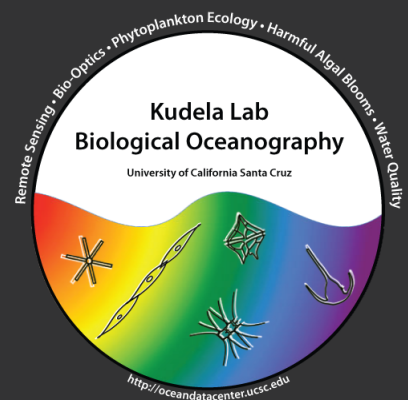
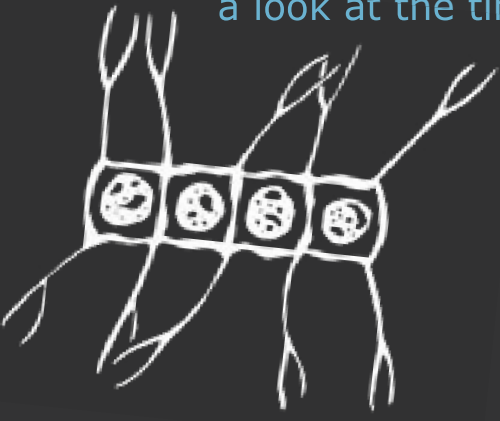


# Phytoplankton Identification

a look at the tiny drifters along the California coast

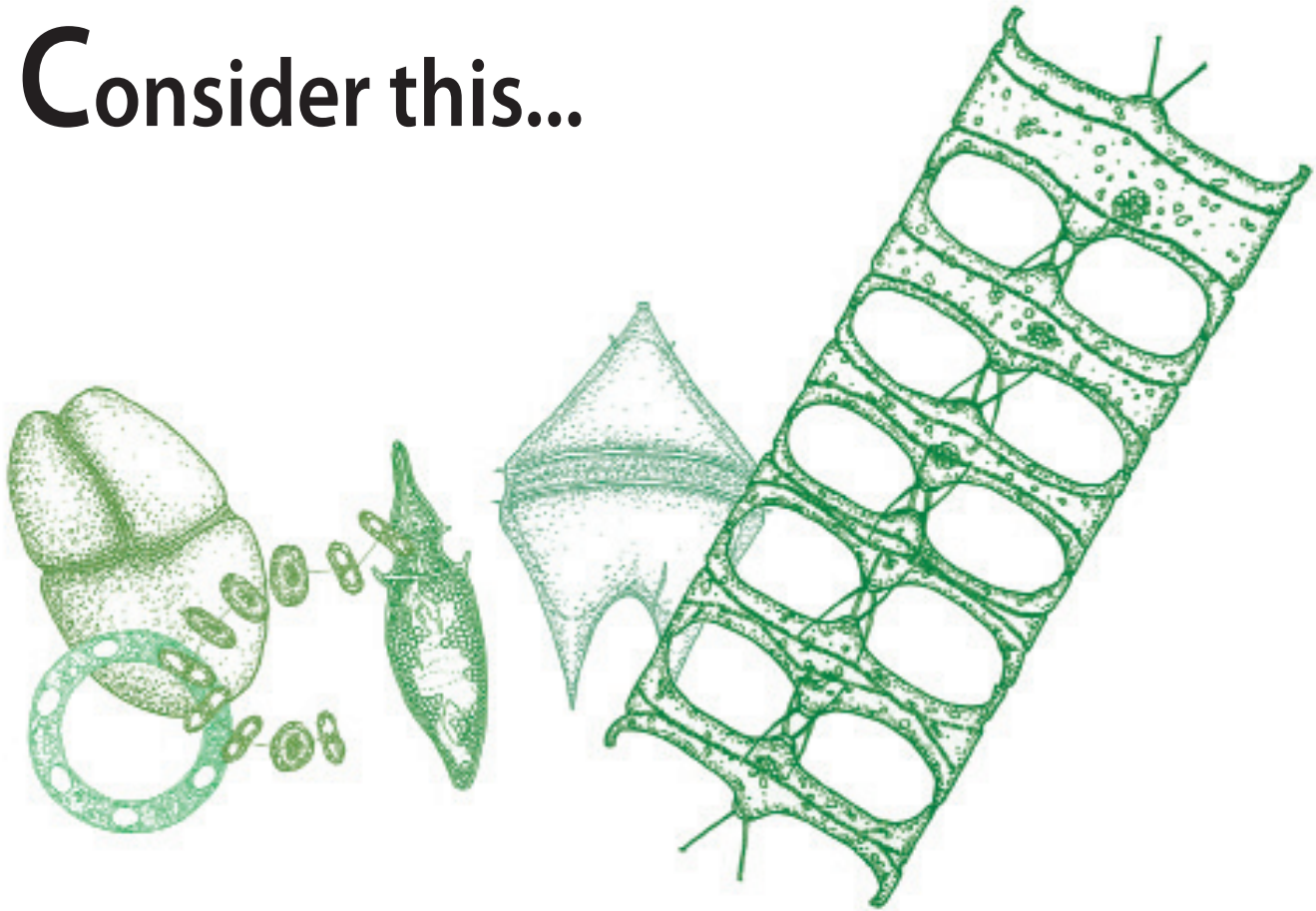




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# Consider this...



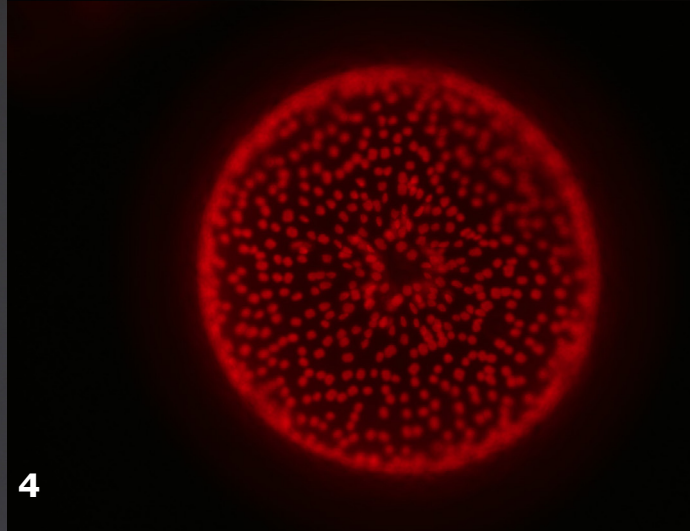
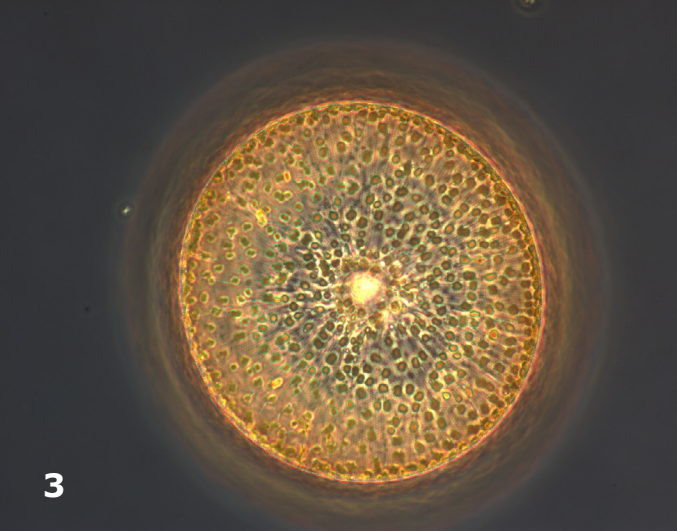
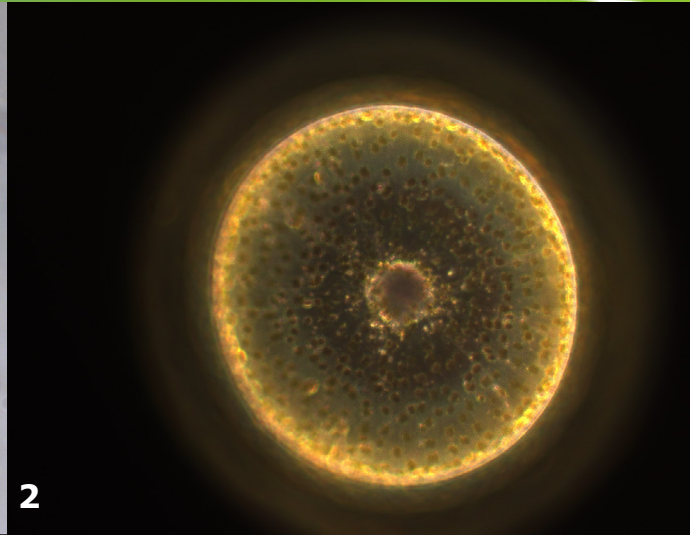
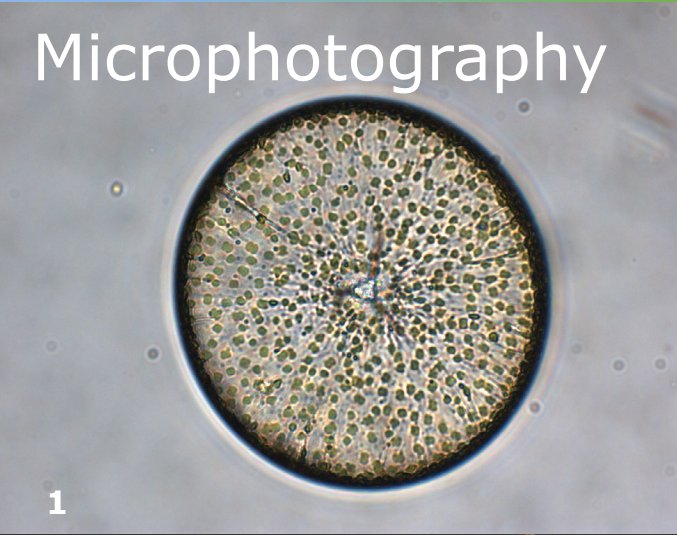
**for** every breath of air you take, half the oxygen is courtesy of plants from the land, and the other half from the phytoplankton - the plant-like organisms of the ocean. Phytoplankton produce oxygen and contribute close to half of the total global oxygen supply. On the other side of the equation, phytoplankton absorb one third of the carbon dioxide ( $\text{CO}_2$ ) produced globally, whether from our exhaled breath or by the combustion of fossil fuels. Phytoplankton play a pivotal role in the removal of  $\text{CO}_2$  from the atmosphere to the oceans and thus are key mediators of the global climate.

These tiny one-celled organisms, often less than half the diameter of a human hair, make up what might be considered the grasslands of the ocean. They form the base of the pelagic marine food web and are grazed on by krill, the primary food source of many animals, from sardines to whales. Viewed under a microscope, a mere drop of water teems with an astonishing diversity of phytoplankton. These microscopic organisms, largely invisible to the naked eye, are crucial to the survival of life on earth.





# Microphotography



**1: Brightfield Microscopy:** Simplest microscopy illumination technique. Specimen is illuminated from below and observed from above. Specimens typically appear as dark shapes against a bright background.

**2: Darkfield Microscopy:** Illumination technique used to enhance the contrast in specimens. Specimen is illuminated with light that will not be collected by the objective lens, and therefore will not form part of the image. This produces the appearance of a bright object against a dark or black background.

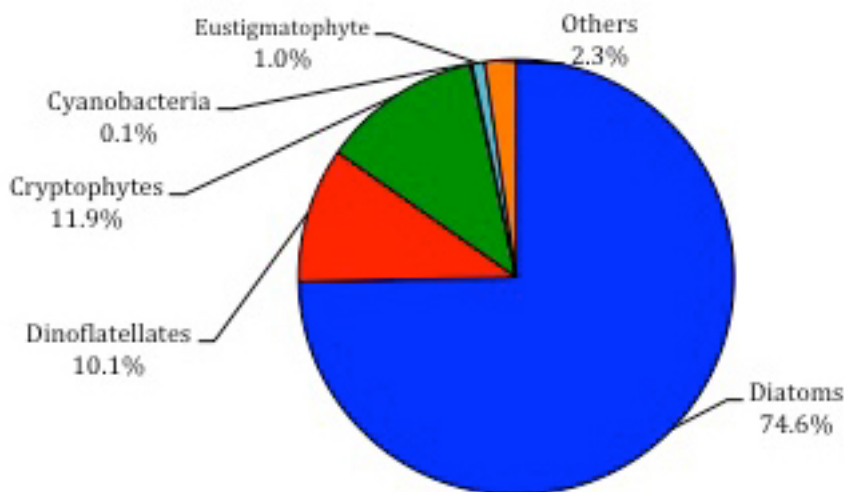
**3: Phase Contrast Microscopy:** An illumination scheme that converts phase shifts of light passing through a transparent specimen into contrast changes, thus rendering cell features more visible.

**4: Epifluorescence Microscopy:** A beam of light causes a cell to fluoresce, and the emitted light is then focused by the objective lens. Stains are commonly used for highlighting specific proteins or molecules of interest; here the chloroplasts are stained.

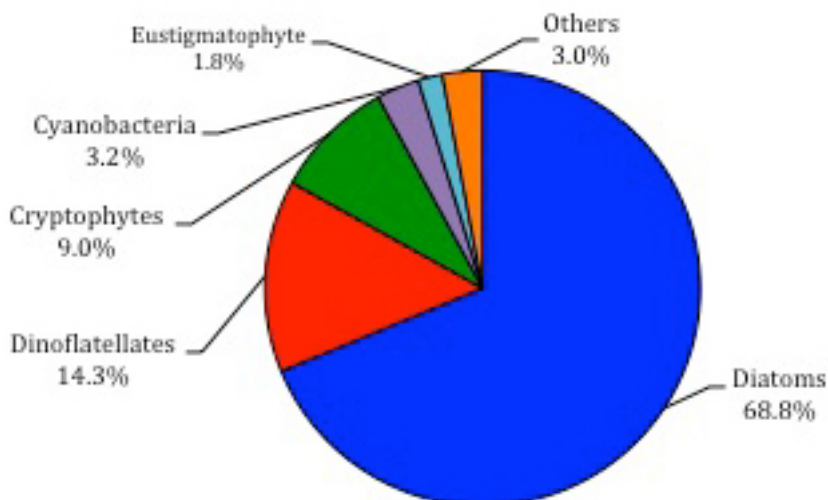
# Pigment analysis

Phytoplankton cells are commonly identified with a microscope. A trained technician can identify many different kinds of diatoms and dinoflagellates in a plankton sample. However, the emerging science of pigment analysis can be faster, cheaper, and less labor-intensive. An advantage to pigment analysis is identification of very small or rare cells that are difficult to detect through microscopy.

Different classes of phytoplankton produce different pigments. In addition to chlorophyll-a, diatoms produce brown fucoxanthin, dinoflagellates have brown-gold peridinin, and cyanobacteria make orange zeaxanthin. By analyzing samples with high-performance liquid chromatography, or HPLC, each type of pigment present is isolated and identified.



This chart shows the relative percentage of each type of phytoplankton in a water sample, as identified through traditional microscopy.



This chart shows the results of analyzing the same sample with HPLC technology.

# HABs and Red Tides

When conditions are favorable, phytoplankton can grow and multiply rapidly, or “bloom.” Due to pigments in the cells, some dense blooms can turn the water red, brown or orange. These blooms are called Red Tides.

Certain phytoplankton species are capable of producing toxins. A bloom of a toxic species, which can be dangerous to animal and human health, is called a Harmful Algal Bloom (HAB).

Red Tides can be harmless, and HABs can be colorless.

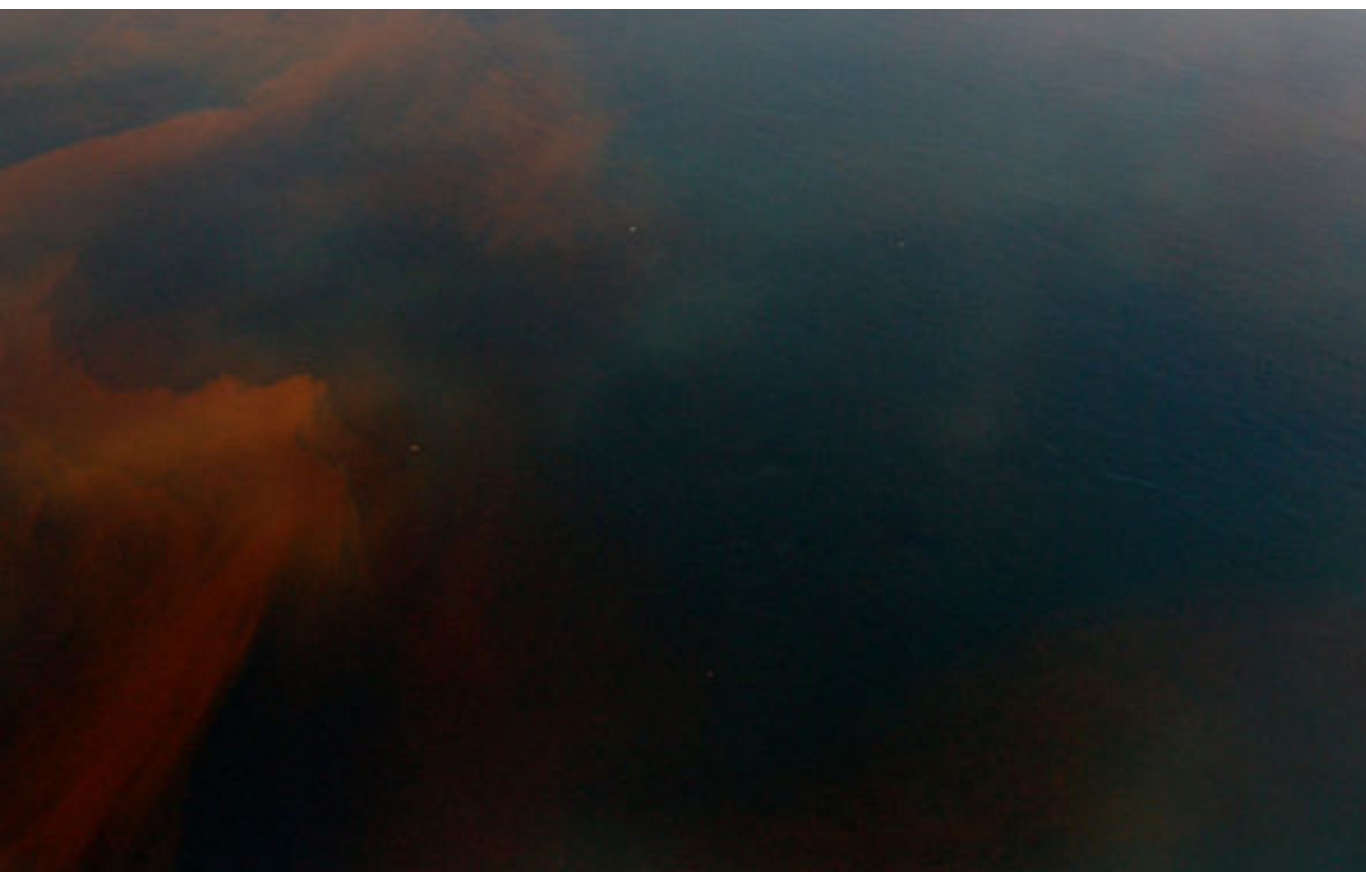
Toxigenic species in this book are identified by this logo:



For more information, visit:

**[www.HABMAP.info](http://www.HABMAP.info)**

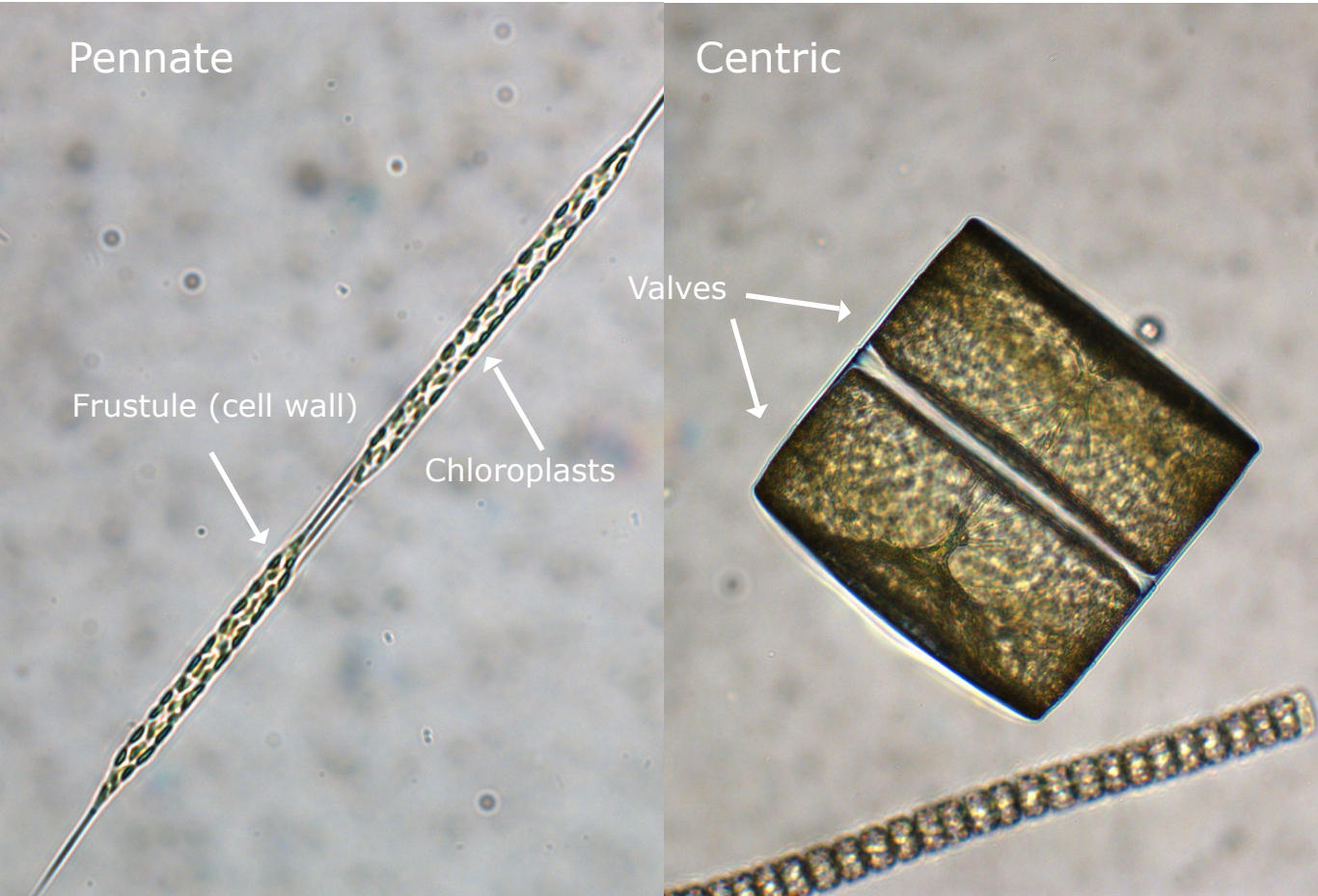
**[http://oceandatacenter.ucsc.edu/PhytoGallery/HABS\\_redtides/html](http://oceandatacenter.ucsc.edu/PhytoGallery/HABS_redtides/html)**

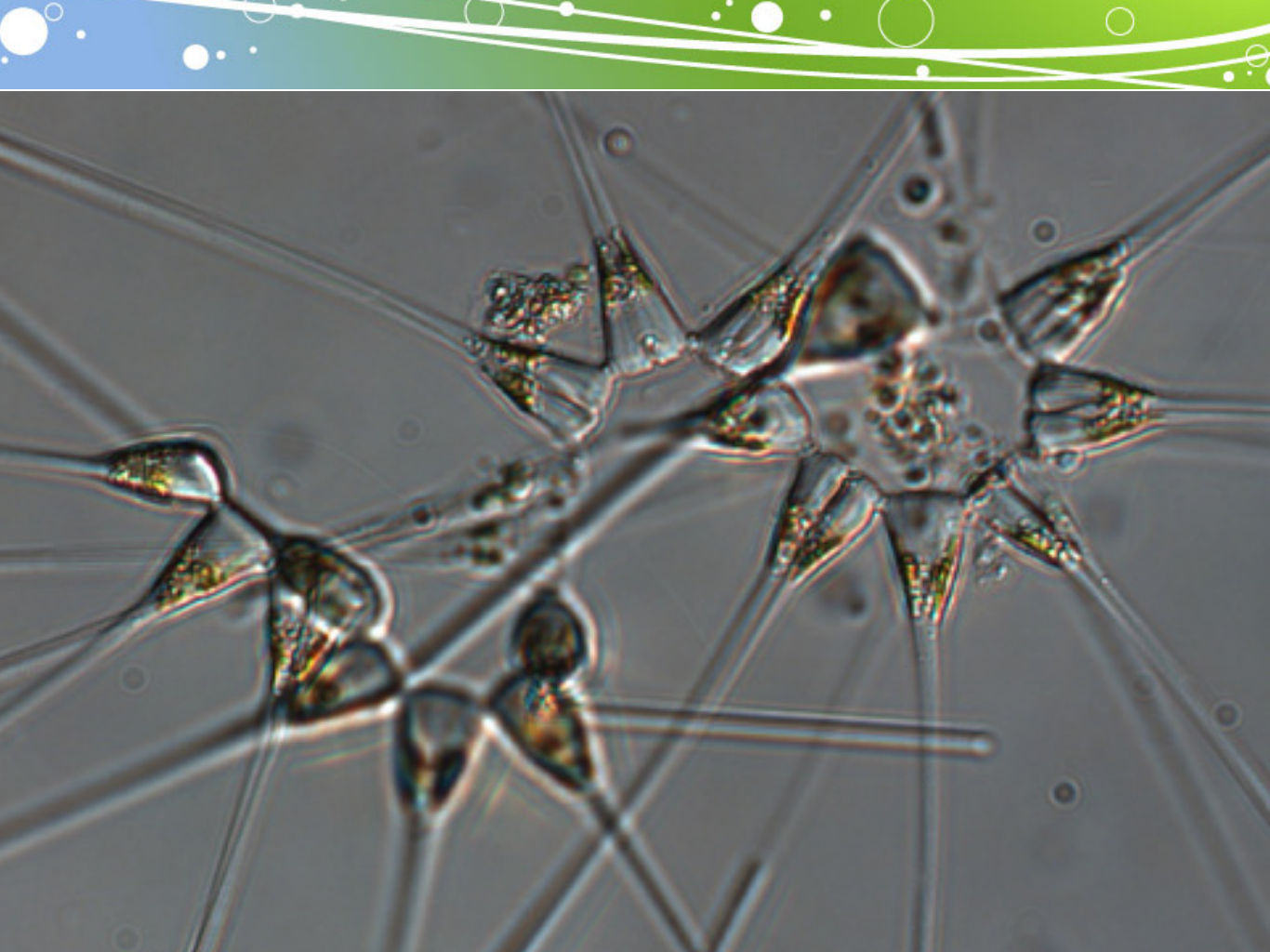




## Marine Diatoms

- Single-celled algae that possess a distinct nucleus (eukaryotic)
- Divided into two major groups based on the structure and shape of the valves: Centrics (Order: Biddulphiales) and Pennates (Order: Bacillariales)
- They are plant-like and meet their nutritional needs through photosynthesis. The presence of chlorophyll and accessory pigments, especially fucoxanthin, give them a golden color and serves to harvest light energy from the sun
- Cells are encased in a transparent glass-like silica frustule that resembles a petri-dish
- Frustules can be ornate and very beautiful, and due to the strength of silica, they form an important part of the fossil record
- Cells may form chains or colonies
- Up to 100,000 species of diatoms have been recorded world-wide





## Genus: *Asterionellopsis*

## Diatom

Monterey Bay Species: *A. glacialis*, *A. kariana*

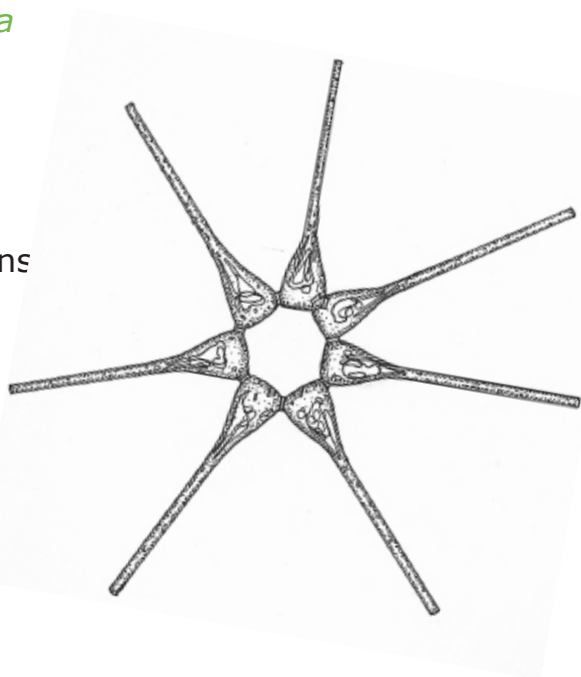
Order: Bacillariales (Pennate)

Family: Fragilariaceae

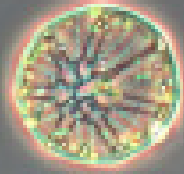
Description: Pennate diatom. Cells joined by valve faces into star-shaped or spiraling chains. Two chloroplasts present.

Cell Size: Length (apical axis) = 30 – 150µm

Distribution: Neritic, cosmopolitan in cold to temperate coastal waters. Often occurs as a member in the diatom surf zone community sometimes can form fairly dense blooms.







## Genus: *Asteromphalus*

## Diatom

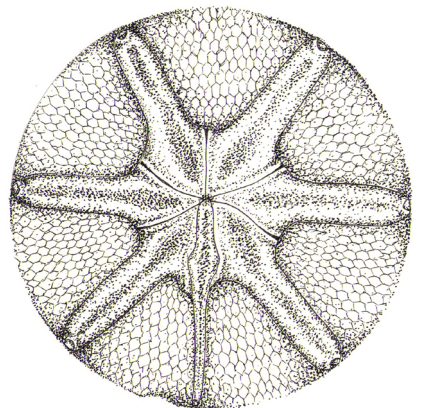
Order: Asterolamprales

Family: Choreutoidea

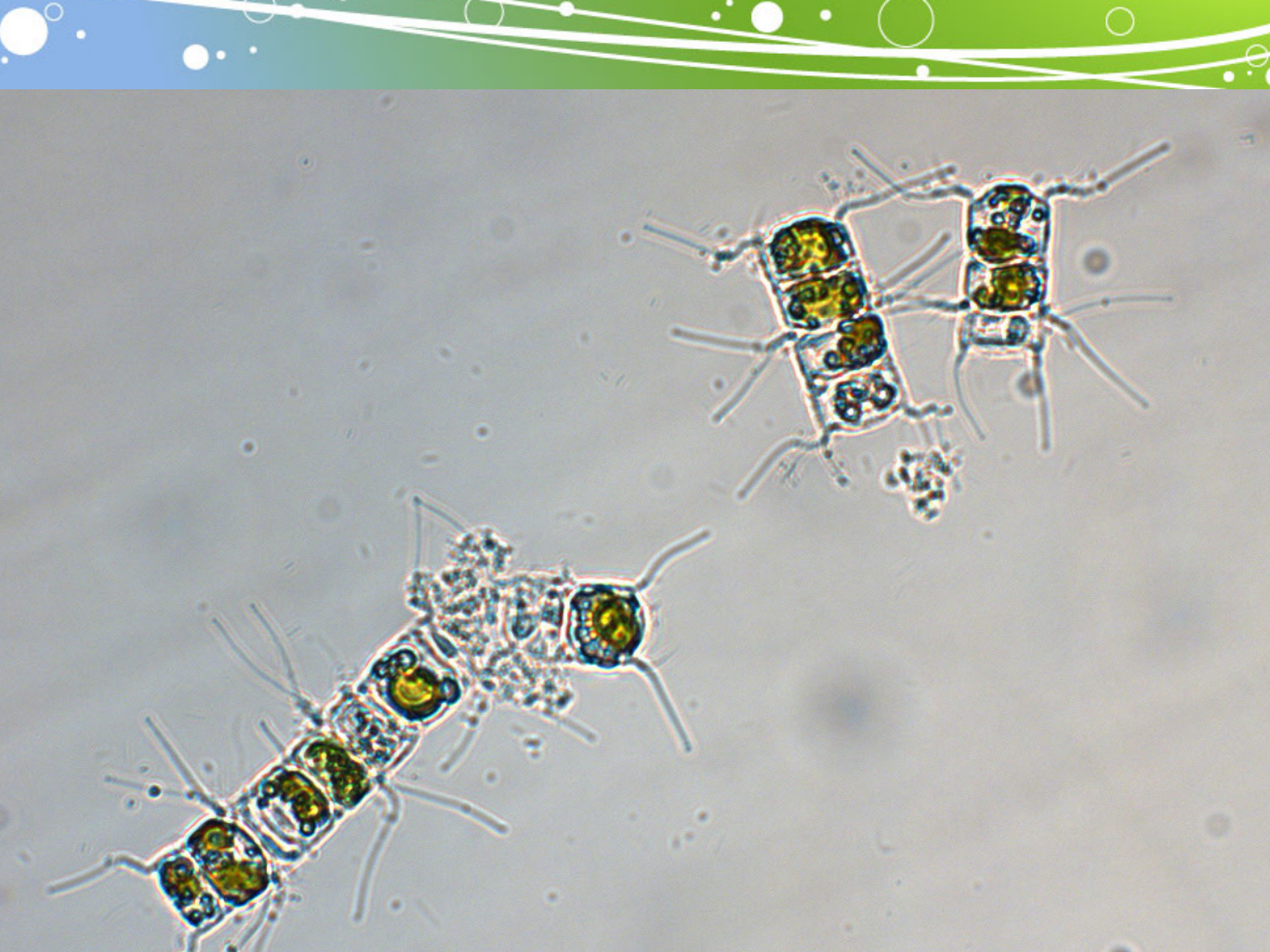
Description: Centric diatom, valve outline broadly oval or circular, or oblong. One hyaline ray narrower than the others (for *A. hookeri*). Narrow ray is either rectangular or bell shaped, and sectors are wedge shaped and curve towards valve center.

