).

The cingulum contains four open bands, each perforated with a single row of puncta lying along the advalvar margin of the band. Occasionally a few puncta beneath this row are present (Fig. 6K).

Nitzschia brebissonii var. *borealis* Grunow in Cleve and Möller 1882, p. 4; Cleve 1896, p. 21, pl. 1, figs. 28–32.

Type Locality: Mys Vankarem.

Lectotype: BM 81564 made from dried material in the Cleve collection from Mys Vankarem.

Material Examined: P.T. Cleve collection, dried material, Mys Vankarem; Cleve and Möller slides 315–318 BM Coll.; Ice core samples 1 and 2.

These cells, which do not form colonies, are linear in girdle view with slightly flared tips (Fig. 7C, E, F). The lanceolate valves are somewhat waisted at the middle, with drawn-out rostrate apices (Fig. 7A, B, D, G).

The external valve surface slightly curves up to the raphe, which is distinctly raised onto a prominent keel (Fig. 7H, J). It is the prominence of the keel and the narrowing of the valve that causes the flaring of the tips seen in cells lying in girdle view (Fig. 7B, F). The interstriae are very strongly developed externally above the rows of

poroid areolae (puncta) and curve slightly downwards to form a shallow mantle (Fig. 7H, J). Internally the interstriae are more or less flush with the striae (Fig. 7G, H).

The raphe, centrally located on the valve, is uninterrupted by a central nodule (Fig. 7B) and ends in a simple helictoglossa (Fig. 7G). A rib accompanies the raphe along its length (Fig. 7J). The outer raphe canal wall does not seem to be perforated. Fibulae are unevenly spaced along the length of the raphe system. At each apex the last fibula spans both valve margins, leaving a distinct circular interspace (Fig. 7G).

The cingulum is composed of three open bands, each with a different structure (Fig. 7I). The valvocopula has two rows of puncta separated by a non-perforate space. The second band is slightly wider but with additional scattered puncta beneath the second abvalvar row. The third and narrowest band is completely different with puncta closely packed into vertical rows.

Nitzschia brebissonii var. *borealis*, when lying on one face, might be confused with *N. taeniiformis* Simonsen (found in the Antarctic) but can be distinguished from that species by the absence of a central nodule and the lack of colony formation. It is more likely that *N. brebissonii* var. *borealis* will be confused with *N. scabra* Cleve and varieties of *N. distans* Greg., which also have a raphe without a central nodule. The tips of cells of these species are also flared in girdle view. Varieties of *N. distans* sometimes form small ribbon colonies but in raw and cleaned material can be distinguished from *N. brebissonii* var. *borealis* by the hyaline appearance of the valves. *Nitzschia scabra* has a mottled appearance to the valve surface due to incompletely perforated striae and also has a sub-eccentric raphe system. The absence of a central nodule will distinguish *N. brebissonii* var. *borealis* from *N. arctica*.

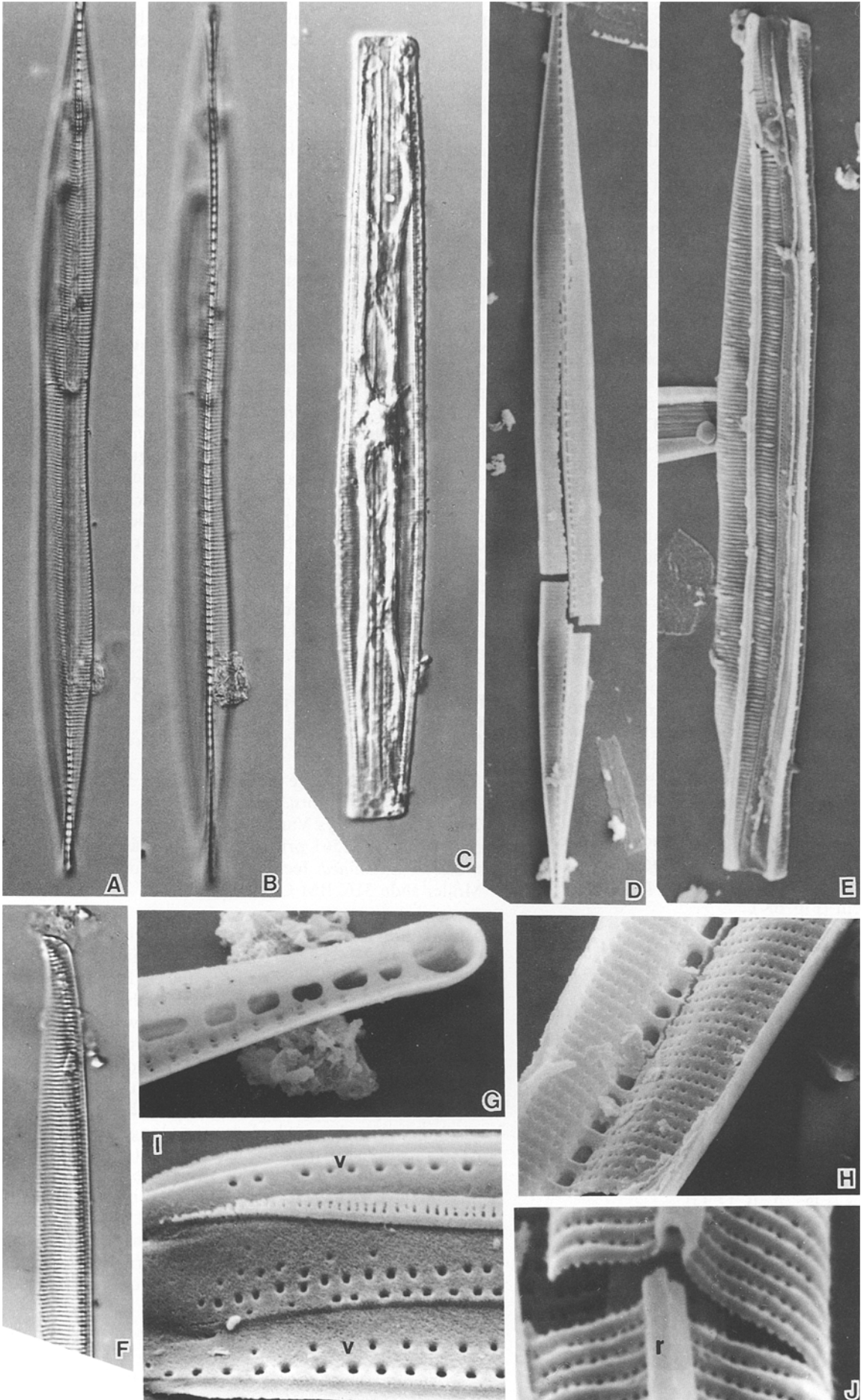
Nitzschia scabra Cleve 1883, p. 480, pl. 38, fig. 73a, b as *N. (Sigma* var.?) *scabra*.

Type Locality: Mys Vankarem.

Neotype: BM 81561 prudhoe Bay Alaska, Ice Core 1.

Material Examined: Ice core samples 1 and 2; Cleve and Möller slide 316, BM Coll.; IMBB 2675.

These solitary cells are sigmoid in girdle view with slightly flared tips (Fig. 8A, D). Valves are linear-lanceolate (Fig. 8B–D), tapering to rostrate apices (Fig. 8E, G). The rounded valve face curves up towards the keeled raphe. Just before the raphe, the face folds downward to the cell's interior and then back onto itself to form a longitudinal channel with an overlying conopeum (canopy) (Fig. 8E, F), which is free along its entire length. Thus, this channel, which is formed along each side of the raphe, is "open" and can be visualised as a shadow area along the raphe with LM as it protrudes into the cell interior (Fig. 8B, D). The channel is quite large at the valve apex and with the prominent keel help to form the flared ends of the cells (Fig. 8A, D, I). The striae are composed of small poroid areolae (puncta) (Fig. 8G, H). The closing membranes (? hymenes Mann 1981) lie close to the external valve surface (Fig. 8F), and internally the areolae are rounded (Fig. 8G, H). Some of the internal openings may be covered with extra silica (Fig. 8H) and this accounts for the mottled



appearance of the valve when seen with LM (Fig. 8D) and hence the name *N. scabra*. The internal openings of the areolae beneath the conopeum (Fig. 8H) may also be more regularly covered by silica. Mann (1986) has previously noted that the change in valve structure at this position also contributed to the longitudinal line seen on both sides of the raphe with LM.

The sub-central raphe is uninterrupted along its entire length. A row of horizontally elongated slits perforates the outer canal wall above the point where the valve face joins the raphe before turning outwards to form the conopeum (Fig. 8F, H). Internally the raphe system is subtended by small thin fibulae irregularly spaced along the raphe length. The bases of the fibulae extend into the face (Fig. 8G, H). At the valve apex, a tear-drop shaped interspace is formed by the juxtaposition of the valve mantles and the last fibula (Fig. 8G).

The cingulum is composed of at least four bands (Fig. 8I). The first two are wide with a single row of puncta lying closest to the advalvar margin, followed by a non-perforated space and then three or four regular rows of puncta and scattered puncta beneath these rows. The third band is narrow with one (two) row(s) of puncta on the advalvar margin again followed by the non-perforated space and one (two) row(s) of smaller puncta. The fourth band, also narrow, lacks the first row of puncta and the non-perforated space is on the advalvar margin. Beneath this, the other row of puncta is formed. The hypovalve on Fig. 8I bears only the first band.

We presume that this species was identified in the Prudhoe Bay samples as either (or both) *Nitzschia sigma* W. Smith or *N. sigmoidea* W. Smith by Horner and Schrader (1982). Both of these taxa are sigmoid in girdle view with an eccentric raphe but can be separated from *N. scabra* by coarser striae but finer fibulae in 10 μm . *N. sigma* is sigmoid in valve view and lacks a conopeum (Mann 1978).

Hantzschia weyprechtii Grunow in Cleve and Grunow 1880, p. 104; Grunow 1884, p. 107, pl. 1, fig. 60a, b.

Type Locality: Franz Josef Land.

Neotype: BM 81562 from IMBB 1615.

