Marine Biodiversity

Kingdom Chromista in New Zealand

***Dennis Gordon** reviews the diversity of New Zealand's third botanical kingdom.*

Kingdom Chromista? More than two decades ago, Tom Cavalier-Smith, currently a professor at Oxford University, argued that the minimum number of kingdoms required for classifying botanical life was three – Fungi, Plantae, and Chromista. Although textbooks have been slow to reflect this new understanding, today Chromista is near universally accepted by biologists, supported by molecular and cellular studies. It is one of six kingdoms in Cavalier-Smith's current schema for all of life, the others being Bacteria, Protozoa, Plantae, Fungi, and Animalia.

What are chromists?

Chromists are diverse in form, ranging from the very large to the very small and including both free-living and parasitic forms, and they are found in almost all environments. The smallest are ultra-tiny planktonic unicells; the largest include structurally complex giant seaweeds like *Macrocystis* kelp, longer than a blue whale.

The greatest number of chromist species are diatoms and some of these are known to kill fish or be harmful to marine life. Many chromists form a siliceous or calcareous skeleton; their remains are commonly found in hardened marine sediments like chalk and diatomite. The famous White Cliffs of Dover are made up almost entirely of the microscopic chalky scales (coccoliths) of chromists called coccolithophores.

Many unicellular chromists, and the sex cells of multicellular chromists like large brown seaweeds or water moulds, have two cilia – tiny hairs used for swimming or feeding. What distinguishes most chromists from other kingdoms of life is that one of the cilia is hairy. This hairy cilium is known as the tinsel type of cilium because it resembles Christmas tinsel. A second key characteristic of most chromists is an additional membrane around their plastids (structures inside their cells, like green chloroplasts, responsible for processes such as photosynthesis and food storage). This extra membrane was an important clue in the discovery that these plastids actually represent the evolutionary remains of a captured organism, probably a unicellular red alga, that persisted as a symbiont living within chromist cells.

Different groups of chromists

Chromists are divided into six phyla: Cryptista, Ochrophyta, Bigyra, Sagenista, Haptophyta, and Heliozoa. An all-biota inventory known as Species 2000 New Zealand has arrived at a national tally of 1868 chromist species, although not all of these have been fully identified yet. This number is conservative and many more chromists are likely to be discovered.

From diatoms to giant kelp

- Chromista was first named as the third botanical kingdom in 1981.
- All six phyla, 20 of the 27 classes, and 1868 chromist species have been reported in New Zealand, but this number is conservative and many more species are likely to be found.
- Many chromist species are ecologically or economically significant, especially diatoms, brown algae, downy mildews, and water moulds.

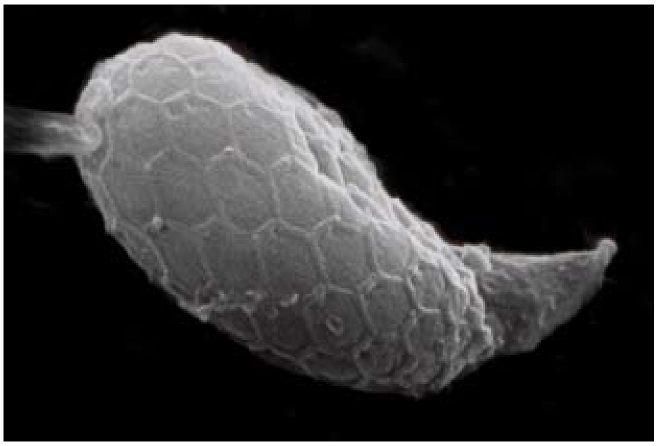

Photo: Hoe Chang

Phylum Cryptista: scanning electron micrograph of a cell of the microalga *Plagioselmis punctata*, a kind of marine phytoplankton.

Phylum Cryptista, also known as cryptophytes or cryptomonads, is found in both marine and fresh water. Some marine species, like *Hillea marina*, can dominate spring phytoplankton blooms, with densities of 1.8 million cells per litre of seawater and abundances twice that of all other phytoplankton combined. Cryptophytes can also mediate blooms in other organisms; for example, the bloom-forming protozoan *Myrionecta rubra* depends heavily on cryptophytes as a food source.

Phylum Ochrophyta is by far the most diverse chromist group in New Zealand, both in terms of numbers of species (1608) and in form. Its nine classes are spread across both marine and freshwater environments and include plankton, flagellates, yellow-green algae, and brown algae (including some seaweeds). Some of the more notable classes are Raphidophyceae (raphidophytes), Chrysophyceae (golden algae), Xanthophyceae (yellow-green algae), Phaeophyceae (brown algae), and Bacillariophyceae (diatoms).

Raphidophytes include the fish-killing species of *Heterosigma and Chattonella*. *Heterosigma akashiwo* has been implicated in the deaths of New Zealand farmed salmon.

Photo: Craig Stevens

Phylum Ochrophyta: the bull-kelp *Durvillaea antarctica*. The piece cut open reveals a honeycomb structure that aids in buoyancy.