Cell Size: Diameter = 42 – 175µm

Distribution: Warm , temperate and southern cold water regions.







## Genus: *Attheya*

## Diatom

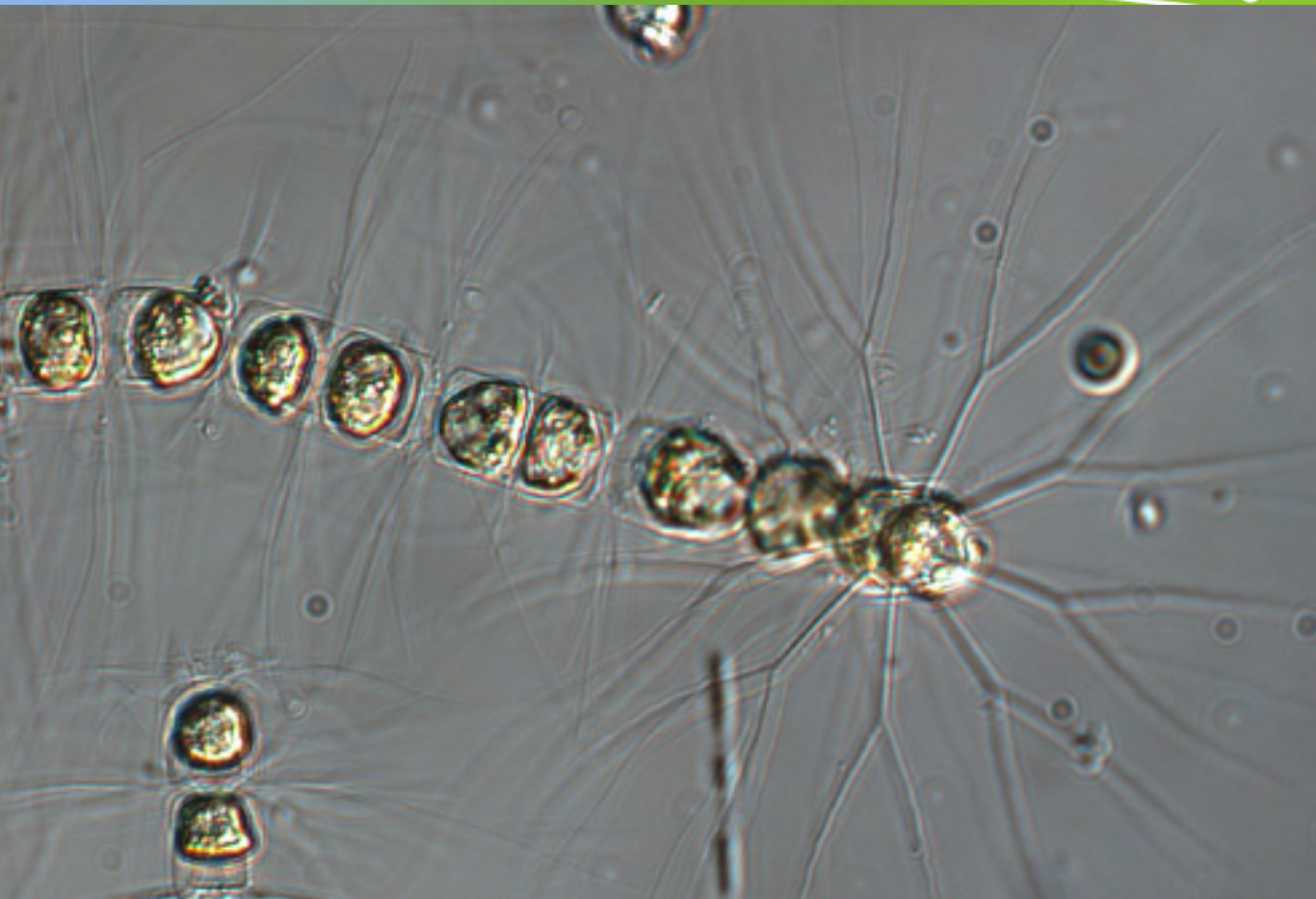
Order: Chaetocerotales

Family: Attheyaceae

Description: Centric diatoms. Cells can be solitary or form short chains. *Attheya* is similar in appearance to *Chaetoceros*, but can be identified by valve out-growths or horns and by type of girdle bands. *Attheya* can be both planktonic or epiphytic and is often found attached to sand grains or other diatoms.

Cell Size: Width (apical axis) = 4-10um

Distribution: Northern cold water to temperate, also found in freshwater.



## Genus: *Bacteriastrium*

## Diatom

Monterey Bay Species: *B. cosmosum*,  
*B. hyalinum*

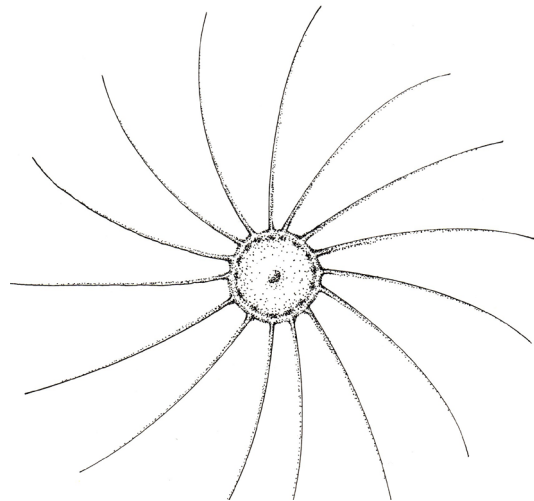
Order: Biddulphiales

Family: Chaetocerotaceae

Description: Cylindrical cells bound together by the fusion of numerous setae that are regularly arranged around the cell margin. Cells have numerous small round chloroplasts. Setae are of varying shapes (branched, divided, & curved).

Cell Size: Diameter (apical axis) = 5 – 56µm

Distribution: Temperate, coastal waters.







## Genus: *Cerataulina*

## Diatom

Monterey Bay species: *C. pelagica*, *C. bicornis*,  
*C. dentata*

Order: Hemiaulales  
Family: Hemiaulaceae

Description: Cells form close-set chains by apposition of tips of elevations. Cells have bipolar symmetry and bipolar elevations, and numerous small disk-like chloroplasts. The apertures between cells in chains are narrow, and cells are twisted about the pervalvar axis.

Cell Size: Pervalvar axis = 55-200um, diameter = 5-75um

Distribution: Cosmopolitan, warm coastal areas.



## Genus: *Chaetoceros*

## Diatom

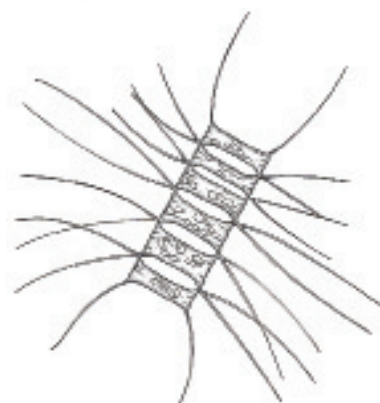
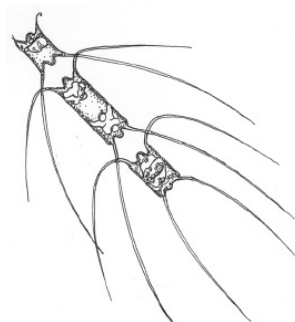
Monterey Bay species: *C. didymus*,  
*C. decipiens*, *C. debilis*, *C. convolutus*,  
*C. constrictus*, *C. compressus*, *C. radicans*

Order: Biddulphiales  
 Family: Chaetocerotaceae

Description: Cells form chains that are coiled, curved or straight. Long setae emerge from corners of cells. One of the largest genera of diatoms, roughly 400 species, most of which are marine. Some species form resting spores and/or auxospores.

Cell Size: Width (apical axis) varies with species, roughly ranges from <10um to 50um.

Distribution: Widespread throughout the world's oceans, often dominant in Monterey Bay.







## Genus: *Corethron*

## Diatom

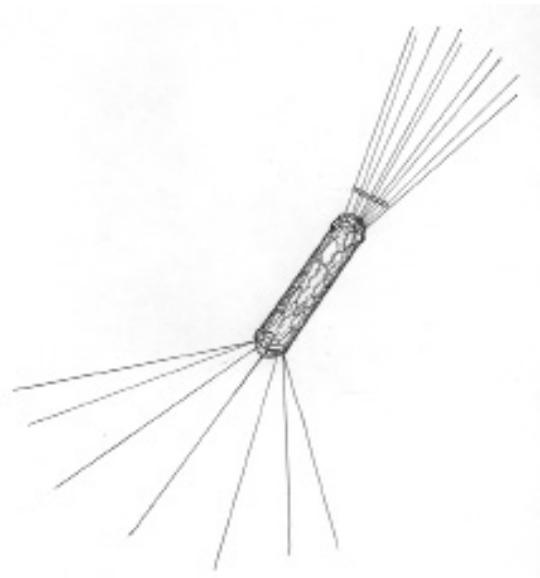
Monterey Bay species: *C. hystrix*

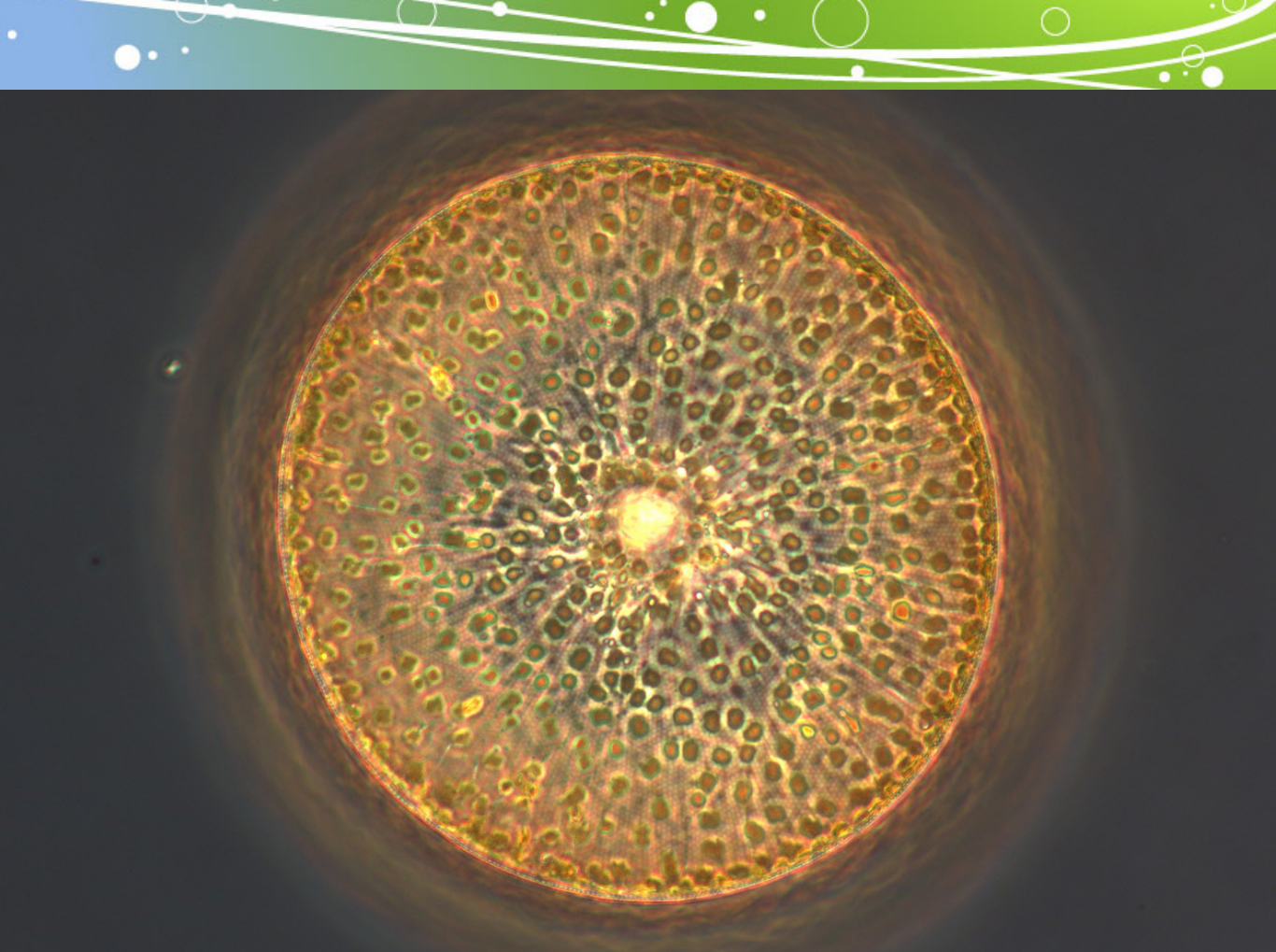
Order: Biddulphiales  
Family: Corethraceae

Description: Cylindrical cells with more or less dome-shaped valves. Generally solitary. Girdle is composed of many bands. Spines on both valves, one valve with series of short hooked spines, in addition to the longer ones. Chloroplasts are flat, elongated, and near the center of the cell.

Cell Size: Diameter (apical axis) = 20 – 40µm,  
Length (perivalvar axis) = 20 – 150µm

Distribution: Oceanic in the North Atlantic and North Pacific, sometimes found in inshore waters.





## Genus: *Coscinodiscus*

## Diatom

Monterey Bay Species: *C. centralis*, *C. granii*

Order: Biddulphiales

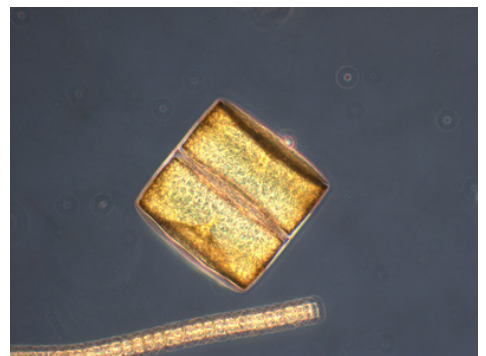
Family: Coscinodiscaceae

Description: Cells disc-shaped, cylindrical or wedge-shaped, and solitary. Distinct rosette of large areolae in the center of the valve.

Cell Size: Diameter (apical axis) = 30 – 500um

Distribution: Widespread-warm water to boreal.

Interesting Facts: One of the largest marine planktonic diatom generas (400–500 taxa described and identified).







## Genus: *Cylindrotheca*

## Diatom

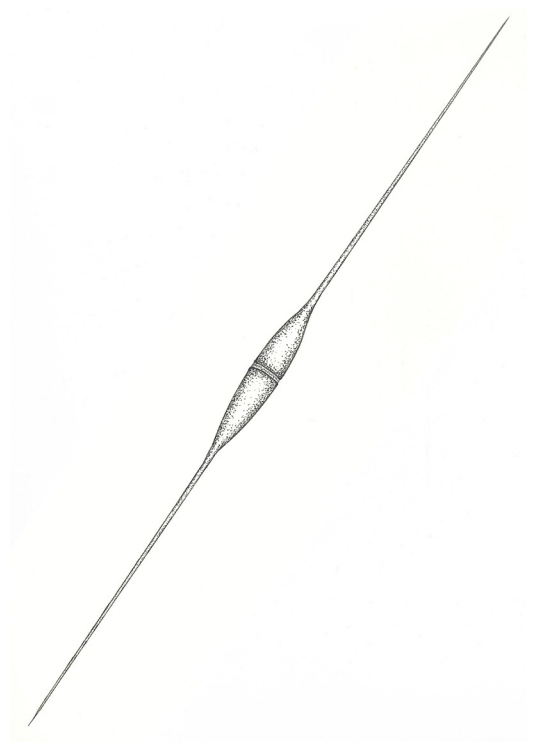
Monterey Bay Species: *C. closterium*,  
*C. fusiformis*

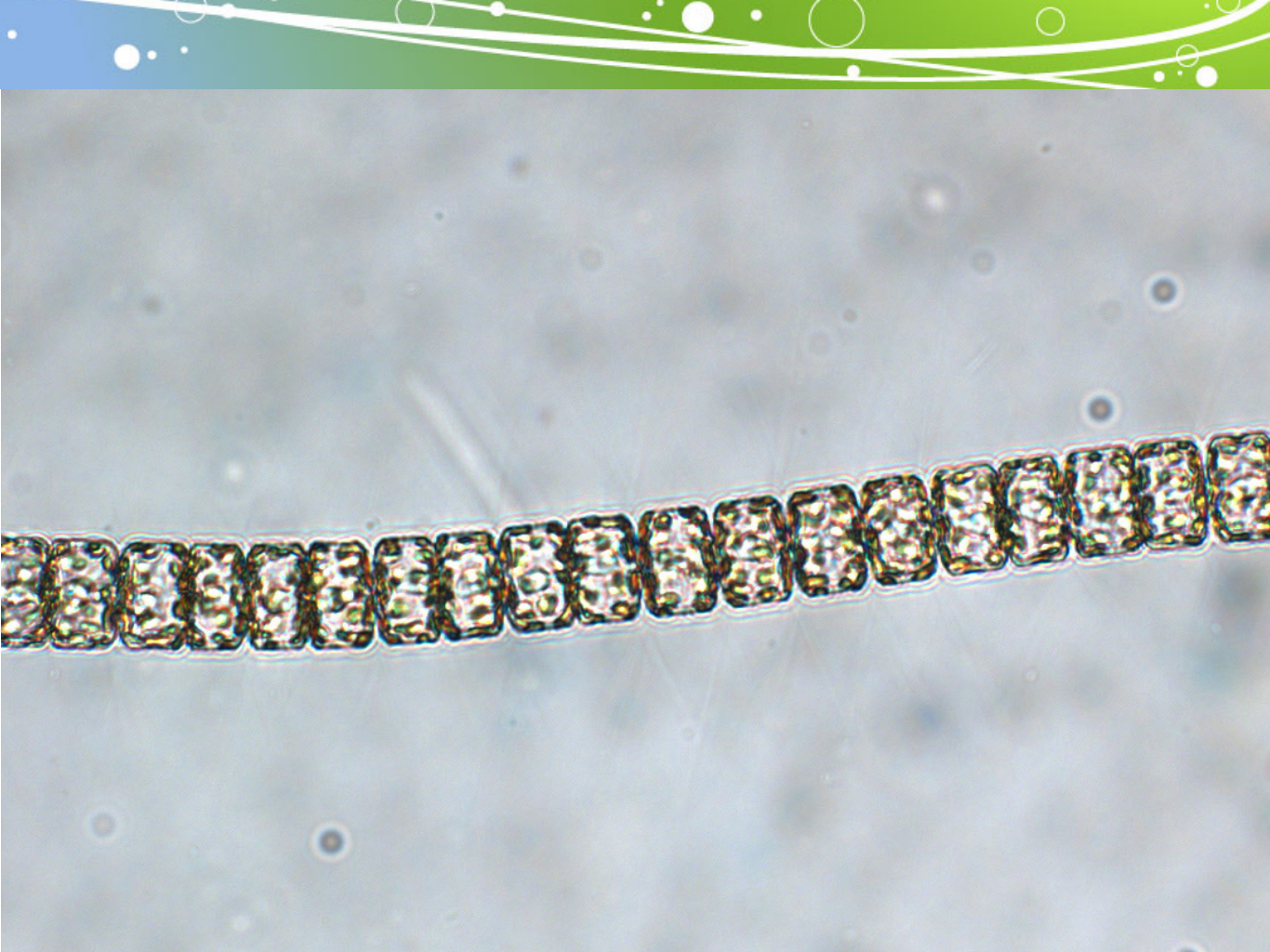
Order: Bacillariophycidae  
Family: Bacillariaceae

Description: Valve faces weakly silicified.  
Raphe transversed by a series of fibulae which  
are joined directly to the valve face. Two  
prominent chloroplasts.

Cell Size: length (apical axis) 30-400um,  
transapical axis 2.5-8um

Distribution: Cosmopolitan. Planktonic,  
commonly found on seaweeds and polar ice.





## Genus: *Detonula*

## Diatom

Monterey Bay Species: *D. pumila*

\*similar appearance to *Lauderia*

Order: Biddulphiales

Family: Thalassiosiraceae

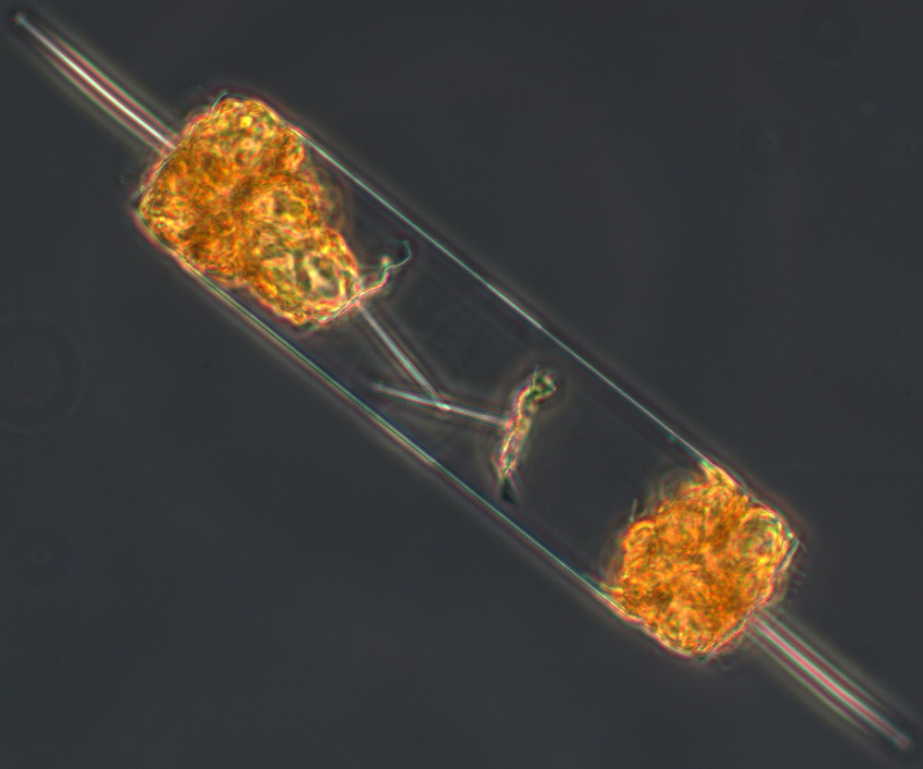
Description: Cylindrical cells joined together in straight, stiff chains by short processes and mucilage threads.

Cell Size: Diameter (apical axis) = 16 – 42µm

Distribution: Neritic, cosmopolitan, may prefer warmer waters

Synonym: *Schroederella delicatula*.





## Genus: *Ditylum*

## Diatom

Monterey Bay Species: *D. brightwellii*

Order: Biddulphiales

Family: Lithodesmiaceae

Description: Cells solitary, in short chains or, rarely, long chains. Cells have small, numerous chloroplasts and a long central spine. Produce resting spores.

Cell Size: Length (perivalvar axis) = 80 – 130um

Distribution: Cosmopolitan excluding polar waters.







## Genus: *Entomoneis*

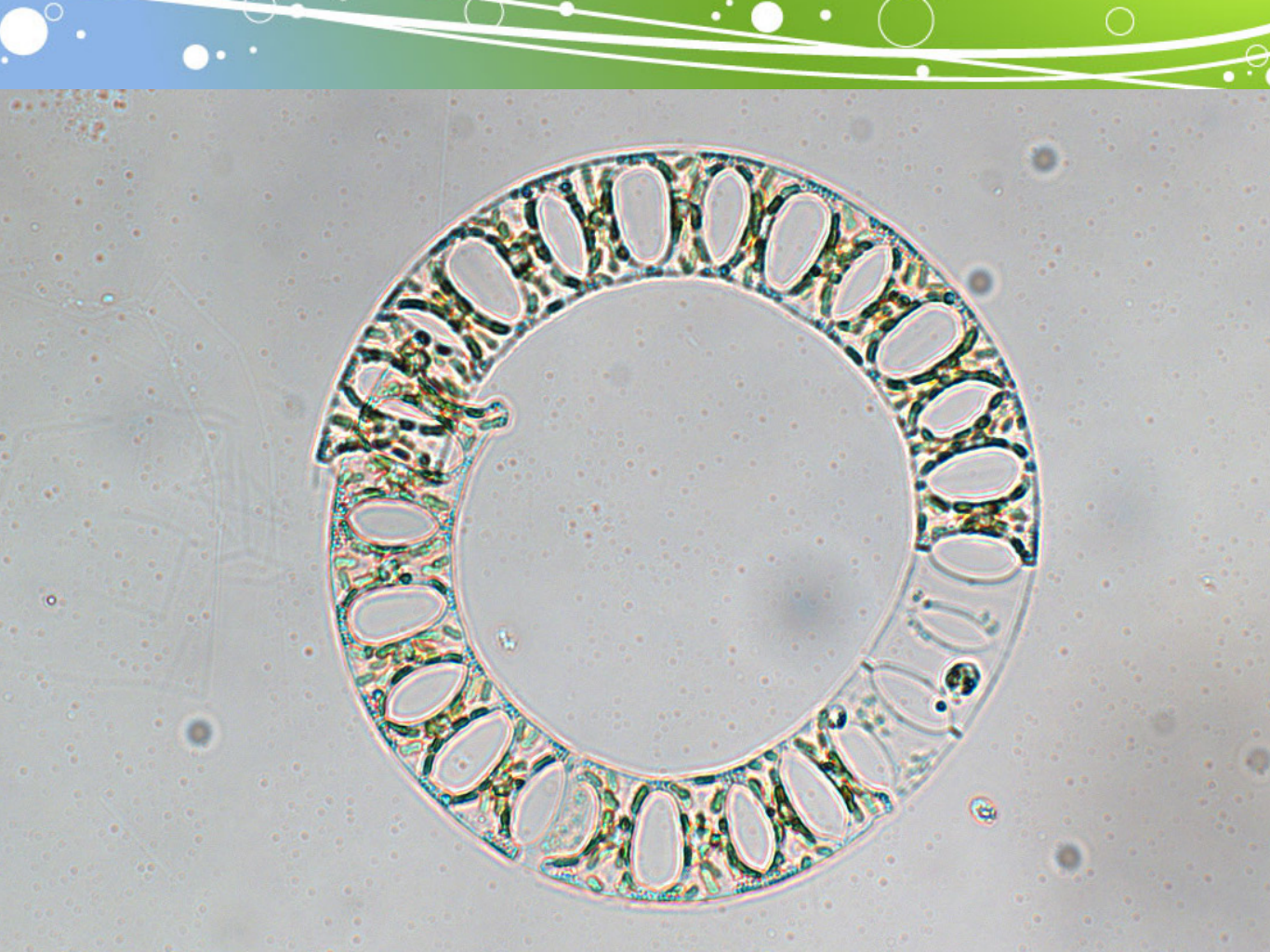
## Diatom

Order: Rhopalodiales

Family: Entomoneidaceae

Description: Genus found in marine, brackish, and freshwater environments. Girdle view shows two highly arched bilobate keels, one on each valve. The keels are slightly torsioned so that the lobes are not all in focus at one time. Several girdle bands are present and form a crossing, sigmoid pattern.

Cell Size: length 35-85um, width 20-30um



## Genus: *Eucampia*

## Diatom

Monterey Bay Species: *E. zoodiacus*

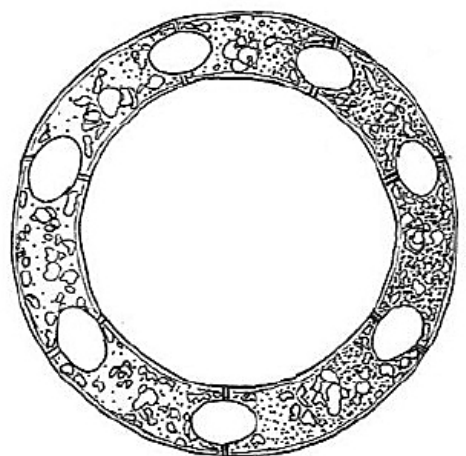
Order: Biddulphiales  
Family: Hemiaulaceae

Description: Forms elliptical chains. Cells are connected by two processes. Many discoid chloroplasts.

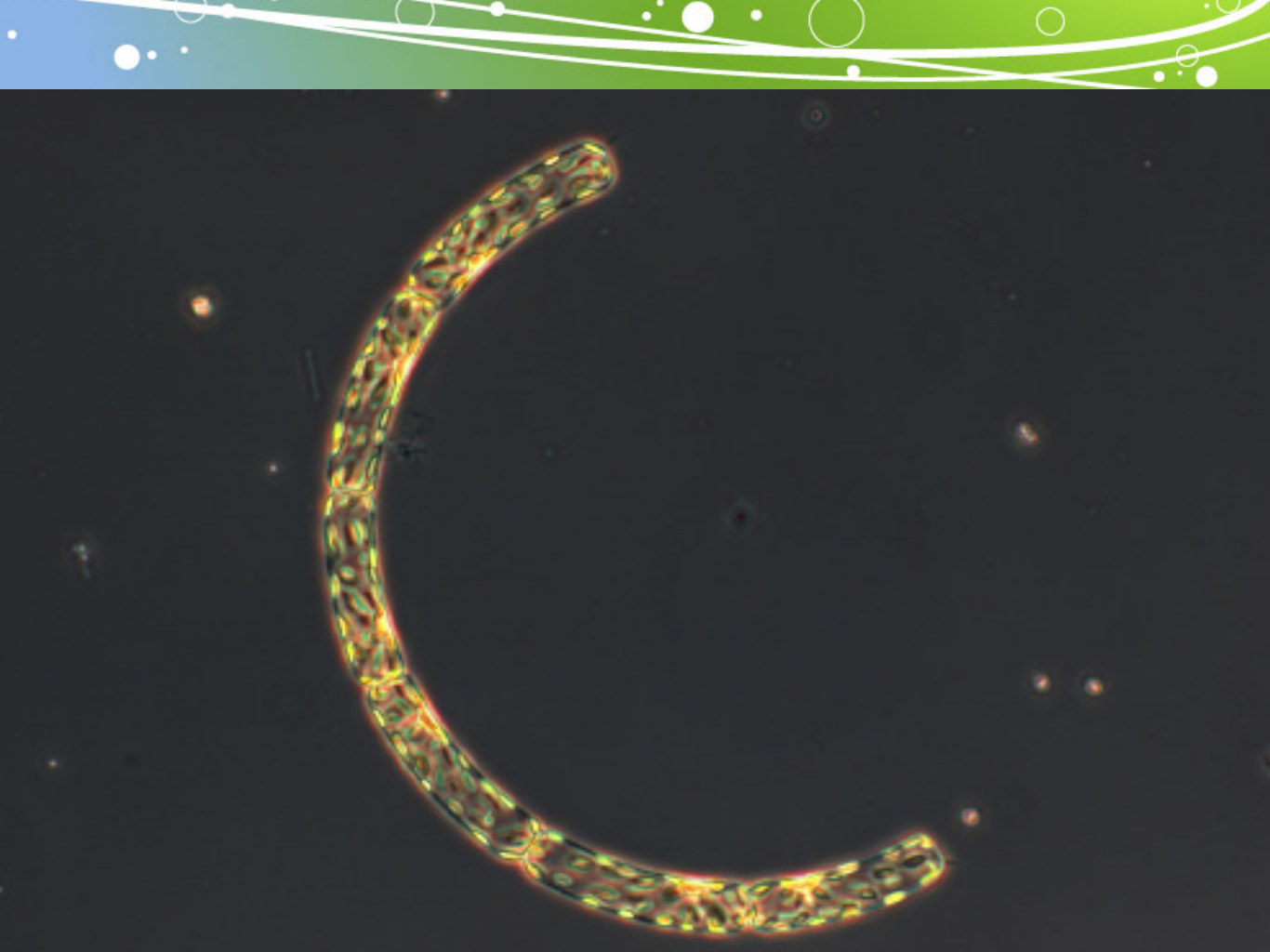
Cell Size: Length (apical axis) = 10 – 92µm

Distribution: Cosmopolitan, probably absent from polar regions.