Material Examined: Cleve and Möller slide 314, BM Coll.; IMBB samples 568, 1615, 2706; Cleve and Möller slide 292 of *Hantzschia pettitiana*, Firth of Tay, Scotland, BM Coll.

These solitary cells have linear frustules without the obvious dorsi-ventrality seen in other *Hantzschia* spp. Valves are lanceolate with a curved dorsal margin and a straight ventral margin slightly indented at the central nodule (Fig. 9A–C). The valve ends are drawn out, slightly capitate and turned towards the dorsal margin (Fig. 9D,

G). The parallel striae are slightly radiate opposite the central nodule (Fig. 9H). Within each stria the areolae become occasionally biseriate along the dorsal margin (Fig. 9F). Mann (1977) found that in the specimens of *H. weyprechtii* he examined the striae were regularly biseriate. The interstriae are more strongly developed externally and the striae are recessed from the external valve surface (Fig. 9H). The ventral valve margin is also more strongly silicified (Fig. 9H, I). The striae along this margin are “trough-like” when viewed externally and are composed of 1–4 puncta (Fig. 9E, H).

The raphe system lies atop a low keel. The outer canal wall is perforated on the dorsal side of the raphe by a single row of large puncta and on the ventral side by two rows of small puncta (Fig. 9E). The raphe slit is interrupted by a distinct central nodule. The central endings meet coaxially internally (Fig. 9E, J) but are deflected dorsally on the external surface of the central nodule (Fig. 9H). At the poles, the hook-shaped terminal fissures curve towards the ventral margin (Fig. 9G, I). The fibulae are irregularly spaced with two to five striae corresponding to the interspace between the fibulae (Fig. 9E). Each fibula is narrow and attached at its base to a silica rib on the valve face. At each apex, the last fibula spans the valve.

Cleaned valves might easily be mistaken for a *Nitzschia* species because *H. weyprechtii* does not exhibit the strong dorsi-ventrality of other *Hantzschia* species. *Nitzschia hyperborea* Grun. resembles *H. weyprechtii* in valve outline but lacks a central nodule and presumably possesses nitzschioid symmetry. The illustration of *H. weyprechtii* in Schmidt's Atlas (1922, pl. 345 Figs. 1–3) is of a taxon without a central nodule. Its closest relative, *Hantzschia pettitiana* Grun., has coarser striae.

Observations from Antarctic Material

Nitzschia stellata Manguin 1957, p. 132, pl. 7, fig. 47a–e; Manguin 1960, p. 335, pl. 19, figs. 234–236, pl. 31, figs. 379–380

Type Locality: Cap Margerie, Terre Adélie.

Lectotype: Manguin slide 1.

Material Examined: Manguin slide 1, Terre Adélie, Antarctica; Heiden slides BRM 283/83, 283/90, 283/92 and 284/1, all from Kaiser Wilhelm II Land, Antarctica; Quad 1; Ant III/13, Cores 6c and 7; Site L; IMBB samples 2589, 2590, 2596 and 2707.

Manguin (1957, 1960) first described this species forming arborescent colonies from sediment collections and plankton tows taken along the coast of Terre Adélie and

Fig. 7. *Nitzschia brebissonii* var. *borealis*. *A* Valve view, focus on apices, NIC, lectotype material, Mys Vankarem, $\times 1000$. *B* Same specimen as *A*, focus on valve centre, NIC, $\times 1000$. *C* Girdle view, rinsed preparation, note flared tips of frustule, NIC, Prudhoe Bay, $\times 1000$. *D* Internal valve view, SEM, as for *C*, $\times 1000$. *E* External view of valve with bands, SEM, as for *C*, $\times 1200$. *F* Girdle view, detail of valve apex, NIC, as for *C*, $\times 1000$. *G* Detail of internal valve apex,

note final interspace formed by the last fibula spanning both valve margins, SEM, as for *C*, $\times 5500$. *H* Internal valve view near centre, note arched valve face, SEM, as for *C*, $\times 4400$. *I* Detail of bands from bottom to top: valvocopulae (*v*) plus 2 bands from epivalve followed by valvocopulae (*v*) of hypovalve, SEM, as for *C*, $\times 6300$. *J* External valve view near centre, note prominent keel and rib (*r*), SEM, as for *C*, $\times 6300$

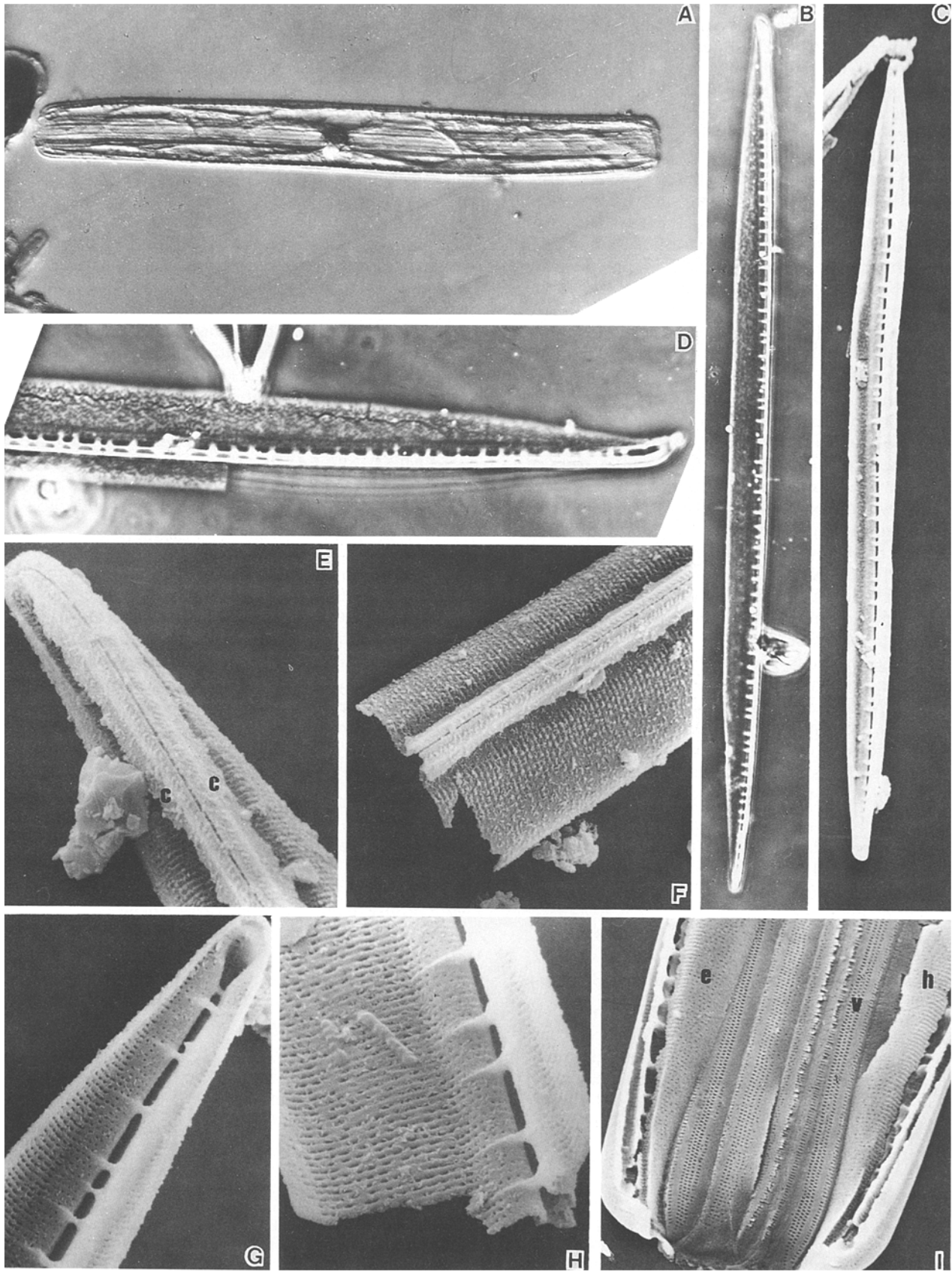


Fig. 8. *Nitzschia scabra* all figures lectotype material from Prudhoe Bay. *A* Sigmoid girle view, NIC, $\times 400$. *B* Lectotype specimen, Valve view with slightly eccentric raphe, PC, $\times 600$. *C* Valve view, SEM, $\times 600$. *D* Detail of broken valve showing eccentric raphe and mottled appearance of striae, PC, $\times 1000$. *E* Detail of external valve apex showing conoepium (*c*) extending from both sides of raphe, SEM, $\times 4500$. *F* Detail of external surface fractured near valve centre, note enfolding of valve on both sides of raphe to form

channel, SEM, $\times 3700$. *G* Detail of internal valve apex showing irregular spaced fibulae and large tear-drop shaped interspace beyond the last fibula, SEM, $\times 4500$. *H* Detail of internal surface fractured near valve centre, note fibulae spanning enfolded regions adjacent to raphe and the irregularly perforated striae, SEM, $\times 5600$. *I* Detail of epivalve (*e*) with four bands and hypovalve (*h*) with only the valvocopulae (*v*), note channel opening beneath conoepium, SEM, $\times 2600$.

