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Pioneers of Plankton Research: Eugen Jørgensen (1862-1938)

Among those of us who work on dinoflagellates, ciliates or radiolaria of the marine plankton, the name Eugen Jørgensen (fig. 1) may ring a bell. However, you might think it is spelled Jörgensen, or Jorgensen, or Joergensen as he wrote in Norwegian, German and English. He authored several important monographs on different groups of marine microplankton in the early 20th century. What is little known, even among those of us who know his work, is that Jørgensen was actually an unlikely plankton researcher. Like many of us in the field today, he came to work on plankton almost accidentally. When he began working on plankton, his expertise and a professional position were completely unrelated to plankton research. However, at the age of 36, he became seriously taken with microplankton, and subsequently spent nearly the next three decades working on various studies, and oceanographic expedition reports. Hence, Jørgensen's story is, I believe, one we can relate to. Here I will give a sketch of his life from middle school teacher, to renowned expert on Arctic flora, and finally, an authority on microplankton. The following account of the events in Jørgensen's life and career are based on the memorial biography of Jørgensen by Holmeboe (1939) and statements in Jørgensen's publications.

Jørgensen was born on the 29th of November 1862 in Oslo, the son of a merchant. He attended the prestigious upper secondary school, the Oslo Cathedral School. He was said to have been drawn early on to botanical studies. Jørgensen graduated in 1880 and by 1887 he became *Candidatus realium* (roughly equivalent to an M.S.), permitting him to be a school teacher. Whether due to the availability of jobs or by choice, as a young man, he changed jobs frequently. He at first first worked in the Arctic, beginning in a middle school in Tromsø, just above the Arctic circle in Western Norway and he then taught at the Hammerfest middle school, in the northern most city in world for three years. Subsequently, he taught at the middle school of Sandefjord in the south east of Norway, and then in 1892, he took a post at the Christiania Burgher School, near Oslo. It functioned as preparatory school for the Oslo Cathedral School, his alma mater. It was not until 1894, Jørgensen, at age 32, moved to his final home in Bergen on the West coast of Norway to take a post at the Bergen Cathedral School where he remained until his retirement in 1932.

Jørgensen's first publication was, perhaps not surprisingly on the flora of the Kaafjord region east of Tromsø (Jørgensen 1893). He convinced the Kristiana University College to provide him with a travel grant to more thoroughly explore the flora of region, at that time difficult to access. He traveled by flat-bottom boat, but mostly by hiking. Jørgensen produced a 100-page monograph on the flora (Jørgensen 1895), establishing himself as a botanist,