Interesting Facts: First identified in 1831.







**Genus: *Guinardia***

**Diatom**

Monterey Bay Species: *G. striata*, *G. delicatula*

Order: Biddulphiales  
Family: Rhizosoleniaceae

Description: Cylindrical cells that form curving and sometimes spiraling chains. Girdle bands appear as collars. Small numerous chloroplasts.

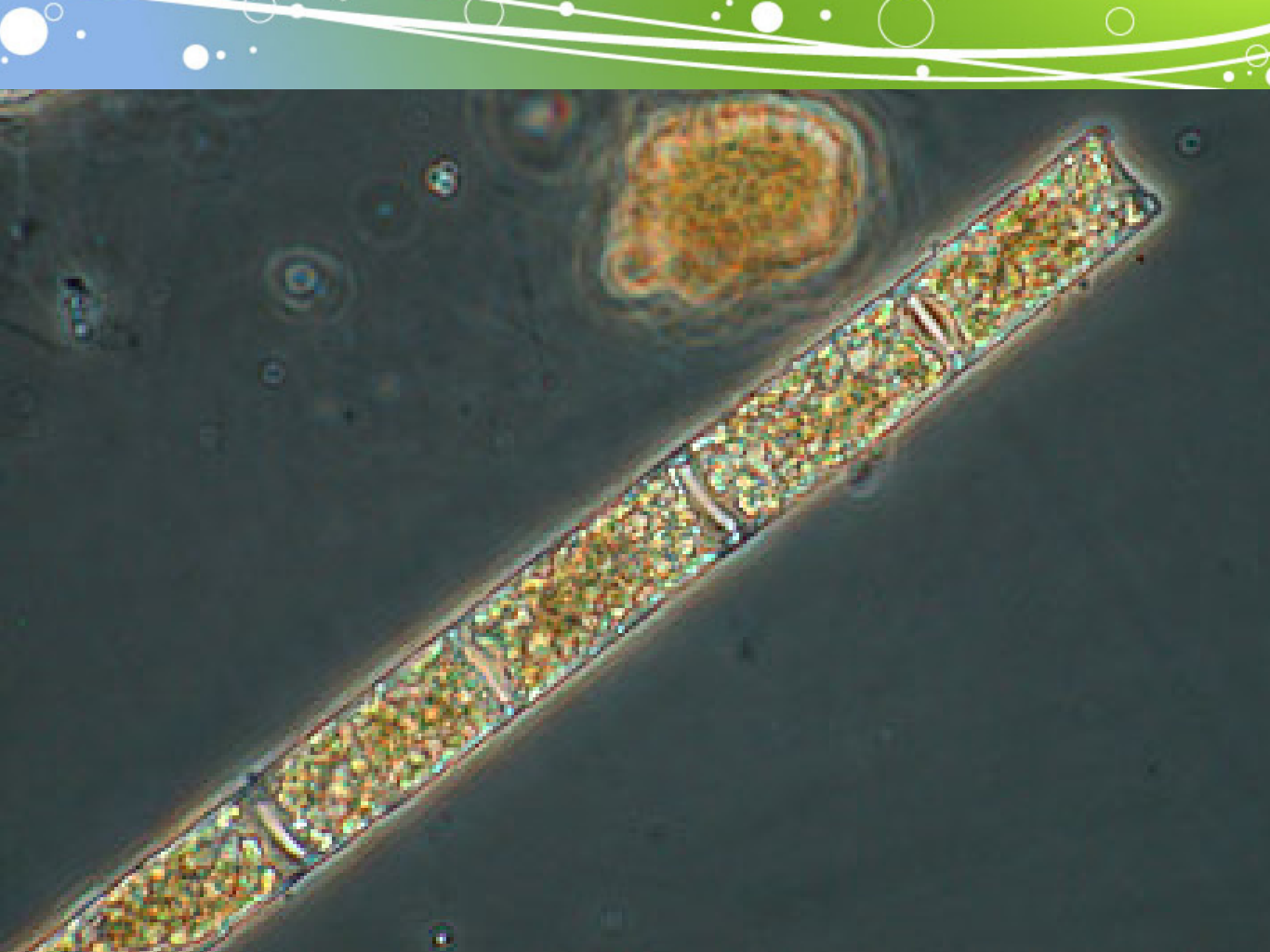
Cell Size: Width = 6 – 45um, Length = 250um

Distribution: Neritic, widespread, probably cosmopolitan.

Synonym: *Rhizosolenia stolterfothii*







## Genus: *Hemiaulus*

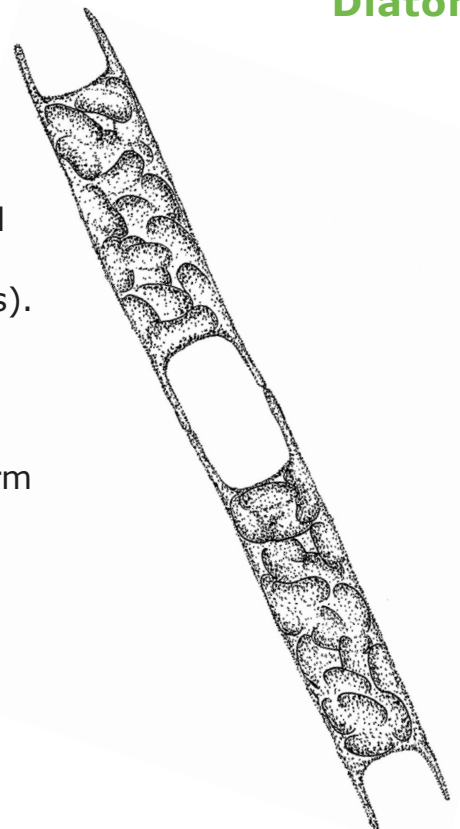
Order: Hemiaulales  
Family: Hemiaulaceae

Description: Cells form chains, sometimes curved or twisted. Valves are elliptical with long and sometimes claw-like elevations (connecting horns).

Cell Size: Width (apical axis) = 15-35um

Distribution: Oceanic to neritic, temperate to warm water

## Diatom





**Genus: *Lauderia***

**Diatom**

\*similar appearance to *Detonula*

Order: Biddulphiales

Family: Thalassiosiraceae

Description: Centric diatom. Cells form chains, and are separated by occluded processes on marginal part of valve. The valve surface has faint radial ribs.

Cell Size: Diameter = 24-75um, Width (perivalvar axis) = 26-96um

Distribution: warm water to temperate



## Genus: *Leptocylindrus*

## Diatom

Monterey Bay Species: *L. danicus*,  
*L. mediterraneus*, *L. minimus*

Order: Biddulphiales

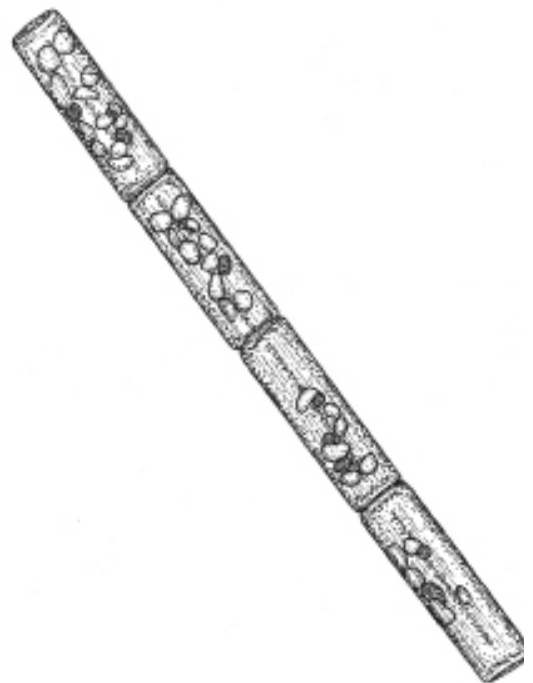
Family: Leptocylindraceae

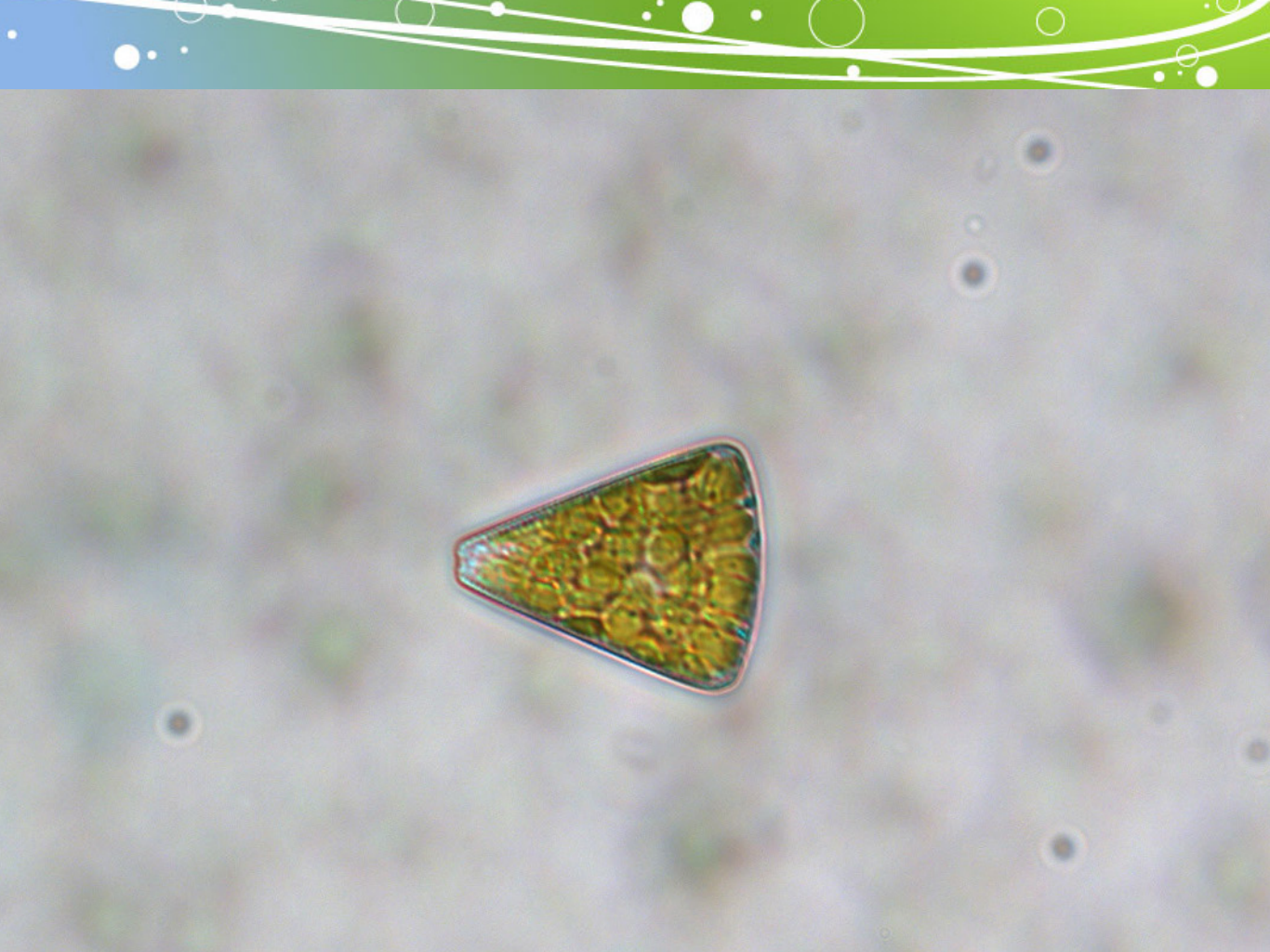
Description: Tight chains with abutting valve surfaces. Forms resting spores.

Cell Size: Diameter (apical axis) = 5 – 16µm

Distribution: Cosmopolitan.

Interesting Fact: *L. mediterraneus* is nearly always found with epiphytic flagellate *Solenicola setigera*.





**Genus: *Licmophora***

**Diatom**

Order: Licmophorales  
Family: Licmophoraceae

Description: Epiphytic diatom, cells grow on a common stalk that is attached to rocks or algae. Often found in low numbers in shallow or turbid environments, both marine and freshwater. Distinct triangular or fan-shaped cells.

Cell Size: length 150-250um





## Genus: *Lioloma*

## Diatom

Monterey Bay species: *Lioloma pacificum*

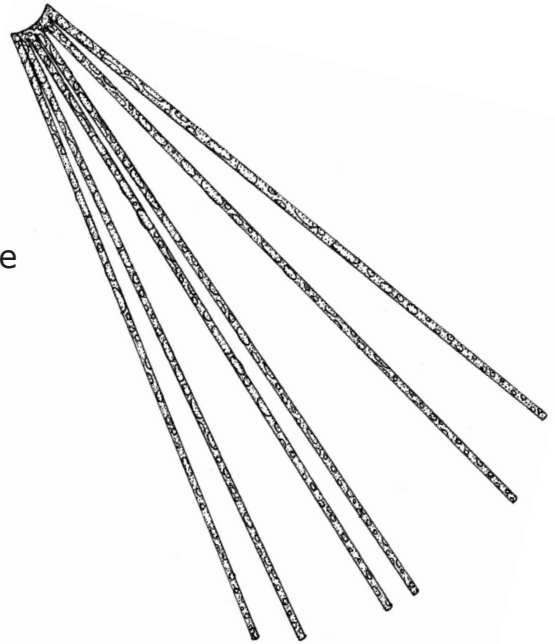
Order: Bacillariales

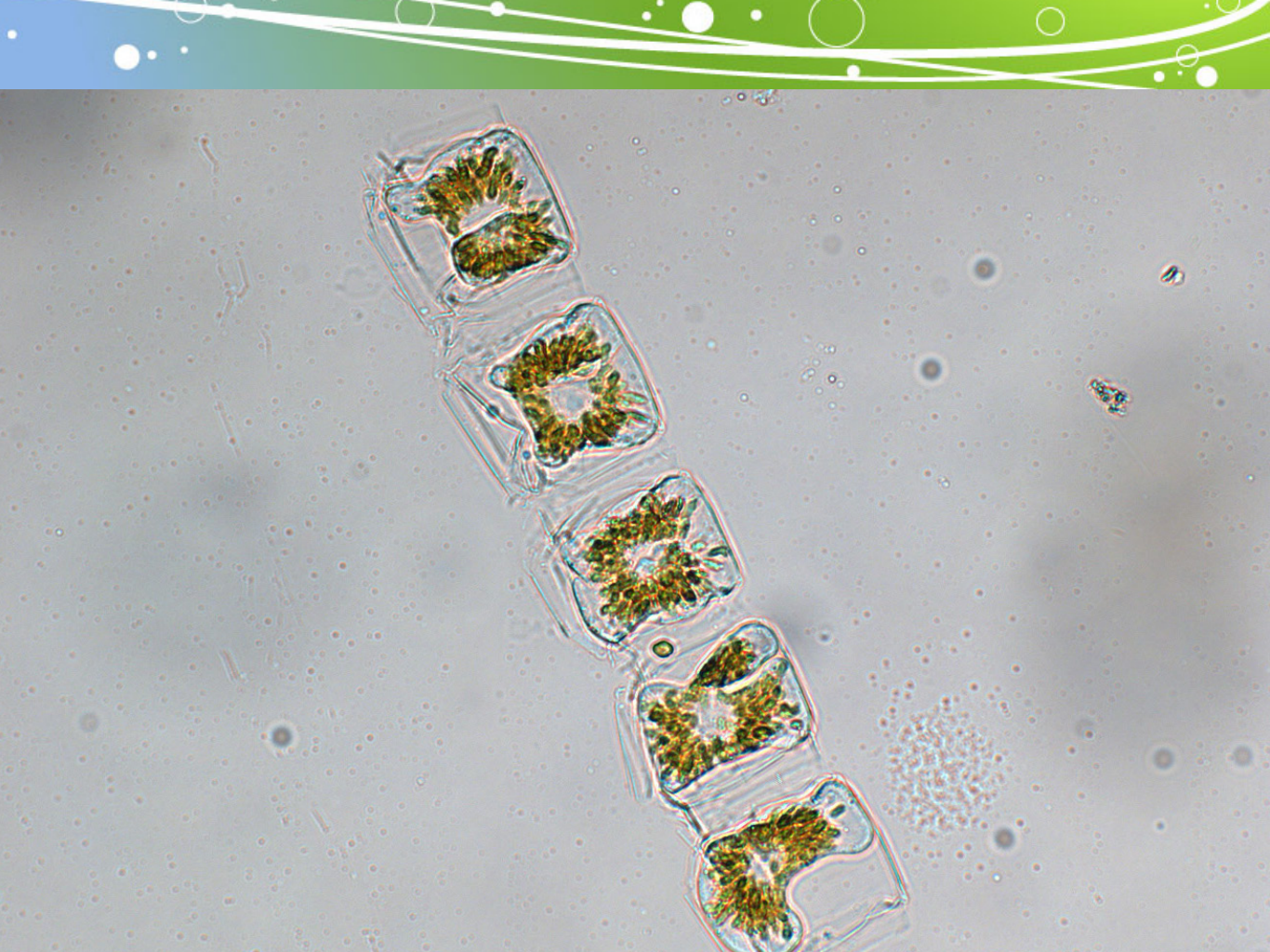
Family: Thalassionemataceae

Description: Delicate cells are united in fan-like colonies.

Cell Size: Width (perivalvar axis) = 1.8-7 $\mu$ m,  
Length (apical axis) = 525-1,920 $\mu$ m

Distribution: Warm to temperate waters





## Genus: *Lithodesmium*

## Diatom

Order: Lithodesmiales

Family: Lithodesmiaceae

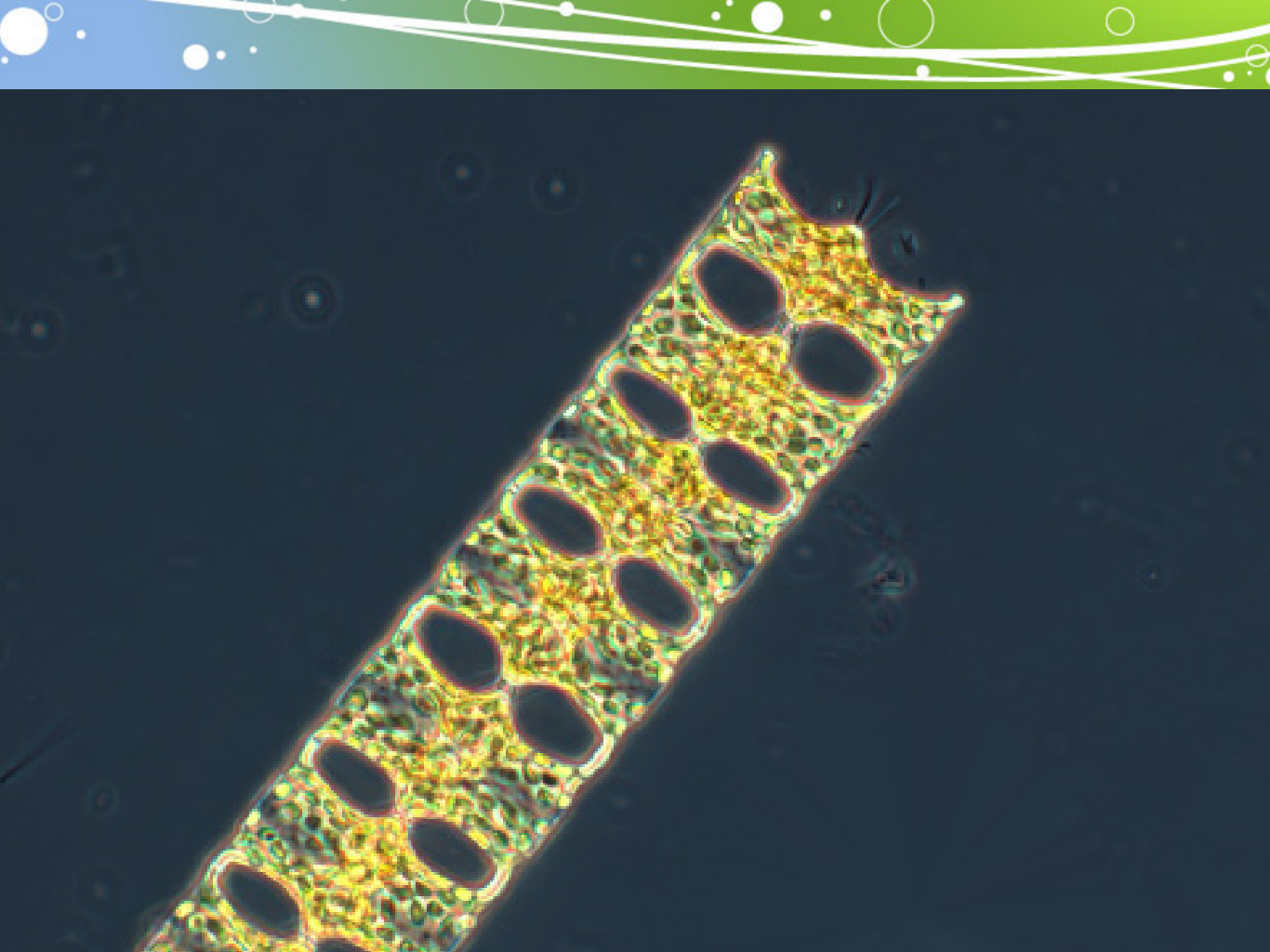
Description: Centric diatom. Cells can be solitary or form ribbon-like chains. Cells are rectangular or square in girdle view, and triangular or quadrangular in valve view. Cells have elevations at valve corner, and numerous small chloroplasts are visible.

Cell Size: Width (perivalvar axis) = 20-75  $\mu\text{m}$

Distribution: Range from warm to temperate waters. Some species are benthic.

Distribution: Warm to temperate waters.





## Genus: *Odontella*

## Diatom

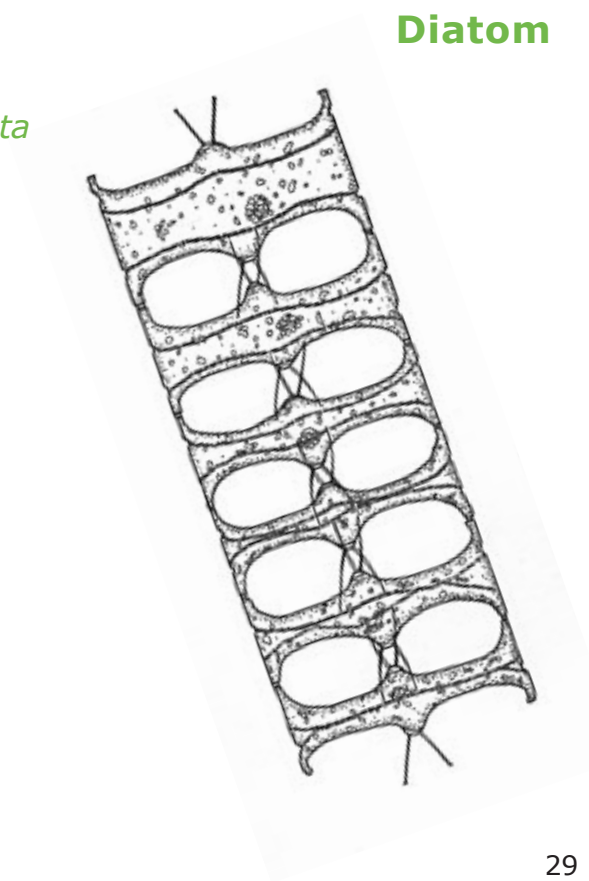
Monterey Bay Species: *O. longicuris*, *O. aurita*

Order: Biddulphiales  
Family: Eupodiscaceae

Description: Heavily silicified cells form curving or spiraling chains joined by mucous pads on ends of elevations. Numerous small chloroplasts.

Cell Size: Width (apical axis) = 10 – 97µm

Distribution: Most abundant in north temperate regions, and likely cosmopolitan. May be a littoral species.





**Genus: *Pleurosigma***

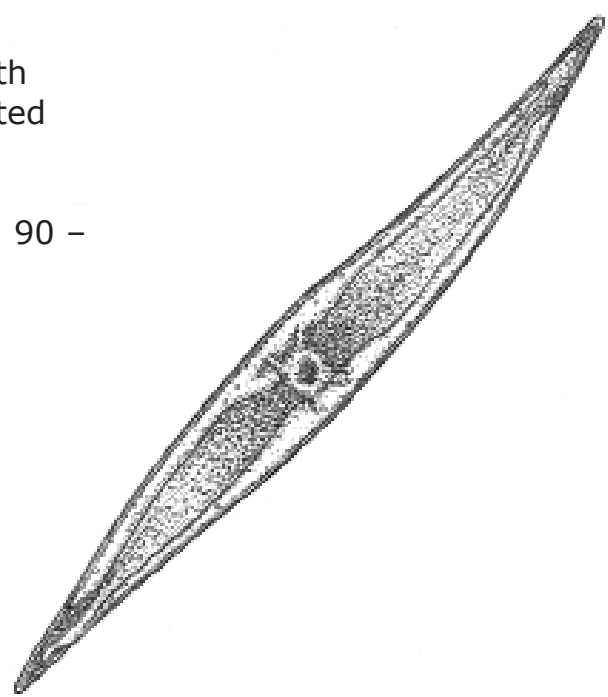
**Diatom**

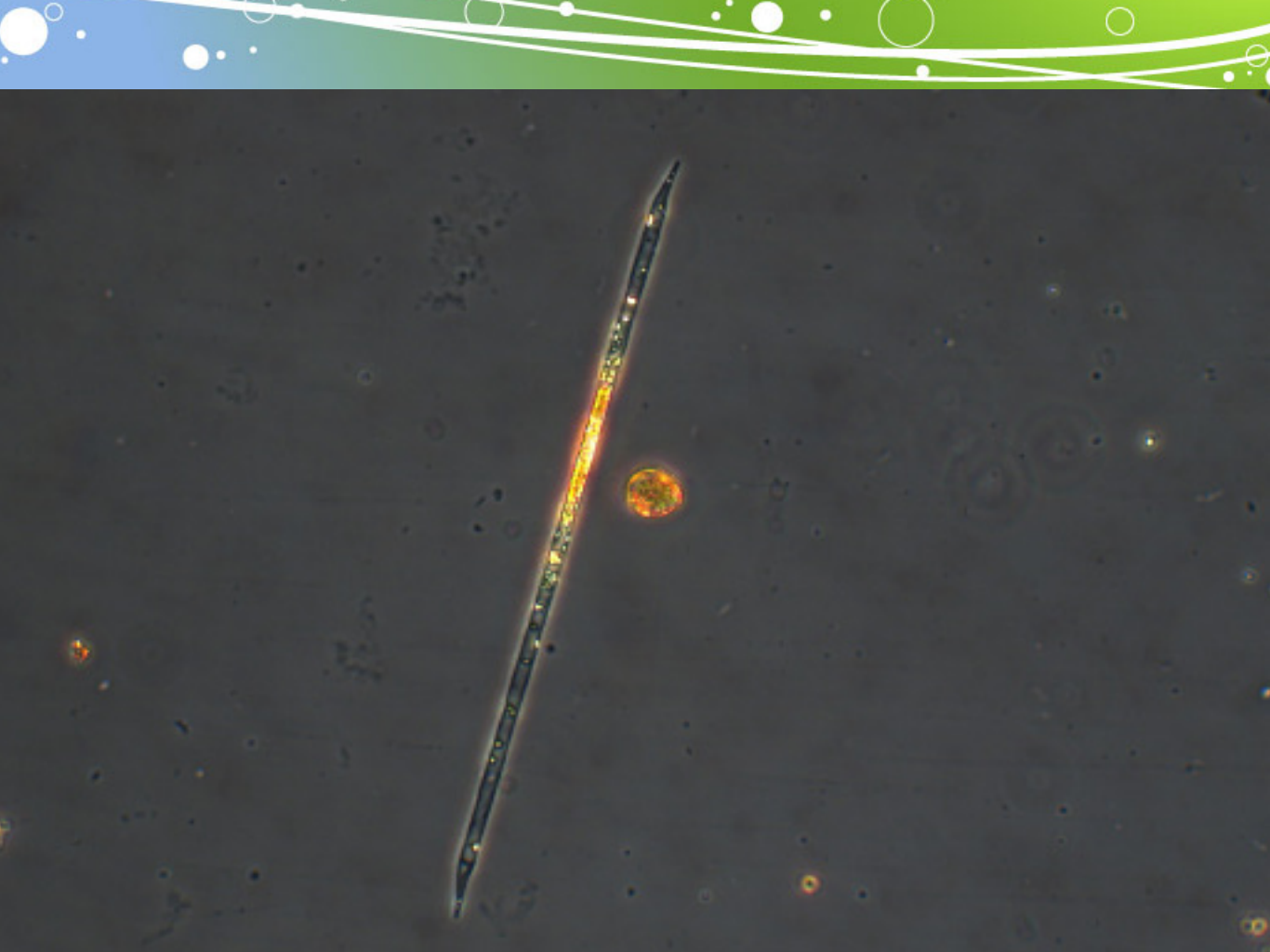
Order: Bacillariales  
Family: Bacillariineae

Description: Solitary pennate diatom with a gentle sigmoid shape. Has 2-4 elongated chloroplasts.

Cell Size: Width = 28 – 75um, Length = 90 – 600um

Distribution: Cosmopolitan.





## Genus: *Proboscia*

## Diatom

Monterey Bay Species: *P. alata*

Order: Biddulphiales  
Family: Rhizosoleniaceae

Description: Long, cylindrical cells. Valves terminate in a proboscis. Auxospores sometimes present.

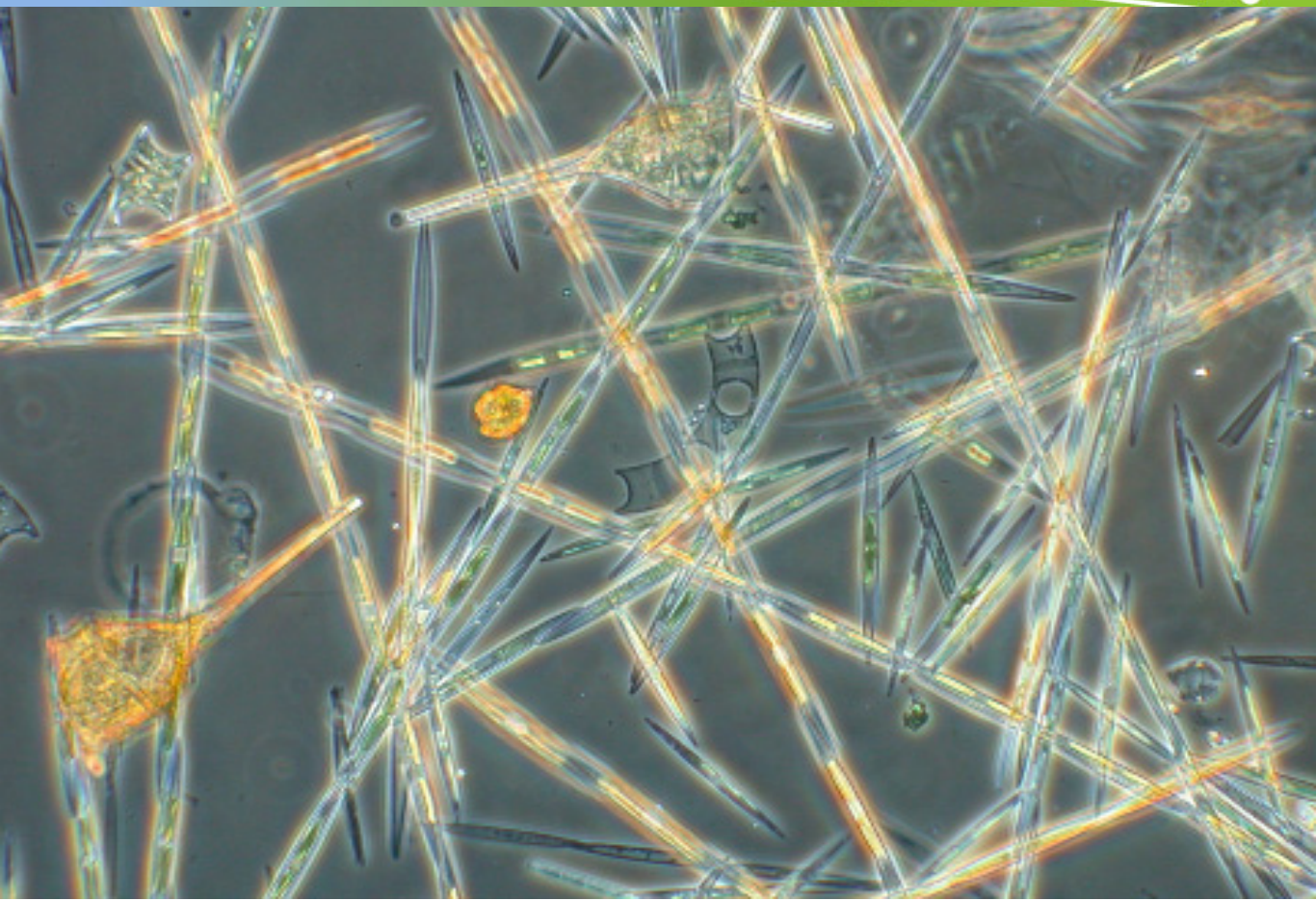
Cell Size: Diameter (apical axis) = 7 – 18µm,  
Length (per valve) = 1mm

Distribution: Oceanic temperate waters,  
sometimes coastal.

