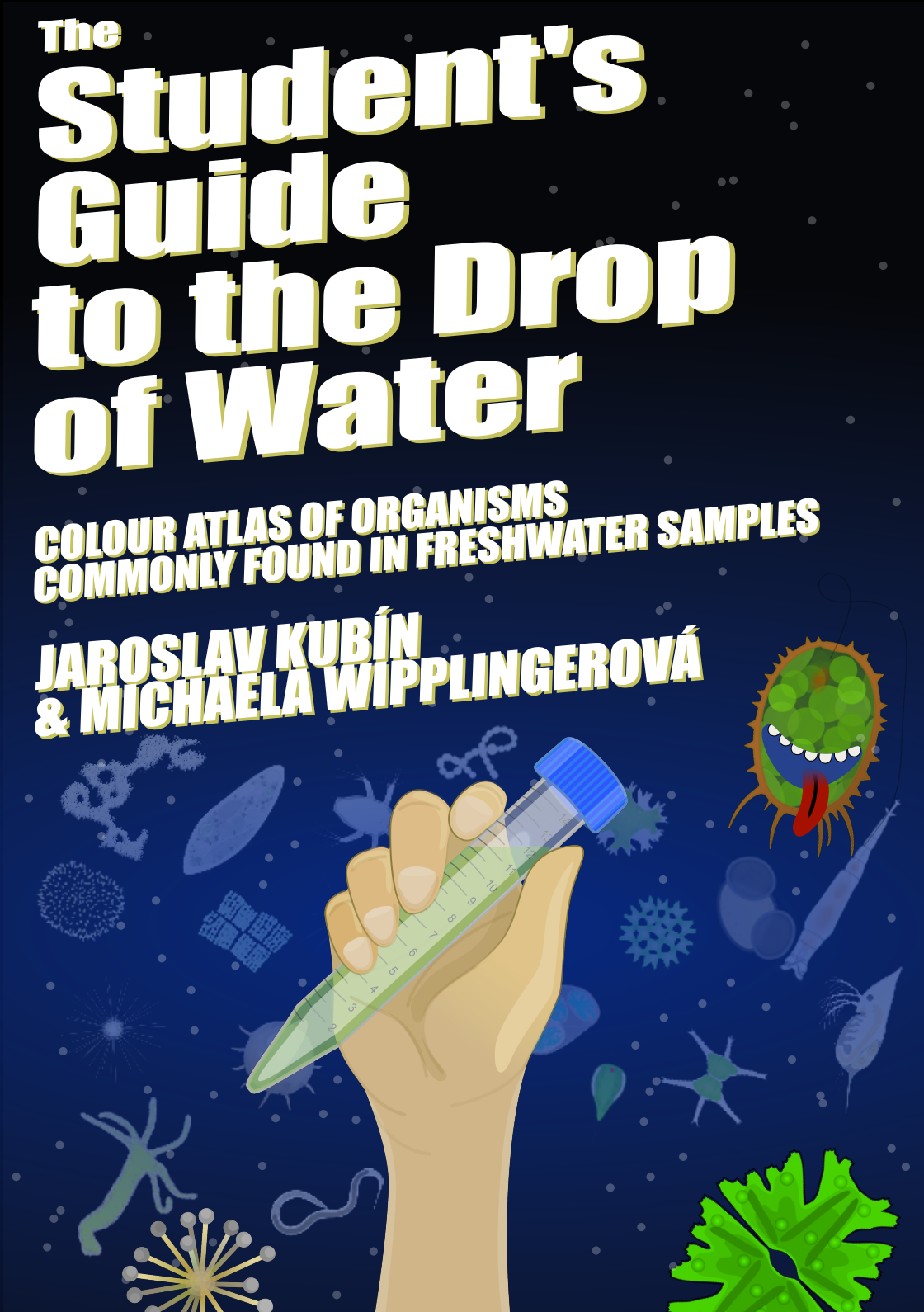
The Student's Guide to the Drop of Water

COLOUR ATLAS OF ORGANISMS COMMONLY FOUND IN FRESHWATER SAMPLES

JAROSLAV KUBÍN
& MICHAELA WIPPLINGEROVÁ



The Student's Guide to the Drop of Water

Colour atlas of organisms commonly found in freshwater samples

Despite its title, The Student's Guide to a Drop of Water is not only for students. It is meant for enthusiasts and beginners who need help with identifying organisms and other objects they meet during microscopic analysis of water samples. It contains 582 colour illustrations arranged in broad taxonomic or practical groups. The selection covers not only common freshwater species and genera, but also all major morphological groups, including those that are hard, or even impossible, to identify to species level. We hope the Guide will lead users at least to a reasonably close identification, even at higher taxonomic levels, and leave as few deep uncertainties as possible. Its aim is to raise awareness of microorganisms and offer a friendly first step into this wonderful microworld.