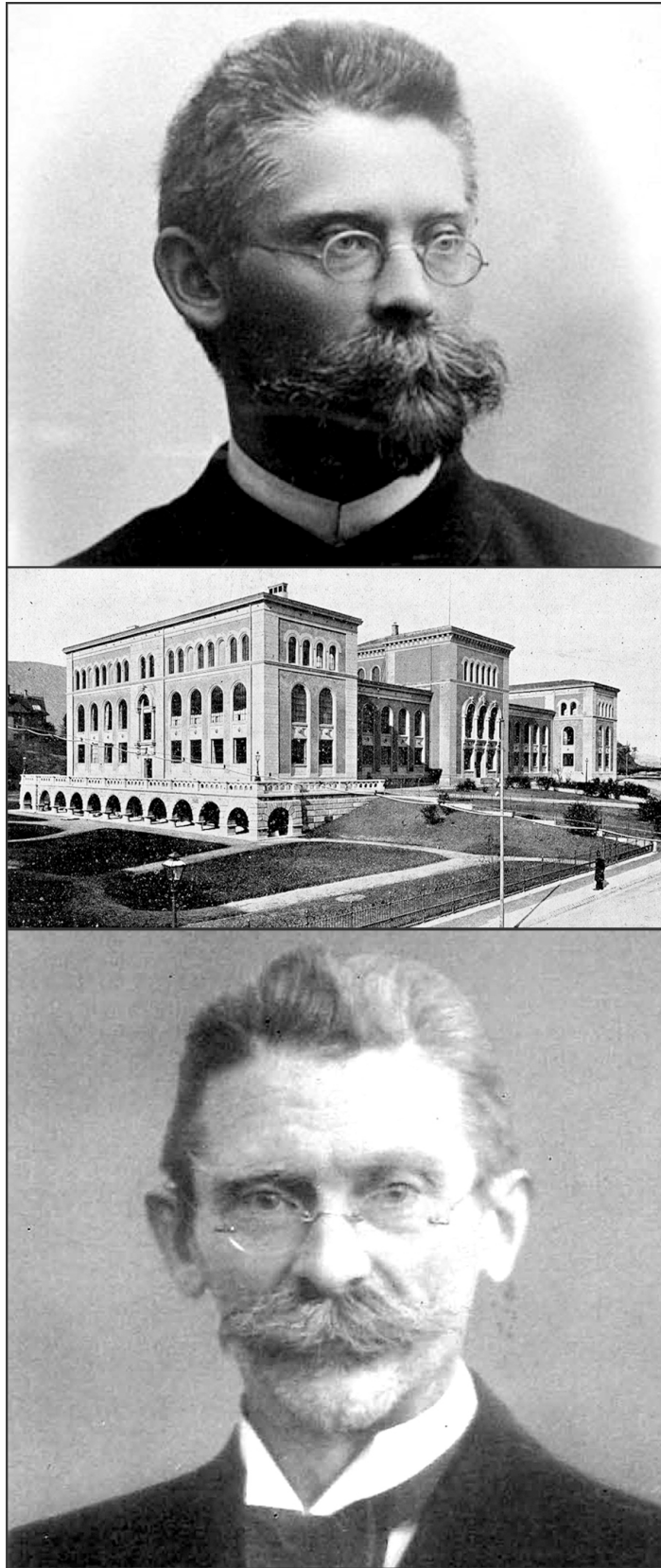


Fig. 1. Eugen Jørgensen ca. age 35 (top), Jørgensen's professional home, the Bergen Museum in 1898 (middle), and Jørgensen after retirement, *ca.* age 70 (bottom).

a specialist on arctic flora. In 1896 he published his first papers in the journal of the Bergen Museum (Jørgensen 1896a,b). 1898 was an important year for Jørgensen. He became a botanical research fellow of the Museum, receiving a stipend and office space. The Bergen Museum was an important institution and would become the University of Bergen. His botanical studies (e.g. Jørgensen, 1896c, 1902a,b, 1922) later established him as the world expert on Arctic mosses. His major botanical work, a book on Arctic Mosses (Jørgensen 1934) earned him the Fridtjof Nansen Award of the Academy of Sciences in 1935. However, 1898 was also an important year as it was apparently Jørgensen's first exposure to the microorganisms of the marine plankton. While he never earned any awards for his plankton work, they became his major heritage, at least in terms of citations, as we will see.

For many years, the renown polar explorer (and later inventor of the Hansen closing net- Hansen 1915), Fridtjof Hansen long had lobbied for the foundation of a marine station for the Bergen Museum, and the first was established in 1892 on Puddefjord in Bergen (Brattstrom 1967). Jørgensen's plankton studies began in 1898 with a request for aid from the then director of the Museum's Biology Station, Ole Nordgaard. The two men were, no doubt, acquainted. Like Jørgensen, Nordgaard was a school teacher but had been working at the Biological Station since 1892 as he was also, like Jørgensen, attached to the Museum (Brattstrom 1967). His specialty was benthic invertebrates but he also published on metazoan zooplankton (Nordgaard 1899a). In 1897 and 1898 he undertook extensive investigations of the fauna of the fjords near Bergen (Nordgaard 1899b) and in September of 1898 asked Jørgensen to examine the microplankton in plankton net samples. It is unclear why Nordgaard asked Jørgensen, the moss expert, to help with his samples. Perhaps Nordgaard considered the microplankton to be mostly a botanical group. At the time, diatoms and dinoflagellates, for example, were considered by many as belonging to the plant kingdom (e.g., Dolan 2024). Regardless of the Nordgaard's motivation, his request was granted and Jørgensen not only examined Nordgaard's samples, Jørgensen began gathering his own samples (Nordgaard 1899b).

There are at least two, non-exclusive, explanations for Jørgensen's abrupt turn towards plankton. The first, one with which we all familiar, is that he discovered the surprising beauty of the plankton (e.g. Dolan 2023a). The second is that is relative ease of field work on plankton in Bergen, especially compared to conducting studies of arctic flora. The Bergen Museum's Biological Station on the PuddeFjord was quite close to both the Bergen Museum, and the Cathedral School (Fig. 2.). Jørgensen would later, as a professional marine biologist, teach summer classes at the station (Brattstrom 1967).

From his first article on plankton concerning tintinnid ciliates (Jørgensen 1900a), it is apparent that Jørgensen had mastered the existing literature in French, German, and English. He knew



Fig. 2. A map of Bergen from 1907 showing the locations of the three work sites of Jørgensen. A is the Cathedral School where he taught, B is the Bergen Museum, and C is the Biological Station of the Bergen Museum on the Puddefjord. The Biological Station was only about 1.5 Km from the Bergen Museum. The plankton of the Puddefjord was at Jørgensen's doorstep, in contrast to the distant arctic flora.

well the landmark work of Claparède and Lachmann on protists (Claparède and Lachmann 1858-1860), and its shortcomings. It was based largely on their observations made in the fjords near Bergen in 1855 during a 3 autumn month field expedition (Dolan 2021). Theirs was the first major study of marine protists, and in the 50 years since its appearance, the literature on marine protists had grown enormously, including literature on tintinnid ciliates. However, the protist fauna of Western Norway had not been investigated since their visit. At the Biological Station Jørgensen made observations on living specimens of tintinnids from the Puddefjord. However, his study was based largely on samples taken by Nordgaard surface using a Nansen net made with #20 Dufour silk (nominal pore size of 76 μm). He acknowledged that this net likely missed the smaller taxa. Jørgensen found 24 different forms of tintinnid ciliates, four of which he described as new species.