Synonym: *Rhizosolenia alata*.







## Genus: *Pseudo-nitzschia*

## Diatom

Monterey Bay species: *P. australis*, *P. multiseriis*, *P. pungens*, *P. fraudulenta*, *P. pseudodelicatissima*

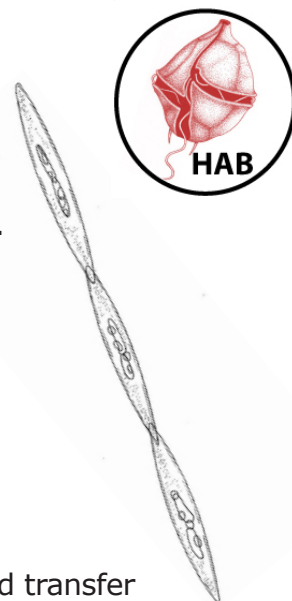
Order: Bacillariales  
Family: Bacillariaceae

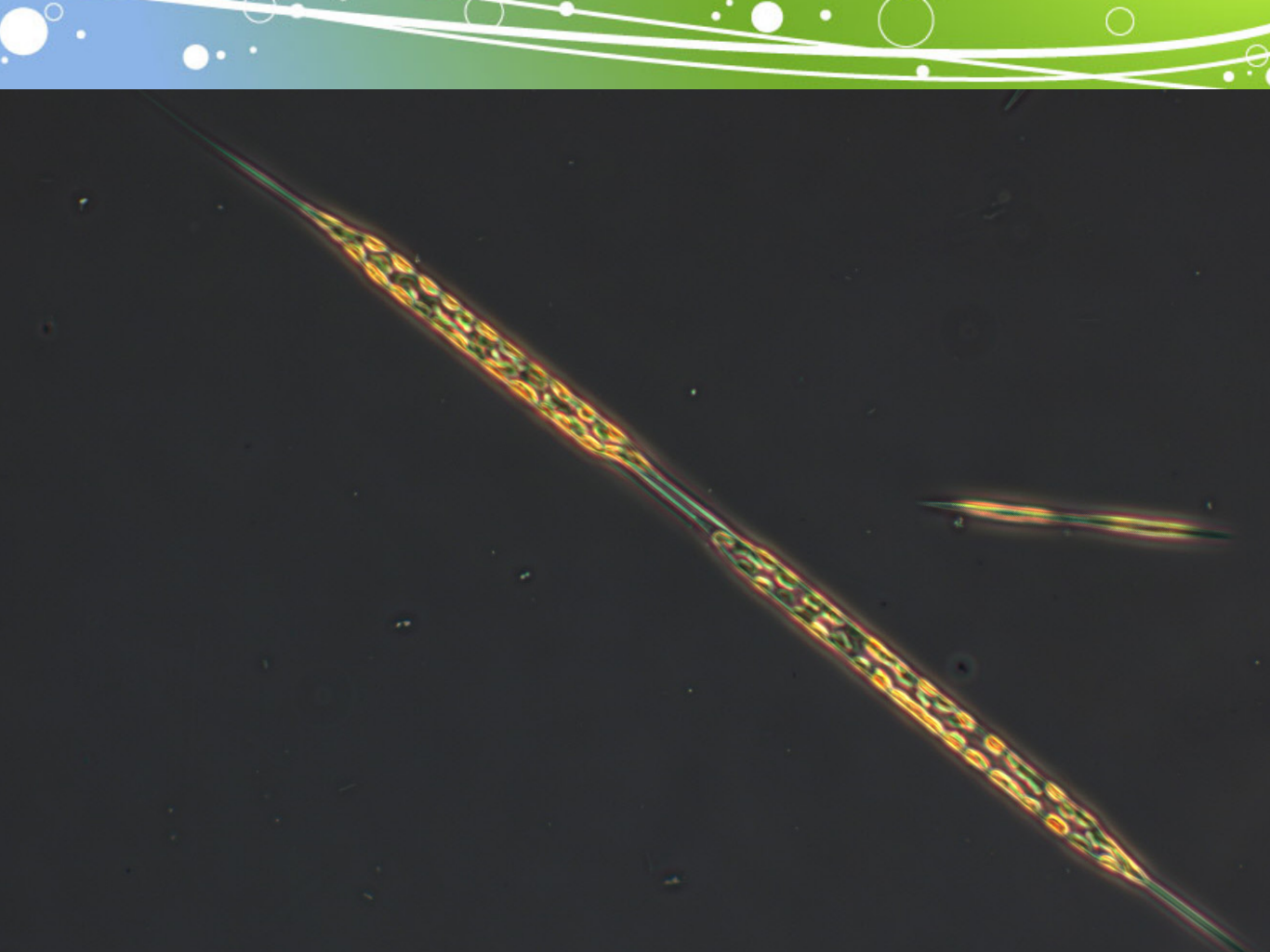
Description: Cells are elongate, fusiform or rectangular in girdle view. Form chains by overlapping of cell ends. Chains of 20 or more cells are not uncommon.

Cell Size: Width = 2 – 8µm, Length = 40 – 175µm

Distribution: Widespread

Interesting Facts: Many species produce domoic acid, the neurotoxin responsible for Amnesiac Shellfish Poisoning. Fish feed on these cells and transfer the domoic acid to their predators, which include seabirds and marine mammals. The toxin has a deleterious effect on these animals, often resulting in their deaths. The species capable of producing domoic acid do not do so all the time. The conditions that trigger toxin production are of great interest to researchers.





## Genus: *Rhizosolenia*

## Diatom

Monterey Bay species: *R. setigera*, *R. hebatata*,  
*R. styliformis*, *R. robusta*

Order: Biddulphiales

Family: Rhizosoleniaceae

Description: Long, cylindrical, straight or slightly curved cells with a spine-like process on one end. Cells may be solitary or in short chains. Valves are conical or subconical. Segmented girdle bands are in longitudinal columns roughly parallel to the perivlavar axis. Cells have numerous small chloroplasts.

Cell Size: Diameter = 13 – 230um among five most common species.

Distribution: Widespread throughout the world's oceans.





**Genus: *Skeletonema***

**Diatom**

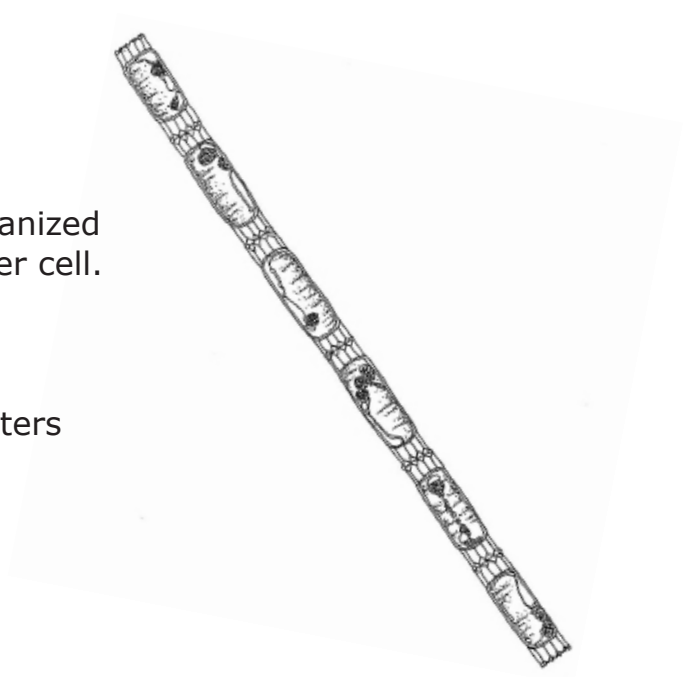
Monterey Bay species: *S. costatum*

Order: Biddulphiales  
Family: Thalassiosiraceae

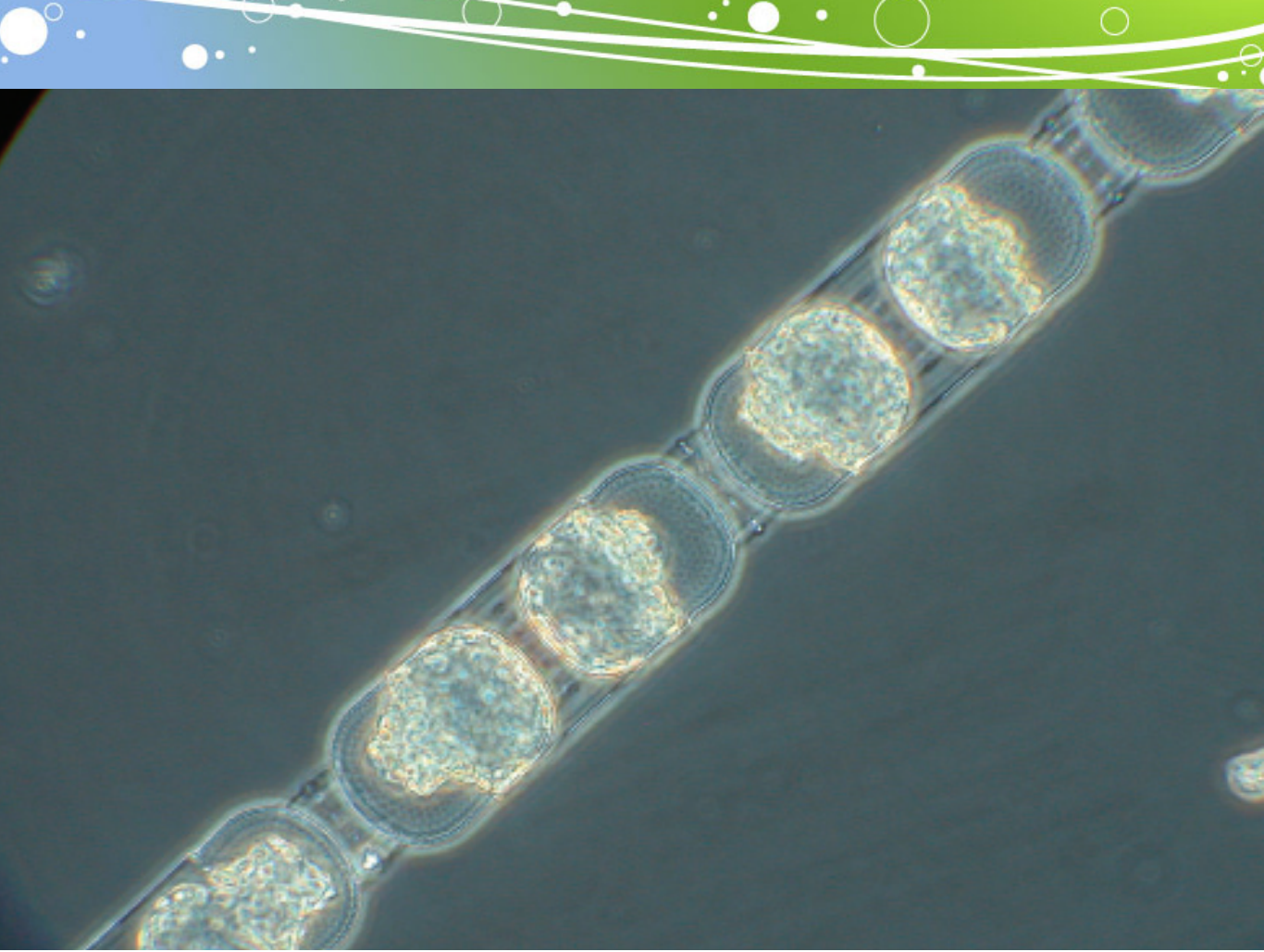
Description: Cells in chains, attached by external tubes or strutted processes organized in one marginal ring. Two chloroplasts per cell.

Cell Size: Diameter = 2 – 21µm

Distribution: Cosmopolitan in coastal waters excluding polar regions.







## Genus: *Stephanopyxis*

## Diatom

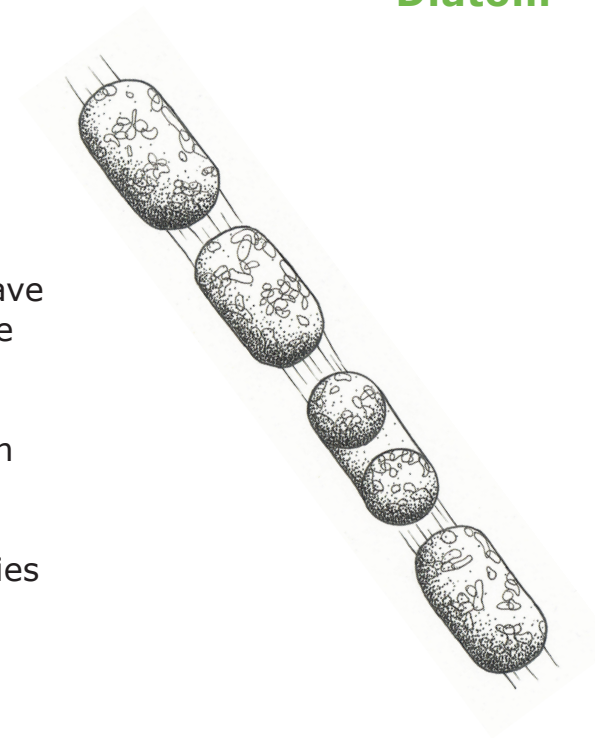
Order: Biddulphiales

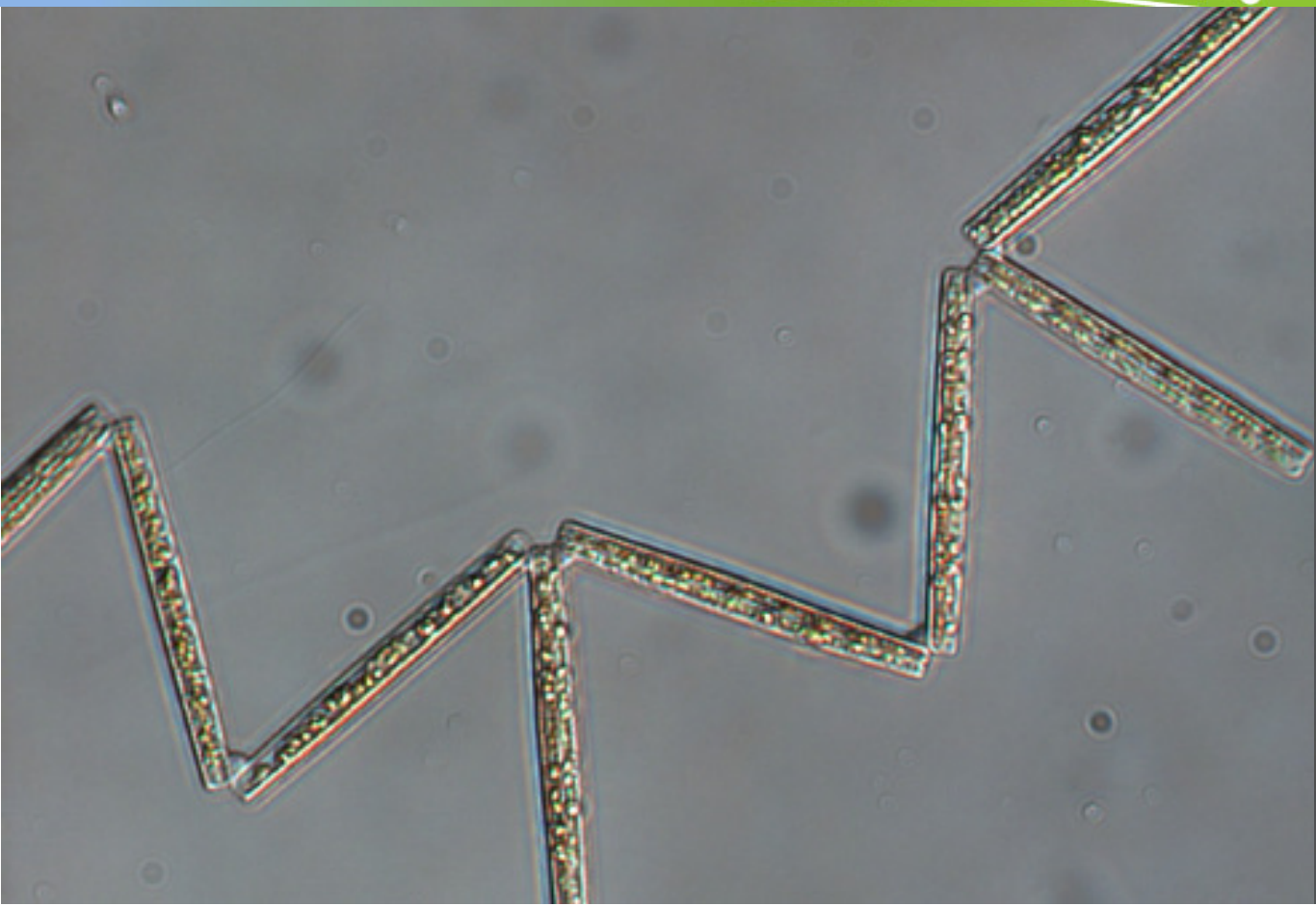
Family: Melosiraceae

Description: Cylindrical, sometimes nearly spherical, capsule-shaped cells. Valves are domed with large hexagonal areolae. Cells have numerous discoid or lobed chloroplasts. Some species form resting spores.

Cell Size: Diameter (apical axis) = 24 – 71µm

Distribution: Some species are found in temperate to northern cold water, other species are found in temperate to warm waters.





## Genus: *Thalassionema*

## Diatom

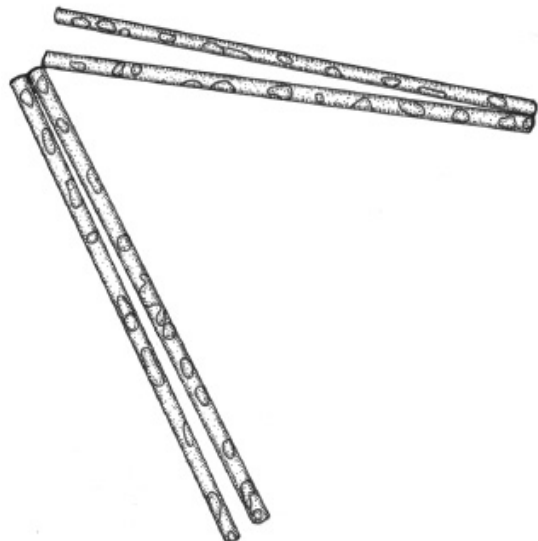
Order: Bacillariales

Family: Thalassionemataceae

Description: Cells attached together by mucilage pads at their ends into stellate and/or zigzag-like colonies.

Cell Size: Length (apical axis) = 10 – 80µm,  
Width (perivalvar) = 2 – 4µm

Distribution: Neritic, cosmopolitan in temperate to tropical waters.





## Genus: *Thalassiosira*

## Diatom

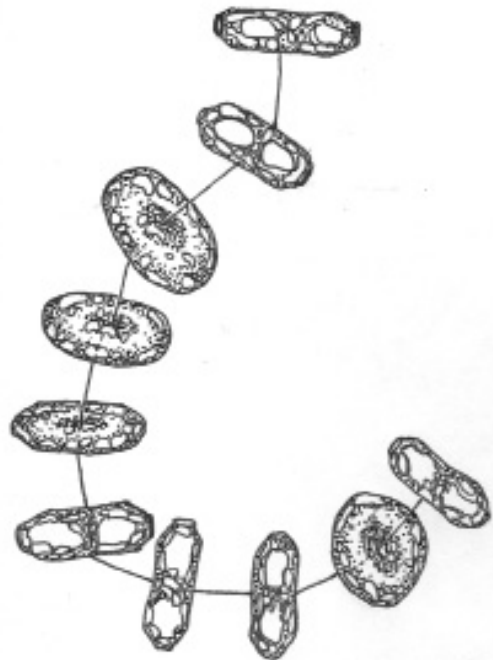
Monterey Bay Species: *T. rotula*, *T. aestivalis*,  
*T. nordenskioldii*, *T. anguste-lineata*,  
*T. weissflogii*

Order: Biddulphiales  
Family: Thalassiosiraceae

Description: Well-studied marine genus with over 100 species. Discoid cells are in chains or are embedded in mucilage (i.e. *T. subtilis*). Chains-forming species are connected by a central organic thread. Numerous spine-like threads also extruded from strutted processes on valve margins.

Cell Size: Diameter (apical axis) = 3 – 186µm

Distribution: Widespread throughout the world's oceans







## Genus: *Thalassiothrix*

## Diatom

Monterey Bay Species: *T. longissima*, *T. antarctica*,  
*T. gibberula*

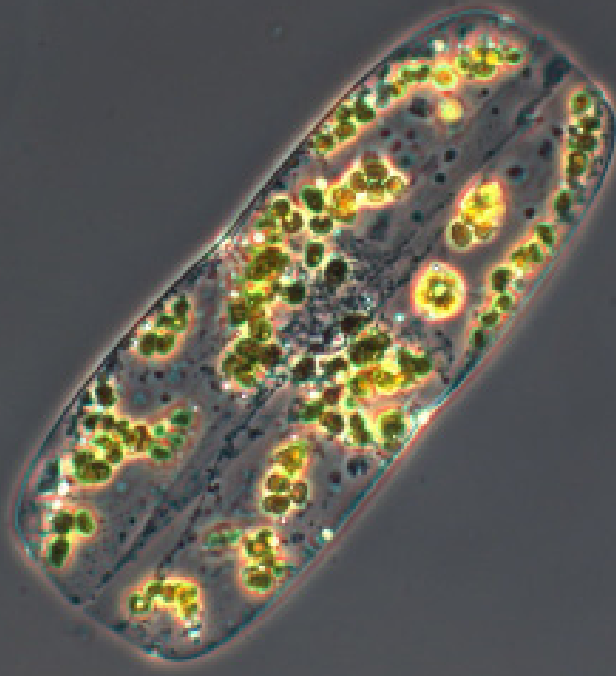
Order: Bascillariales

Family: Thalassionemataceae

Description: Very long cells that can be solitary or form radiating colonies. Cells can be straight, slightly curved, or sigmoid, and are usually strongly twisted. Valves inflated at the center and apices, and marginal spines are present. Can be mistaken for *Thalassionema*.

Cell Size: Apical axis = 530-4000um, transapical axis 2.5-6um

Distribution: Widespread throughout the world's oceans



## Genus: *Tropidoneis*

## Diatom

Monterey Bay Species: *T. antarctica*

Order: Naviculales  
Family: Naviculaceae

Description: Solitary cells. Elliptical or slightly constricted in the center in valve view. Chloroplasts rod-like and numerous, radiating from central nucleus.

Cell Size: 160-350  $\mu\text{m}$

Distribution: Common in Puget Sound in the summer, occasionally found in California waters.

## Marine Dinoflagellates

- Single-celled algae that possess a distinct nucleus (eukaryotic)
- Possess two flagellae for mobility
- Cells are covered by a cellulose theca (sheath) that can be smooth or ornamented
- Some species migrate vertically in the water, possibly seeking nutrients, prey or refuge from damaging UV rays
- Many species form chains of linked cells
- Nearly half of known species are capable of photosynthesis (autotrophy) and possess light-harvesting pigments
- Some can absorb organic matter &/or engulf microbial prey (heterotrophy)
- Some species are capable of a combination of autotrophy and heterotrophy
- Of the 2000 species identified, about 60 are known to produce complex toxins
- When conditions are favorable, a population explosion or bloom may occur, sometimes resulting in contamination of fish and shellfish and posing a threat to human and animal health.

Unarmoured

Photosynthetic pigments

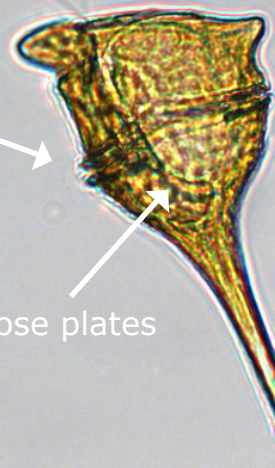
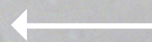


Cingulum



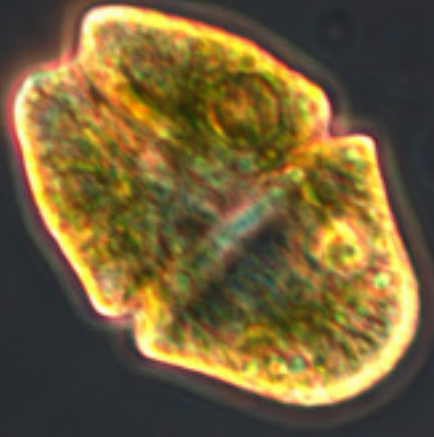
Armoured

Flagellum



Cellulose plates





## Genus: *Akashiwo*

## Dinoflagellate

Monterey Bay Species: *A. sanguinea*

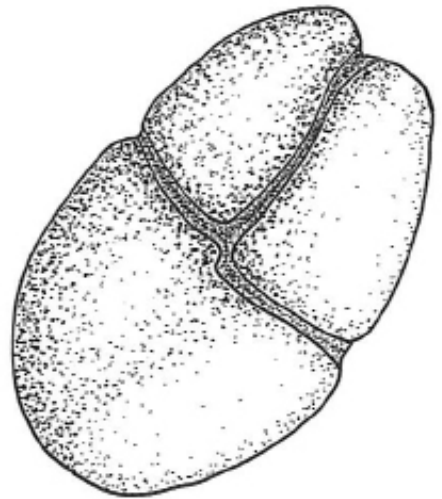
Order: Prorocentrales  
Family: Gymnodiniales

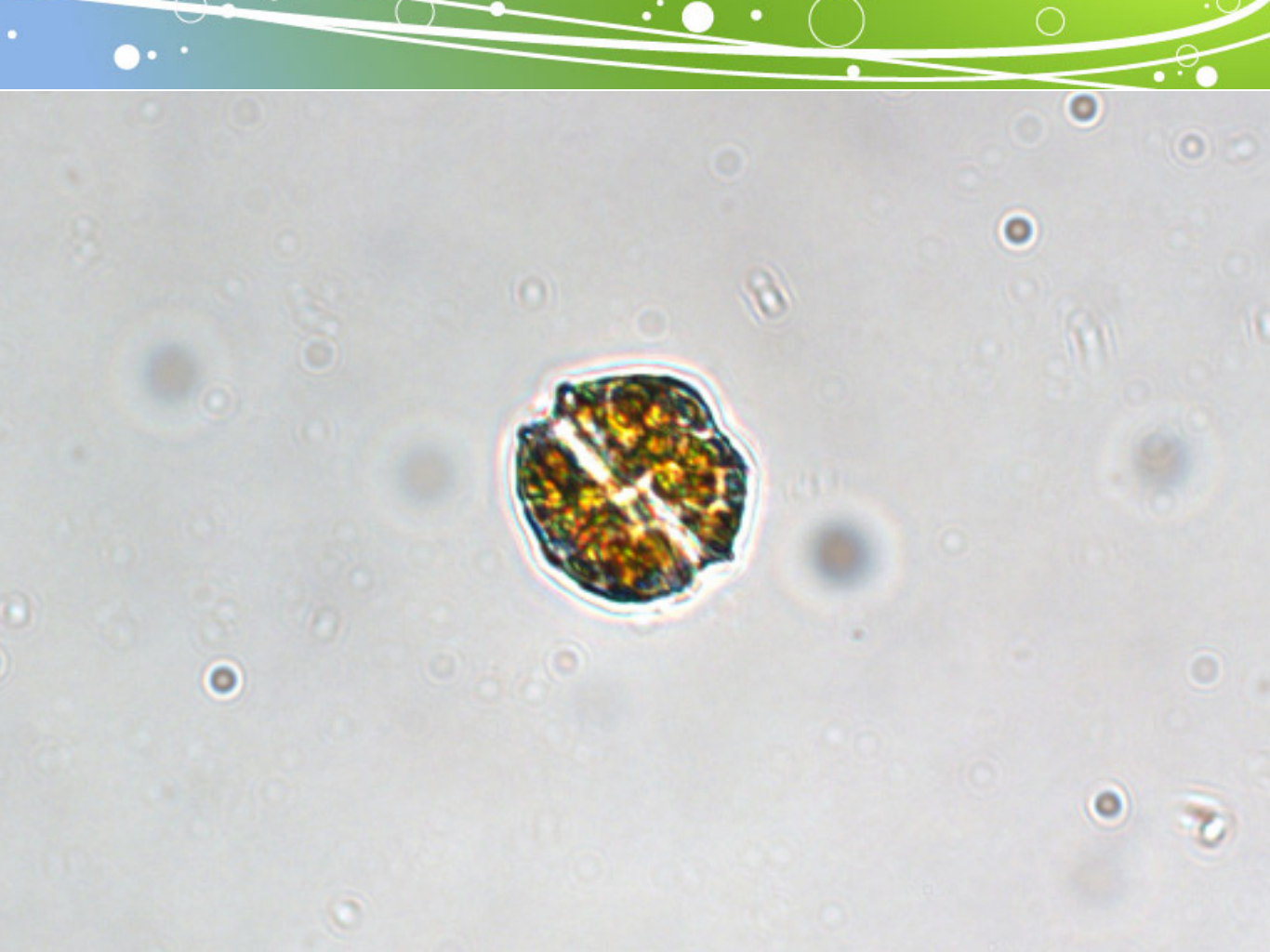
Description: Unarmored cells. Dorsoventrally flattened. Epitheca is broadly conical and the hypotheca is bilobed. Large, central nucleus and numerous chloroplasts. Cells can be deeply pigmented or clear, can form extensive blooms that color the water red.

Cell Size: Length = 40 – 80um

Distribution: Cosmopolitan in temperate to tropical coastal and estuarine waters.

Synonyms: *G. sanguineum* and *G. splendens*.