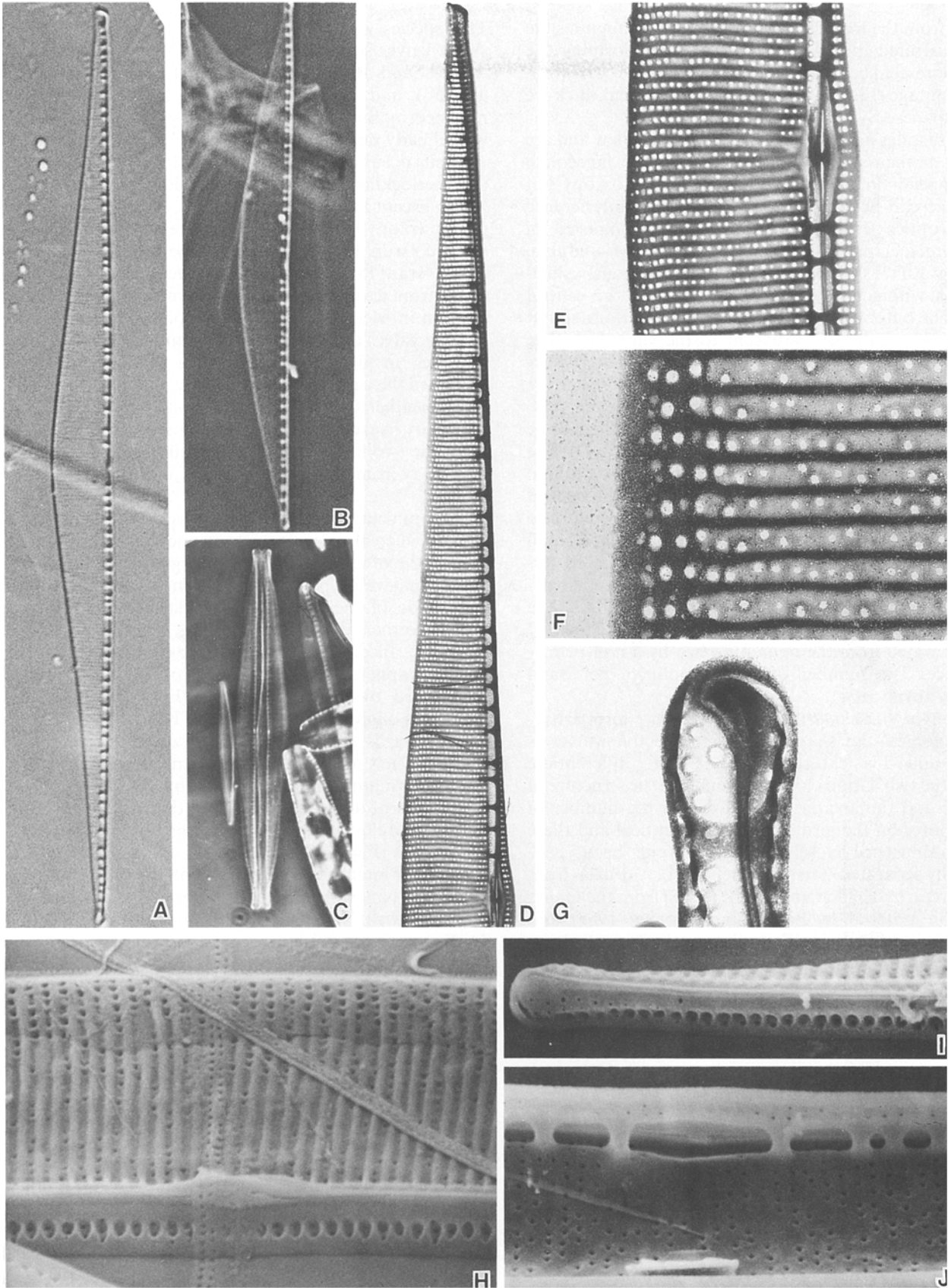


Fig. 9. *Hantzschia weyprechtii*. *A* Valve view, NIC, IMBB 1615, $\times 2000$. *B* Valve view, PC, IMBB 1615, $\times 2000$. *C* Whole frustule, rinsed, PC, IMBB 2706, $\times 600$. *D* Valve view from central nodule to apex, TEM, IMBB 1615, $\times 3400$. *E* Detail of central nodule, note partially occluded striae, TEM, IMBB 1615, $\times 6700$. *F* Detail of distal valve margin, TEM, IMBB 1615, $\times 20000$. *G* Detail of valve apex and terminal fissure, TEM, IMBB 1615, $\times 25000$. *H* Detail of

external valve view showing central nodule and ventral valve margin, note deflection of central raphe endings to dorsal margin, SEM, IMBB 1615, $\times 8800$. *I* Detail of external view of valve apex and ventral valve margin, note deflection of terminal fissure to ventral margin, SEM, IMBB 1615, $\times 8800$. *J* Detail of central nodule, SEM, IMBB 1615, $\times 8700$

seaward from the ice edge. Specimens from Manguin slide 1 are illustrated in Fig. 10B, C. Specimens forming the same arborescent colonies were dominant in ice cores from Cape Armitage (Fig. 10A, D) and beneath 60 cm thick ice at the Japanese Syowa Station.

The frustules are narrowly linear in girdle view and are attached at their poles to adjacent cells. The lanceolate valves appear almost hyaline with light microscopy but faint striae can be resolved using Nomarski interference contrast optics (Fig. 10D). Each stria is composed of poroid areolae (puncta) arranged in irregular undulate rows (Fig. 10E, F). Often there are homogeneously silicified areas within each stria, especially near the central nodule. The outer wall of the raphe canal is perforated but usually only on the side adjacent to the valve face. The proximal mantle (that closest to the raphe) is also perforated but these puncta appear smaller than those on the face itself (Fig. 10F).

The eccentric raphe system lies primarily in the mantle and is interrupted by a central nodule (Fig. 10B–D). The two central fibulae are very widely spaced (3–4 μm) and the remaining fibulae are irregularly spaced. The central raphe endings meet coaxially and are not deflected onto the valve face. The polar endings terminate into small helictoglossae internally and form a slightly curved terminal fissure externally.

The cingulum has nine or more bands (Fig. 10 G). The valvocopula is perforated by three rows of puncta: the first being separated from the remaining two by a non-perforated space. The number of rows of puncta per band decreases abvalvarly.

Although *Nitzschia frigida* and *N. stellata* form arborescent colonies, the shape of their respective valves is different and this feature can be used to differentiate between the two. Upon closer examination the structure of the valve and the arrangement of decreasing number of rows of pores on the girdle bands are identical and these two taxa must be closely related, despite being geographically separated. Therefore, reports of *N. frigida* from the Antarctic by Heiden and Kolbe (1928) from the Gauss Expedition material, by Everitt and Thomas (1986), and by McConville and Wetherbee (1983) are misidentifications of *N. stellata*.

Nitzschia taeniiformis Simonsen 1987, p. 452, pl. 673, figs. 1–6.

Synonym: *Nitzschia taenia* Hustedt 1958, p. 180, Fig. 195 non *Nitzschia taenia* W. Smith 1853.

Type Locality: 69°43'S, 06°30'E.

Lectotype: BRM W5/23 and *Isolectotype* BRM 276/100b (Simonsen 1987, p. 452).

Material Examined: Hustedt Collection type slide BRM 276/100b; Heiden slides BRM 283/90, 283/91, 283/92 and 284/1; Quad 1, 1–7; IMBB samples 58(10), 1592 and 2486.

This species was first described by Hustedt (1958) from single valves seen in the stomach contents of salps near Adélie Land and along the coast of Queen Maud Land (04°25'W and 06°30'E), Antarctica. It has been recently renamed by Simonsen (1987) because the specific epithet was already occupied.

Cells occur in short chains of up to ten cells formed by the interlocking of the keels of the cells along most of their length except at the apices (Fig. 11A, B). A similar type of ribbon colony formation has been reported for *Nitzschia hybrida* Grun. found attached to the ice in the Karajakfjord (Gran 1897). We also have reported *N. pellucida* Grun. from ice cores in the Arctic forming similar colonies (Medlin in Medlin and Priddle, in press).

The valves are strongly convex and tend to lie on one face, i.e., in girdle view (Fig. 11C, D). Hustedt (1958) described the valve shape not unlike a "bracket". The valve faces on either side of the central raphe system are in close proximity to each other and are spanned by robust fibulae. Once the two faces have been braced by the fibulae, they flare away from each other at about a 45° angle (Fig. 11E, F).

The punctate striae extend across the face stopping at the keel where there is a groove on one side of the raphe slit and on the other side a rib and flange (Fig. 11E–H). The outer canal wall is perforated by a single row of puncta on either side of the raphe slit. The striae do not extend exactly to the valve margin and this non-perforated area has been called the marginal strip by Mann (1978).