Jørgensen's second plankton study (Jørgensen 1900b), was a continuation of his study on tintinnid ciliates, but was a much

more ambitious project. Based on the same samples, he set out to produce an inventory, as complete as possible, of all of the "protopyhtes" (phytoplankton) and 'protozoans' of the plankton of the West Coast of Norway. He enumerated all of the diatoms, silicoflagellates, and dinoflagellates, the so-called protophytes), as well the radiolarians and tintinnids found in each of 137 plankton net tow samples taken from various depths in six sites of the southwest coast of Norway. Jørgensen catalogued the presence or absence of 119 forms of diatoms, 43 forms of dinoflagellates including two new species, two flagellate species, six silicoflagellate species and 66 radiolarian species of which were 28 species described as new species, plus a new tintinnid species not described in his previous study. One of the forms of radiolaria, described as a new species, was named for Nordgaard by Jørgensen, *Acanthostarus nordgaardi* (Fig. 3). Of all the new species described in the report, it was the only one named for a person. One might speculate that it was acknowledging the debt Jørgensen owed Nordgaard for the introduction to plankton! Jørgensen's second study was a major work of 110 pages of text accompanied by 5 plates and 83 pages of tables.

Jørgensen continued his collaboration with Nordgaard, through plankton samples that Nordgaard had collected in arctic waters "at the expense of the Bergen Museum" by sealers of Tromsø from 1897 to 1900 (Nordgaard 1902). Jørgensen published his results quite quickly, in 1901 (Jørgensen 1901). His article appeared before the 1902 report of Nordgaard giving the sample locations, dates, and his observations on the metazoan zooplankton. Thus, Jørgensen had to cite a paper yet to appear for precise data regarding his samples! He used the term "protistenplankton" in the title of his report, "Protistenplankton aus dem Nordmeere in den Jahren 1897-1900". In the introduction, Jørgensen stated that the new term, following Haeckel's terminology in his *Plankton-Studien* (Haeckel 1890), groups both the 'protophytes' and the 'protozoa'. As in his previous report he included a large table listing all the species found by sample station number without the station location. He noted that the microplankton was much less diverse than that of Bergen area fjords. For example, he found 41 diatom species and 19 dinoflagellate species, compared to, respectively, 119 and 43 species in the Bergen area samples. 15 forms of tintinnid ciliates, that he described as varieties and are now known as *Parafavella* species (e.g. Fig. 4).

During these early years of his plankton studies, Jørgensen did not completely abandon botanical work. In the same issue of the journal of the Bergen Museum as Nordgaard's article on the plankton studies of 1897-1900, Jørgensen published two botanical articles (Jørgensen 1902a,b). However, he was soon engaged in another large endeavor with Nordgaard. In 1899 and 1900, Nordgaard sampled both the plankton and the benthos of several fjords. As in their previous collaborations, Jørgensen was responsible for the protist plankton but, unlike his previous work, Jørgensen was also tasked with analysing the dredge samples to document