## Genus: *Alexandrium*

## Dinoflagellate

Monterey Bay Species: *A. catenella*

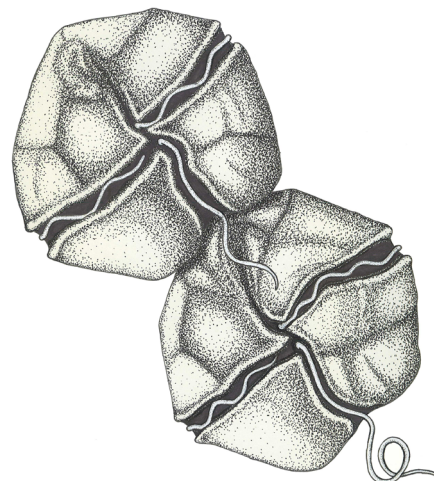
Order: Gonyaulacales  
Family: Goniodomataceae

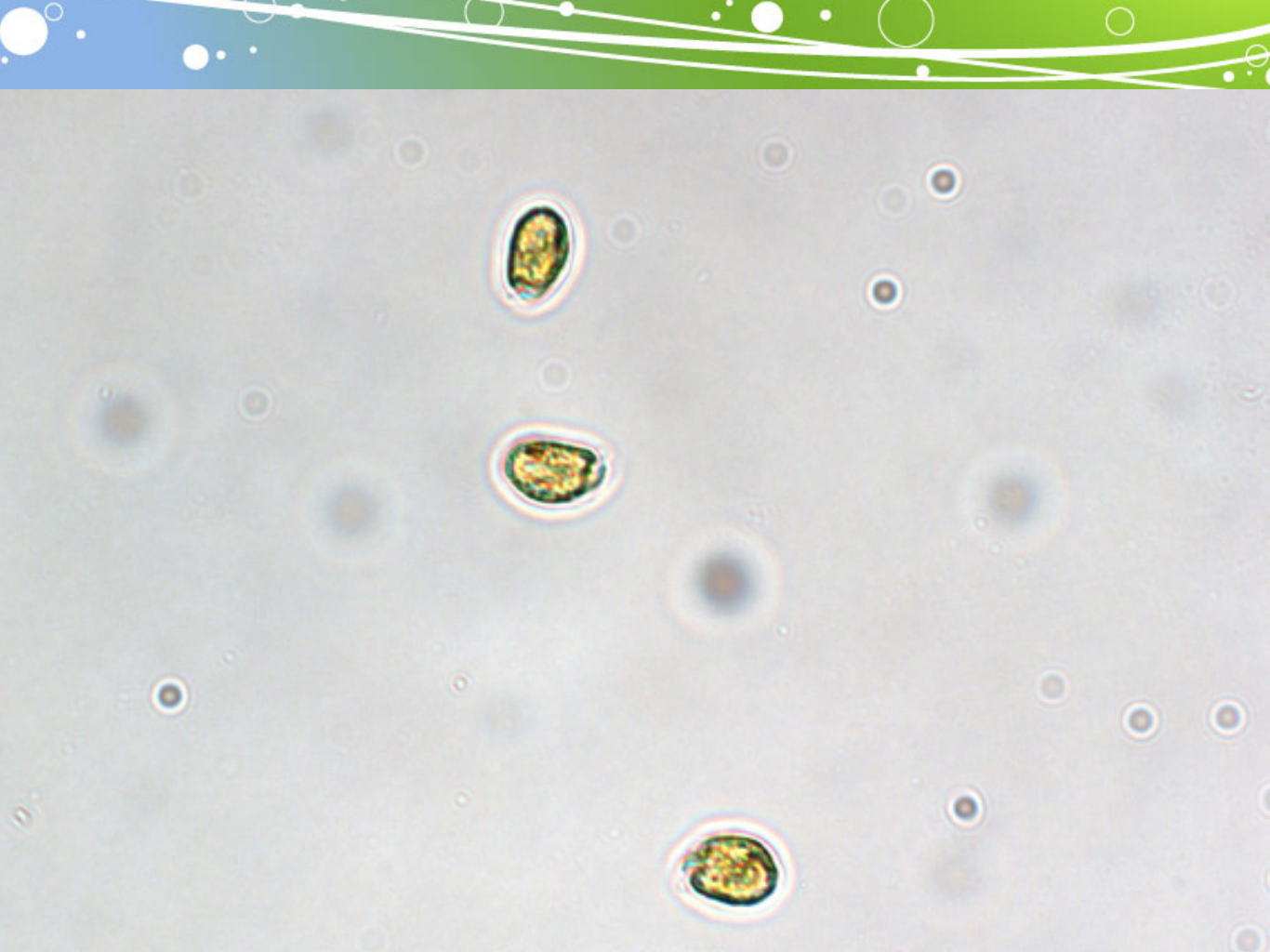
Description: Armoured cells, typically spherical.

Cell Size: Less than 45um

Distribution: Coastal temperate to tropical waters.

Interesting Facts: Several species, including *Alexandrium catenella*, are toxic and/or bioluminescent. They produce saxotoxins, among others, which lead to paralytic shellfish poisoning.





## Genus: *Amphidinium*

## Dinoflagellate

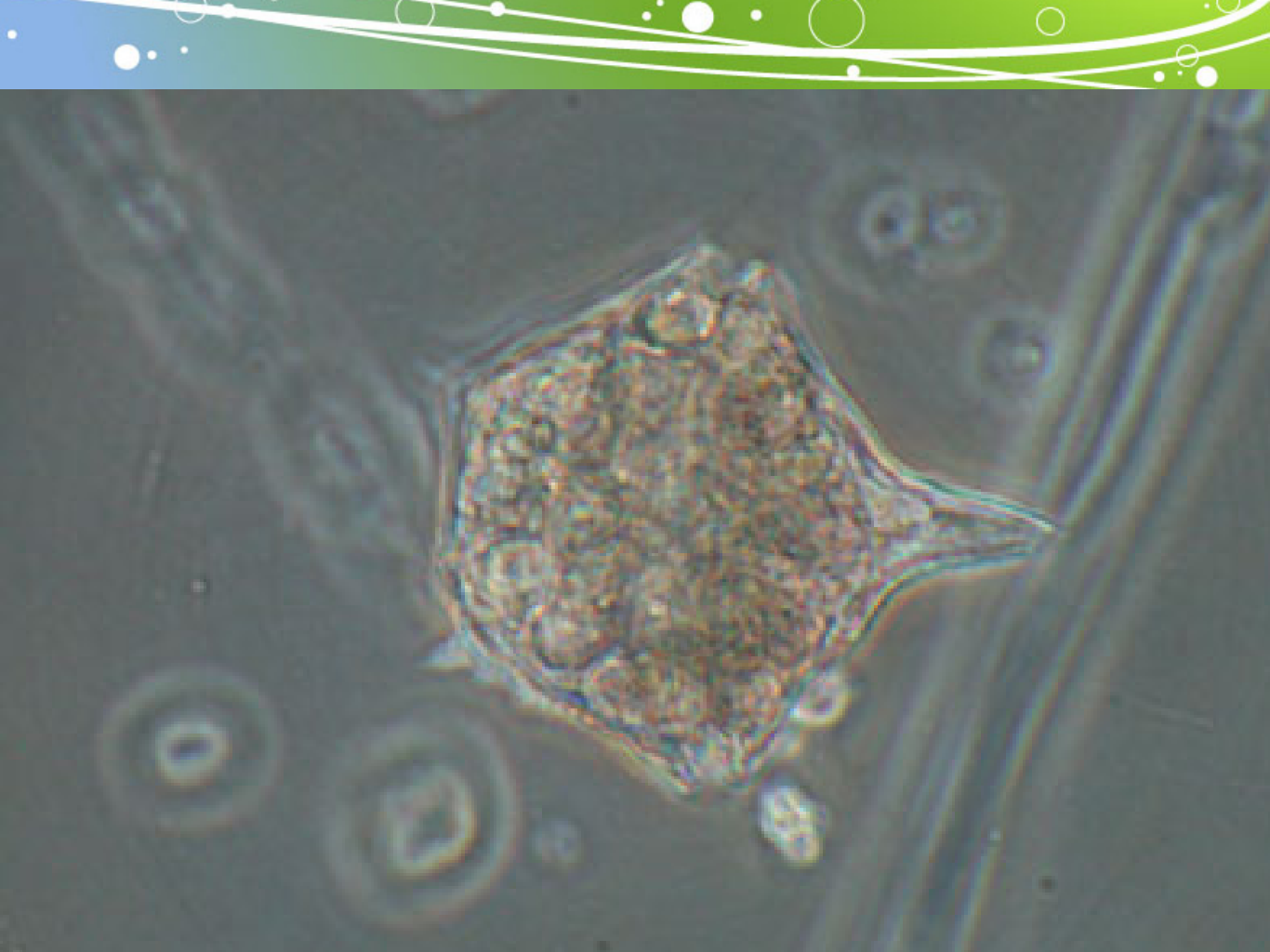
Order: Gymnodiniales

Family: Gymnodiniaceae

Description: Unarmoured (athecate) free-living cell, sometimes enclosed in a hyaline cyst. Some species are benthic or epiphytic. Cells can be globular or fusiform, and contain one large, lobed chloroplast. Large, dense blooms of *Amphidinium* can result in red tides. Some species can produce toxins.

Cell size: 12-18um length, 8-10um wide





## Genus: *Amylax*

## Dinoflagellate

Monterey Bay Species: *A. triacantha*

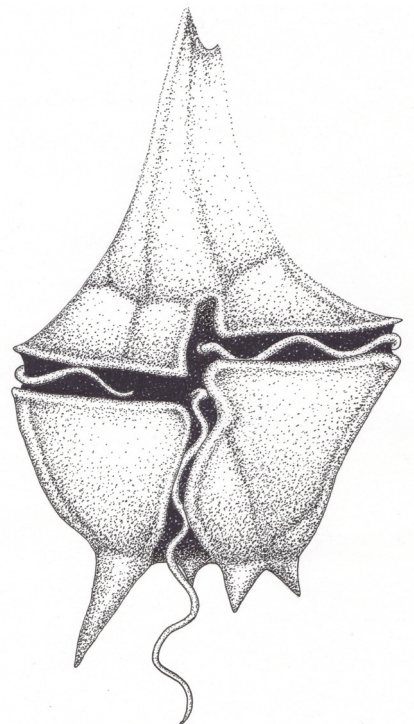
Order: Gonyaulacales  
Family: Gonyaulacaceae

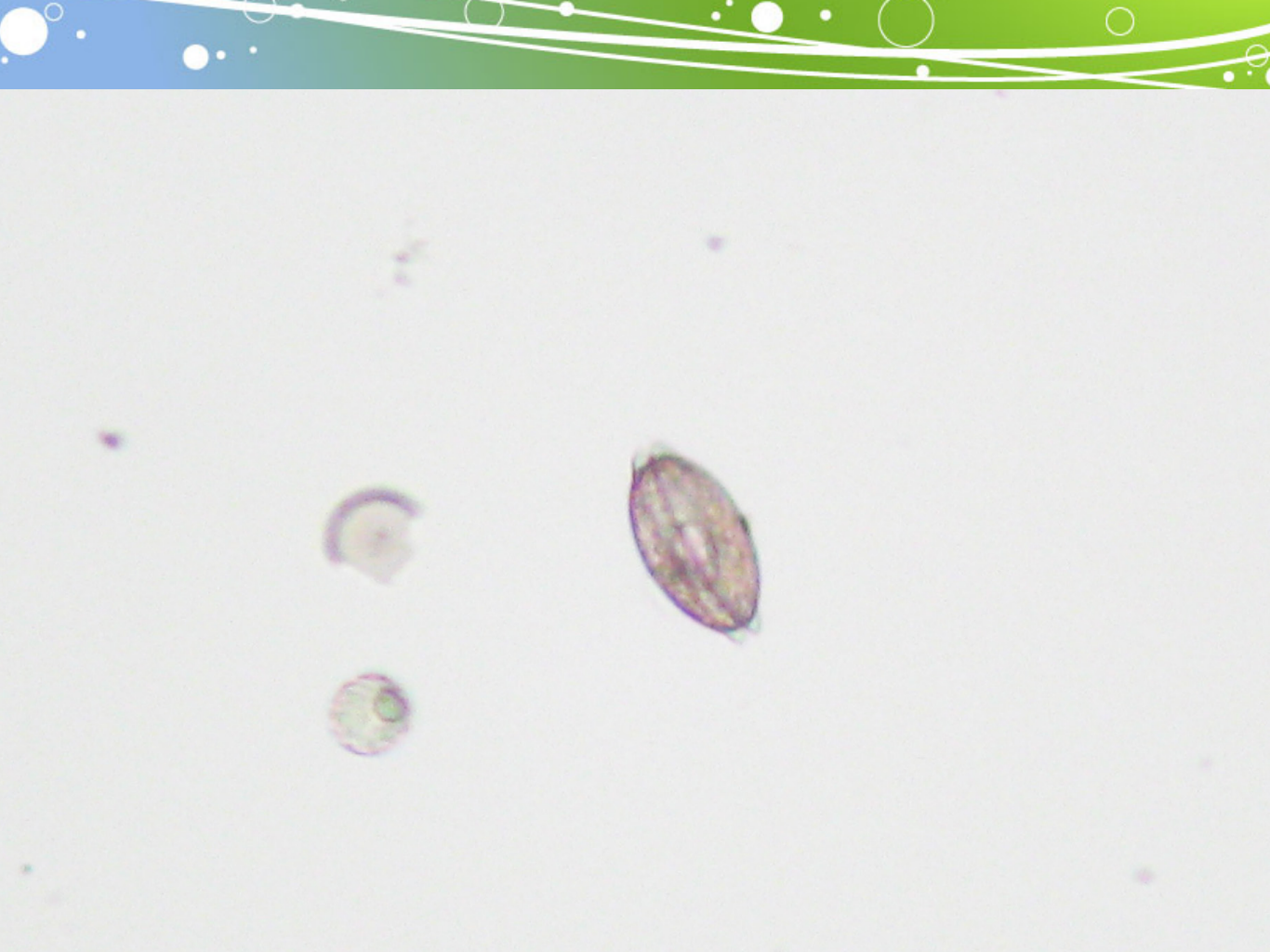
Description: Cells are small and delicate with a tapered apical horn or spine and one or more antapical spines. Chloroplasts present.

Cell Size: Length = 42-60µm

Distribution: Coastal cold water species in both Pacific and Atlantic.

Synonym: *Amylax triacantha* = *Gonyaulax triacantha*





**Genus: *Boreadinium***

**Dinoflagellate**

Monterey Bay Species: *B. pisiforme*

Order: Peridiniales

Family: Diplosaliacea

Description: Slightly compressed thecate cells, with prominent left sulcal list. Scattered pores on cell surface. Chloroplasts absent.

Cell Size: Less than 45um

Distribution: Coastal, cold temperate



## Genus: *Ceratium*

## Dinoflagellate

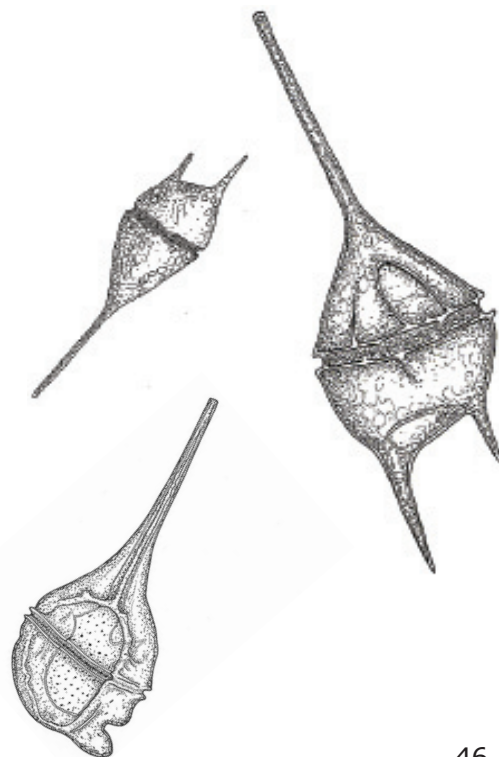
Monterey Bay species: *C. furca*, *C. lineatum*,  
*C. pentagonum*, *C.cf fusus*, *C. platycorne*

Order: Gonyaulacales  
Family: Ceratiaceae

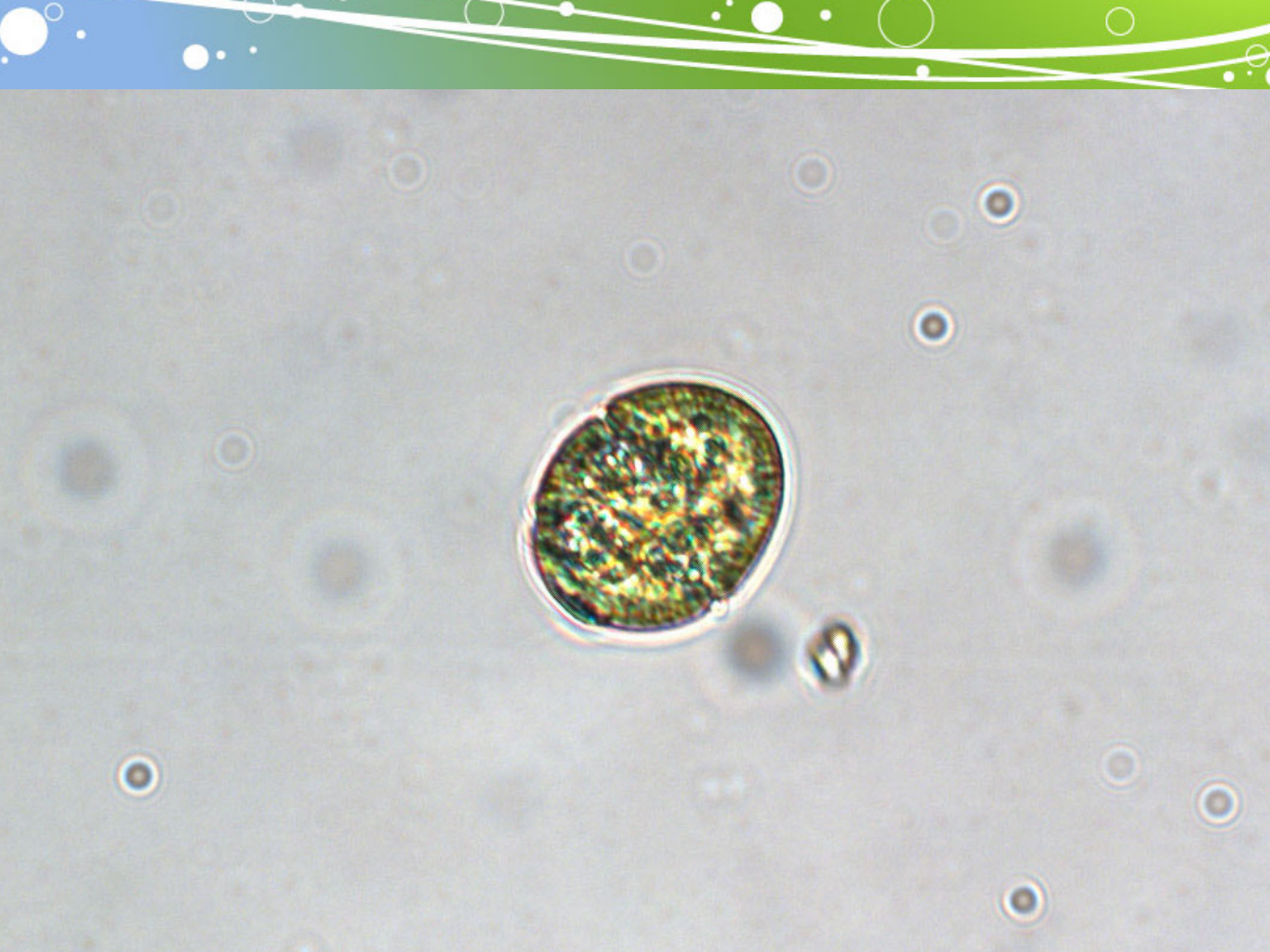
Description: Large, diverse genus. Armoured,  
gonyaulacoid body, two to four hollow horns.  
Horns open or closed. Chloroplasts present

Cell Size: Width = 5 – 50um, Length = ~70 –  
500um

Distribution: Cosmopolitan, neritic, cold and  
warm waters. *C. furca* is very common in  
Monterey Bay and often forms dense blooms.







## Genus: *Cochlodinium*

## Dinoflagellate

Monterey Bay species: *C. fulvescens*

Order: Gymnodiniales

Family: Gymnodiniaceae

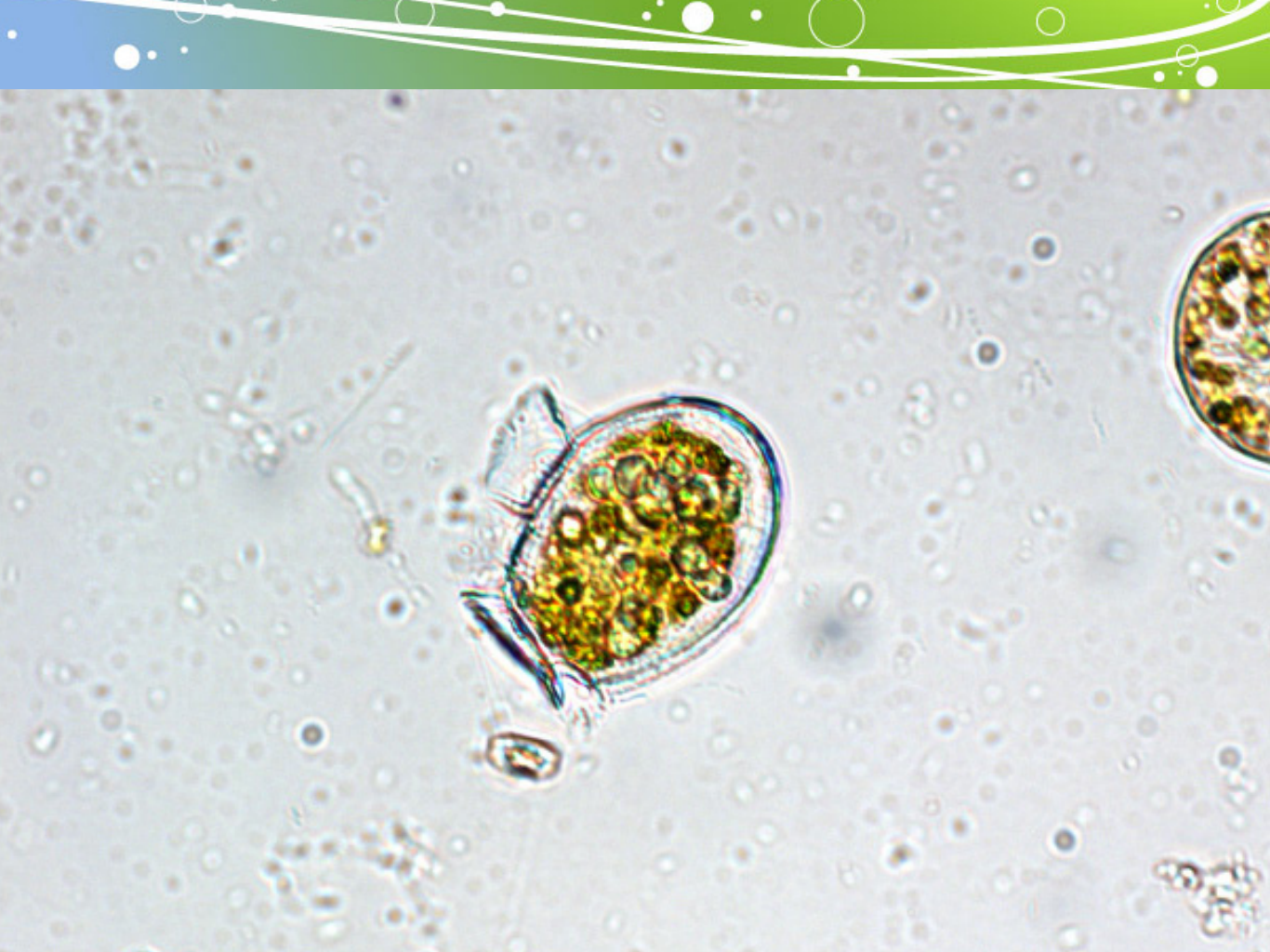
Description: Unarmored cells with cingulum rotating more than 1.5x. Single cells or chain-forming, with or without chloroplasts. Encystment common.

Cell Size: Width = 20 – 40um, Length = 60 – 80um

Distribution: Cosmopolitan in warm and temperate waters.

Interesting Facts: A toxin producer. Recently, and for the first time, dense blooms of *Cochlodinium* have been reported in Monterey Bay.





## Genus: *Dinophysis*

## Dinoflagellate

Monterey Bay species: *D. acuminata*, *D. fortii*,  
*D. tripos*, *D. rotundata*, *D. caudata*

Order: Dinophysiales

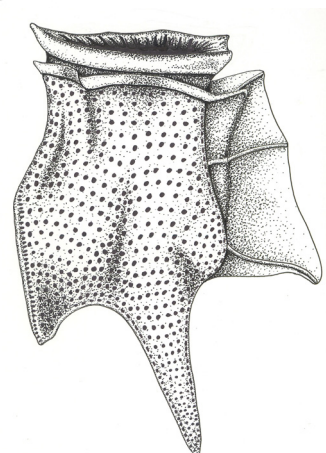
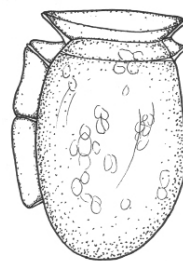
Family: Dinophysiaceae

Description: Armored, laterally flattened, oval-shaped cells with small flat or rounded epitheca. Hypotheca is usually about  $\frac{3}{4}$  of the cell length. Wide girdle bounded by lists. Chloroplasts present or absent.

Cell Size: Width = 30 – 60um, Length = 22 – 105um

Distribution: Widespread throughout the world's oceans.

Interesting Facts: Produce toxins.







## Genus: *Gonyaulax*

## Dinoflagellate

Monterey Bay species: *G. spinifera*,  
*G. polyedrum*

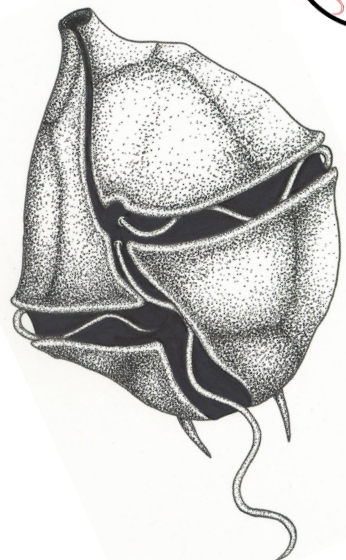
Order: Gonyaulacales  
Family: Gonyaulacaceae

Description: Armored, ovoid to fusiform cells with chloroplasts. Some species form benthic cysts. Distinguished by descending cingulum up to 6x girdle width.

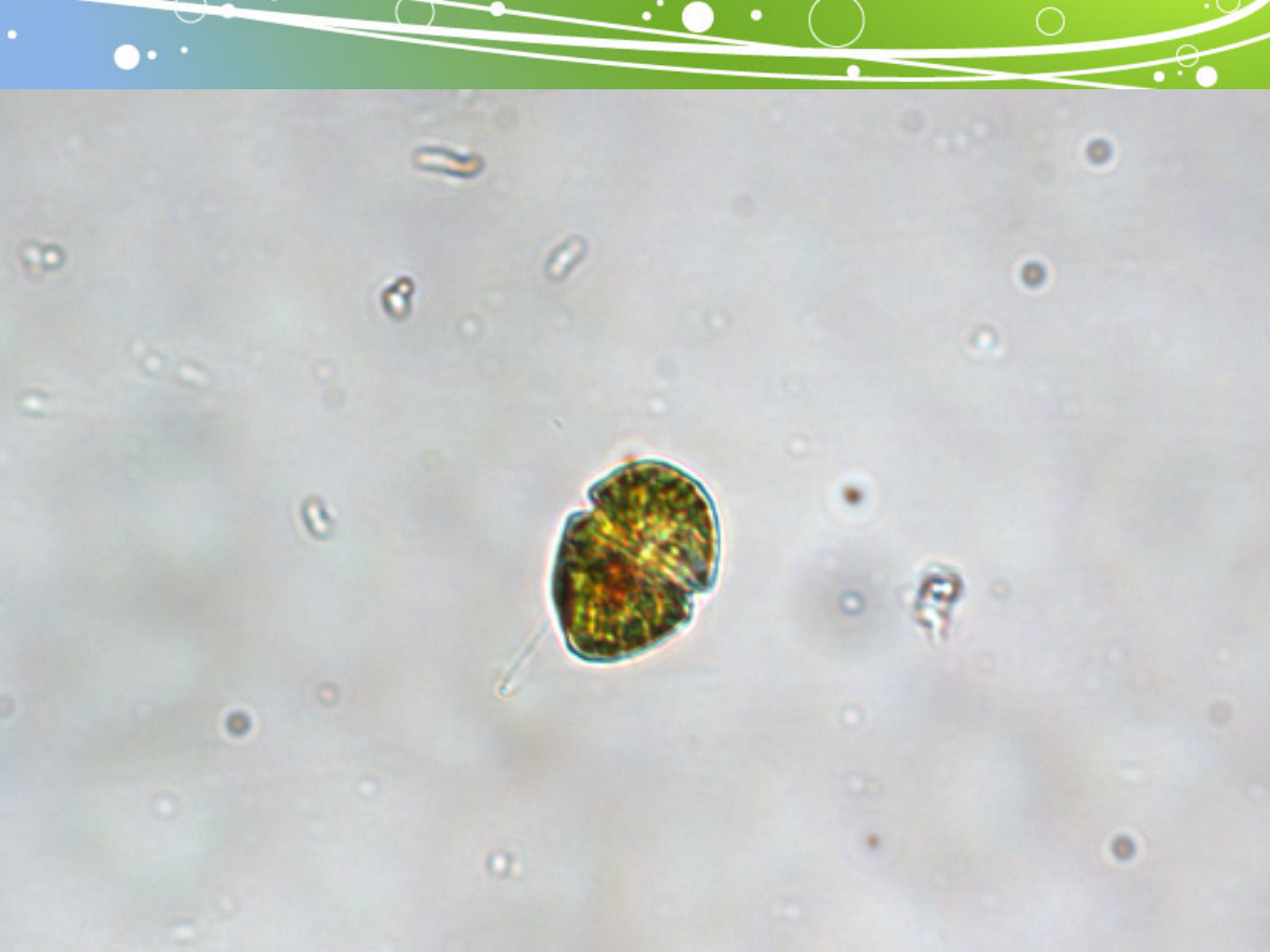
Cell Size: Width = 25 – 136µm

Distribution: Widespread throughout the world's oceans.

Interesting Fact: *Gonyaulax spinifera* can produce yessotoxin.







## Genus: *Gymnodinium*

## Dinoflagellate

Monterey Bay species: *G. breve*, *G. catenatum*

\*Similar appearance to non-toxic Gyrodinium (next page)

Order: Dinotrichales

Family: Dinotrichaceae

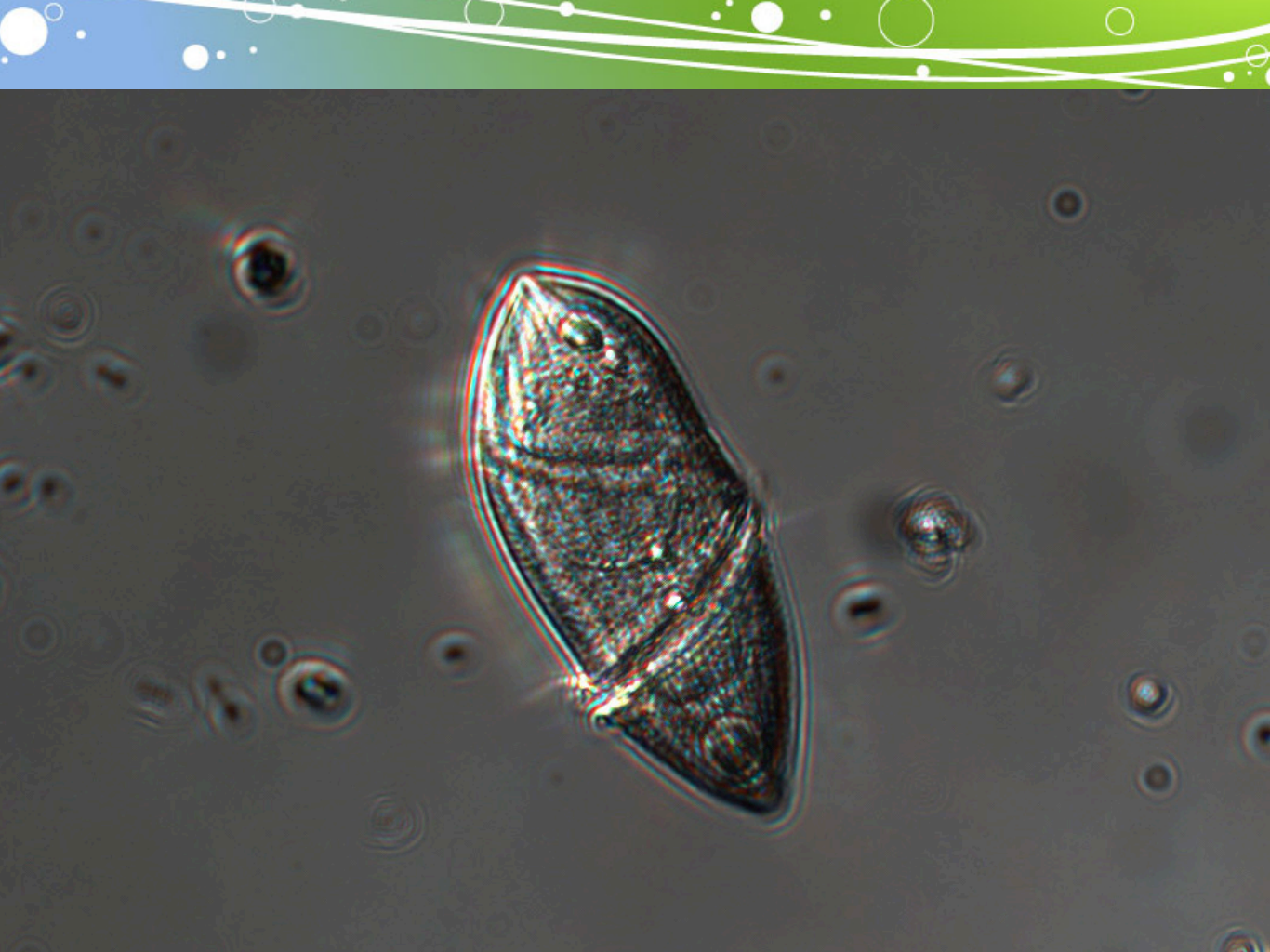


Description: Small- to medium-sized cells often pentagonal with a conical epitheca, bilobed hypotheca, and large nucleus. Chloroplasts present. Can be circular or compressed in cross-section. *G. catenatum* produces characteristic cysts.