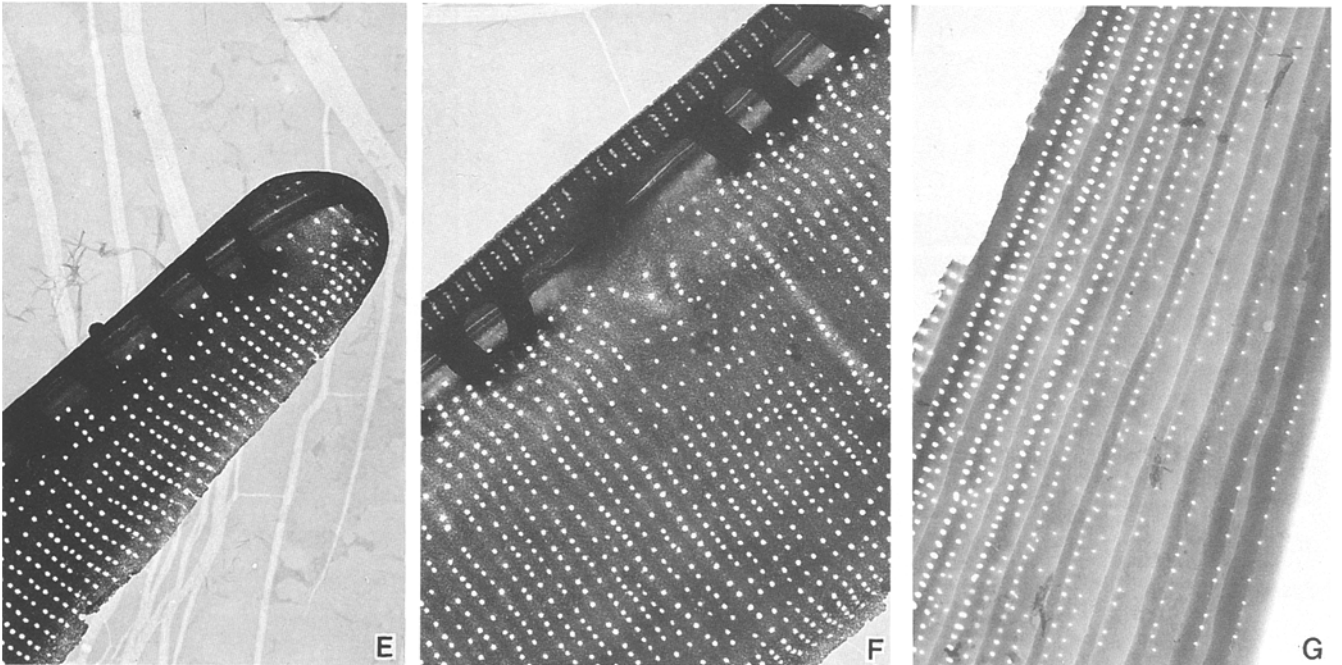
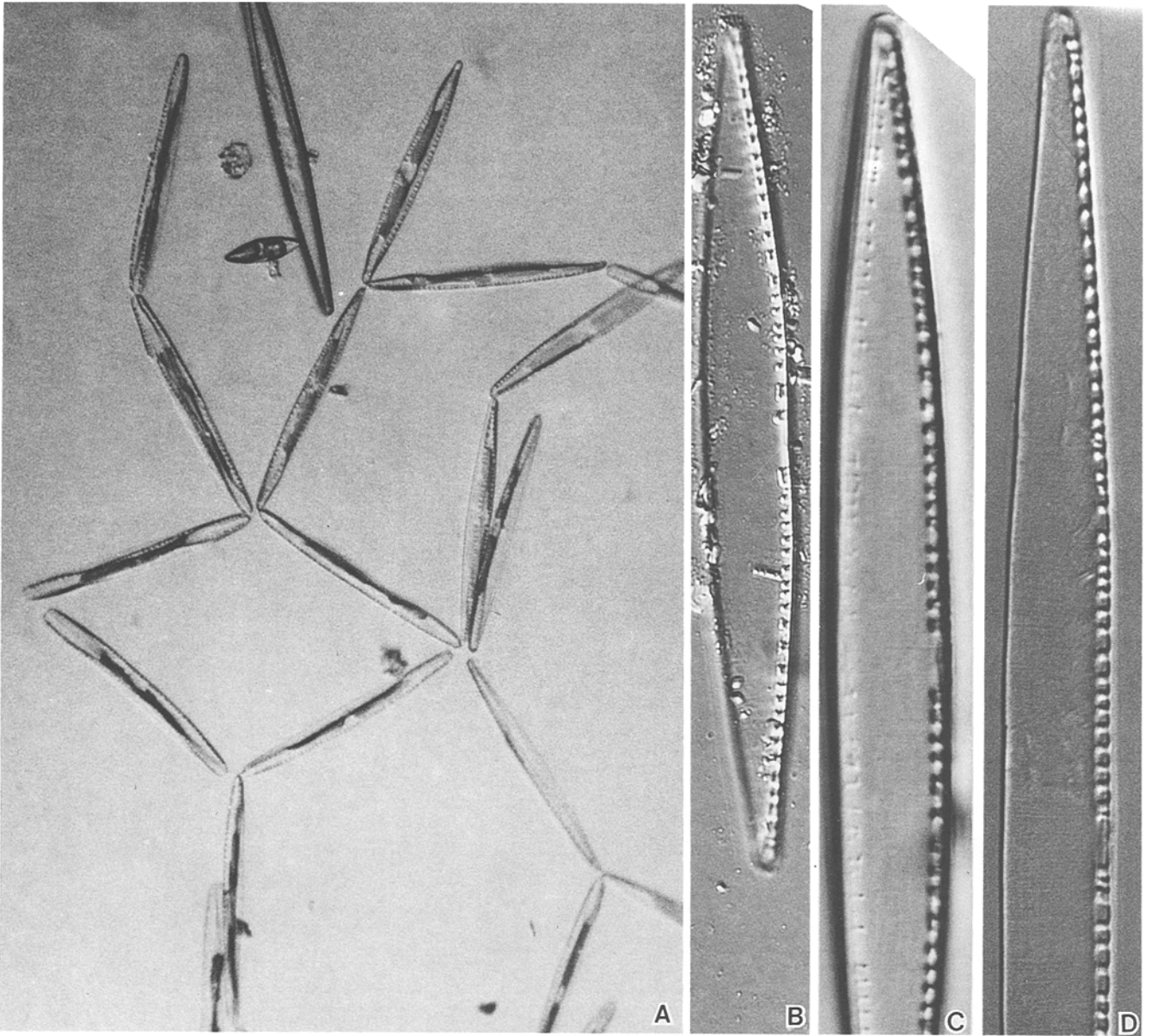
The raphe slit runs atop a prominent keel and is interrupted by a central nodule (Fig. 11C, D, I). The frustule is slightly depressed here. The terminal fissures curve towards the grooved side of the raphe (Fig. 11F). Internally a small helictoglossa can be seen (Fig. 11E). Colony formation is accomplished by the interlocking of the flanges of adjacent cells. Note that both "left-hand" central nodules are in focus in this short chain of *N. taeniiformis* (Fig. 11B).

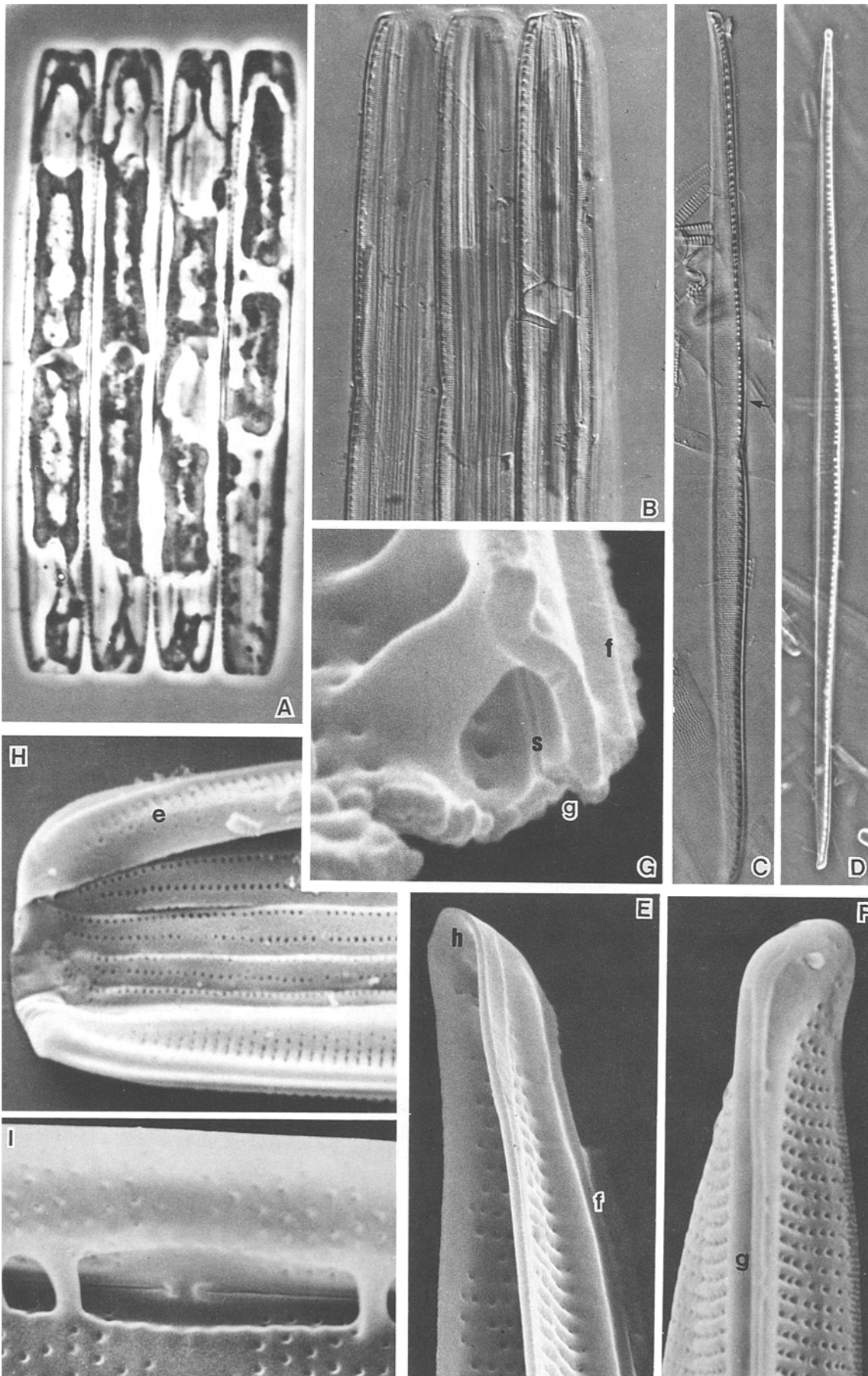
The few intact cells encountered in the samples possess numerous bands. A wide non-perforated space separates the two rows of regularly spaced puncta (Fig. 11H).

N. taeniiformis was present on several slides in the Heiden collection from the Gauss Antarctic Expedition. We think that *N. taeniiformis* was identified as *N. laevis-sima* by Heiden and Kolbe (1928), but as this species is not illustrated, we cannot be sure of the identification. However, *N. taeniiformis* is quite abundant on several of these slides (e.g., 284/1) and it seems doubtful that Heiden would not have identified it. The only species cited in Heiden and Kolbe that could be mistaken for *N. taeniiformis* is *N. laevis-sima* and this species is listed as being present on all of the slides that we examined which contained *N. taeniiformis*. Some of the specimens on these slides are slightly long and twisted and this is probably

Fig. 10. *Nitzschia stellata*. A Arborescent colony, BF, Cape Armitage, $\times 300$. B Valve view, type slide, PC, Terre Adélie $\times 1000$. C Valve view, striation just visible, NIC, lectotype material, Manguin slide 1, $\times 2000$. D Valve view, NIC, Cape Armitage, $\times 2000$. E Detail

of valve apex, TEM, Cape Armitage, $\times 7500$. F Detail of central nodule, note irregular striation, TEM, Cape Armitage, $\times 10,000$. G Detail of 9 bands, each with rows of puncta decreasing abvalvarly, TEM, Cape Armitage, $\times 10,000$





what has prompted the identification of this taxon as *N. laevis*. We have found a few specimens slightly resembling *N. taeniiformis* from IMBB sample 1014 from Newfoundland, but without SEM observations we are unable to exactly determine the raphe position. These cells are slightly wider than *N. taeniiformis* and may be very large cells of *N. hybrida*.