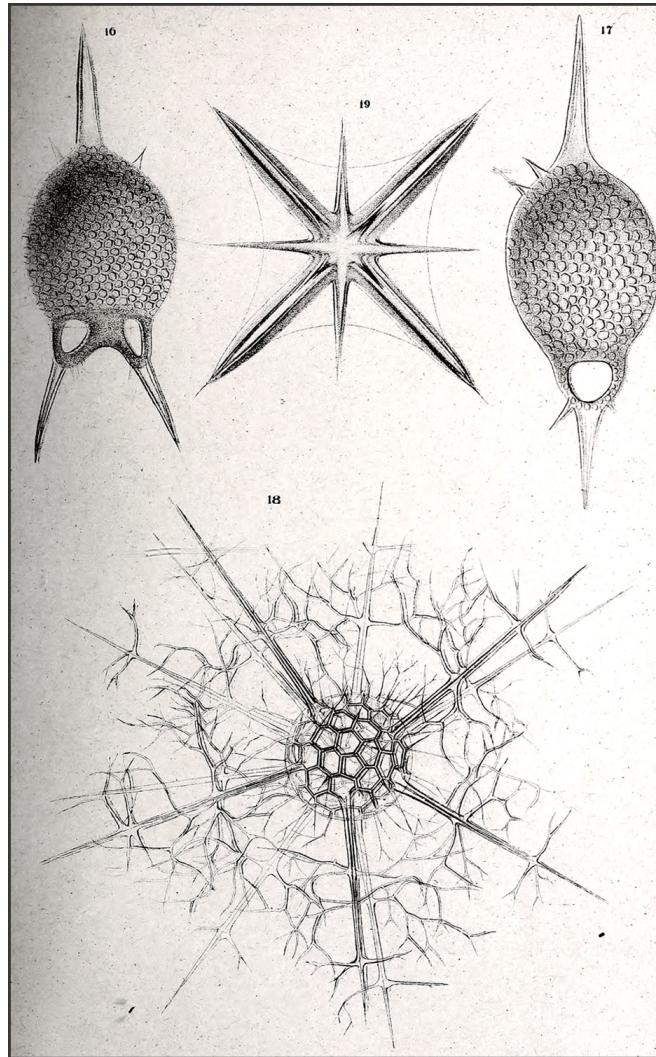


Fig. 3. From Jørgensen 1900b, plate. The top left and right figures are the phaeodarian *Challengeron heteracanthum*, n. sp. The top central figure is the acantharian *Acanthostaurus nordgaardi* n. sp. named by Jørgensen for Ole Nordgaard, and the bottom figure is *Arachnosphaero dichtoma* n. sp.

the diatoms in the benthic samples. For this 'non-plankton work', slides were prepared by Eduard Thum of Leipzig, a very well-known preparer of diatom slides whose diatom arrangements are collector's items today. (Hutchinson 2023).

The 1905 report of Nordgaard and Jørgensen is a very substantial work, weighing in about three Kg! Besides the hydrological data gathered, data on the contents of 200 plankton net samples and 78 dredge samples is presented. The bulk of Jørgensen's analyses were focused primarily on the radiolarians (Jørgensen 1905a), and secondarily on the diatoms (Jørgensen 1905b). While few new diatom species were found, Jørgensen made a significant contribution to the taxonomy of the radiolaria in 1905 report. He described 8 new genera, 14 new species, and provided a key to the Nassularian genera, as well as proposing a phylogenetic tree of the Nassularia. Along with his 1900 article on the 'protophytes' and 'protozoans' (Jørgensen 1900b), the 1905 report made Jørgensen a major figure in radiolarian studies of the early 20th century (i.e., Dolven et al. 2014). Jørgensen eventually

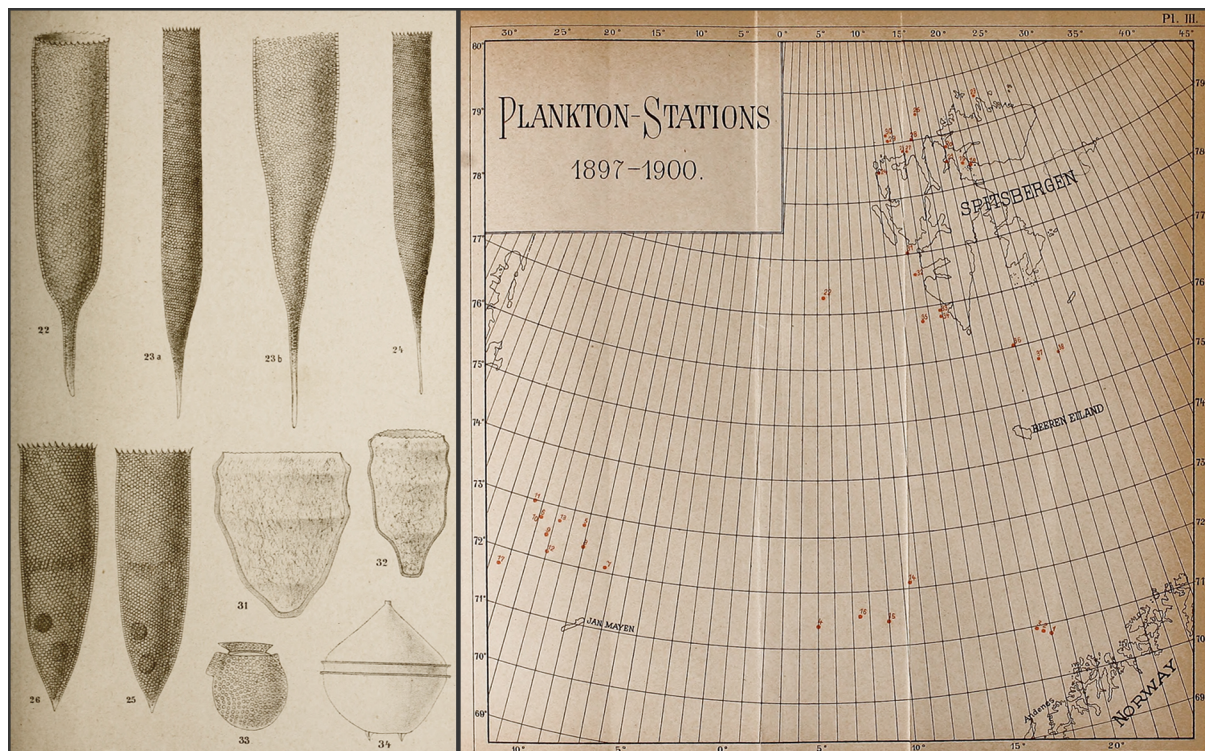


Fig. 4. The left panel is plate 3 from Jørgensen's 1901 article on arctic microplankton, 'Protistenplankton', showing forms of tintinnid ciliates now known as species of *Parafavella*, *Ptychocylis* and two dinoflagellates. The right panel is from Nordgaard's 1902 article giving details of the samples that Jørgensen analyzed, and Nordgaard's observations on the metazoan zooplankton.

had a radiolarian species named for him, *Joergensenium rotatile* (Bjørklund et al. 2004).