Cell Size: Length = 40-75um

Distribution: Oceanic to estuarine; warm temperate to tropical

Interesting Facts: Some species produce saxitoxins.



## Genus: *Gyrodinium*

## Dinoflagellate

\*Similar appearance to toxin-producing *Gymnodinium* (previous page)

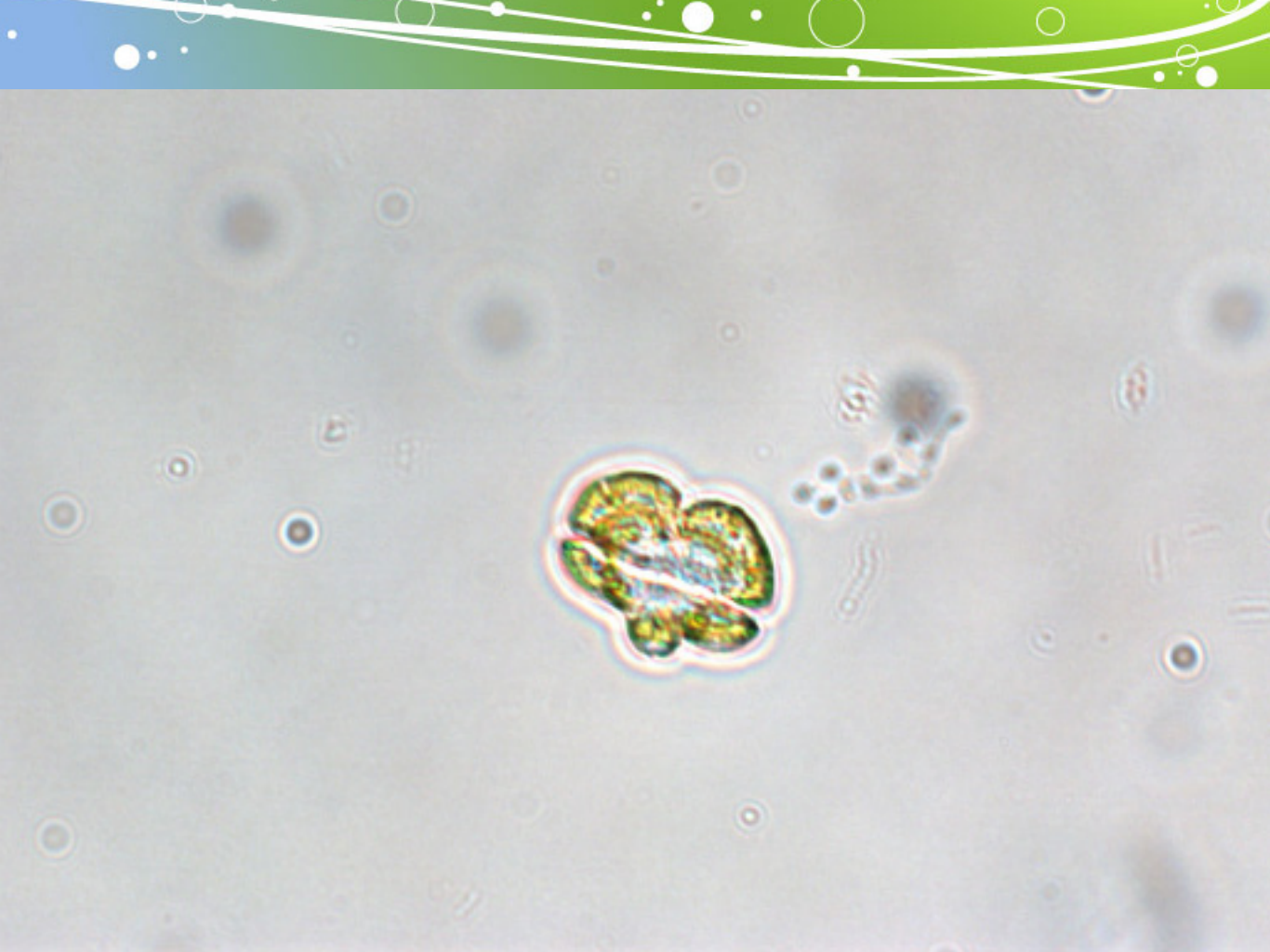
Order: Gymnodiniales

Family: Gymnodiniaceae

Description: Small- to large-sized cells. Can be fusiform, biconical, ovoid, or tear-shaped, sometimes compressed dorsoventrally or laterally. Some species have apical groove. Pigmentation and nutrition vary - some species have food vacuoles.

Cell Size: Varies from <5um to >200um

Distribution: Oceanic to estuarine; temperate to tropical, cosmopolitan



## Genus: *Karenia*

## Dinoflagellate

Order: Gymnodiniales

Family: Kareniaceae

Description: Unarmoured dorsoventrally-flattened cells. Cell ventrally concave, dorsally convex. Round nucleus present, and chloroplasts present. Apical groove is straight. Of the 12 accepted species, many were formerly in the genus *Gymnodinium*.

Cell Size: 20-40um

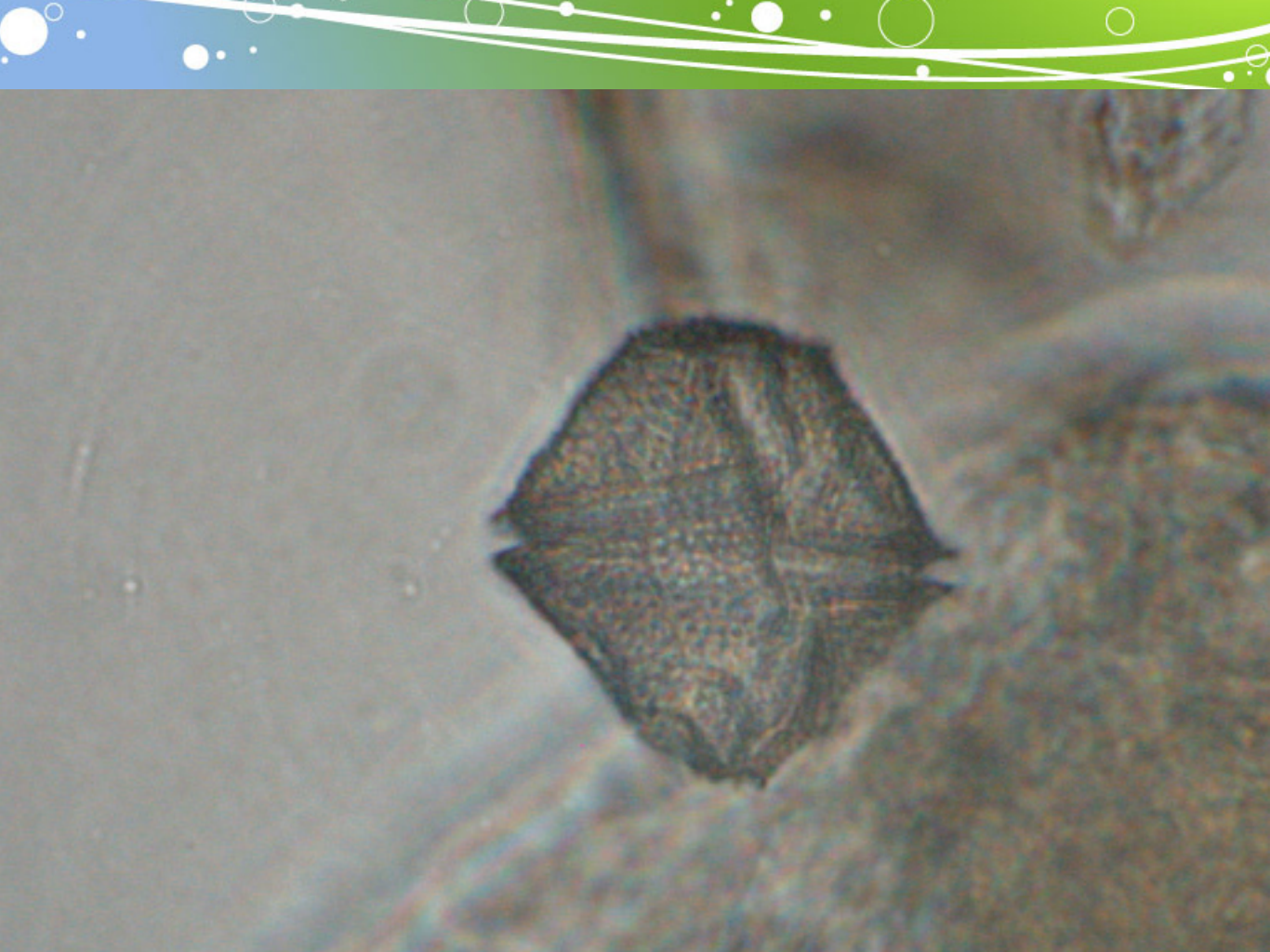
Distribution: Oceanic to estuarine, warm temperate to tropical.

Synonym: *Karenia brevis* formerly *Gymnodinium brevis*

Interesting Facts: *Karenia brevis* produces brevetoxin, a potent neurotoxin







## Genus: *Lingulodinium*

## Dinoflagellate

Monterey Bay species: *L. polyedrum*

Order: Gonyaulacales

Family: Gonyaulacaceae

Description: Armored, polyedral cells without spines or horns. Strong ridges define thecal plate sutures. Chloroplasts present. Forms distinctive cysts.

Cell Size: Width = 42 – 54um

Distribution: Neritic, warm temperate to tropical waters

Synonym: *Gonyaulax polyedra*

Interesting Facts: Bioluminescent and toxic (can produce yessotoxin.)





## Genus: *Noctiluca*

## Dinoflagellate

Species: *N. scintillans*

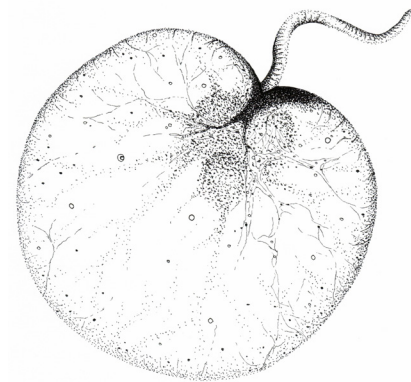
Order: Noctilucales  
Family: Noctilucaceae

Description: Large unarmored, round or kidney shaped cells with a striated tentacle, one flagellum and a eukaryotic nucleus. Phagotrophic with food vacuoles containing prey. No chloroplasts.

Cell Size: Diameter = 200 – 2,000um

Distribution: Cosmopolitan, neritic, cold and warm waters.

Interesting Facts: Bioluminescent except in the North East Pacific. Reported to produce ammonium during large blooms (orange-red), which may be toxic to fish.







## Genus: *Oxyphysis*

## Dinoflagellate

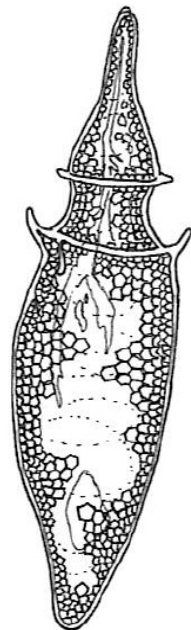
Species: *O. oxitoides*

Order: Dinophysiales  
Family: Oxyphysaceae

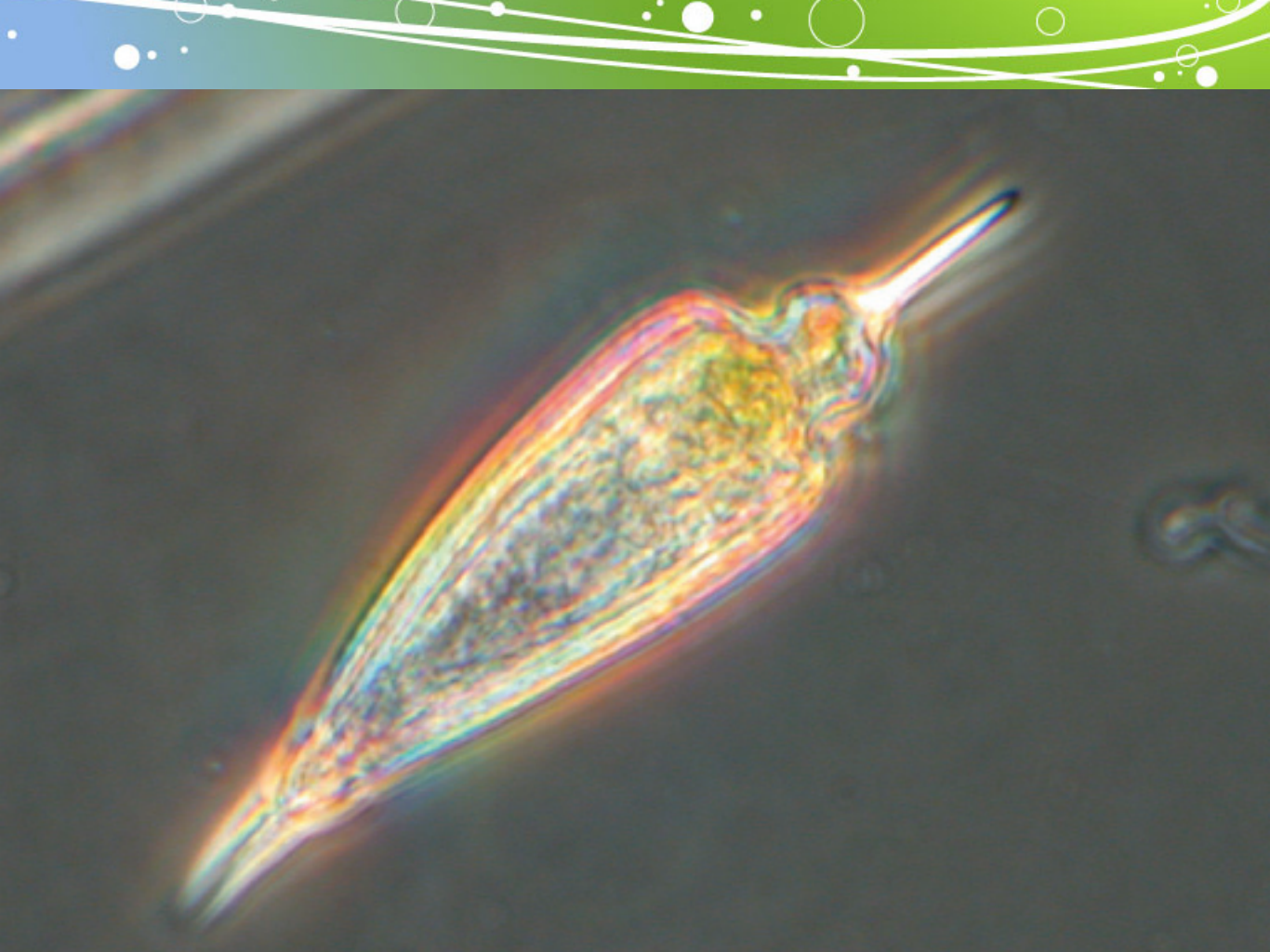
Description: Armored, elongate cell, with length less than 4x the width. Well-developed epitheca with a spine on the right. Hypotheca laterally compressed. Chloroplasts are absent.

Cell Size: Width = 16 – 25µm, Length = 60 – 68µm

Distribution: Worldwide. Estuarine to open water. Cold and warm temperate waters.







## Genus: *Oxytoxum*

## Dinoflagellate

Order: Dinophysiales  
Family: Oxytoxaceae

Description: Armored, needle or top-shaped cell.  
Chloroplasts present.

Size (cell range): Width = 12 – 25um, Length =  
17 – 75um

Distribution: Oceanic; warm temperate to tropical.



## Genus: *Polykrikos*

## Dinoflagellate

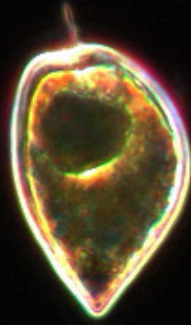
Monterey Bay Species: *P. schwartzii*

Order: Gymnodiniales  
Family: Polykrikaceae

Description: Unarmored. Medium to large pseudo-colony of 4 to 16 zooids. Species with >2 zooids usually have one nucleus per 2 zooids. Chloroplasts absent, nematocysts present or absent, food vacuoles often present. *Polykrikos* often feeds on other dinoflagellates, such as *Ceratium* and *Gonyaulax*, and on diatoms.

Cell Size: 100-150um

Distribution: temperate to tropical, cosmopolitan



## Genus: *Prorocentrum*

## Dinoflagellate

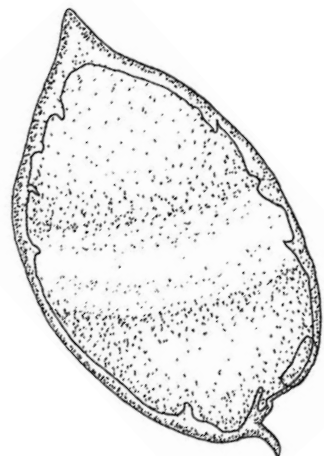
Monterey Bay Species: *P. micans*

Order: Prorocentrales  
Family: Prorocentraceae

Description: Laterally compressed armored cell, ranging from heart-shaped to pyriform. There is no cingulum or sulcus. Well developed apical spine. Chloroplasts present.

Cell Size: Width = 35 – 70µm, Length = 20 – 50µm

Distribution: Oceanic, neritic, worldwide distribution warm to arctic waters.







## Genus: *Protoceratium*

## Dinoflagellate

Monterey Bay Species: *P. reticulatum*

Order: Gonyaulacales  
Family: Gonyaulacaceae

Description: Polyhedral-shaped cell with prominent reticulations that can obscure underlying plates. Forms cysts.

Cell Size: Length = 28-53um, width 25-45um

Distribution: Neritic, estuarine. Cold temperate to subtropical waters.

Interesting fact: Cells can produce yessotoxin





## Genus: *Protoperidinium*

## Dinoflagellate

Monterey Bay species: *P. oceanicum*,  
*P. conicum*, *P. divergens*, *P. crassipes*,  
*P. steinii*, *P. excentricum*, *P. depressum*

Order: Peridiniales

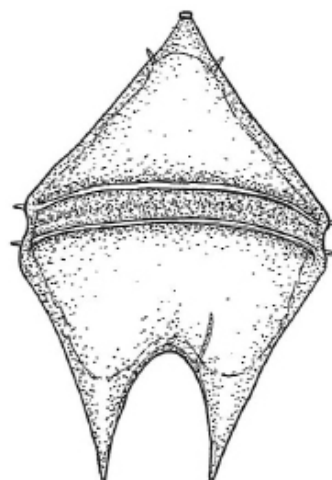
Family: Protoperidiniaceae

Description: Armored cell of variable shape and size. Many species have apical and antapical horns and/or antapical spines.

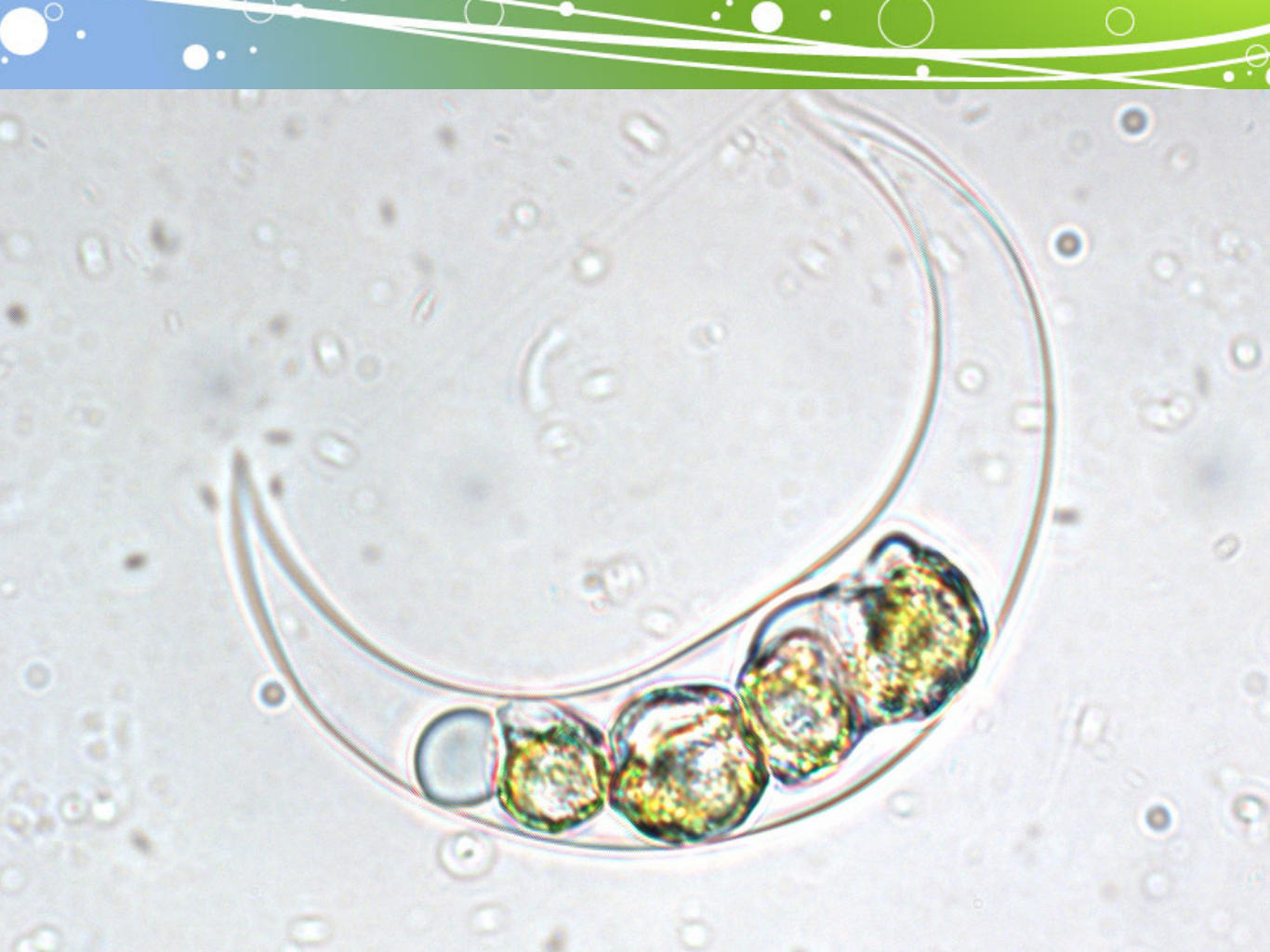
Chloroplasts absent in most species.

Cell Size: Variable from < 50um to >100um

Distribution: Widespread throughout the world's oceans.







**Species:** *Pyrocystis lunula*

**Dinoflagellate**

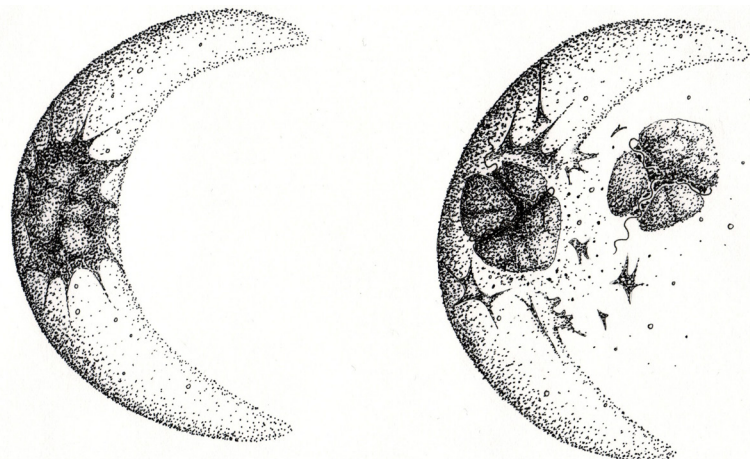
Order: Gonyaulacales  
Family: Pyrocystaceae

Description: Unarmored, crescent moon-shaped cells. Chloroplasts present. May be bioluminescent. Easily confused with *Dissodinium pseudolunula*.

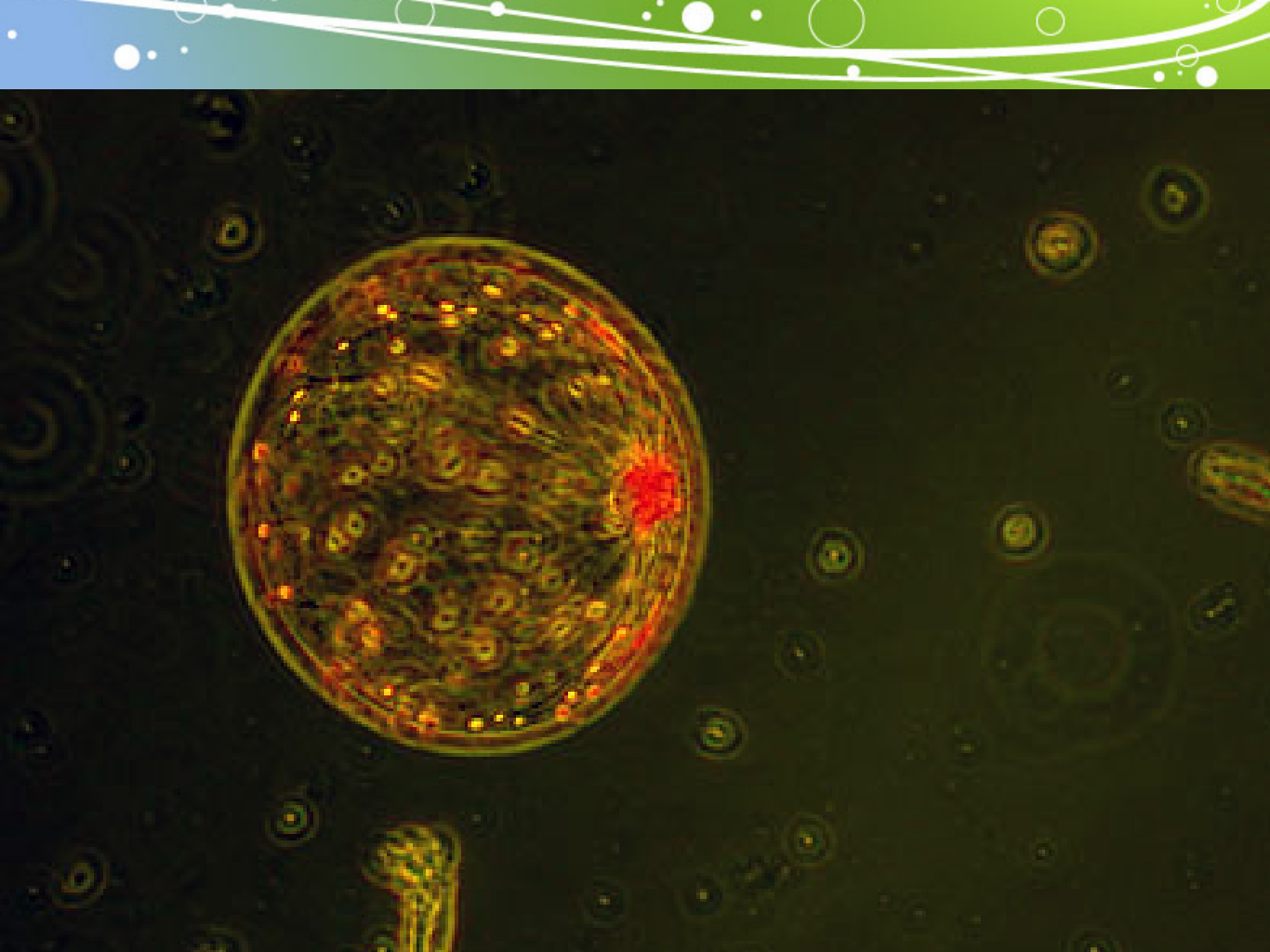
Cell Size: Length = 100-140um

Distribution: Oceanic and coastal. Warm temperate to tropical waters.

The illustration depicts a cell reproducing by production of motile planospores. The planospores look very similar to *Alexandrium*.







## Species: *Pyrocystis noctiluca*

## Dinoflagellate

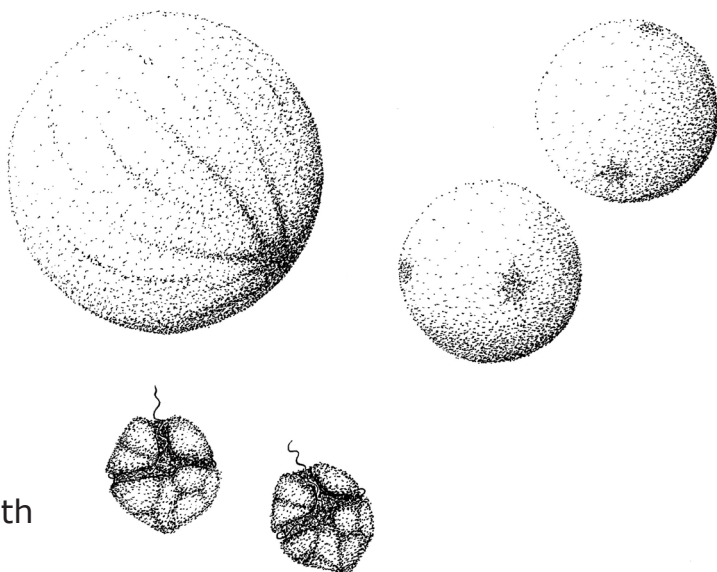
Order: Gonyaulacales  
Family: Pyrocystaceae

Primary vegetative stage is a large unarmored cell (>350um diameter spherical or subspherical.) Produces 1-2 biflagellated armored cells that resemble *Alexandrium*.

Cell Size: 350um or more

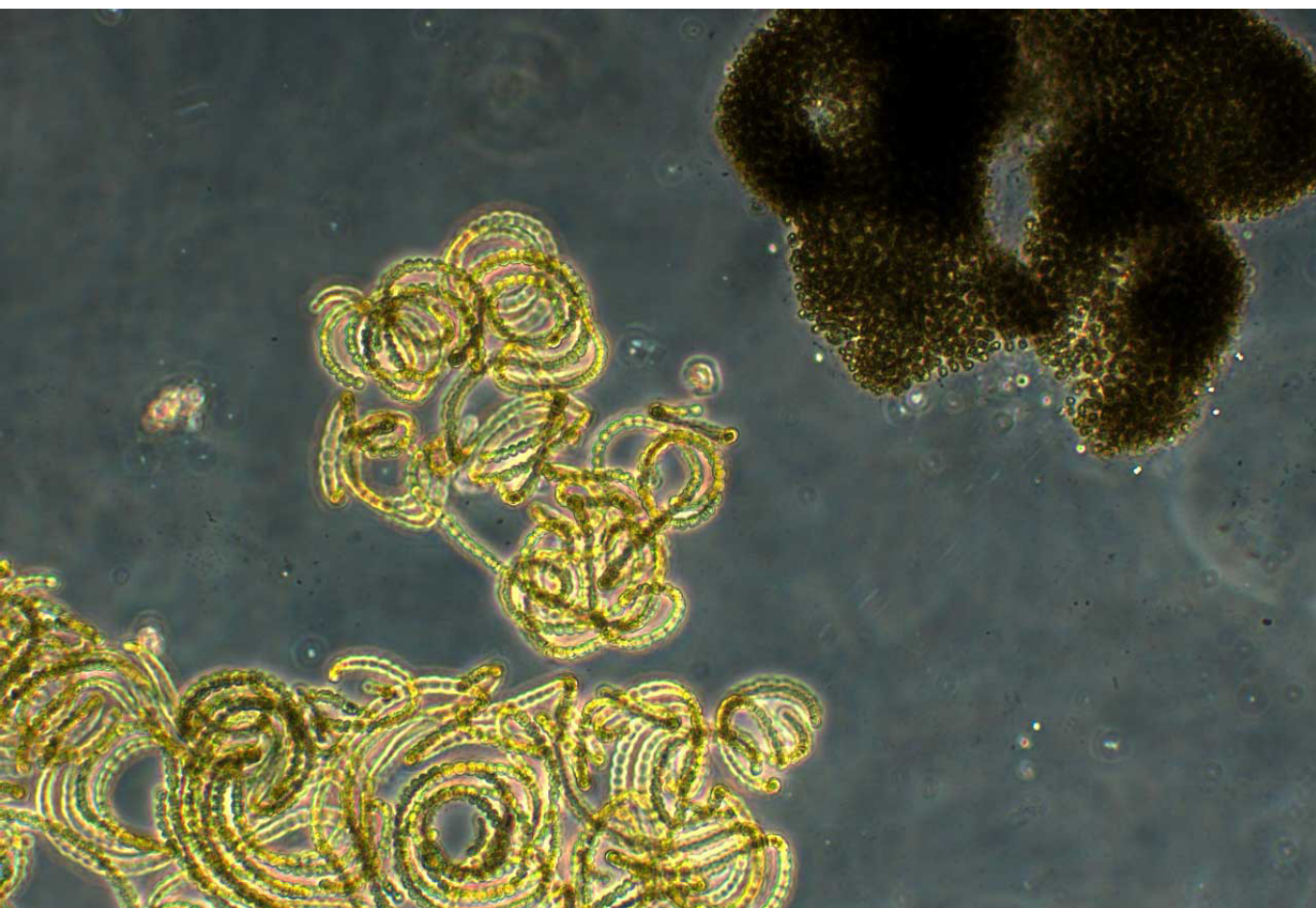
Distribution: Oceanic species.  
Cosmopolitan in warm temperate to tropical waters

The illustration shows a parent cell with both planospores and spherical aplanospores.