We wish everyone good luck on their walks through drops of water. It is great that you want to enter this realm. Keep in mind that even for us it often still feels like unknown territory. And most importantly...



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University of South Bohemia in České Budějovice

živa

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Thanks

We sincerely thank everyone who helped us choose the taxa and draw them correctly. We would never have dared to cover all groups included in the Guide on our own.

Besides the consultants, we also invited about twenty reviewers: specialists and teachers from secondary schools and universities. Together we fine-tuned the details and adapted the Guide to our aim: to make it useful in teaching. We owe them great thanks for the time they gave to the Guide and for their valuable comments.

Only by bringing together so many experts could the Guide reach its present form.

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Many thanks belong to the **journal Živa**, which supported us in completing and publishing the Czech and English versions, and to Mgr. **Alžběta Bartoňová** for proofreading the English version.

Using the Guide

The Guide begins with a short excursion into microorganism biology, but its main and largest part consists of **53 pages of illustrations** showing organisms, or their parts, found in freshwater samples. They are divided into **4 large groups** and one bonus page. This division follows taxonomy and phylogeny only partly; it is guided mainly by **visible morphological traits**, especially **thallus or body type** and **nutrition.** At the end there is a brief introduction to sorting organisms into communities and ecosystems, followed by **10 pages** showing what samples from various habitats may look like.

It is important to remember that covering the full diversity of microorganisms would take **thousands of pages.** This Guide therefore presents only a tiny fraction of it. We believe, however, that it is the fraction needed to recognize the **most common taxa** a user is likely to encounter.

Because this atlas was created in the Czech Republic, its species selection reflects mainly **Central European, temperate-zone freshwater habitats.**

The guide is freely available online on the website of the Živa journal, including individual graphics in an editable format.

ziva.avcr.cz/student-s-guide-to-a-drop-of-water.html

For easier orientation, individual chapters are colour-coded.

On some pages, important features are highlighted in **beige boxes**. We consider this information essential for identifying the organisms concerned.

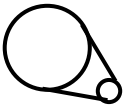
Other pages have **coloured dots** next to organism names. These tell the user which taxonomic group the organism belongs to. The colour key is always shown in a box on the page and matches **the phylogenetic tree in the introduction** (see System).



In some illustrations, **red arrows** mark important features or point to the organism itself, especially in parasites and attached forms.



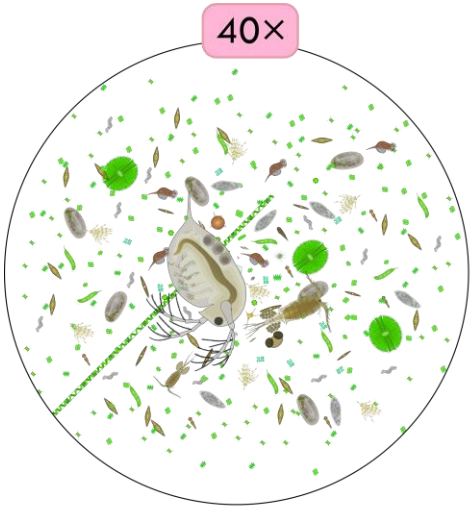
Some organisms (colonial, attached, or too large) are shown in **close-up** so their features are clearer. This often also shows their macroscopic appearance.