The 1905 study actually appears to be, by far, Jørgensen's most cited work. According Google Scholar (Mar. 14, 2024), it has been cited 168 times whereas Jørgensen book on Norwegian mosses (Jørgensen 1934), which won him the Nansen Award, is his second most cited work, and has been cited 116 times. Some of the citations of Jørgensen's 1905 study may have been missed as exactly how it should be cited is far from clear, given the odd title page of the report (see fig. 5). For example, Jørgensen himself cited the report as "Jørgensen, E., Protist Plankton of Northern Norwegian Fiords. *Bergens Museums Skrifter* 1905" (Jørgensen 1912) and remarkably, the phrase "Protist plankton of the Northern Norwegian fiords" does not appear anywhere in the work.

In 1905 Jørgensen's friend, collaborator, and supplier of plankton samples, Norgaard, left Bergen to take the directorship of the Biological Station in Tromsø. The new director of the Bergen Biological Station was a physical oceanographer. From that time on, Jørgensen was dependent on others to send him plankton sample. However, by then he had established himself as an authority on microplankton and apparently his expertise was solicited. Jørgensen analysed samples from the 1905 Belgica Expedition to Greenland and reported on the radiolaria (Jørgensen 1907a). It was his last work dedicated to radiolarians. He soon turned his attention to dinoflagellates, even traveling to the coast of Florida to study living tropical forms.

In 1910 Jørgensen received funding from the Carnegie Foundation (USA), for a research stay, including travel expenses, to study the "Peridinea" at the foundation's 'Tortugas Marine Laboratory' on the Gulf Coast of Florida. It was one of the few field laboratories in the world located in the tropics, and for a time it was important research site (Yonge 1941; Colin 1980). Given the means of travel in the early 1900's, the voyage from Bergen to Southern Florida likely took at least a week. He arrived on May 16th and stayed until June 9th. Living conditions in the laboratory were 'primitive' with beds enclosed in mosquito nets in a dormitory, and no women were allowed (Yonge 1941). According to his report (Jørgensen 1911a), he had hoped to study motility in different species of *Ceratium*, but ended up making observations of diverse forms of dinoflagellates brought back to laboratory from frequent off-shore sampling.