Nitzschia neglecta Hustedt 1958, p. 175, pl. 13, figs. 162–164.

Synonym: *N. angularis* var. *tenuistriata* Van Heurck 1909, p. 19, pl. 3, figs. 60, 61; *Nitzschia spec?* Van Heurck 1909, pl. 3, fig. 58.

Non Nitzschia dippelii Grun. sensu Krammer and Lange-Bertalot (1988, p. 66, pl. 52, Figs. 3–5, pl. 53, Fig. 1–6, 8).

Type Locality: 69°43'S, 06°30'E.

Holotype: BRM 276/99b.

Material Examined: BRM Hustedt Collection type slide 276/99b; BRM Heiden slide 283/96; Ant II/4, core 5; Ant III/3, core 6c and 7, IMBB 2596.

This species was originally described as *Nitzschia angularis* var. *tenuistriata* by Van Heurck (1909) from ice. His fig. 60 and 61 depict this cell in valve view and fig. 58 is the girdle view of the same species, although van Heurck lists it as *Nitzschia spec?*. Hustedt (1958) found it in the stomach contents of salps and gave it the name *neglecta* because the specific epithet *tenuistriata* was already occupied and because the presence of a central nodule precluded it from remaining a variety of *N. angularis*.

Cells do not form colonies. The frustule is broadly rectangular in girdle view and slightly pinched in at the central nodule (Fig. 12A, C, D, G). The valves are asymmetrically placed in the frustule. The valve faces either side of the raphe are not the same width (Fig. 12F). The valves are arranged so that on one girdle side the wide side of one valve is placed with the narrower side on the opposing valve so that the frustule is symmetrical (Fig. 12D).

The valves are linear-lanceolate to lanceolate with small rostrate apices (Fig. 12B, F). The mantle is deepest at the apex so that when the valves lie in girdle view, the apex is rectangular (Fig. 12C). The valve is sharply angled up towards a prominent central keel which bears the raphe (Fig. 12G, I, J). No conopeum is formed.

The striae, composed of poroid areolae (puncta), are parallel and can be randomly occluded particularly around the central nodule (Fig. 12J). They continue into the outer canal wall, while a narrow marginal strip is left unperforated around the mantle edge (Fig. 12G, I).

The raphe runs along a prominent keel formed by the angled up sides of the valve. The two sides of the external fissure of the raphe are unequal in height and one side

protrudes above the other to form a narrow flange (Fig. 12G, H). The terminal fissures continue down over the valve apex and curve slight to one and the same side of the valve at each apex (Fig. 12E). A small helictoglossa is formed internally just beyond the valve apex in the mantle. The raphe system is interrupted by a central nodule and the distance between the two fibulae on either side of the central nodule is quite distinct (Fig. 12J). The valve is depressed at the central nodule towards the widest valve face. Thus the central nodule is depressed in opposite directions on opposing valves.

The raphe system is spanned internally by wide, irregularly spaced fibulae, which lie more or less flush with the valve surface but attached to a narrow strip of silica running along both sides of the raphe (Fig. 12J). This strip of silica can be seen with LM, a feature noted earlier by Hustedt (1958). This arrangement of the fibulae enables the keel to protrude above the valve surface. The last fibula before the apex is quite broad (Fig. 12I).

The cingulum is composed of at least six punctate bands (Fig. 12H). The valvocopula has two rows of puncta next to the pars interior followed by a non-perforated strip, then three to four additional horizontal rows of puncta aligned into equally spaced vertical rows. At the apex the first two rows end and the vertical rows become randomly orientated to perforate the ligulae of the band. Internally the vertical arrangement of these rows is more distinct because the non-perforated strip separating not only the vertical rows but also the two major areas of horizontal rows is strongly silicified.

Each subsequent band has more or less the same construction but the number of rows in each band decreases abvalvarly. The last band has only one row of puncta separated by a non-perforated space and beneath it, the puncta are randomly arranged.

This species is quite distinct and would be difficult to confuse with other species especially if seen in girdle view. The species identified as *N. polaris* by Krebs (1983) from Antarctic waters is of a lanceolate cell and is *N. neglecta*.

Krammer and Lange-Bertalot (1988) have put *N. neglecta* in synonymy with *Nitzschia dippelii*. However this cannot be upheld because *N. neglecta* has a central raphe subtended by broad, but thin fibulae attached to a strip of silica along side of the raphe, while *N. dippelii* has a slightly eccentric raphe subtended by narrow, but thick fibulae attached directly to the valve surface. *N. dippelii* occurs in inland saline ponds.

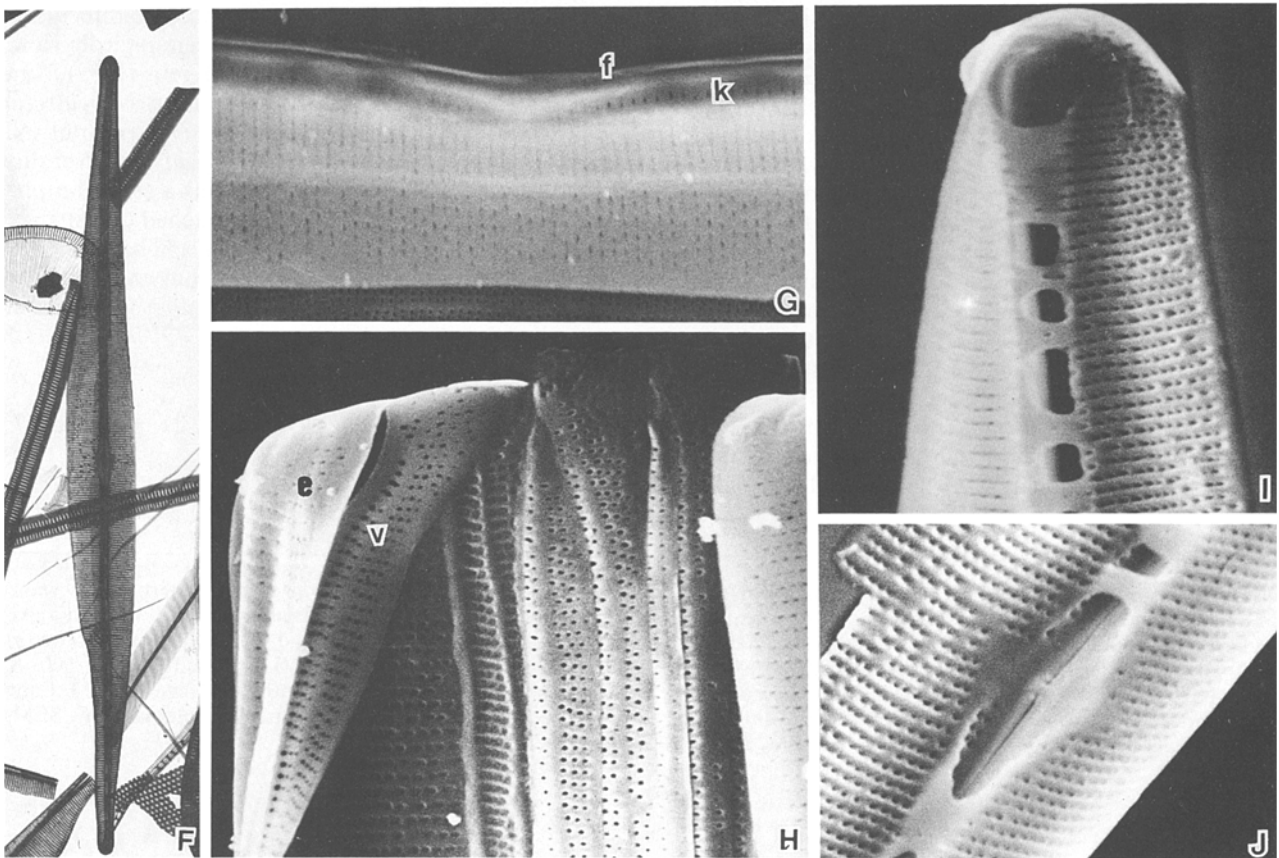
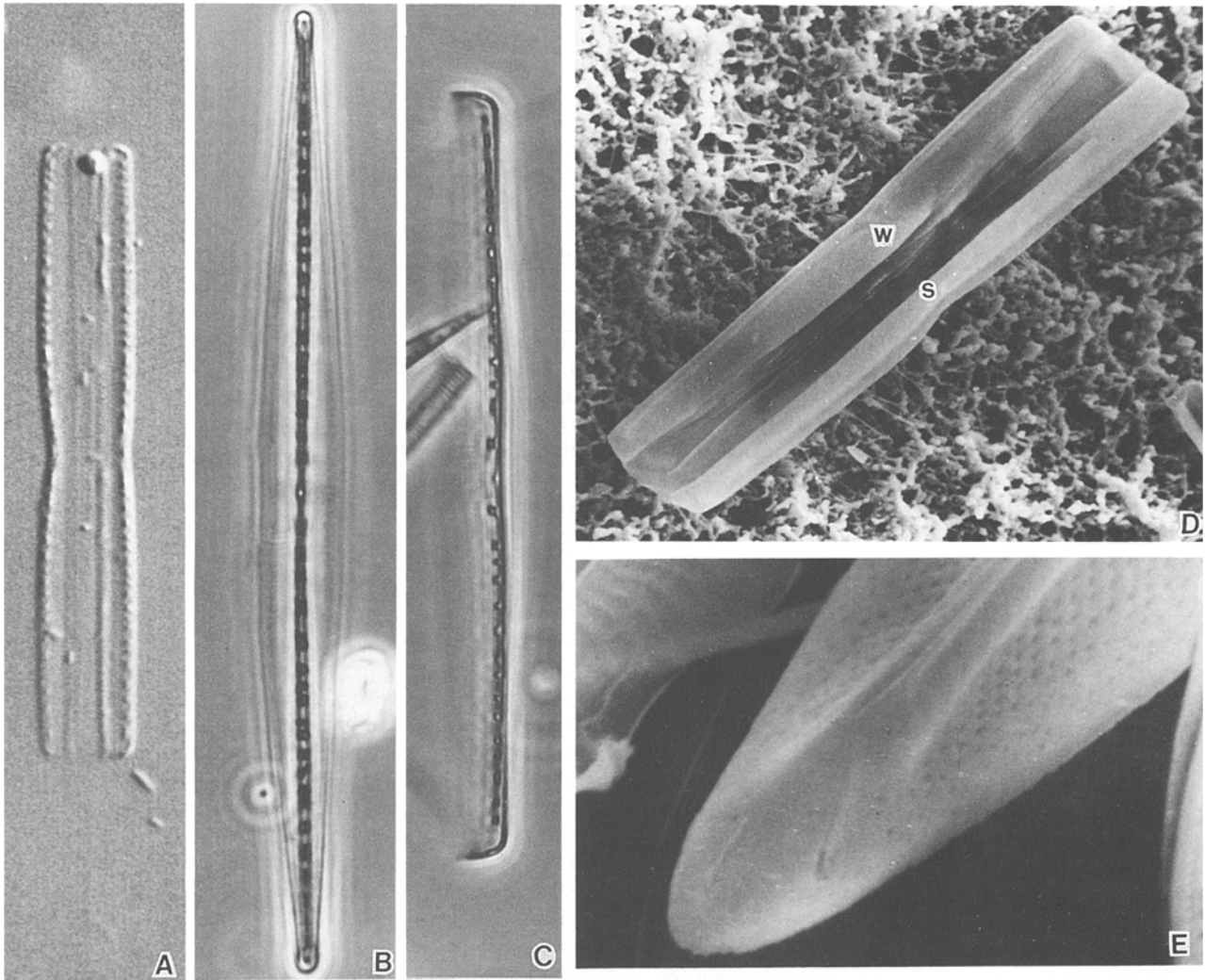
Nitzschia lecointei Van Heurck, 1909, p. 21, pl. 3, fig. 57.