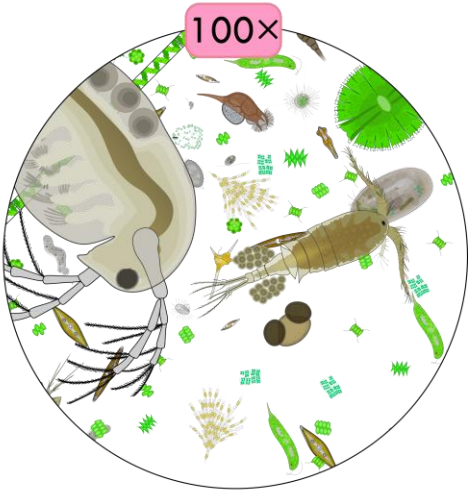


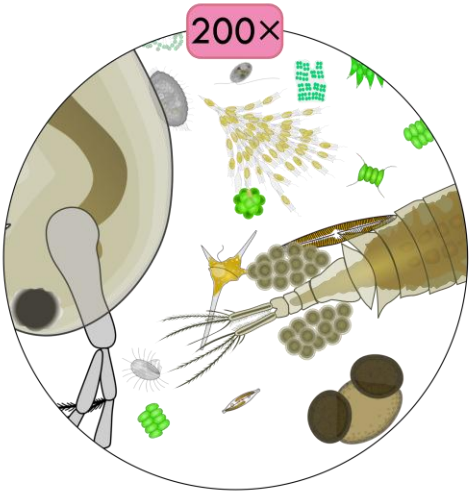
The illustration pages are numbered

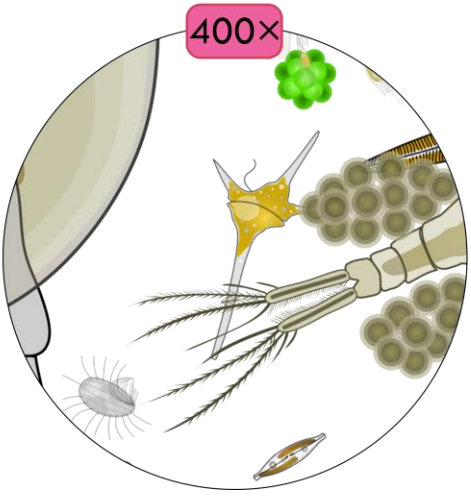
Scale

We tried to depict organisms so that all key morphological traits are visible. When observing and identifying organisms, the correct magnification must be chosen.

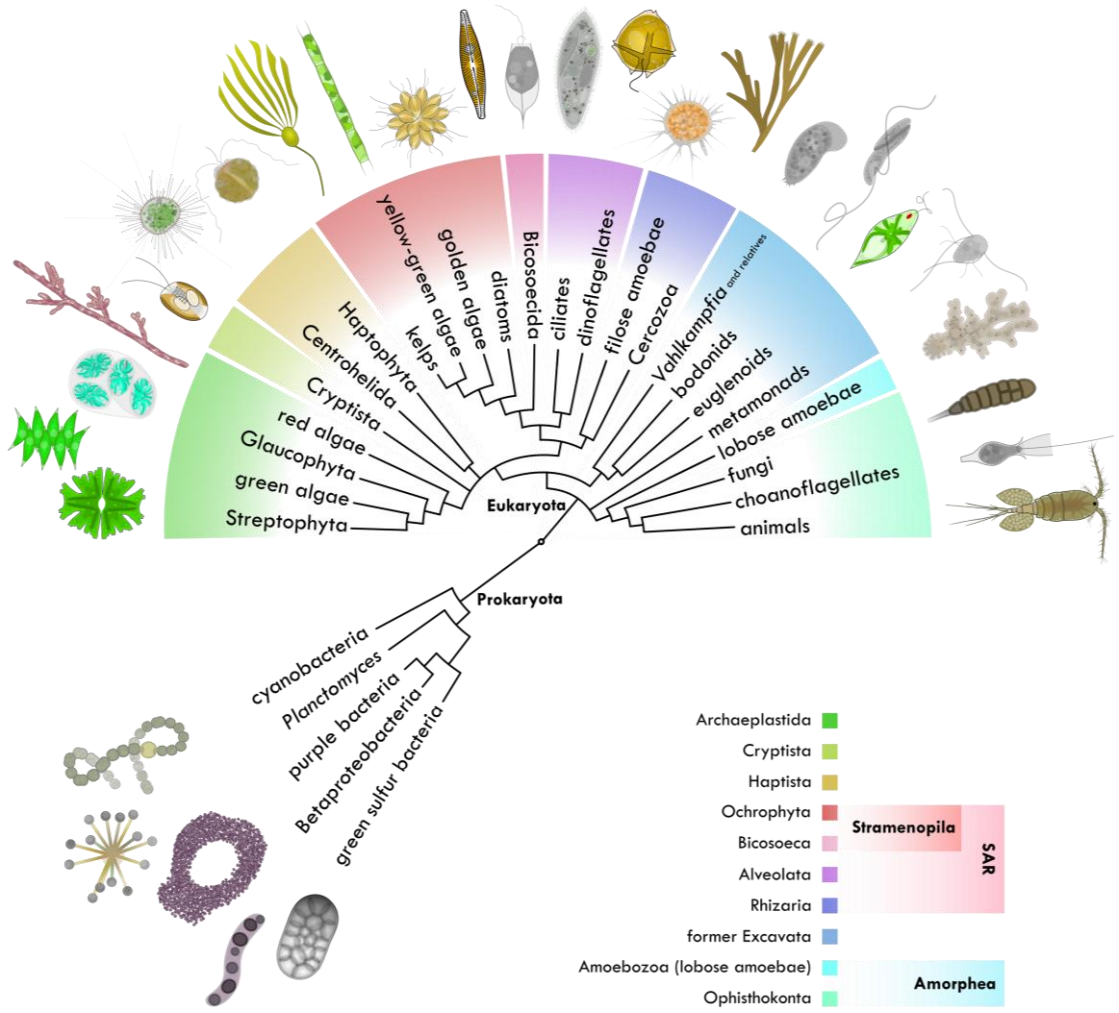








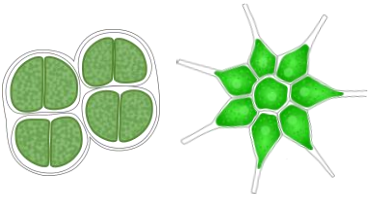
The organisms in the Guide range from **about 5 to 2000 µm**. Their relative sizes are therefore only **approximate**, and the **scale applies to each page separately**. Do not compare sizes between different pages. Size ratios also need not hold in every case: most taxa have broad size ranges, so an organism drawn smaller than another may in fact be larger in a real sample.



