Table 1.1 | Survey of the organisms in the phytoplankton

Domain: BACTERIA

Division: **Cyanobacteria** (blue-green algae)

Unicellular and colonial bacteria, lacking membrane bound plastids. Primary photosynthetic pigment is chlorophyll a, with accessory phycobilins (phycocyanin, phycoerythrin). Assimilation products, glycogen, cyanophycin. Four main sub-groups, of which three have planktic representatives.

Order: CHROOCOCCALES

Unicellular or coenobial Cyanobacteria but never filamentous. Most planktic genera form mucilaginous colonies, and these are mainly in fresh water. Picophytoplanktic forms abundant in the oceans.

Includes: *Aphanocapsa, Aphanothece, Chroococcus, Cyanodictyon, Gomphosphaeria, Merismopedia, Microcystis, Snowella, Synechococcus, Synechocystis, Woronichinia*

Order: OSCILLATORIALES

Uniseriate–filamentous Cyanobacteria whose cells all undergo division in the same plane. Marine and freshwater genera.

Includes: *Arthrospira, Limnothrix, Lyngbya, Planktothrix, Pseudanabaena, Spirulina, Trichodesmium, Tychonema*

Order: NOSTOCALES

Unbranched–filamentous Cyanobacteria whose cells all undergo division in the same plane and certain of which may be facultatively differentiated into heterocysts. In the plankton of fresh waters and dilute seas.

Includes: *Anabaena, Anabaenopsis, Aphanizomenon, Cylindrospermopsis, Gloeotrichia, Nodularia*

Exempt Division: **Prochlorobacteria**

Order: PROCHLORALES

Unicellular and colonial bacteria, lacking membrane-bound plastids. Photosynthetic pigments are chlorophyll *a* and *b*, but lack phycobilins.

Includes: *Prochloroccus, Prochloron, Prochlorothrix*

Division: **Anoxyphotobacteria**

Mostly unicellular bacteria whose (anaerobic) photosynthesis depends upon an electron donor other than water and so do not generate oxygen. Inhabit anaerobic sediments and (where appropriate) water layers where light penetrates sufficiently. Two main groups:

Family: Chromatiaceae (purple sulphur bacteria) Cells able to photosynthesise with sulphide as sole electron donor. Cells contain bacteriochlorophyll *a*, *b* or *c*.

Includes: *Chromatium, Thiocystis, Thiopedia.*

Family: Chlorobiaceae (green sulphur bacteria) Cells able to photosynthesise with sulphide as sole electron donor. Cells contain bacteriochlorophyll *a*, *b* or *c*.

Includes: *Chlorobium, Clathrocystis, Pelodictyon.*

Domain: EUCARYA

Phylum: **Glaucophyta**

Cyanelle-bearing organisms, with freshwater planktic representatives.

Includes: *Cyanophora, Glaucocystis.*

Phylum: **Prasinophyta**

Unicellular, mostly motile green algae with 1–16 laterally or apically placed flagella, cell walls covered with fine scales and plastids containing chlorophyll *a* and *b*. Assimilatory products mannitol, starch.

(cont.)

Table 1.1 | (cont.)

CLASS: Pedinophyceae
Order: PEDINOMONADALES
Small cells, with single lateral flagellum.
Includes: *Pedinomonas*
CLASS: Prasinophyceae
Order: CHLORODENDRALES
Flattened, 4-flagellated cells.
Includes: *Nephroselmis, Scherffelia* (freshwater); *Mantoniella, Micromonas* (marine)
Order: PYRAMIMONADALES
Cells with 4 or 8 (rarely 16) flagella arising from an anterior depression. Marine and freshwater.
Includes: *Pyramimonas*
Order: SCOURFIELDIALES
Cells with two, sometimes unequal, flagella. Known from freshwater ponds.
Includes: *Scourfieldia*
Phylum: **Chlorophyta** (green algae)
Green-pigmented, unicellular, colonial, filamentous, siphonaceous and thalloid algae. One or more chloroplasts containing chlorophyll *a* and *b*. Assimilation product, starch (rarely, lipid).
CLASS: Chlorophyceae
Several orders of which the following have planktic representatives:
Order: TETRASPORALES
Non-flagellate cells embedded in mucilaginous or palmelloid colonies, but with motile propagules.
Includes: *Paulschulzia, Pseudosphaerocystis*
Order: VOLVOCALES
Unicellular or colonial biflagellates, cells with cup-shaped chloroplasts.
Includes: *Chlamydomonas, Eudorina, Pandorina, Phacotus, Volvox* (in fresh waters); *Dunaliella, Nannochloris* (marine)
Order: CHLOROCOCCALES
Non-flagellate, unicellular or coenobial (sometimes mucilaginous) algae, with many planktic genera.
Includes: *Ankistrodesmus, Ankyra, Botryococcus, Chlorella, Coelastrum, Coenochloris, Crucigena, Choricystis, Dictyosphaerium, Elakatothrix, Kirchneriella, Monorophidium, Oocystis, Pediastrum, Scenedesmus, Tetrastrum*
Order: ULOTRICHALES
Unicellular or mostly unbranched filamentous with band-shaped chloroplasts.
Includes: *Geminella, Koliella, Stichococcus*
Order: ZYGNEMATALES
Unicellular or filamentous green algae, reproducing isogamously by conjugation. Planktic genera are mostly members of the Desmidaceae, mostly unicellular or (rarely) filmentous coenobia with cells more or less constricted into two semi-cells linked by an interconnecting isthmus. Exclusively freshwater genera.
Includes: *Arthrodesmus, Closterium, Cosmarium, Euastrum, Spondylosium, Staurastrum, Staurodesmus, Xanthidium*