Type Locality: 65°15.5'S, 64°30.0'W.

Material Examined: IMBB 2596.

Fig. 11. *Nitzschia taeniiformis*. *A* Four-celled ribbon colony, apices free, PC, Cape Armitage, $\times 1000$. *B* Three-celled colony, note central nodule of both cells are in focus, NIC, Cape Armitage, $\times 1000$. *C* Girdle view, valve folded along raphe, NIC, IMBB 1592, $\times 1000$. *D* Girdle view, NIC, IMBB 1592, $\times 1000$. *E* Detail of valve apex, internal view, note valve flange (*f*) and the helictoglossa (*h*) just barely visible because of the convexity of the valve SEM, Cape

Armitage, $\times 10,000$. *F* Detail of valve apex, external view, note groove (*g*) beside raphe, SEM, Signy Island, $\times 7800$. *G* Detail of valve fracture at the raphe, internal view, note flange (*f*) and groove (*g*) beside external raphe slit (*s*), SEM, Cape Armitage, $\times 30,000$. *H* Detail at valve apex, epivalve (*e*) at top with 4 bands, SEM, Cape Armitage, $\times 6600$. *I* Detail of central nodule, internal view, SEM, Signy Island, $\times 10,000$



The morphology and ecology of this species has been discussed in detail by Hasle (1964) and we have included here only additional information on valve variation and girdle band construction.

This species has been reported forming gelatinous tubes underneath the sea ice by Watanabe (1988) but we have not seen such tubes in this sample from Signy Island nor did Hasle (1964) see this in any of the Brategg samples she examined from the Southern Ocean.

Hasle (1964) has illustrated the change in valve shape throughout the size range of this taxon. Despite its delicate appearance with LM, the valve margins and the area around the central nodule are always distinct (Fig. 13A, B, E). With TEM these features appear to be areas of heavier silicification (Fig. 13B, E). A heavy deposit of silica also appears along side of the raphe beneath the fibulae (Fig. 13B, E). The exact nature of these areas and their variation can be seen with SEM.

In those cells that are heavily silicified (e.g. Fig. 13D, F, H, J), the following characters are well developed. A ridge of silica occurs along the valve margin opposite the raphe, which makes this side of the valve appear distinct with LM. If this ridge is formed, then the distal mantle will also be well demarcated from the valve face (Fig. 13H). If not, then the valve face will tend to slope gently into the distal mantle (Fig. 13I). In heavily silicified valves, the central nodule is quite prominent and protrudes above the valve surface (Fig. 13H). The distal side of the central nodule is perforated by two-three enlarged pores. The central raphe endings are very closely spaced (Fig. 13H, I). A siliceous rib also runs along side the raphe for its entire length (Fig. 13B, E) and can be easily seen externally in heavily silicified valves (Fig. 13F) but not in those more weakly silicified (Fig. 13G). In heavily silicified valves, the poroid areolae have smaller openings and are occasionally randomly occluded (Fig. 13H). In both types of valves, the row of puncta perforating the outer canal wall appears slightly larger than those in the corresponding stria and also slightly displaced from that stria. Each punctum is closed near the external valve surface (Fig. 13J) with a row of randomly scattered pores (Fig. 13E).

The cingulum is composed of three bands, each containing one or two rows of puncta separated by non-perforated space (Fig. 13J).

Auricula compacta (Hust.) Medlin comb. nov.

Basionym: *Nitzschia compacta* Hustedt 1958, p. 169 fig. 160; Simonsen 1987, p. 450, pl. 670, fig. 1.

Type Locality: 69°43'S, 06°30'E.

Holotype: BRM 276/100b.

Material Examined: BRM Hustedt Collection type slide 276/100b; Heiden slides 283/90, 283/92 and 284/1; Quad, 1, 1-7; IMBB samples 2589, 2596 and 2707.

This species was originally described as a member of the genus *Nitzschia* by Hustedt who saw only single valves in the stomach contents of salps. Certainly single valves would be easily confused with *Nitzschia* because the cell symmetry which places this species in *Auricula* is destroyed with acid cleaning.

The frustule is asymmetrical with an elongated elliptic outline. Cells are depressed at the central nodule (Fig. 14F) in the narrow girdle view, while the broad girdle view is more elliptic (Fig. 14G). Valves may be presented in various aspects. Beginning at each apex the raphe branches traverse the valve face to meet at the central nodule on one valve margin (Fig. 14A-D). The raphe system essentially divides the valve into a broad (distal see Fig. 14E) and narrow (proximal) face (Fig. 14A). Isolated valves usually lie with the distal valve face uppermost and the proximal valve face hidden from view by being folded beneath the raphe (Fig. 14E).

The valve is highly vaulted with the raphe system lying atop the highest point (Fig. 14H, I). Here the fibulae brace the two valve faces to form the canal raphe (Fig. 14K). The external central raphe endings are deflected towards the broad valve face (Fig. 14J).

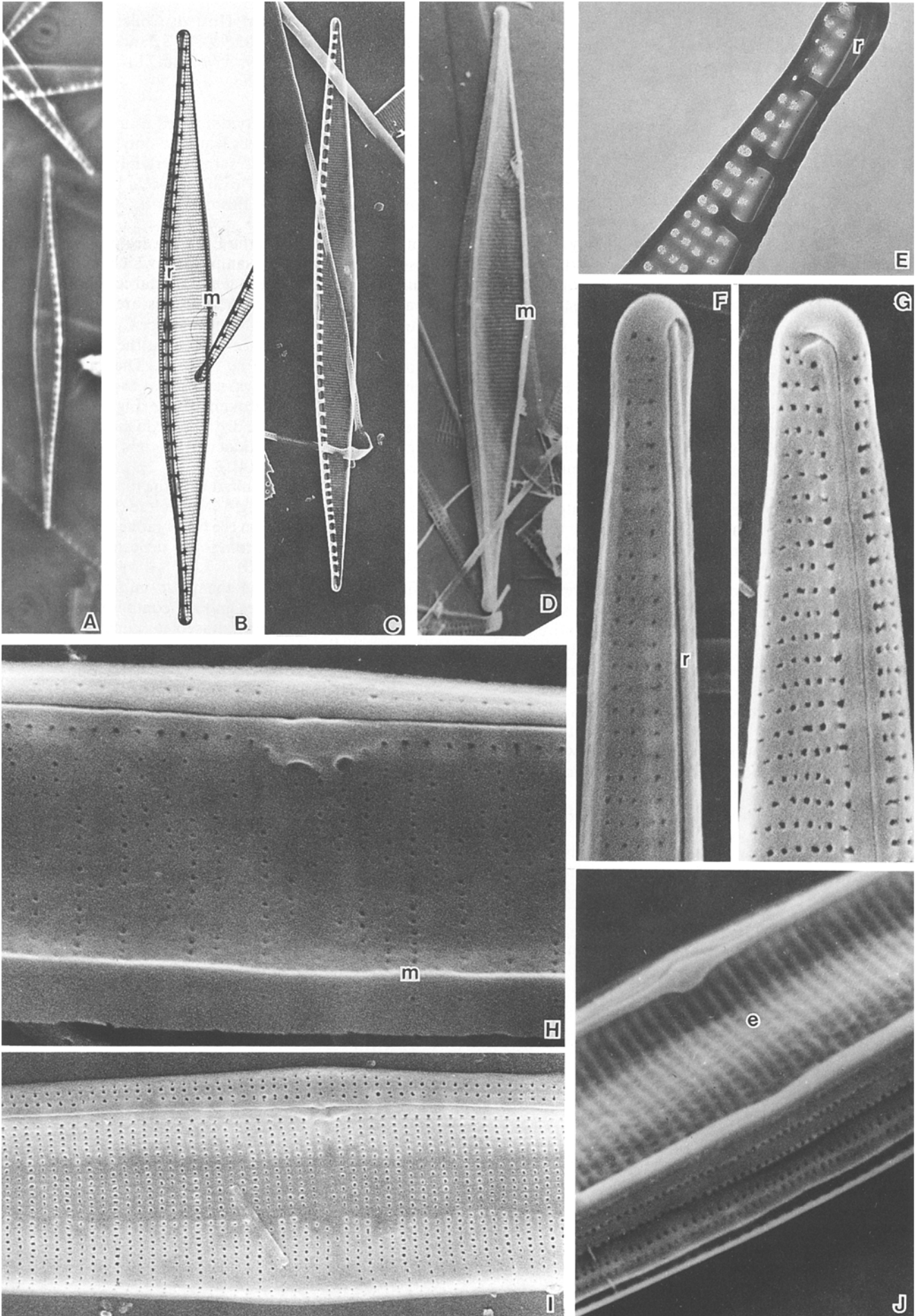
The striae, parallel in the valve midregion, become radiate towards the apices and are composed of a double row of small, regular poroid areolae (puncta) (Fig. 14L). This perforation pattern continues into the outer canal wall, but the perforation here is isolated from the valve striae by a rib of silica, which runs along both sides of the canal raphe and provides the attachment for the fibulae (Fig. 14K). The interstriae are more strongly silicified internally than externally.