This tree of life is based on Burki et al.: *The New Tree of Eukaryotes* (2019), Terpis et al.: *Multiple plastid losses within photosynthetic stramenopiles revealed by comprehensive phylogenomics* (2025), and Valta et al.: *Rare microbial relict sheds light on an ancient eukaryotic supergroup* (2025). It is highly simplified and mainly, though not exclusively, shows groups included in the Guide.

Nutrition

There are **3 basic types of nutrition:**

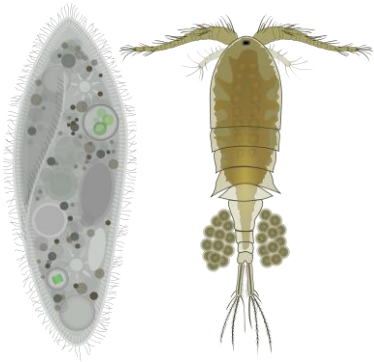


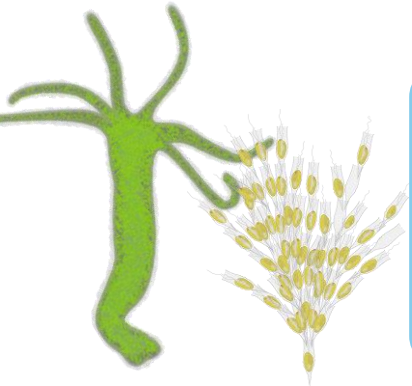
1

Photoautotrophs obtain energy from light, for example sunlight. We call them ***producers*** and they include for example cyanobacteria, most algae, landplants and some sulfur bacteria.

2

Heterotrophs feed on organic matter made by producers; we call them ***consumers***. They use ***phagocytosis*** (swallowing solid particles or whole cells), or ***osmotrophy*** (taking up dissolved nutrients). Animals are typical consumers. In microscopy we often meet both phagocytosis (for example cell-eating ciliates) and osmotrophy (also known as *saprotrophy*, for example fungi decomposing dead matter).





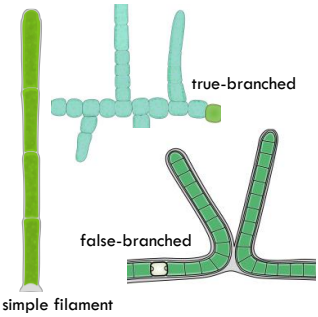
3

Mixotrophy is a common but often overlooked phenomenon. Mixotrophs use both sunlight and organic matter made by other organisms. Most algae photosynthesise, yet also absorb dissolved organic substances (via osmotrophy). Some algae, for example golden alga *Dinobryon*, can even phagocytose and actively hunt bacteria or other protists.

Thallus

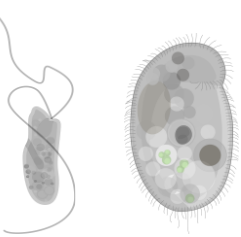
The simplest thallus type is ***coccal***. It occurs in many bacteria, algae and heterotrophic protists. The cells lack locomotory organelles and, with few exceptions, **do not move**. They usually reproduce asexually by division and often form colonies.





Another simple thallus type is ***filamentous***. Filamentous organisms rarely move actively on their own, though some cyanobacteria such as *Oscillatoria* can. Filaments may or may not branch. Branching is either **true**, involving side filaments grow from the main filament, or **false**, with the side filament physiologically connected to only one half of the main filament.

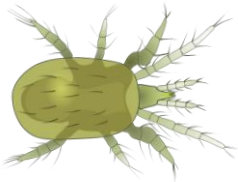
Flagellates are an important part of the protists. They occur among both photoautotrophs and heterotrophs. ***Ciliates*** are a special type of flagellated organisms: their ***cilia*** are structurally equivalent to ordinary flagella, so they are basically flagellates with thousands of short flagella arranged in rows.





Amoebae are a very diverse group. They move by ***pseudopodia***, which have four main types: broad finger-like **lobopodia**, thin long **filopodia**, stiffened long **axopodia**, or complex net-like ***reticulopodia***. Classic amoeboid groups are distinguished by pseudopod type, although most are not closely related. Some amoebae live in a shell; these are ***testate amoebae***. The shell may be a porous chitin-like material, scales, or detritus, i.e. tiny particles collected from the environment, and it often allows a fairly reliable species identification.