(cont.)

Table 1.1 (cont.)

Phylum: **Euglenophyta**

Green-pigmented unicellular biflagellates. Plastids numerous and irregular, containing chlorophyll *a* and *b*. Reproduction by longitudinal fission. Assimilation product, paramylon, oil. One Class, Euglenophyceae, with two orders.

Order: EUTREPTIALES

Cells having two emergent flagella, of approximately equal length. Marine and freshwater species.

Includes: *Eutreptia*

Order: EUGLENALES

Cells having two flagella, one very short, one long and emergent.

Includes: *Euglena, Lepocinclis, Phacus, Trachelmonas*

Phylum: **Cryptophyta**

Order: CRYPTOMONADALES

Naked, unequally biflagellates with one or two large plastids, containing chlorophyll *a* and c_2 (but not chlorophyll *b*); accessory phycobiliproteins or other pigments colour cells brown, blue, blue-green or red; assimilatory product, starch. Freshwater and marine species.

Includes: *Chilomonas, Chroomonas, Cryptomonas, Plagioselmis, Pyrenomonas, Rhodomonas*

Phylum: **Raphidophyta**

Order: RAPHIDOMONADALES (syn. CHLOROMONADALES)

Biflagellate, cellulose-walled cells; two or more plastids containing chlorophyll *a*; cells yellow-green due to predominant accessory pigment, diatoxanthin; assimilatory product, lipid. Freshwater.

Includes: *Gonyostomum*

Phylum: **Xanthophyta** (yellow-green algae)

Unicellular, colonial, filamentous and coenocytic algae. Motile species generally subapically and unequally biflagellated; two or many more discoid plastids per cell containing chlorophyll *a*. Cells mostly yellow-green due to predominant accessory pigment, diatoxanthin; assimilation product, lipid. Several orders, two with freshwater planktic representatives.

Order: MISCHOCOCCALES

Rigid-walled, unicellular, sometimes colonial xanthophytes.

Includes: *Goniochloris, Nephrodiella, Ophiocytium*

Order: TRIBONEMATALES

Simple or branched uniseriate filamentous xanthophytes.

Includes: *Tribonema*

Phylum: **Eustigmatophyta**

Coccoid unicellular, flagellated or unequally biflagellated yellow-green algae with masking of chlorophyll *a* by accessory pigment violaxanthin. Assimilation product, probably lipid.

Includes: *Chlorobotrys, Monodus*

Phylum: **Chrysophyta** (golden algae)

Unicellular, colonial and filamentous. often uniflagellate, or unequally biflagellate algae. Contain chlorophyll *a*, c_1 and c_2, generally masked by abundant accessory pigment, fucoxanthin, imparting distinctive golden colour to cells. Cells sometimes naked or or enclosed in an urn-shaped lorica, sometimes with siliceous scales. Assimilation products, lipid, leucosin. Much reclassified group, has several classes and orders in the plankton.

(cont.)

Table 1.1 | (cont.)

CLASS: Chrysophyceae
Order: CHROMULINALES
Mostly planktic, unicellular or colony-forming flagellates with one or two unequal flagella, occasionally naked, often in a hyaline lorica or gelatinous envelope.
Includes: *Chromulina, Chrysococcus, Chrysolykos, Chrysosphaerella, Dinobryon, Kephyrion, Ochromonas, Uroglena*
Order: HIBBERDIALES
Unicellular or colony-forming epiphytic gold algae but some planktic representatives.
Includes: *Bitrichia*
CLASS: Dictyochophyceae
Order: PEDINELLALES
Radially symmetrical, very unequally biflagellate unicells or coenobia.
Includes: *Pedinella* (freshwater); *Apedinella, Pelagococcus, Pelagomonas, Pseudopedinella* (marine)
CLASS: Synurophyceae
Order: SYNURALES
Unicellular or colony-forming flagellates, bearing distinctive siliceous scales.
Includes: *Mallomonas, Synura*