The cingulum is composed of several open bands, each with one row of puncta. There may be fewer or perhaps narrower bands in the narrow girdle view than in the broad girdle view (unpublished observation).

This species occurs as single cells and was also present on the slides we examined from the Heiden Collection. We compared the distribution of each *Nitzschia* with the slides we examined and came to the conclusion that this species was probably misidentified as *N. hybrida* Grun. Again this species was not illustrated by Heiden and Kolbe (1928) and we cannot be sure how they identified it. *Auricula compacta* could possibly be misidentified as *N. hybrida* if it were seen in the narrow girdle view.

Fig. 12. *Nitzschia neglecta* all figures from IMBB 2596. *A* Girdle view, complete frustule, note valve depressed at central nodule, NM, $\times 1000$. *B* Valve view, note dark line on either side of the fibulae, PC, $\times 2000$. *C* Girdle, note rectangular valve apex, PC, $\times 2000$. *D* Complete frustule, note wide valve face (*w*) of one valve paired with a shallow face (*s*) of the opposite valve, SEM, $\times 1600$. *E* Detail of valve apex showing raised keel and terminal fissure of raphe, SEM, $\times 13,800$. *F* Valve view showing central raphe with valve faces of 2

widths, TEM, $\times 1300$. *G* External valve surface a central nodule, note raised perforated keel (*k*) and raphe flange (*f*), SEM, $\times 6000$. *H* Epivalve (*e*) with 5 bands, note different morphology of external and internal surface of the valvocopulae (*v*), SEM, $\times 1200$. *I* Internal view of valve apex, note small areolae and fibulae nearly flush with valve surface, SEM, $\times 7200$. *J* Internal view of central nodule, note perforations of canal wall and central raphe endings, SEM, $\times 7200$



Discussion

Species Distribution

One of the most common approaches to identifying species from new areas or habitats is to use existing literature from other, often comparable habitats. This has been a distinct problem in examining diatoms from both polar regions because most of the early descriptive works were done from Arctic material and these were then later used for identifying Antarctic material. Taxa have often been given the same name as their seemingly morphological Arctic counterpart. If the taxon in question is cosmopolitan, then it may well range into both polar regions. However, truly bipolar species are rare indeed and it is more likely that a new, closely related taxon is involved. This new taxon is simply described as a new variety of a previously described species, in this instance an Arctic taxon, e.g. *N. polaris* var. *antarctica* Per. In either case, careful examination of material from early polar expeditions as well as that more recently taken is necessary to ensure that exact species comparisons are made and the addition of superfluous taxa is not made.

If a taxon exhibits a particular shape or distinctive colony formation, it has often been assumed that this feature can be used almost exclusively to identify that taxon. Because of this assumption, rarer forms are often included in the distribution of more cosmopolitan taxa, e.g., *Lithodesmium intricatum* (West) H. & M.Per. with *Lithodesmium undulatum* Ehrenb. (Von Stosch 1980), and *Rhizosolenia phuketensis* Sund. with *Rhizosolenia stolterfothii* H. Per. (Sundström 1980) and extensive recordings of various *Nitzschia* spp. of the marine planktonic section *Pseudonitzschia* as *N. seriata* Cleve (Hasle 1972).

This certainly seems to have occurred in some of the taxa we have studied here. Identifications of *Nitzschia frigida* from the Antarctic (see above) must have been based on the similarity of the colony formation between *N. frigida* and *N. stellata*. Enough differences were found between the two diatoms to maintain them as distinct species rather than placing *N. stellata* as a variety of *N. frigida*. *Nitzschia taeniiformis* and *Auricula compacta* were present in the material we examined from the Gauss-Expedition but, we presume, cited by Heiden and Kolbe (1928) under different taxa based on the distinctive shape of those species, i.e. *N. laevisissima* and *N. hybrida*, respectively. Similarly, the sigmoid *Nitzschia scabra* from the Arctic ice has probably been identified as the sigmoid *N. sigma* or *N. sigmoidea* from the littoral and the linear hyaline *N. polaris* from the Arctic confused with the lanceolate hyaline *N. neglecta* from the Antarctic.

Slowly, the situation of distinguishing between Arctic and Antarctic taxa is rectifying itself as detailed examinations of species from each region are completed. In our examinations we were able to question the report of four Arctic species, *Nitzschia frigida*, *N. polaris*, *N. laevisissima*, and *N. hybrida* as being present in the Antarctic. However, we have only begun a more extensive examination of fast ice-associated *Nitzschia* species from Antarctic material.

Of the species studied here only *Nitzschia frigida*, *N. laevisissima*, *N. promare*, and *Hantzschia weyprechtii* were present in the ice and plankton samples we examined from the Barents Sea in the Eurasian sector of the Arctic. Most of the plankton samples in which these species occurred were taken near the marginal ice zone in more open water sites. These same species are commonly reported from the North American sector of the Arctic (Grøntved 1950; Horner and Schrader 1982; Hsiao 1983; Østrup 1895; Poulin and Cardinal 1983). The remaining species, *N. neofrigida*, *N. polaris*, *N. brebissonii* var. *borealis*, and *N. arctica* were predominant in samples or reported from the literature (e.g. Cleve 1883, 1896; Hsiao 1983; Østrup 1895; Poulin and Cardinal 1983) from the North American sector of the Arctic, particularly in sites located closer to land. The only report of any of these species from the Eurasian sector of the Arctic is that of *N. arctica* by Jørgensen (1905) from northern Norwegian fjords, again in sites located closer to land. We also found one valve of *N. scabra* in the plankton samples taken in Kings Bay, Spitzbergen. It appears that these six species may be part of a more littoral community, but it is difficult to be more precise in their distribution because of the bias of the samples we examined. We have no samples from the Russian coast between Mys Vakarem and Franz Josef Land as well as few littoral ice samples from the northern coast of Norway. The first four species appear to be circumpolar in distribution and more abundant in ice and in plankton samples taken near the marginal ice zone in more open water.

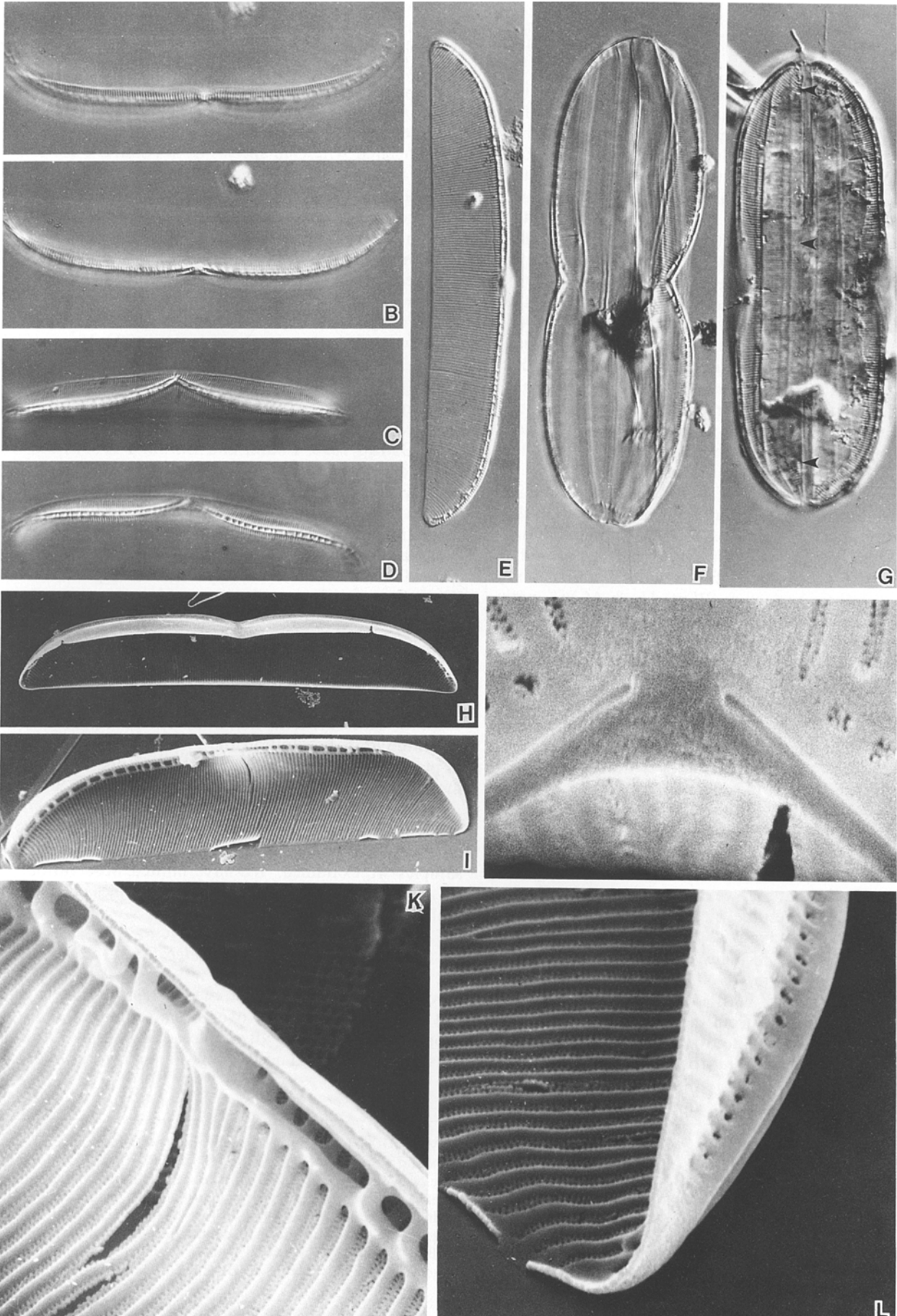
In the Antarctic, *Nitzschia stellata*, *N. taeniiformis*, *N. lecointei*, and *Auricula compacta* appear to have a circumpolar distribution, being present in all of the fast ice samples we examined. We have limited observations of *N. neglecta* and it is absent from the samples collected in Halley Bay and in the Ross Sea.