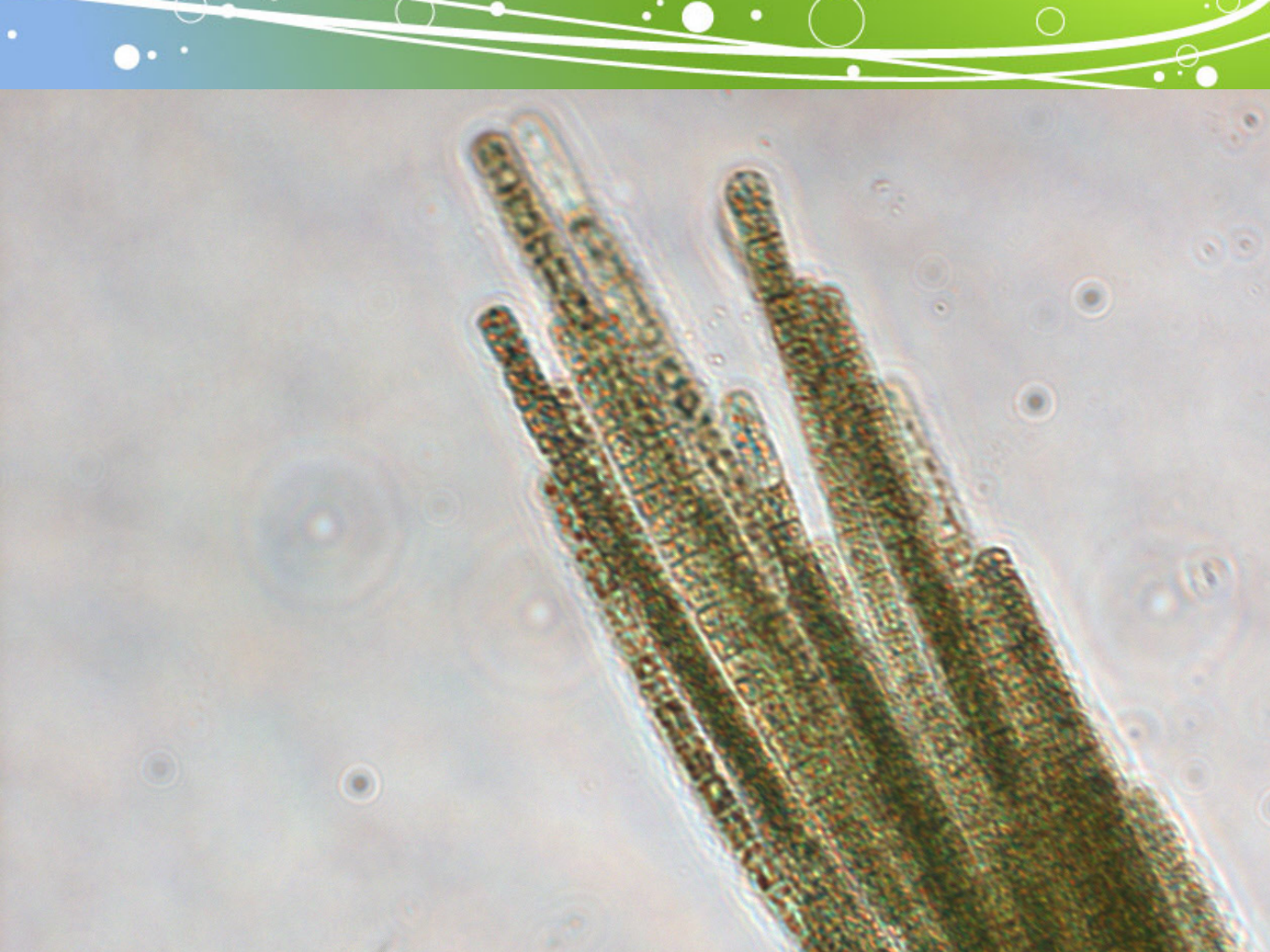


## Freshwater phytoplankton

- Phytoplankton can be found in nearly any body of fresh water: rivers, lakes, drainage ditches, cattle ponds, reservoirs, etc.
- Many species can tolerate a range of salinities, and some can be found in freshwater, brackish, and marine environments.
- Freshwater communities can be comprised of many different groups of organisms, including diatoms, dinoflagellates, cyanobacteria, chrysophytes, and chlorophytes.
- Most cells are too small to be visible without a microscope, but some kinds can form visible colonies.
- Some species can produce toxins







**Species:** *Aphanizomenon flos-aquae*

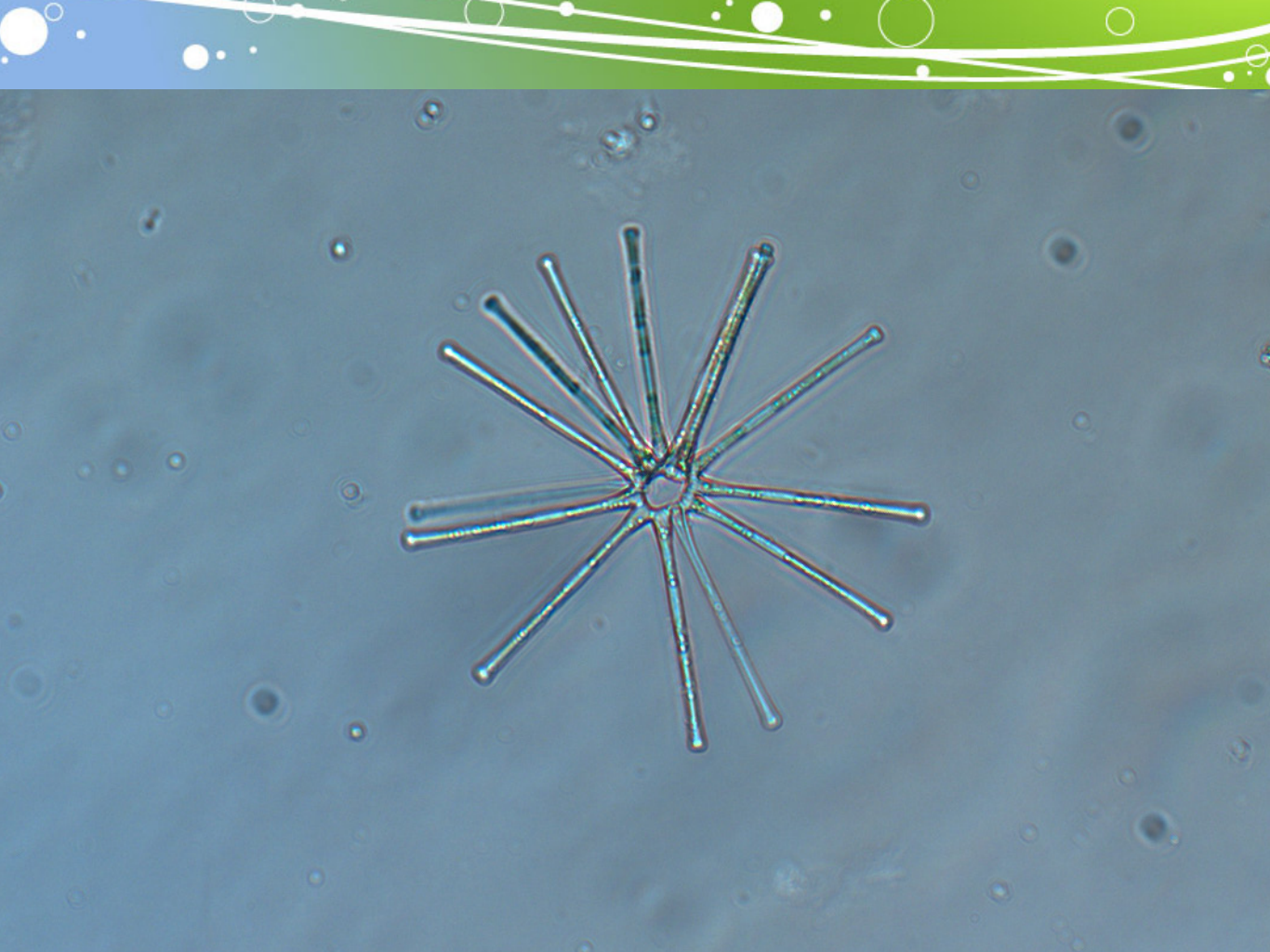
**Cyanobacteria**

Order: Nostocales  
Family: Nostocaceae

**Description:** The thallus of *Aphanizomenon* is filamentous. Filaments can be free-floating and solitary or form colonies. Colonies have a characteristic parallel arrangement and may look like clumps of grass clippings floating on the surface. Cells are cylindrical or barrel-shaped and pale blue-green. All species are planktonic and can form dense blooms, and can produce saxitoxins. *Aphanizomenon flos-aquae* is often found in eutrophic lakes, reservoirs, regulated fish ponds, and cattle ponds.







**Genus: *Asterionellopsis***

**Diatom**

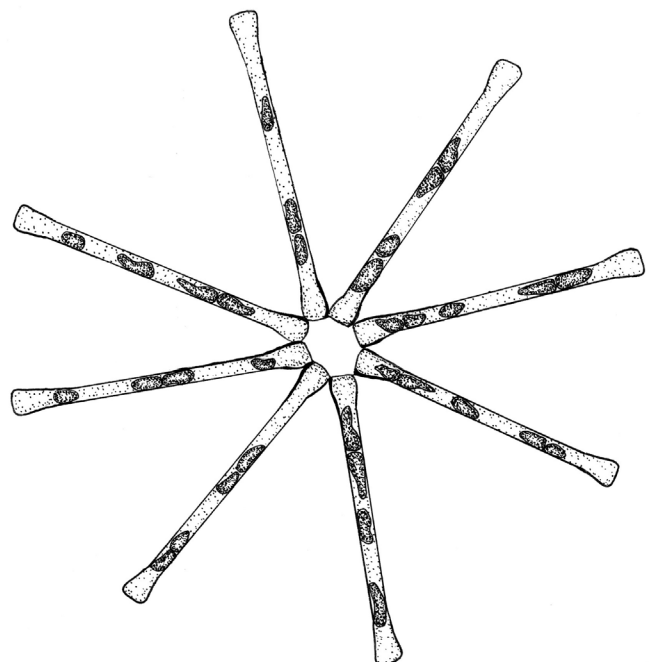
Pinto Lake, CA Species: *A. formosa*

Order: Bacillariales (Pennate)  
Family: Fragilariaceae

Description: Pennate diatom. Cells joined by valve faces into star-shaped or spiraling chains. *A. formosa* characterized by elongated valves with wide poles.

Cell Size: Length (apical axis)= 30-150um

Distribution: Found in nutrient-rich temperate lakes; is a major contributor to spring blooms.





## Genus: *Ceratium*

## Dinoflagellate

Freshwater Species: *A. formosa*

Order: Gonyaulacales  
Family: Ceratiaceae

Description: Antapical and apical horns present, 1-4 horns total. Cells heavily thecate and pale yellow to golden in color.

Cell Size: Varies by species. Length 65-400  $\mu\text{m}$ .





## Genus: *Cylindrospermopsis*

## Cyanobacteria

Sample collected in Pinto Lake, CA

Order: Nostocales  
Family: Nostocaceae

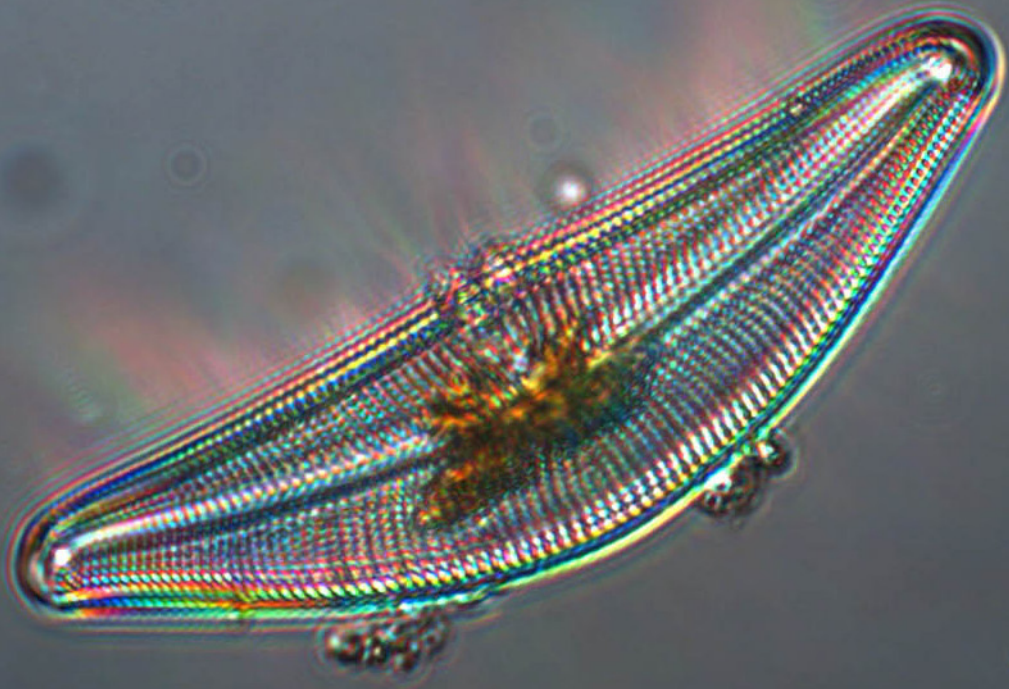


**Description:** This genus is composed of trichomes (chained filaments) that are solitary and straight. The terminal cells may differentiate into cone-shaped heterocysts. Akinetes (thick-walled spore-like structures) are cylindrical to oval-shaped, found singly or in pairs, near the terminal heterocysts. Both straight and coiled trichomes of this species exist.

Some strains are capable of producing cylindrospermopsin, a toxic compound that affects the human liver and kidneys, as well as anatoxin-a and saxitoxin.

**Distribution:** Genus is tropical/subtropical in origin, but it has expanded into temperate areas, particularly the northern hemisphere.



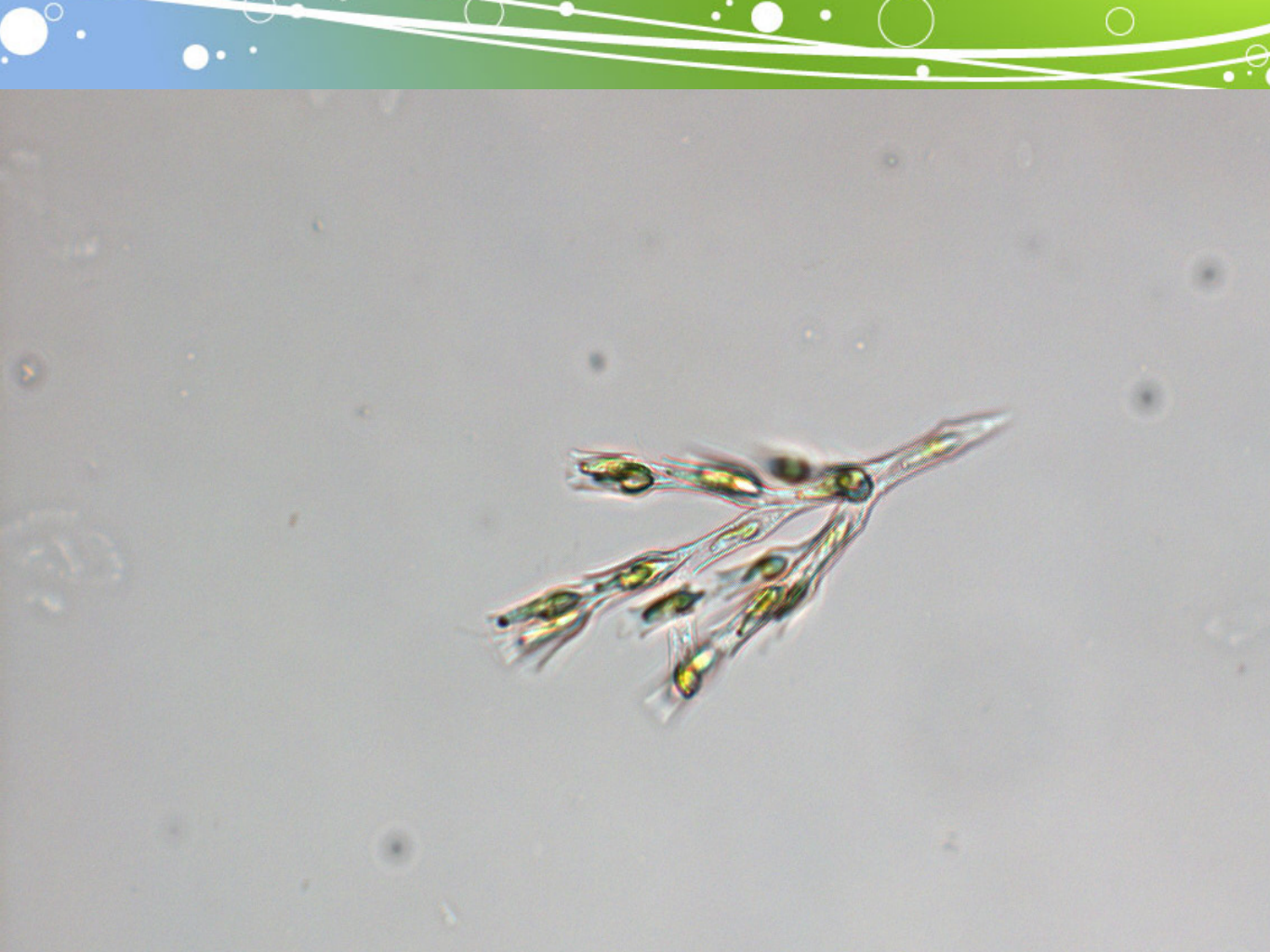


**Genus: *Cymbella***

**Diatom**

Order: Cymbellales  
Family: Cymbellaceae

Description: Pennate diatom. Typically benthic, often attaches to substrate with a mucilaginous stalk. Members of this genus can form “rock snot” in creeks and rivers by forming colonial aggregates.



## Genus: *Dinobryon*

## Chrysophyte

Colonial subgenus: Eudinobryon  
Order: Chromulinales  
Family: Dinobryaceae

Description: Cells are housed in individual loricae, which are vase- or funnel-shaped. Cells have two unequal flagella and one or two chloroplasts. Species are determined by lorica and colony morphology. Dinobryon are very common in freshwater lakes, and some species can be found in estuarine or coastal marine waters. Blooms of Dinobryon can have an unpleasant fishy odor.

Cell Size: including lorica, 20um length, 10um width.





**Species: *Dolichospermum circinalis***

**Cyanobacteria**

Order: Nostocales  
Family: Nostocaceae

Description: Colonies grow in filamentous clumps of multi-cell chains. Cells are cylindrical or barrel shaped. The end cells are often much longer than mid-chain cells, and may be hyaline (having a glass-like appearance). *Dolichospermum*, formerly *Anabaena*, is one of four cyanobacteria genera that can produce toxins.



Cell Size: 4-50um; varies with type of cell (vegetative smallest, akinetes largest)

Distribution: Common worldwide. 110 species have been described. Both benthic and planktonic species can be found in North America.

This sample collected from Lopez Lake, California





**Species: *Dolichospermum flos-aquae***

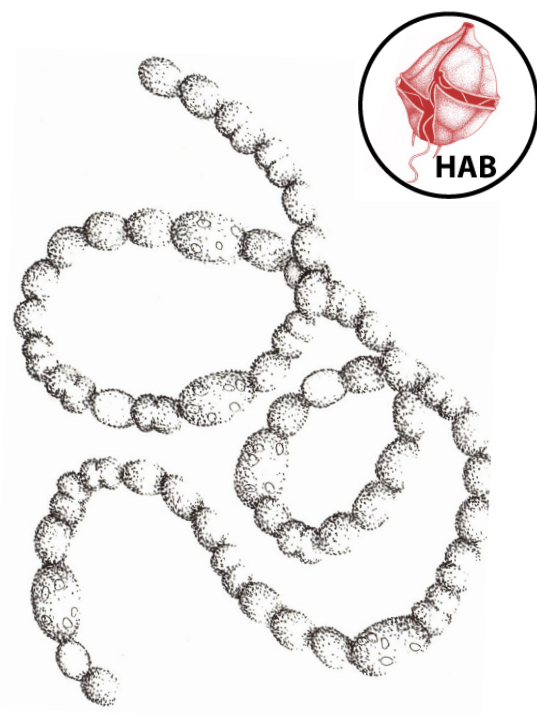
**Cyanobacteria**

Order: Nostocales  
Family: Nostocaceae

Description: Colonies grow in filamentous clumps of multi-cell chains. Cells are cylindrical or barrel shaped. The end cells are often much longer than mid-chain cells, and may be hyaline (having a glass-like appearance). *Dolichospermum*, formerly *Anabaena*, is one of four cyanobacteria genera that can produce toxins.

Cell Size: 4-50um; varies with type of cell (vegetative smallest, akinetes largest)

Distribution: Common worldwide. 110 species have been described. Both benthic and planktonic species can be found in North America.





**Species: *Dolichospermum* unknown**

**Cyanobacteria**

Order: Nostocales  
Family: Nostocaceae

Description: Colonies grow in filamentous clumps of multi-cell chains. Cells are cylindrical or barrel shaped. The end cells are often much longer than mid-chain cells, and may be hyaline (having a glass-like appearance). *Dolichospermum*, formerly *Anabaena*, is one of four cyanobacteria genera that can produce toxins.



Cell Size: 4-50um; varies with type of cell (vegetative smallest, akinetes largest)

Distribution: Common worldwide. 110 species have been described. Both benthic and planktonic species can be found in North America.

This sample collected from Pinto Lake, California



**Species: *Entomoneis paludosa***

**Diatom**

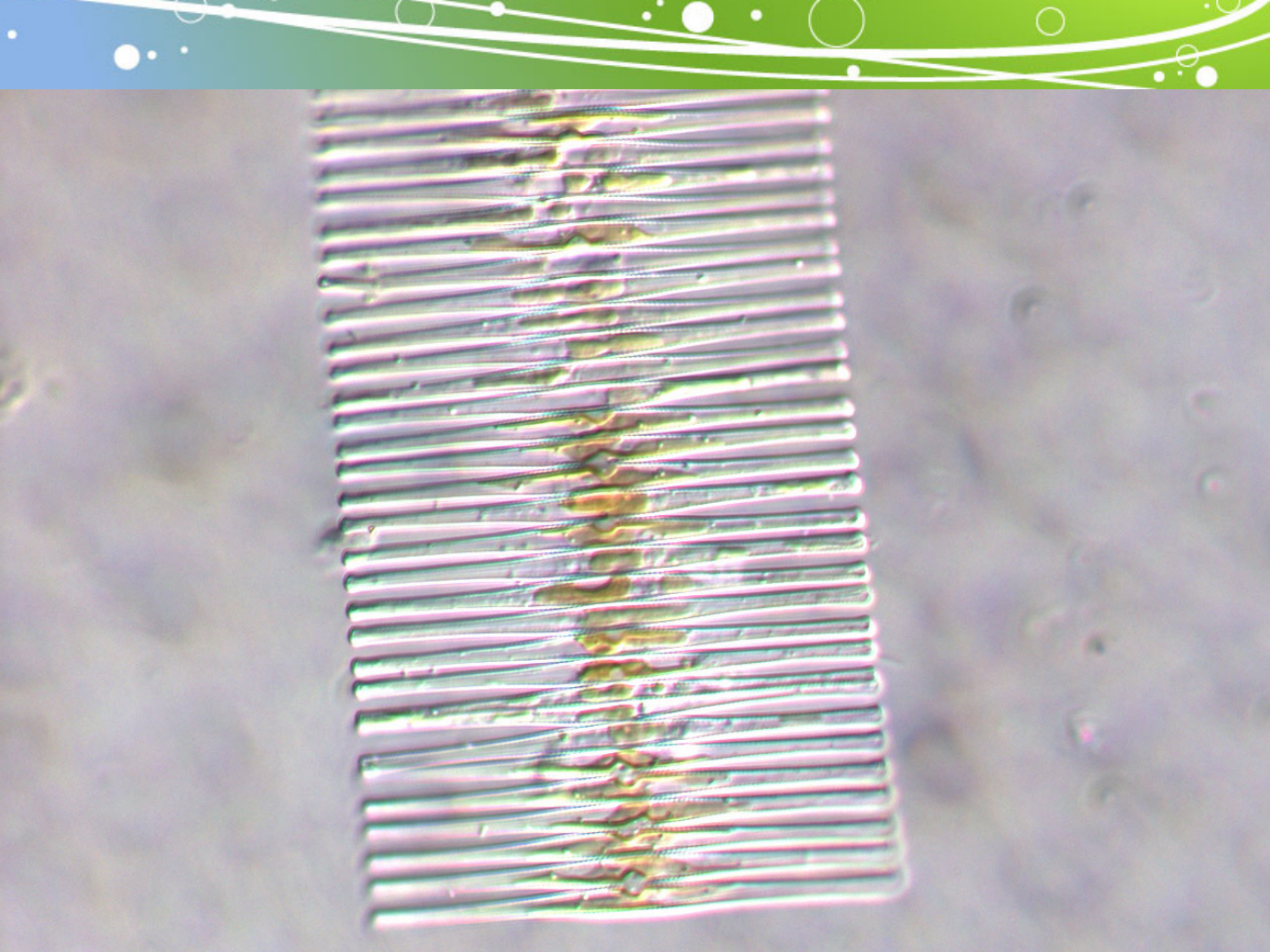
Order: Rhopalodiales

Family: Entomoneidaceae

Description: Genus found in marine, brackish, and freshwater environments. Girdle view shows two highly arched bilobate keels, one on each valve. The keels are slightly torsioned so that the lobes are not all in focus at one time. Several girdle bands are present and form a crossing, sigmoid pattern.

Cell Size: length 35-85um, width 20-30um





**Genus: *Fragilaria***

**Diatom**

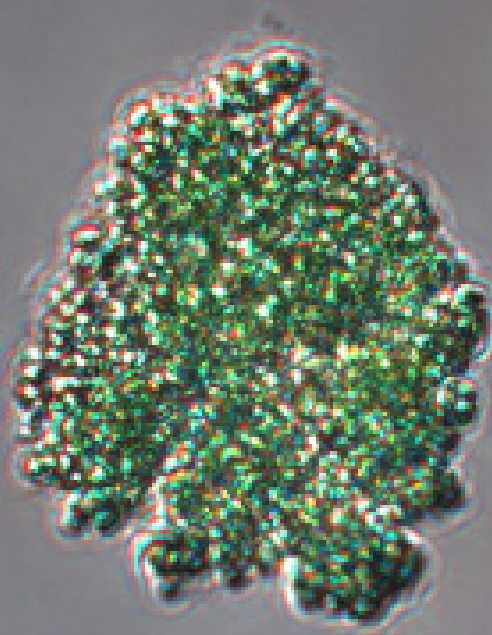
Species: *Fragilaria crotonensis*, collected in Pinto Lake, CA

Order: Fragilariales  
Family: Fragilariaceae

Description: Cell frustules swollen at the center. Cells are joined at center, forming ribbon-like colonies.

Cell Size: length 40-170um, width 2-5um

Distribution: *Fragilaria* is an important component of the spring bloom in freshwater lakes, particularly in eutrophic conditions. Blooms often decline when the lake becomes stratified.



## Genus: *Gloeocapsa*

## Cyanobacteria

Species in photograph and illustration:

*G. alpicola*

Order: Chroococcales

Family: Noctuoidea

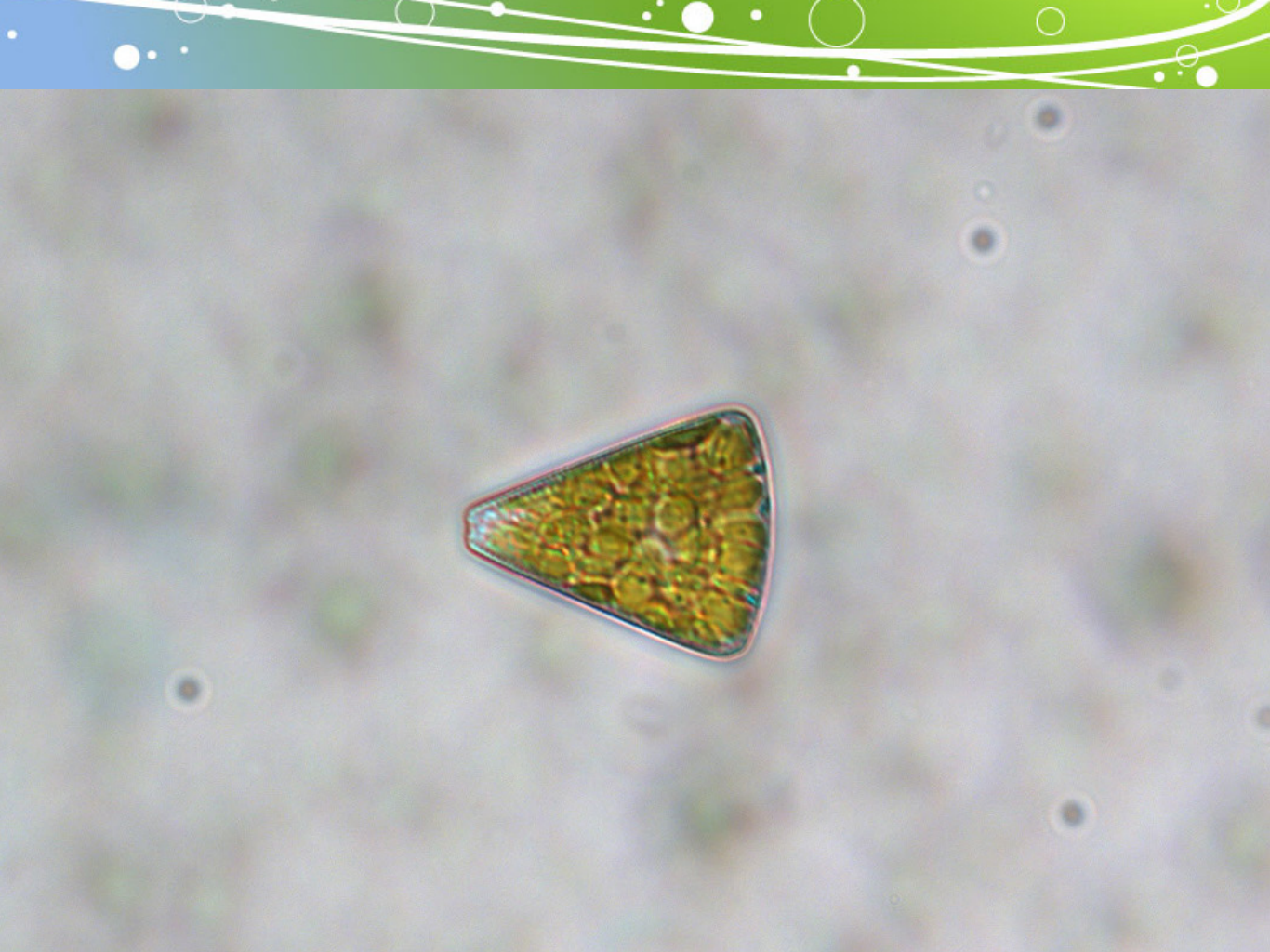
Description: Colonies are usually spherical. In addition to aquatic environments, can commonly be found on wet stony surfaces or tree bark. Cells and colonies are surrounded by gelatinous sheaths that can be brightly colored. *Gloeocapsa alpicola* have colorless sheaths.