Phylum: **Bacillariophyta** (diatoms)
Unicellular and coenobial yellow-brown, non-motile algae with numerous discoid plastids, containing chlorophyll *a*, c_1 and c_2, masked by accessory pigment, fucoxanthin. Cell walls pectinaceous, in two distinct and overlapping halves, and impregnated with cryptocrystalline silica. Assimilatory products, chrysose, lipids. Two large orders, both conspicuously represented in the marine and freshwater phytoplankton.
CLASS: Bacillariophyceae
Order: BIDDULPHIALES (centric diatoms)
Diatoms with cylindrical halves, sometimes well separated by girdle bands. Some species form (pseudo-)filaments by adhesion of cells at their valve ends.
Includes: *Aulacoseira, Cyclotella, Stephanodiscus, Urosolenia* (freshwater); *Cerataulina, Chaetoceros, Detonula, Rhizosolenia, Skeletonema, Thalassiosira* (marine)
Order: BACILLARIALES (pennate diatoms)
Diatoms with boat-like halves, no girdle bands. Some species form coenobia by adhesion of cells on their girdle edges.
Includes: *Asterionella, Diatoma, Fragilaria, Synedra, Tabellaria* (freshwater); *Achnanthes, Fragilariopsis, Nitzschia* (marine)

Phylum: **Haptophyta**
CLASS: Haptophyceae
Gold or yellow-brown algae, usually unicellular, with two subequal flagella and a coiled haptonema, but with amoeboid, coccoid or palmelloid stages. Pigments, chlorophyll *a*, c_1 and c_2, masked by accessory pigment (usually fucoxanthin). Assimilatory product, chrysolaminarin. Cell walls with scales, sometimes more or less calcified.
Order: PAVLOVALES
Cells with haired flagella and small haptonema. Marine and freshwater species.
Includes: *Diacronema, Pavlova*

(cont.)

Table 1.1 | (cont.)

Order: PRYMNESIALES
Cells with smooth flagella, haptonema usually small. Mainly marine or brackish but some common in freshwater plankton.
Includes: *Chrysochromulina, Isochrysis, Phaeocystis, Prymnesium*

Order: COCCOLITHOPHORIDALES
Cell suface covered by small, often complex, flat calcified scales (coccoliths). Exclusively marine.
Include: *Coccolithus, Emiliana, Florisphaera, Gephyrocapsa, Umbellosphaera*

Phylum: **Dinophyta**
Mostly unicellular, sometimes colonial, algae with two flagella of unequal length and orientation. Complex plastids containing chlorophyll *a*, c_1 and c_2, generally masked by accessory pigments. Cell walls firm, or reinforced with polygonal plates. Assimilation products: starch, oil. Conspicuously represented in marine and freshwater plankton. Two classes and (according to some authorities) up to 11 orders.

CLASS: Dinophyceae
Biflagellates, with one transverse flagellum encircling the cell, the other directed posteriorly.

Order: GYMNODINIALES
Free-living, free-swimming with flagella located in well-developed transverse and sulcal grooves, without thecal plates. Mostly marine.
Includes: *Amphidinium, Gymnodinium, Woloszynskia*

Order: GONYAULACALES
Armoured, plated, free-living unicells, the apical plates being asymmetrical. Marine and freshwater.
Includes: *Ceratium, Lingulodinium*

Order: PERIDINIALES
Armoured, plated, free-living unicells, with symmetrical apical plates. Marine and freshwater.
Includes: *Glenodinium, Gyrodinium, Peridinium*

Order: PHYTODINIALES
Coccoid dinoflagellates with thick cell walls but lacking thecal plates. Many epiphytic for part of life history. Some in plankton of humic fresh waters.
Includes: *Hemidinium*

CLASS: Adinophyceae

Order: PROROCENTRALES
Naked or cellulose-covered cells comprising two watchglass-shaped halves. Marine and freshwater species.
Includes: *Exuviella, Prorocentrum*

pigments, called phycobilins, are associated with these membranes, where they are carried in granular phycobilisomes. Life forms among the Cyanobacteria have diversified from simple coccoids and rods into loose mucilaginous colonies, called coenobia, into filamentous and to pseudotissued forms. Four main evolutionary lines are recognised, three of which (the chroococcalean, the oscillatorialean and the nostocalean; the stigonematalean line is the exception) have major planktic representatives that have diversified greatly among marine and freshwater systems. The most ancient group of the surviving groups of photosynthetic organisms is, in