The most familiar brown algae are intertidal Venus's necklace, the southern bull kelps, and laminarian kelps. The Asian kelp *Undaria pinnatifida* is the most serious algal pest in New Zealand.

Phylum Bigyra in New Zealand includes the pseudofungi, which live as plant parasites or form moulds on decaying freshwater organisms, the gut symbionts known as opalinids, and the gut parasite *Blastocystis*. The best-known classes are Hyphochytrea and Oomycetes; the latter includes such economically important genera as *Phytophthora* and *Pythium*, which infect agricultural and horticultural plants. Water moulds include pathogens of algae, fish and their eggs, and invertebrates. Hyphochytrids are common in New Zealand soils. Class Blastocystea is represented by the wide-spread human parasite *Blastocystis hominis*, which causes abdominal pain and diarrhoea. Only two species of class Opalinea occur in New Zealand, both of which live in the guts of introduced Australian frogs; New Zealand native frogs lack opaline associates.

Photo: Ross Beever, Landcare Research

Phylum Bigyra: reproductive body of the blight organism *Phytophthora* sp., an unnamed species that kills kauri.

Phylum Sagenista is a small phylum of non-photosynthetic chromists. Two classes are found in New Zealand – Labyrinthulea, which includes the slime-net *Labyrinthula* that infects the seagrass *Zostera*, and Bisoecea, which comprises three species of protozoan-like organisms. These have a sort of casing around their cells and are freshwater bacteria-eaters.

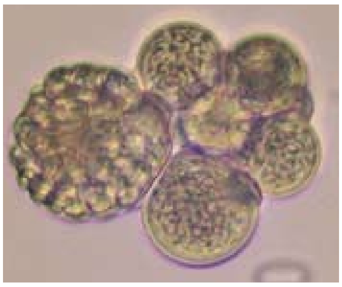

Photo: Serena Cox

Phylum Sagenista: an unidentified thraustochytrid showing cells of various growth stages and a reproductive body containing zoospores.

Phylum Haptophyta comprises the golden-brown microalgae found in marine, estuarine, and freshwater environments. Marine species can be major components of coastal and oceanic phytoplankton, sometimes forming blooms of exceptional density and spread. Like diatoms, they contribute to atmospheric dimethyl sulphide, which seeds clouds and forms rain, including acid rain. In New Zealand, *Phaeocystis poucheti* can occasionally form foamy mucilaginous blooms that suffocate marine life. A native species of *Prymnesium* has also been implicated in fish kills. Other species can cause non-toxic blooms and the skeletal remains of some species in marine sediments are useful palaeoindicators of climate change.

Photo: Hoe Chang

Phylum Haptophyta: the colonial form of the marine phytoplankton *Phaeocystis pouchetii*.

Phylum Heliozoa (or sun protists) used to be classified among protozoans but molecular evidence suggests they are chromists, most closely related to haptophytes. Only three species (one marine) have been formally recorded in New Zealand, even though heliozoans are known to be common inhabitants of freshwater and marine environments.

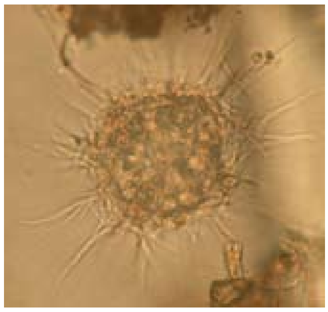

Photo: Rebecca Stott

Phylum Heliozoa: an unidentified centroheliozoon isolated from a freshwater stream.

NIWA's chromist research

Among the most notorious chromists is the invasive freshwater diatom *Didymosphenia geminata*. Better known as didymo, it was first found in New Zealand in October 2004. NIWA scientists are heavily involved with the biosecurity response, conducting research on didymo ecology, survivability, potential distribution, and control methods. We also study other diatoms, for example, as biological indicators in fresh waters.

On the marine front, we're monitoring and studying the full range of chromist phytoplankton, with a focus on invasive and harmful species collected from ports and harbours and the North Island northeast coast. These studies are important for aquaculture and biosecurity.

Our research on brown algae includes work on the life-histories and ecology of kelps, farming trials using brown algae in multi-species aquaculture, and taxonomic research to discover and document the diversity of species in New Zealand waters.

We're also investigating microscopic pseudofungi in the phylum Sagenista, in particular the genera *Thraustochytrium* and *Schizochytrium*. Their species produce high levels of omega-3 fatty acids, believed to be beneficial for both human and animal health. Some species also produce an interesting array of pigments, including antioxidants, and enzymes that degrade the woody components of organic matter. W&A

Dr Dennis Gordon's work at NIWA in Wellington focuses on marine biodiversity. He has spearheaded New Zealand's participation in Species 2000.

The Species 2000 New Zealand *inventory is a multi-scientist project. Information on New Zealand living Chromista has been contributed by Dr Hoe Chang, Dr Wendy Nelson (NIWA), Dr Lesley Rhodes (Cawthron Institute), Dr Vivienne Cassie Cooper, Dr Shaun Pennycook, Dr Barbara Paulus(Landcare Research), and Dr Paul Broady (Canterbury University).*