The body organisation most familiar to us is ***multicellularity***. Multicellular organisms include all plants and animals, but also some algae and heterotrophic protists. Their cells are grouped by function into tissues and, in more complex cases, organs.



Sources

For those who would like to identify organisms in more detail, we list suitable identification literature. We should also note that our drawings were often based not only on our own microphotographs and materials from our consultants, but also on the publications below. Our main source for **cyanobacteria and algae** was ***Atlas sinic a řas ČR*** (Kaštovský et al. 2018), also available online on our laboratory website **(www.sinicea-rasy.cz/matlas)**. For bacteria and fungi we often followed ***Atlas vodních organismů se zřetelem na vodárenství, povrchové vody a čistírny*** odpadních vod by the Sládečeks (1996), which was also helpful for other groups.

Cyano-bacteria

Hindák: Colour Atlas of Cyanophytes (2008)

Komárek & Anagnostidis: Süßwasserflora von Mitteleuropa: Cyanoprokaryota

Komárek & Fott: Das s Phytoplankton des Süßwassers, t. 7: Chlorophyceae (1983) — **Green algae**

Desmids

Coesel & Meesters: Desmids of the Lowlands, 2nd ed. (2023)

Desmid species (Desmidiaceae) in the Netherlands, **online: www.desmids.nl**

Huber-Pestalozzi: Das Phytoplankton des Süßwassers, t. 4: Euglenophyceen (1955)

Starmach: Flora Słodkowodna Polski, t. 3: Euglenophyta-Eugleniny (1983) — **Euglenids**

Diatoms

Cox: Identification of Freshwater Diatoms from Live Material (1996)

Lange-Bertalot: Freshwater Benthic Diatoms of Central Europe (2017)

Berger & Foissner – Illustrated guide and ecological notes to ciliate indicator species (Protozoa, Ciliophora) in running waters, lakes, and sewage plants (2014) — **Ciliates**

Amoeba and heliozoans

Siemensma: Microworld, world of amoeboid organisms, **online: www.arcella.nl**

Todorov & Bankov: An atlas of *Sphagnu*m-dwelling testate amoebae in Bulgaria (2019)

Jeuck & Arndt: A short guide to common heterotrophic flagellates of freshwater habitats based on the morphology of living organisms (2013)

Zhukov: Atlas of freshwater heterotrophic flagellates (1993) — **Heterotrophic flagellates**

Animals

Bartoš: Fauna of ČSR, Vol. 15: Vířníci – Rotatoria (1959)

Hudec: Fauna Slovenska III: Anomopoda, Ctenopoda, Haplopoda, Onychopoda (2010)

More general publications

John et al.: The Freshwater Algal Flora of the British Isles (2011)

Kaštovský et al.: Atlas sinic a řas ČR 1+2 (2018), **online: www.sinicearasy.cz/matlas**

Kreutz & Foissner: The *Sphagnum* ponds of Simmelried in Germany: a biodiversity hot-spot for microscopic organisms (2006)

Plewka: PlingFactory, **online: www.plingfactory.de**

Rogers & Thorp: Thorp and Covich's Freshwater Invertebrates v. 4: Keys to Palaearctic Fauna (2019)

Sládeček & Sládečková: Atlas vodních organismů se zřetelem na vodárenství, povrchové vody a čistírny (1996)

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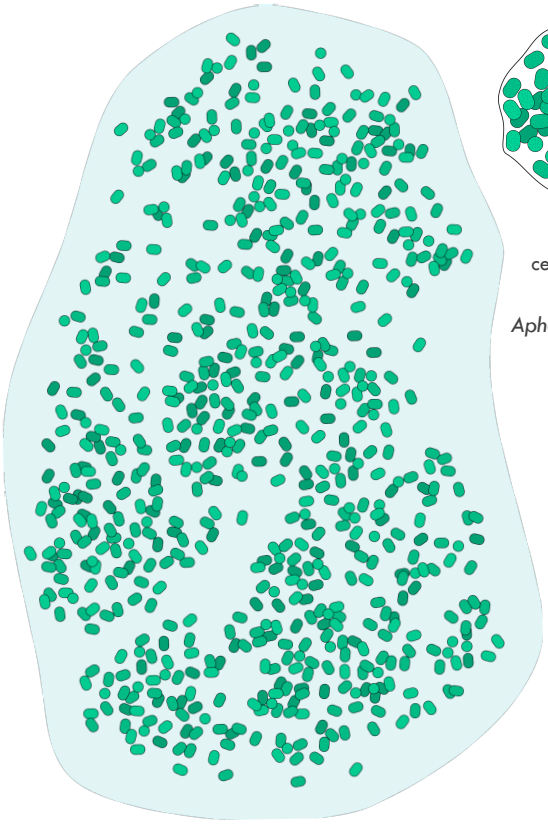
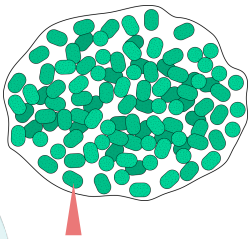
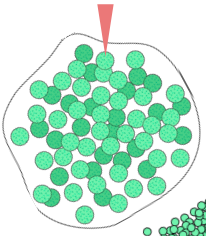
Coccal cyanobacteria I