Taxonomic and Systematic Considerations

Another aim in taxonomic studies such as we have carried out is to contribute to the overall understanding of major groups, in this case the Nitzschiaceae. The genus *Nitzschia* Hass. is very much in need of revision and works by Hasle

Fig. 13. *Nitzschia lecointei*. *A* Valve view, note well defined valve outline, PC, IMBB 2596, $\times 2000$. *B* Valve view, note distinct raphe rib (*r*) and marginal ridge (*m*), IMBB 2596, $\times 3500$. *C* Internal valve view, note evenly spaced fibulae, SEM, IMBB 2589, SEM, $\times 2400$. *D* External valve view, note marginal ridge (*m*), IMBB 2589, SEM, $\times 3800$. *E* Detail valve apex, note raphe rib (*r*), marginal ridge, and rica detail in areolae, IMBB 2596, TEM, $\times 20,000$. *F* Detail valve apex, external valve view with distinct raphe rib (*r*), IMBB 2596,

SEM, $\times 20,000$. *G* Same as *F*, but without well developed rib, note proximal mantle, IMBB 2589, SEM, $\times 20,000$. *H* valve mid-region, note well developed central nodule raised above valve surface, distinct valve marginal ridge (*m*) and enlarged pores along outer raphe canal wall, IMBB 2596, SEM, $\times 20,000$. *I* Same as *H*, except central nodule weakly developed, marginal ridge not developed, IMBB 2589, SEM, $\times 10,000$. *J* Detail of central nodule and bands attached to the epivalve (*e*). IMBB 2596, SEM, $\times 12,000$



(1964, 1965a, b), Lange-Bertalot (1976, 1980), Lange-Bertalot and Simonsen (1978), and Mann (1978, 1986) have certainly made a start. As seen in these works, some sections of *Nitzschia*, such as *Fragilariopsis*, *Pseudonitzschia*, *Tryblionella*, *Panduriformes*, and the subgenus *Nitzschia* including the sections *Nitzschiae* and *Spathulatae*, are quite well defined with distinct valve structures, such as number and kinds of areolae, presence of a conopeum and/or colony formation as the defining characters. Others in the genus, such as sections *Lanceolatae*, *Lineares*, *Vivaces* and *Nitzschiella* as one group and *Bilobatae* and *Dubiae* as another, tend to grade one into another and there is little strong morphological evidence, at present, to split them into distinct entities.

From our studies, we can place some of the taxa we have examined from *Nitzschia* into a well-defined section. There is no doubt that *Nitzschia scabra* belongs in the subgenus *Nitzschia*, section *Nitzschiae* (Mann 1986). It possesses an uninterrupted sub-central raphe with a conopeum and is sigmoid in girdle view. Its girdle bands with numerous punctate rows allies it with the section *Spathulatae*, another section in this subgenus that also has a conopeum. Obviously within this distinct subgenus, characters, such as raphe position and valve symmetry, are more important in defining distinct sub-groups, while the development of the conopeum and structure and number of girdle bands will tend to vary between species although they are included in the range of characters that define the subgenus as a whole, e.g., the conopeum, the lack of a central nodule, and the possession of numerous punctate girdle bands (Mann 1986; Lobban and Mann 1987).

Another taxon, *Nitzschia brebissonii* var. *borealis* was also placed in the section *Nitzschiae* by Cleve (1883). Our studies show that it lacks the features necessary to place it here. This taxon is not sigmoid in girdle view, but only tends to be enlarged in the mid-region of the frustule because the valve tapers to quite narrow apices. This may give the impression of being sigmoid when viewed from this aspect. All other valve features, e.g. the curvature of the valve up towards a central raphe, the external rib accompanying the raphe along its length, the shape of the fibulae, and the lack of a central nodule as well as a conopeum, tend to ally it with the genus *Bacillaria*, an observation made earlier by Østrup (1895) when he described this same species as *Bacillaria socialis* var. *septentrionalis*. As far as we are aware, this species does not form colonies characteristic of the genus *Bacillaria* Gmel. We have also seen *Bacillaria socialis* var. *kariana* Grun. with similar valve morphology from the inner Oslofjord but with no observations on colony formation. An as yet unidentified species of *Bacillaria* has been seen with its distinctive colony formation in benthic samples taken

from Signy Island (Gilbert, personal communication). It may be more satisfactory to define the genus *Bacillaria* using frustule morphology if it proves that the distinctive colony formation heretofore used to define it is only a specific character e.g., found in *Bacillaria paxillifer* (Müll.) Hend., *Bacillaria socialis* (Greg.) Ralfs, and *Bacillaria linkei* (Hust.) Mann. We feel that this issue can only be settled by genetic evidence to support or refute this observation. *Nitzschia brebissonii* var. *borealis* remains in *Nitzschia* without an appropriate section to which it can be assigned.

The sigmoid *Nitzschia laevisissima* presents another problem because it cannot be allied with any sigmoid section as they are presently defined. It lacks the conopeum of the section *Nitzschiae* (Mann 1986). Its central raphe endings are not deflected as in the section *Obtusae* (Germain 1986) and it possesses a central nodule which precludes it from being placed in the other sigmoid section *Sigmata*. As Mann (1978) has already pointed out there are several other sigmoid species, like *Nitzschia laevisissima*, which cannot be relegated to well-established sections and may form a fourth natural sigmoid grouping.

Nitzschia neofrigida, *Nitzschia polaris* and *Nitzschia taeniiformis* form a cluster that have a centrally positioned raphe accompanied by a rib or flange and the raphe is interrupted by a central nodule. The structure of the girdle bands in these taxa is virtually identical. These taxa can probably be assigned to the section *Dubiae* (containing *Bilobatae* see Mann 1978, 1986 for review). Thus, both arborescent and ribbon colonies would be found in this section. Those forming ribbon colonies do so by interleaving the flanges of sister valves, found in at least three species of this section.

Nitzschia neglecta also possesses a central raphe system with a small flange that is formed by the uneven openings of the raphe fissure. The raphe fissure is interrupted by a central nodule. This taxon is probably best placed in the Section *Dubiae* although its girdle bands ally it more closely with the Section *Spathulatae*. However, it lacks the conopeum and absence of a central nodule that would allow it to be placed here. The superficial resemblance of this taxon to this section as seen with LM is noted by the fact that *N. neglecta* was first described as a variety of *N. angularis* Wm. Smith.

The remaining four taxa studied here, *Nitzschia frigida*, *N. stellata*, *N. promare*, and *N. arctica*, must be placed in the Section *Lanceolatae* (including *Lineares* as proposed by Lange-Bertalot and Simonsen 1978) as it is presently defined, although the girdle band structure of *Nitzschia arctica* is close to the cluster of species above assigned to *Dubiae*. We can offer no new information to help separate the continuum in valve structure seen in these sections. No

Fig. 14. *Auricula compacta* all figures from Cape Armitage. *A* Proximal valve view, NIC, $\times 1000$. *B* Central nodule seen from proximal valve view, NIC, $\times 1000$. *C*. Central nodule seen from distal valve view, NIC, $\times 1000$. *D* Canal raphe, focus across valve, NIC, $\times 1000$. *E* Distal valve view, NIC, $\times 1000$. *F* Complete frustule, proximal valve face in focus, broad girdle view, NIC, $\times 1000$. *G* Complete frustule, distal valve face in focus (arrows point to edge of valve), narrow girdle view, NIC, $\times 1000$. *H* Internal valve view, showing

both proximal and distal valve faces, SEM, $\times 1500$. *I* Internal valve view, valve tilted to view canal raphe, SEM, $\times 1500$. *J* External valve view of central raphe endings and striae and canal raphe areolae, SEM, $\times 20,000$. *K* Detail of *I*, at central nodule, note ridge of silica separating canal wall from the valve face, SEM, $\times 10,000$. *L* Detail of valve apex showing striae composed of two rows of poroid areolae, SEM, $\times 10,000$

real differences can be seen in the valve structure of these four taxa as compared with that of other taxa already placed in this section. As more species are studied with electron microscopy, it may be possible to find natural groupings within this rather large and unsatisfactory defined section.

Nitzschia lecointei has been placed in the section *Nitzschiella* by Hasle (1964). Certain valve features, such as the raphe rib and marginal ridge have been found in other *Nitzschia* species belonging to the section *Lanceolatae* and this only serves to underline how ill-defined some of the *Nitzschia* sections are.

The remaining two species studied here, *Auricula compacta* and *Hantzschia weyprechtii*, can easily be confused with the genus *Nitzschia* if whole cells are not seen because single valves do not exhibit the strong asymmetries characteristic of their respective genera that would aid in their identification. *A. compacta* represents the first recording of this genus from sea-ice samples.

As with all of the species studied here, we had to rely on information from whole cells as well as that from cleaned preparations in order to establish the boundaries of each species. Colony formation helped us in several instances to delineate taxa. The type of colony formation does not appear to be restricted to one particular section as it does for the sections *Fragilariopsis* and *Pseudonitzschia*.

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