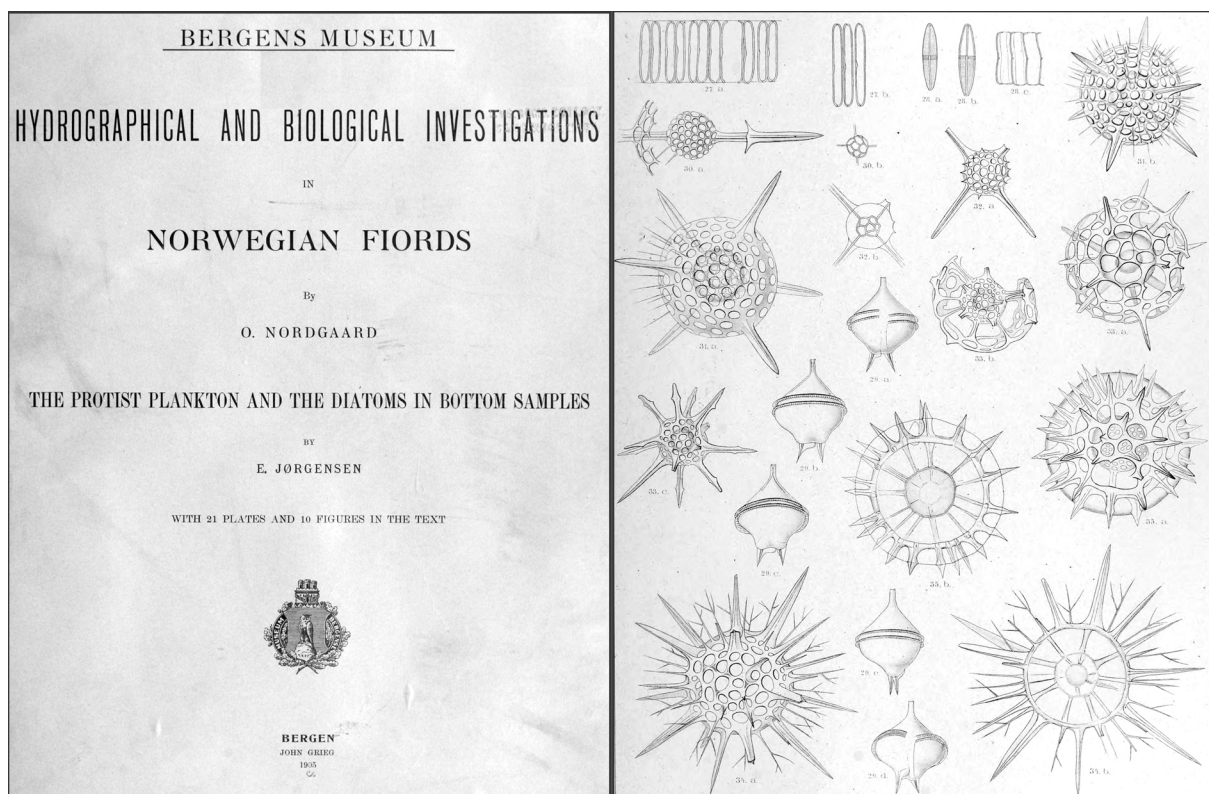


Fig. 5 Jørgensen's 1905 study. The left panel shows the title page of Nordgaard and Jørgensen's report. The nature of the work is unclear. It is often catalogued as a book, but some libraries catalogue as an issue (Nr. 7) of the serial *Bergens Museum skrifter* but that is not indicated on the title page. It is also unclear how to cite Jørgensen's portion: "The Protist Plankton and the Diatoms in Bottom Samples". As it is part of the title of the report, one expects it to be a distinct part of the work but it is not a contiguous portion of the report. The 'Protist Plankton' and 'Diatoms in Bottom Samples' are in distinct parts of the report as, respectively, part of plankton, or bottom organisms; the two parts are thus sometimes cited individually as separate items (as they here in the References section). The Right panel shows plate 8, one of the 13 plates by Jørgensen, with illustrations of diatoms, radiolarians and views of the dinoflagellate *Peridinium pedunculatum*.

Jørgensen published two major monographs on *Ceratium* in 1911, both in German. The first was *Die Ceratien*, a comprehensive review of the genus with several plates. Jørgensen set out to determine the geographic distribution morphological variability of the many species of *Ceratium* (Jørgensen 1911b). Through direct contacts, he obtained samples from around the globe (e.g., Japan, South Atlantic, Indian Ocean, South China Sea, the Mediterranean Sea, etc.) as well original samples from the wide ranging Valdivia Expedition (See Dolan 2023b) and the German South Polar Expedition. The plates were composed of a total of 184 figures, all of which but five, were his original drawings made using a camera lucida. Most plates contained figures of specimens from a wide variety of localities (e.g. Fig. 6). Jørgensen concluded his first review (completed a few months before his voyage to Florida in 1910) saying that individual species of *Ceratium* had a much wider geographic distribution than previously thought with seawater temperature appearing to be the most valuable predictor of the presence of a given species.

His second monograph on *Ceratium* (Jørgensen 1911c) was published by the organization now known as ICES (International Council for the Exploration of the Sea) or Conseil International pour l'Exploration de la Mer (CIEM) as part of the very long-titled "*Bulletin Trimestriel des Résultats Acquis Pendant Les Croisières Périodique et dans les Périodes Intermédiaires: Résumé des Observations sur le Plancton des Mers Explorées par le Conseil Pendant les Années 1902-1908*". In a natural follow-up to his *Die Ceratein*, Jørgensen reviewed the records of the occurrences of *Ceratium* species in Northern European Seas as possible indicators of water masses. Jørgensen next worked on samples collected by the Swedish Hydrobiological Commission in 1908 and 1909. He reported on the presence of a variety of taxa, including copepods, but not surprisingly gave special attention to the dinoflagellates (Jørgensen 1912).