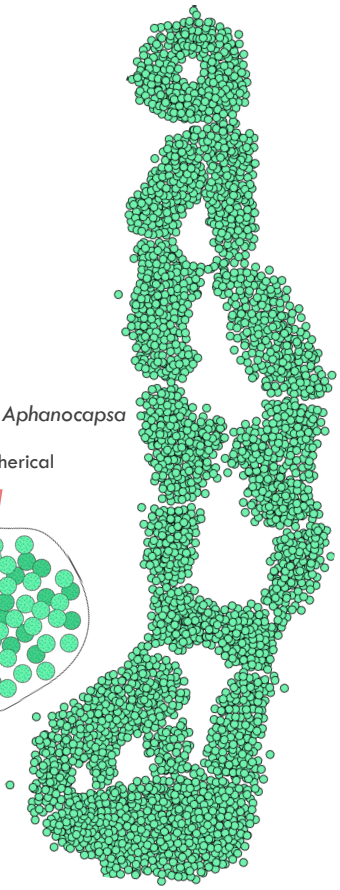


cells oval

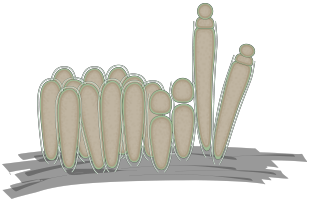
Aphanothece



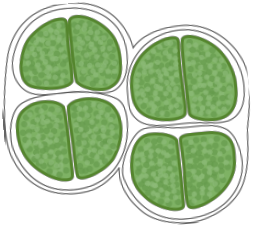
cells spherical



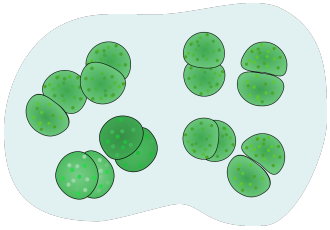
Aphanocapsa



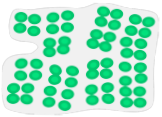
Chamaesiphon



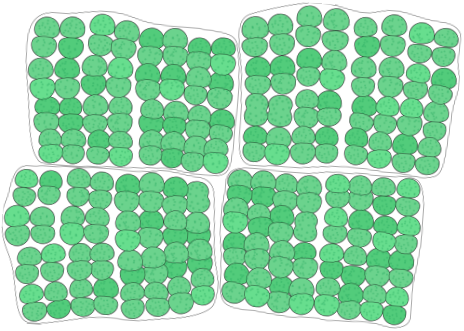
Chroococcus



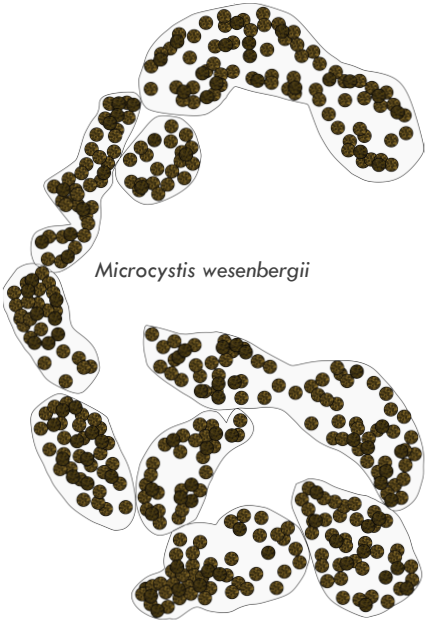
Limnococcus



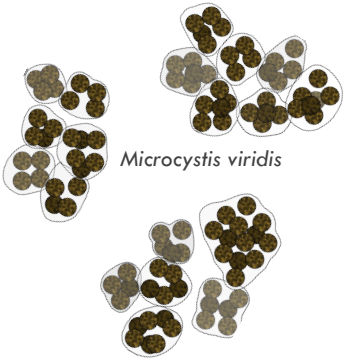
Merismopedia



Coccal cyanobacteria II

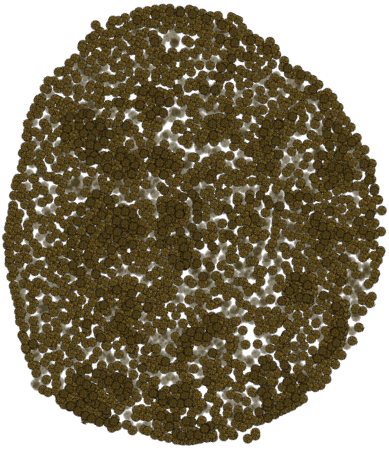