Cell Size: .7-6 um

Synonym: *Gloeocapsa atrata*







**Genus: *Licmophora***

**Diatom**

Order: Licmophorales  
Family: Licmophoraceae

Description: Epiphytic diatom, cells grow on a common stalk that is attached to rocks or algae. Often found in low numbers in shallow or turbid environments, both marine and freshwater. Distinct triangular or fan-shaped cells.

Cell Size: length 150-250um





**Species: *Melosira varians***

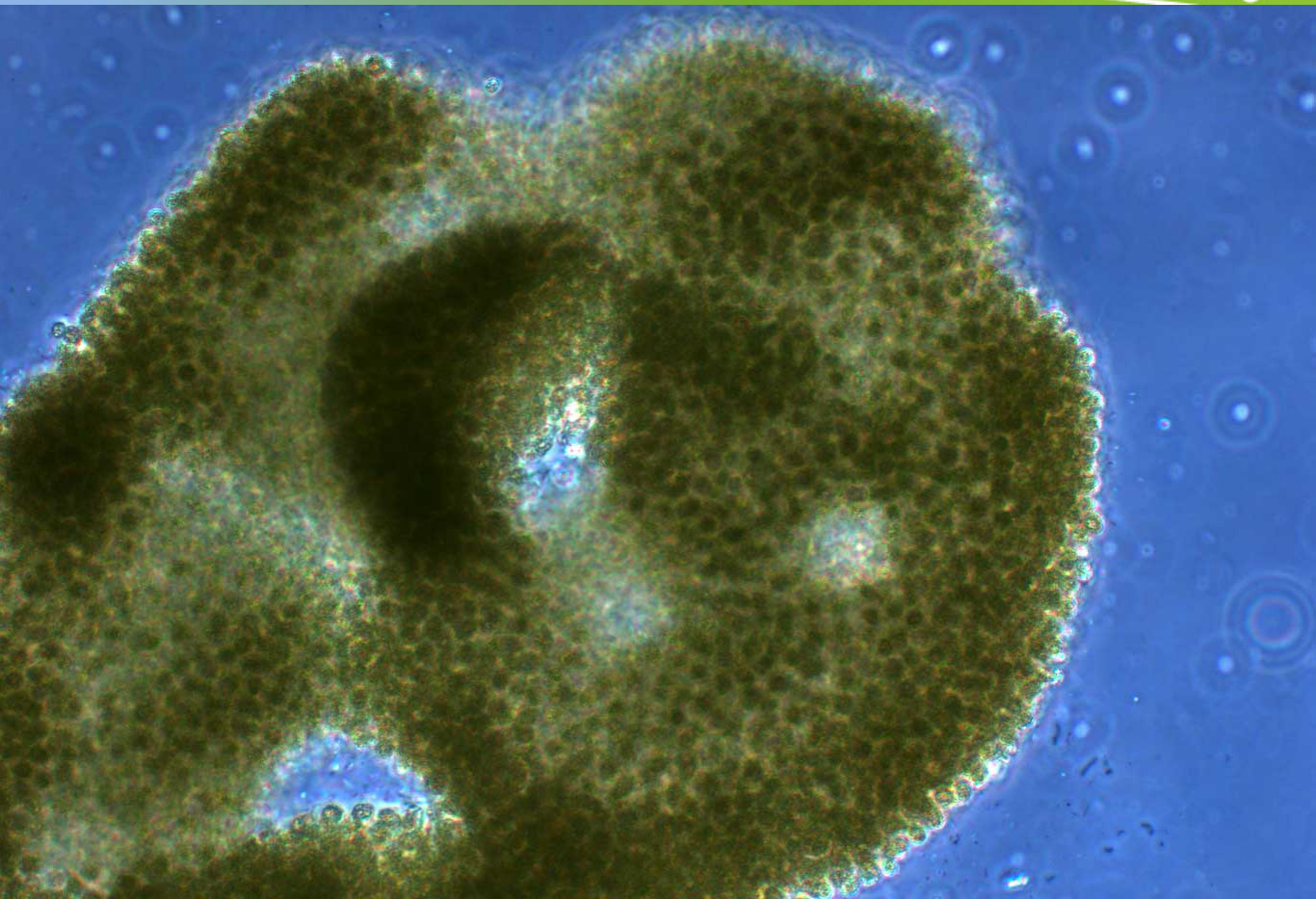
**Diatom**

Order: Melosirales  
Family: Melosiraceae

Description: Cylindrical cells, rectangular in girdle view, often forming long chains. Valve faces are slightly convex and covered with small spines. Little to no ornamentation (areolae) on valve faces. Common in eutrophic freshwater. Can form long filaments along the margins of rivers where the current is weak.

Cell Size: length 6-30um, width 5-15um

Culture library ID: CCMP3440 (Sacramento River)



## Genus: *Microcystis*

## Cyanobacteria

Species in photograph: *M. aeruginosa*

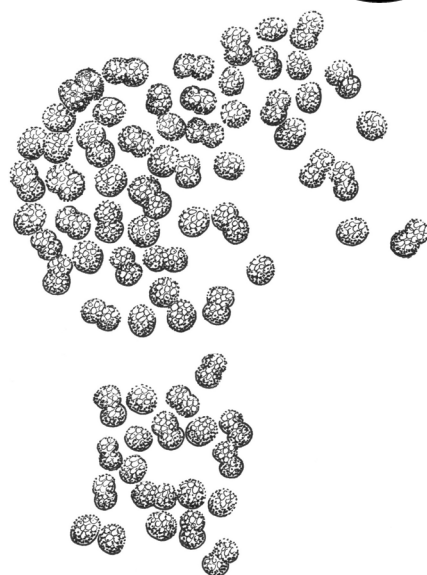
Order: Chroococcales  
Family: Microsystaceae

Description: Colonial species. Colonies tend to float near the surface in nutrient-rich fresh water and other low-salinity waters. Cells have no individual mucilaginous envelopes, but the colony is encased in a fine colorless mucus. Can produce toxins (microcystins), and dense blooms can be dangerous to aquatic ecosystems as well as animal and human health.

Cell Size: 2-3um

Distribution: cosmopolitan

Synonym: *Polycystis aeruginosa*







## Genus: *Nodularia*

## Cyanobacteria

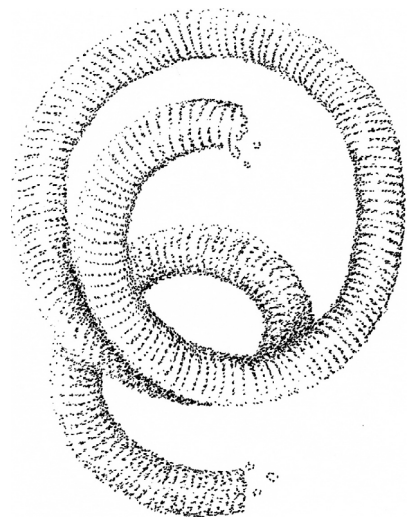
Species in photographs and illustration:  
*N. spumigena*, from Osoyoos Lake, British Columbia

Order: Nostocales  
 Family: Nostocaceae



Description: Filaments may be solitary, or form clumps or mats. Cells are short and barrel shaped, and width always exceeds length. *N. spumigena* have aerotopes (groups of gas vesicles); they are one of four planktonic species that do. Species in this group may form dense blooms in the ocean or river estuaries, brackish coastal lakes and lagoons, and high-salinity inland lakes and reservoirs. Produces nodularin, a potent natural toxin.

Distribution: Worldwide







**Genus: *Oscillatoria***

**Cyanobacteria**

Species in photograph: *Oscillatoria lutea*

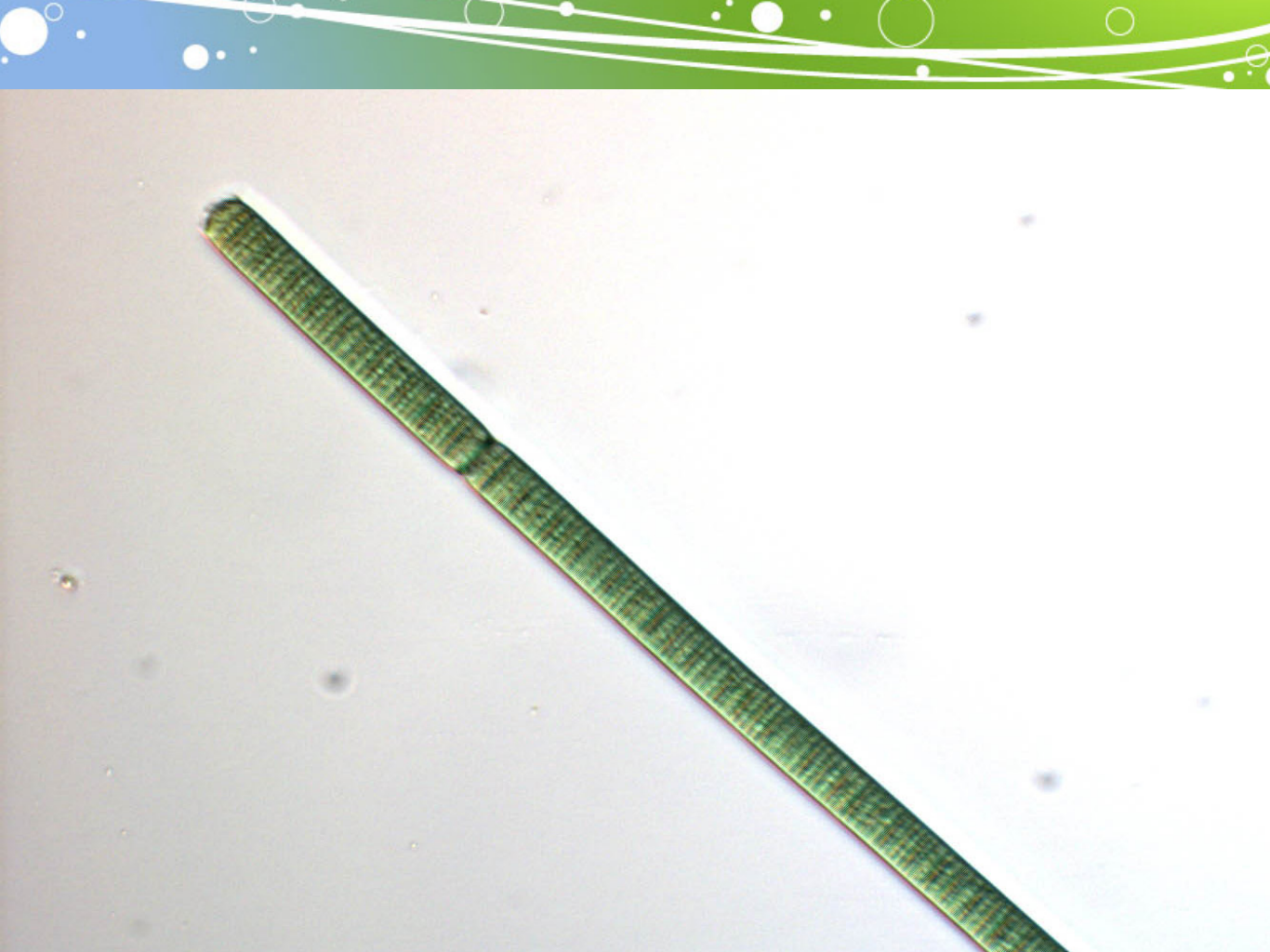
Order: Nostocales  
Family: Oscillatoriaceae



Description: *Oscillatoria* is a genus of unbranched filamentous cyanobacteria with mucilaginous sheaths. The genus is named for its oscillating movement; filaments can slide back and forth in order to orient the colony towards a light source. *Oscillatoria* can produce both anatoxin-a and microcystins.

Synonym: *Oscillatoria* is closely related to the genera *Planktothrix*, *Limnothrix*, *Tychonema*, and *Trichodesmium*.





## Genus: *Planktothrix*

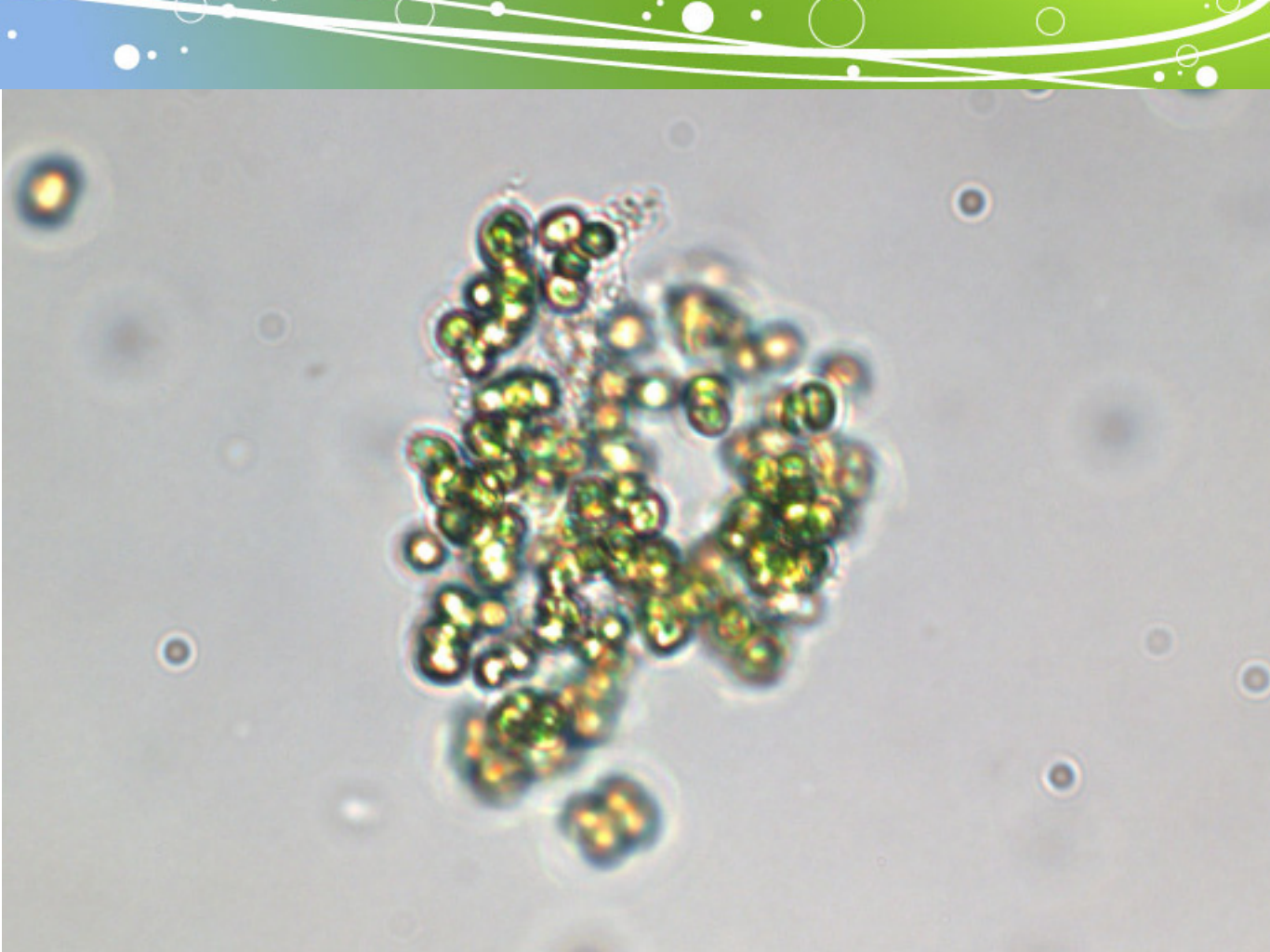
## Cyanobacteria

Order: Oscillatoriales  
Family: Phormidiaceae

Description: *Planktothrix* is a filamentous free-living blue-green alga, normally solitary but sometimes in easily disintegrating groups. Almost all species are planktonic, few of them causing blooms, mainly in mesotroph or slightly eutrophic to eutrophic reservoirs (usually lakes). Cells are slightly shorter than they are wide. End cells widely rounded or slightly narrowed with thickened outer cell wall.

This genus can produce the toxin microcystin.





**Species:** *Radiococcus planktonicus*

**Chlorophyte**

Order: Sphaeropleales

Family: Radiococcaceae

Description: Cells generally grouped in tetrads, within a colony that can be spherical or irregularly shaped, and held together by a structureless mucilaginous envelope. Cell body is spherical and has a single cup-shaped chloroplast.

Cell size: diameter 4-7µm





## Genus: *Spirulina*

## Cyanobacteria

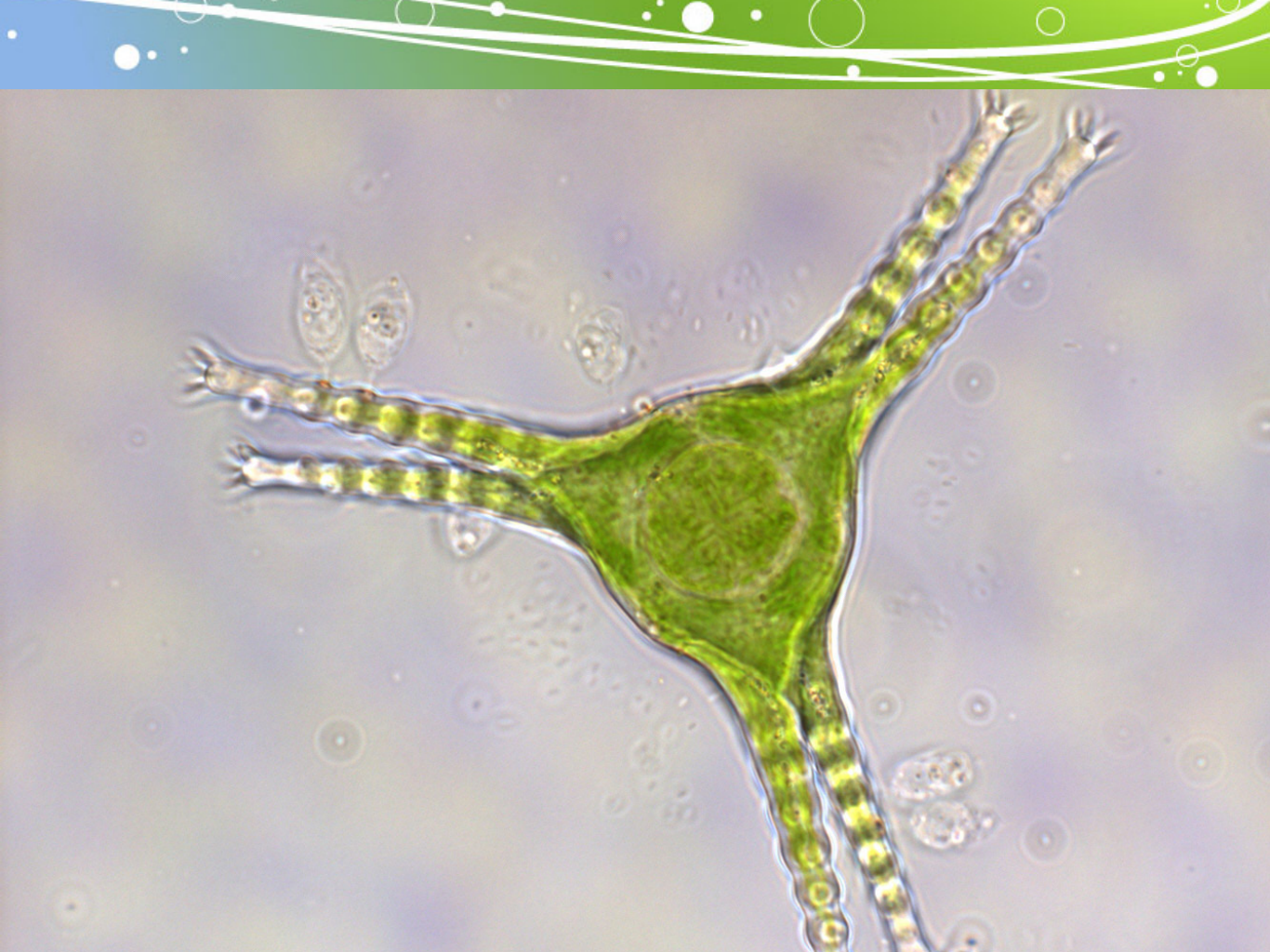
Order: Chroococcales

Family: Spirulinaceae

Description: Free-floating, filamentous cyanobacteria. Filaments unbranched, always without sheaths, rarely solitary, usually in clusters or in fine mats which can cover the substrate. Screw-like coils of cells common. Cells are pale blue-green, olive-green or pinkish.

*Spirulina* is commonly used as a dietary supplement.

Cell size: length 4mm, width 6-9mm. Spiral diameter, 25-45mm



**Genus: *Staurastrum***

**Chlorophyte, desmid**

Species in photograph: *Staurastrum johnsonii*,  
collected at Pinto Lake, California

Order: Desmidiales

Family: Desmidiaceae

Description: A member of the placoderm group of desmids, cells are composed of two halves called semicells. Between the semicells are deep median incisions. Cells have 3-part symmetry and often have elaborate ornamentation.





**Genus: *Stephanodiscus***

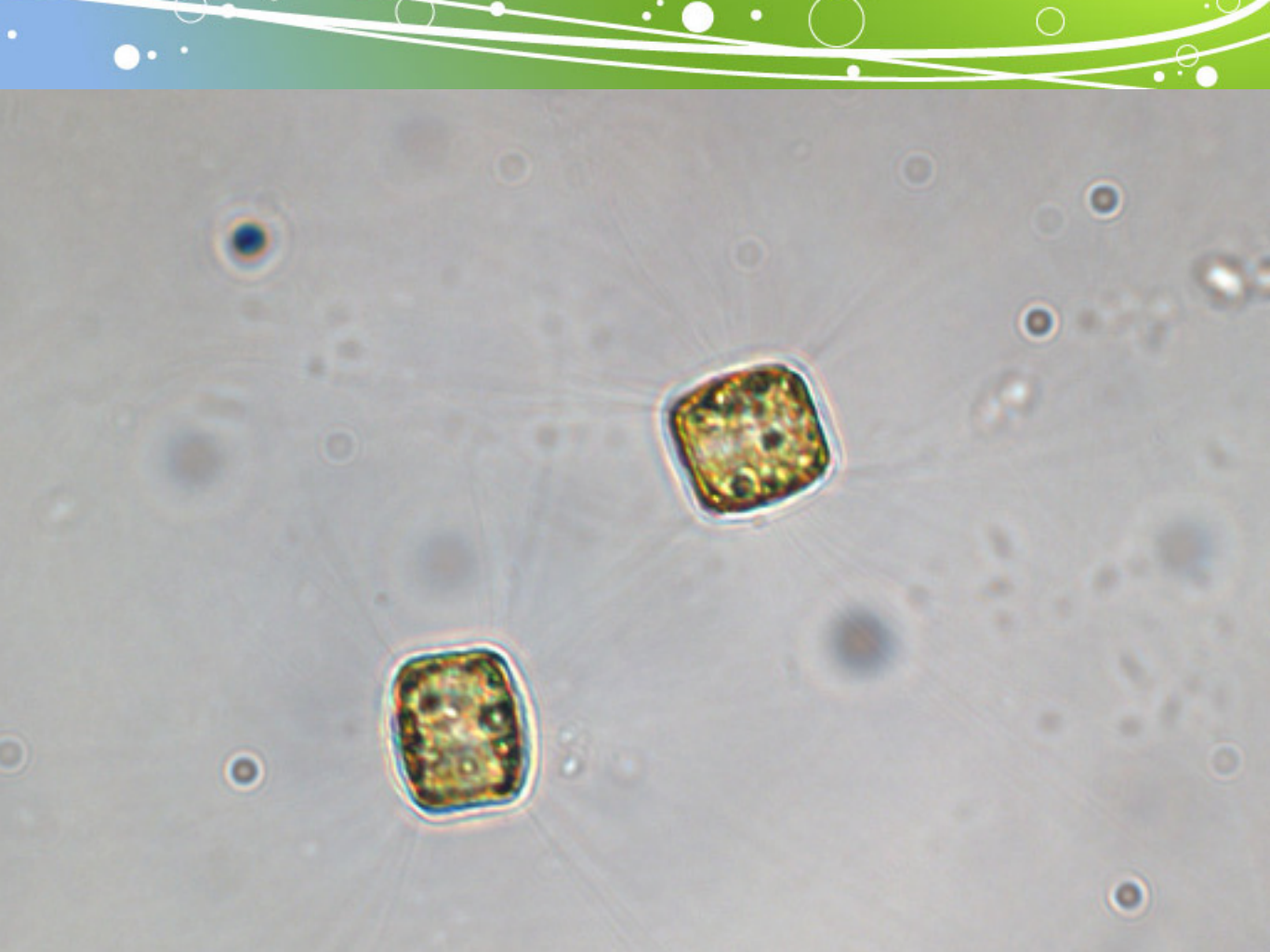
**Diatom**

Species unknown, samples collected in Pinto Lake, California

Order: Thalassiosirales  
Family: Stephanodiscaceae

Description: Cells discoid or barrel-shaped, often with delicate organic threads radiating from around the edge of the valve. A ring of spines is present around the valve face. Plastids numerous, discoid.

Distribution: *Stephanodiscus* is a diverse and widespread planktonic genus of freshwater, primarily lentic (lake), habitats. Many species are variable in morphology (polymorphic) in response to the concentration of dissolved silica in the surrounding waters.



**Species:** *Thalassiosira weissflogii*

**Diatom**

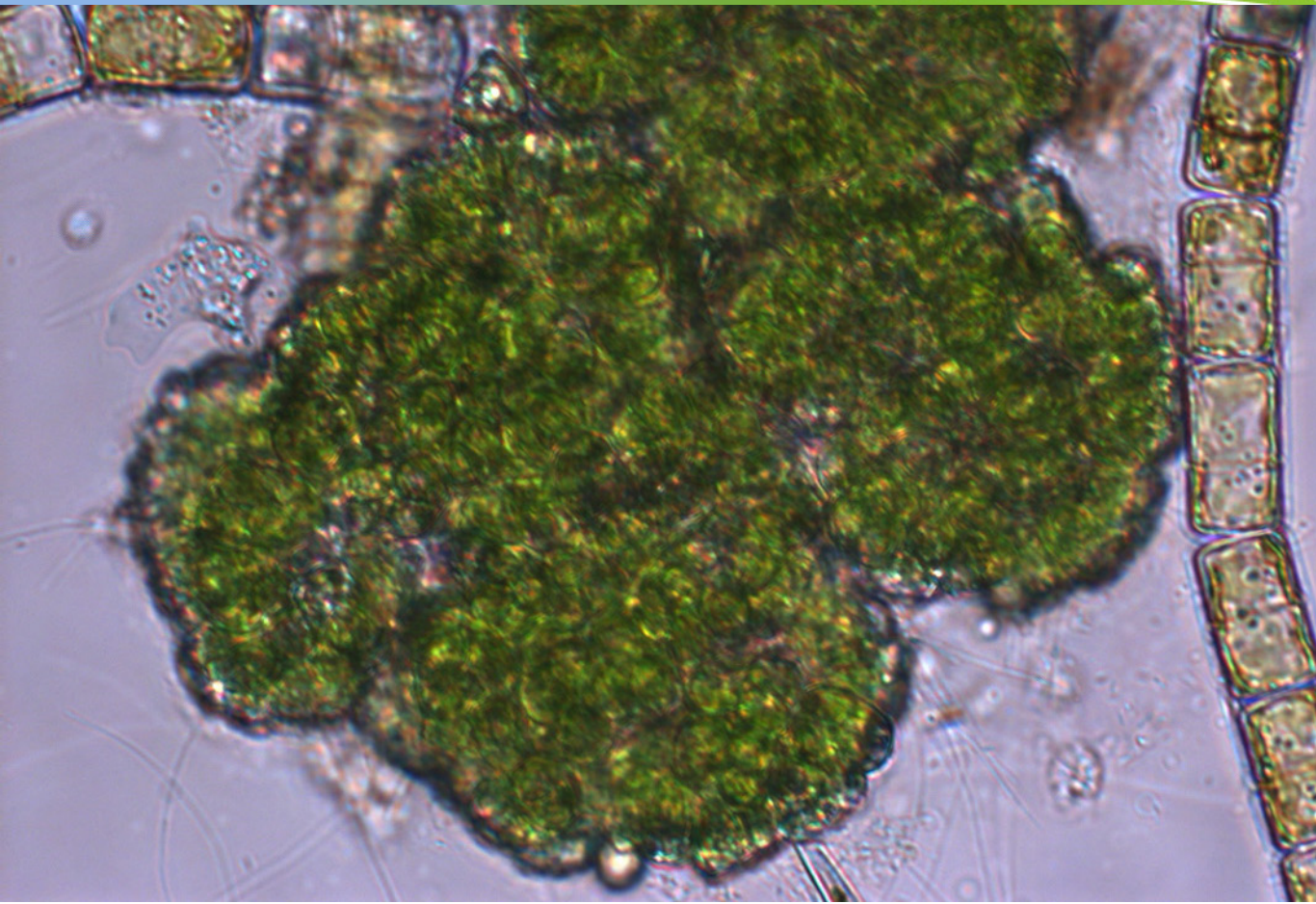
Order: Biddulphiales

Family: Thalassiosiraceae

Description: Centric diatom, found in both marine and fresh/brackish environments. Valve faces are smooth with fine areolae that are difficult to see with a light microscope. A cluster of three to six fultoportulae (pores) are present at the center of the valve face.

Cell Size: diameter 10-20um





**Genus: *Woronichinia***

**Cyanobacteria**

Species in photograph: *Woronichinia naegeliana*

Order: Chroococcales

Family: Gomphosphaeriaceae



Description: This group of about 14 species forms spherical or irregularly oval colonies, commonly composed of sub-colonies, usually with a narrow, colorless enveloping mucilaginous layer. The center of the colonies has a system of radially, parallel oriented, simple, unbranched stalks. Individual cells are usually slightly elongate or oval. Colonies are free-living plankton. Cells are pale blue-green, olive-green, or slightly reddish in color.

Production of both anatoxins and microcystins has been reported.

## GLOSSARY

**Auxospore:** Specialized cells that function to re-establish the normal size of a diatom following multiple mitotic cell divisions, which leads to a decrease in cell size. They may also be formed as a response to non-favorable conditions in which case they are referred to as "resting spores" (see resting spores)

**Benthic:** Living at or near the sea floor

**Bioluminescent:** A biochemical process where chemical energy is converted into light energy by organisms such as fireflies and deep-sea fishes. In the phytoplankton, many species of dinoflagellates are also bioluminescent

**Centric:** Refers to one of two orders of diatoms, characterized by their circular or discoid shape otherwise known as radial symmetry (see Pennate)

**Chloroplasts:** Organelles found in plant cells that conduct photosynthesis, converting light energy into chemical energy, which the plant can use for food

**Cosmopolitan:** Common to the whole world

**Epibenthic:** Living above the bottom of the sea

**Epiphyte:** Organism that grows on or attached to a living plant. Generally using host for physical support and not nutrition

**Estuary:** A semi-enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open ocean. These waters are often associated with high rates of biological productivity

**Littoral:** Refers to the coast of an ocean or sea, or the banks of a river, lake or estuary

**Mucilage:** A viscous or gelatinous fluid. i.e. mucus

**Neritic:** This zone is considered to be the 'shallow' part of the sea, the part of the ocean extending from the low tide mark to the edge of the continental shelf

**Pennate:** Refers to an order of diatoms characterized by their bilaterally symmetry. Pennate diatoms can look feathered or be shaped like a wing



**Resting Spore:** A type of auxospore formed by diatoms during unfavorable periods, such as in winter when nutrients are low. Generally, they are very heavily silicified and allow for a period of dormancy until conditions become more favorable for growth. They are common in the life cycles of marine planktonic centric diatoms but rarely formed by pennate diatoms

**Reticulation:** A network of criss-crossing lines, strands, cables, or pipes. Resembling or forming a net or network; reticulate veins of a leaf

**Seta:** (plural - setae) A stiff hair, bristle or bristle-like structure on a living organism

**Theca:** Membrane system that covers the whole dinoflagellate cell consisting of three to six complex membranes

**Thecal plates:** Armored plates of thecate dinoflagellates, composed of microfibrils made of cellulose or polysaccharides. Size, shape, and arrangement of plates is diagnostic of species

**Valve:** One of two silicified halves of the cell wall of a diatom

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