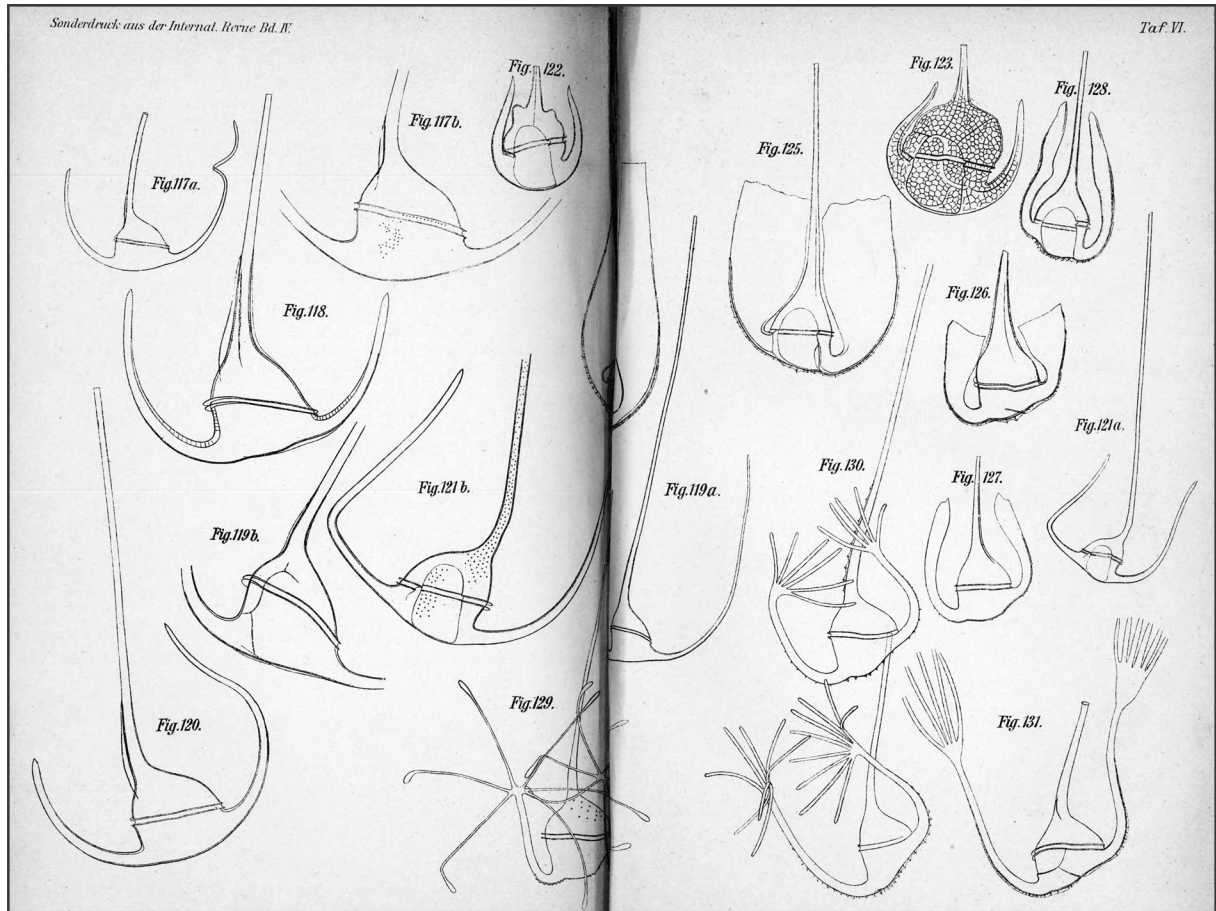


Fig. 6. Plate 6 from Jørgensen's *Die Ceratium* (Jørgensen 1911b). The specimens of *Ceratium* species shown came from a variety of samples examined by Jørgensen that he obtained through a wide web of contacts. Fig. 118 is from a sample taken in the Benguela current system given to him by the Portuguese naturalist Alfonso Chavez, and fig. 121 is from an Indian Ocean sample supplied by the Danish botanists Carl Ostenfeld and Johannes Schmidt.

Jørgensen's last major contributions to plankton research were his reports on samples taken during the Danish Oceanographical Expeditions (1908-1910) to the Mediterranean and Adjacent Seas. Johannes Schmidt, one of Jørgensen's contacts (e.g. Fig. 6) was the instigator and organizer of the cruises. He was, like Jørgensen, first trained as a botanist and early on, turned to marine biology, including plankton, authoring articles on tintinnids and dinoflagellates (Schmidt 1901, 1902). Later, Schmidt worked on fisheries investigations and became involved in the search for the breeding grounds of the eel. The cruises to the Mediterranean, using the steamer *Thor*, were organized in large part to investigate eel reproduction (Poulsen 2016), and involved sampling transects across the Mediterranean Sea in the winter of 1908-1909 and again the summer of 1910. Plankton was given special attention during cruise with deep-water sampling using a closing net as well as the surface layer hauls, both using a 76 μm net. Some of the data from these important cruises has been "rescued" (Mavraki et al. 2016), but unfortunately none of the plankton data have been digitized!

Jørgensen was entrusted by Schmidt with portions of the plankton samples from the cruises of the *Thor*, and Jørgensen produced three substantial reports. The first was, perhaps not surprisingly, on the *Ceratium* species (Jørgensen 1920). He found that,

contrary to previous reports, there were not winter and summer species but rather most were present year-round in different parts of the water column. Supposed 'winter species' did not disappear in the summer, they were in deep water during the summer months. Jørgensen's second treatise was on 'Dinophysid' dinoflagellates, species of the genera *Phalocroma*, *Dinophysis*, *Ornithoceras*, *Histioneis*, *Amphisolenia* and *Triposolenia* (Jørgensen 1923). He found the Dinophysids to be a species-rich group, providing descriptions of over 50 forms, many new, but generally occurring in very low concentrations. Jørgensen's last report was on the tintinnid ciliates (Jørgensen 1924). Similar to the Dinophysids, he found the tintinnids to be species-rich group, documenting the occurrence of over 100 forms, again describing many new forms. Jørgensen's three reports on the Thor expeditions to the Mediterranean Sea, together consist of 248 pages and 272 figures, and represent quite a significant contribution to the literature on plankton.