Microcystis wesenbergii

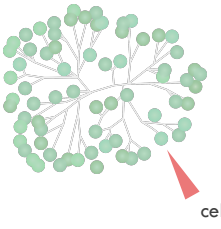


Microcystis viridis

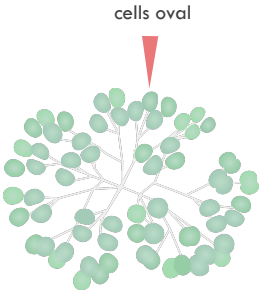
Microcystis aeruginosa



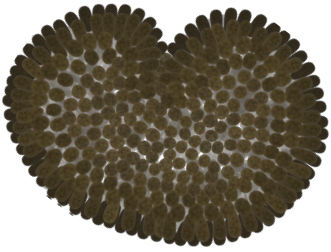
Microcystis flos-aquae



Snowella litoralis



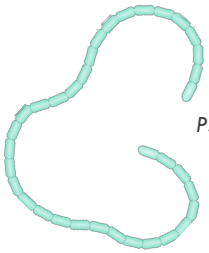
Snowella lacustris



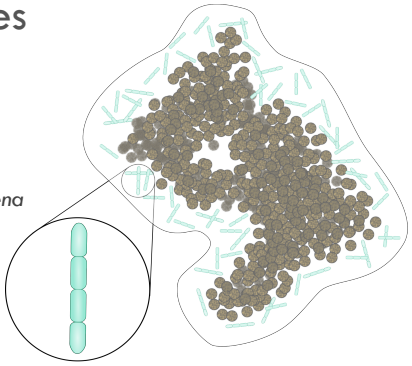
Woronichinia

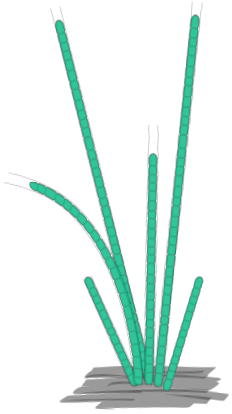
Filamentous cyanobacteria I

- without heterocytes

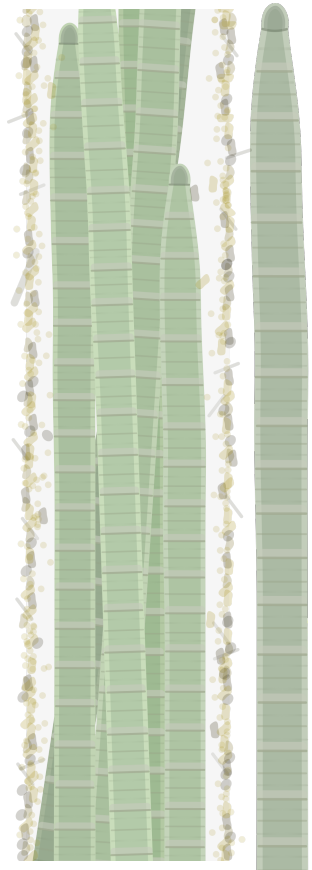


Pseudanabaena