Jørgensen also contributed to popularizing plankton studies. The Bergen Museum published a magazine aimed at the general public and supporters of the Museum. Jørgensen published three 'plankton' articles in the Bergen Museum's "*Naturen*" (Fig. 7). The first appeared in 1907 and was on bioluminescent dinoflagellates (Jørgensen 1907b). In 1909, he wrote an article on the apparent invasion of a species of diatom, *Biddulphia sinensis*, on the coast of Bergen (Jørgensen 1909). His last article in the popular magazine was on the morphological variability of *Ceratium tripos* (Jørgensen 1919b). His three articles addressed topics that are still of interest today: bioluminescence, invasive species, and morphological variability.

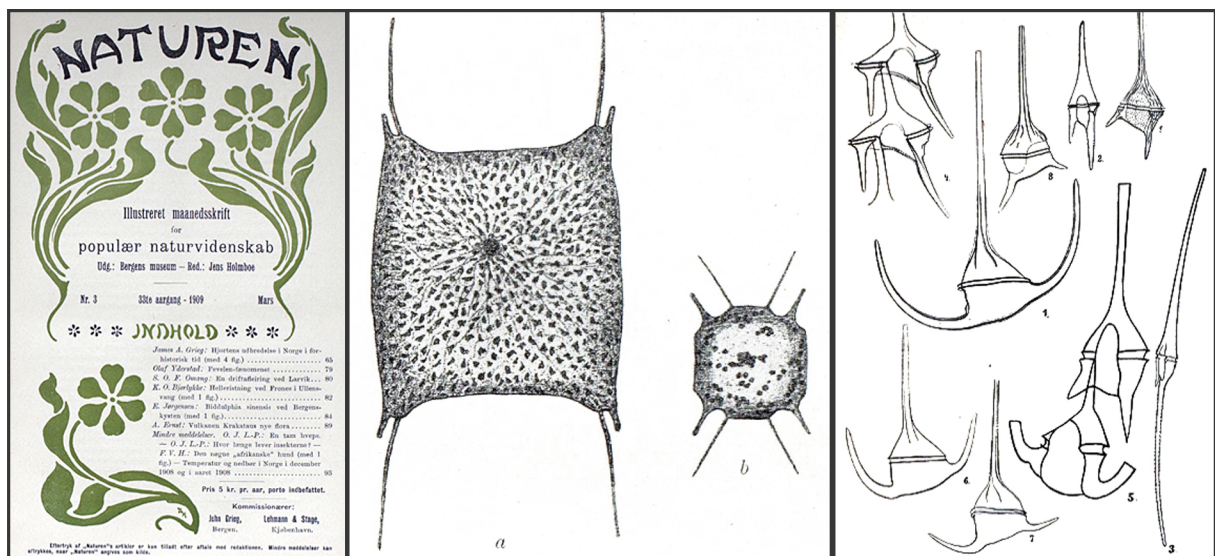


Fig. 7. The cover of the popular magazine of the Bergen Museum, *Naturen* (left panel), Jørgensen's illustration in his 1909 article showing the relatively large 'invasive' diatom *Biddulphia sinensis*, and the previously dominant species *B. mobiliensis* (center panel), and the illustration in his 1919 article on morphological variability in *Ceratium* (right panel).

Jørgensen worked in the department of botany in the Bergen Museum, but for most of his professional career, he focused on plankton. His most cited publications concern plankton. Eugen Jørgensen was then a botanist turned 'planktonologist'. As alluded to above, such a career detour was not rare at the time. Ole Nordgaard, who apparently introduced Jørgensen to plankton, like Jørgensen, was a school teacher before turning to hydrological and plankton studies. Three of Jørgensen's Danish colleagues who sailed on

the *Thor* to the Mediterranean Sea were also first trained as botanists. They were Ove Paulsen (1874-1947), Carl Ostenfeld (1873-1931) and Johannes Schmidt (1877-1933), and all made career detours becoming notable contributors to the literature on plankton. Paulsen published guides on dinoflagellates (Paulsen 1907) and Mediterranean microplankton (Paulsen 1931). Ostenfeld published on a large variety of planktonic organisms (e.g., Ostenfeld 1916) and Schmidt published on plankton in some of his first works on marine organisms (Schmidt 1901, 1902). Yet another very significant plankton worker of their era who made a notable career detour, was Per Tor Cleve (1840-1905) in Sweden. He was a Professor of Chemistry; he discovered new elements in 1879, and was a member of the Nobel Prize committee for Chemistry (Thorpe 1914). However, from about the early 1890's worked mostly on plankton (Bjørklund et al. 2014). From his publications it appears that by 1894 Cleve was decidedly a 'planktontologist' (e.g., Cleve 1894).

What do all of these career detours tell us? The answer may lay in the early prosaic remark of Johannes Müller, to his student, Ernst Haeckel. In 1854, Müller told Haeckel "...once you go into this pelagic magical world, you'll soon see that you can't get away from it again." (Haeckel 1890). By introducing others to our 'wonderland', we may provoke some new career detours and thereby insure the vitality of our field.

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