Heteroleibleinia



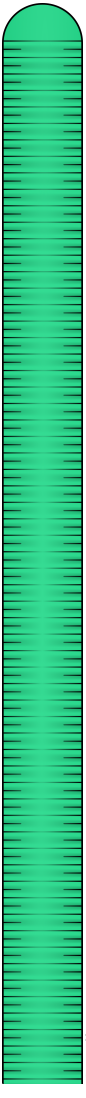
Microcoleus



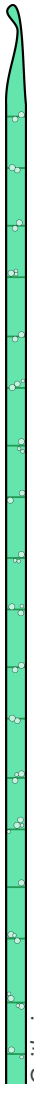
Kamptonema



Phormidium



Oscillatoria



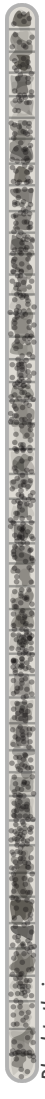
Geitlerinema



Pseudanabaena



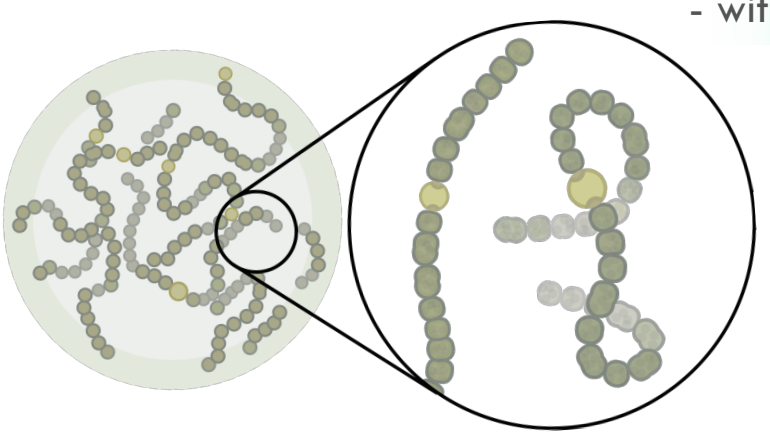
Spirulina

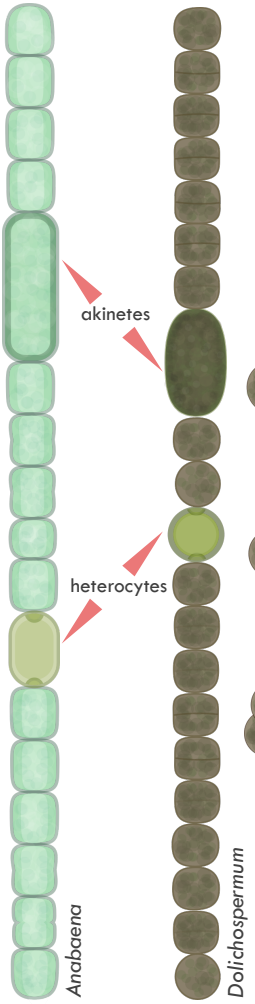


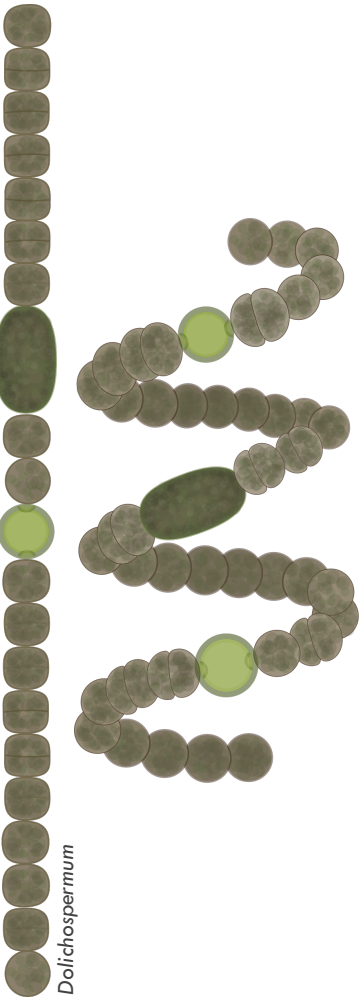
Planktothrix

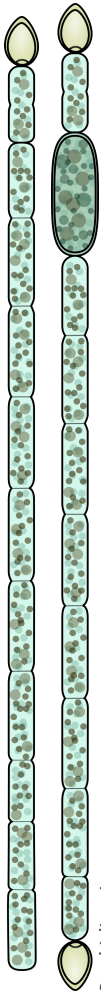
Filamentous cyanobacteria II

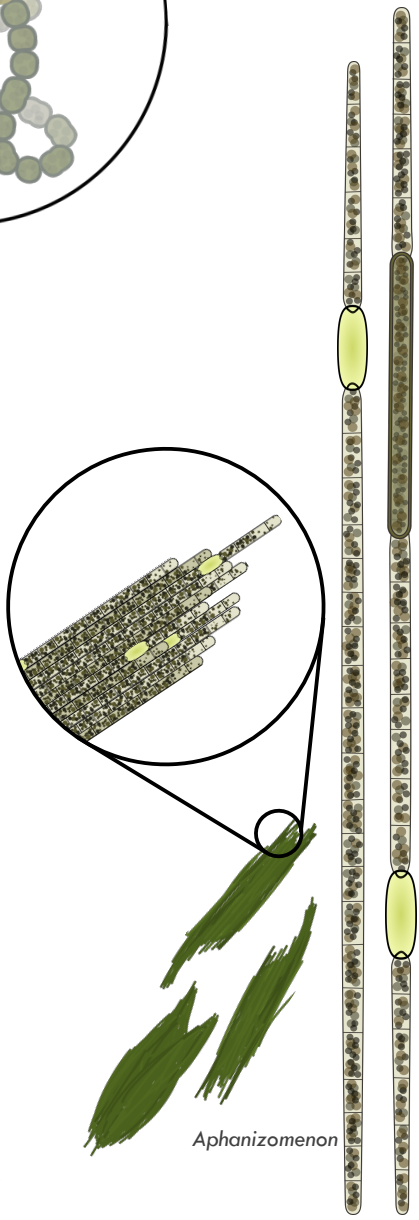
- with heterocytes





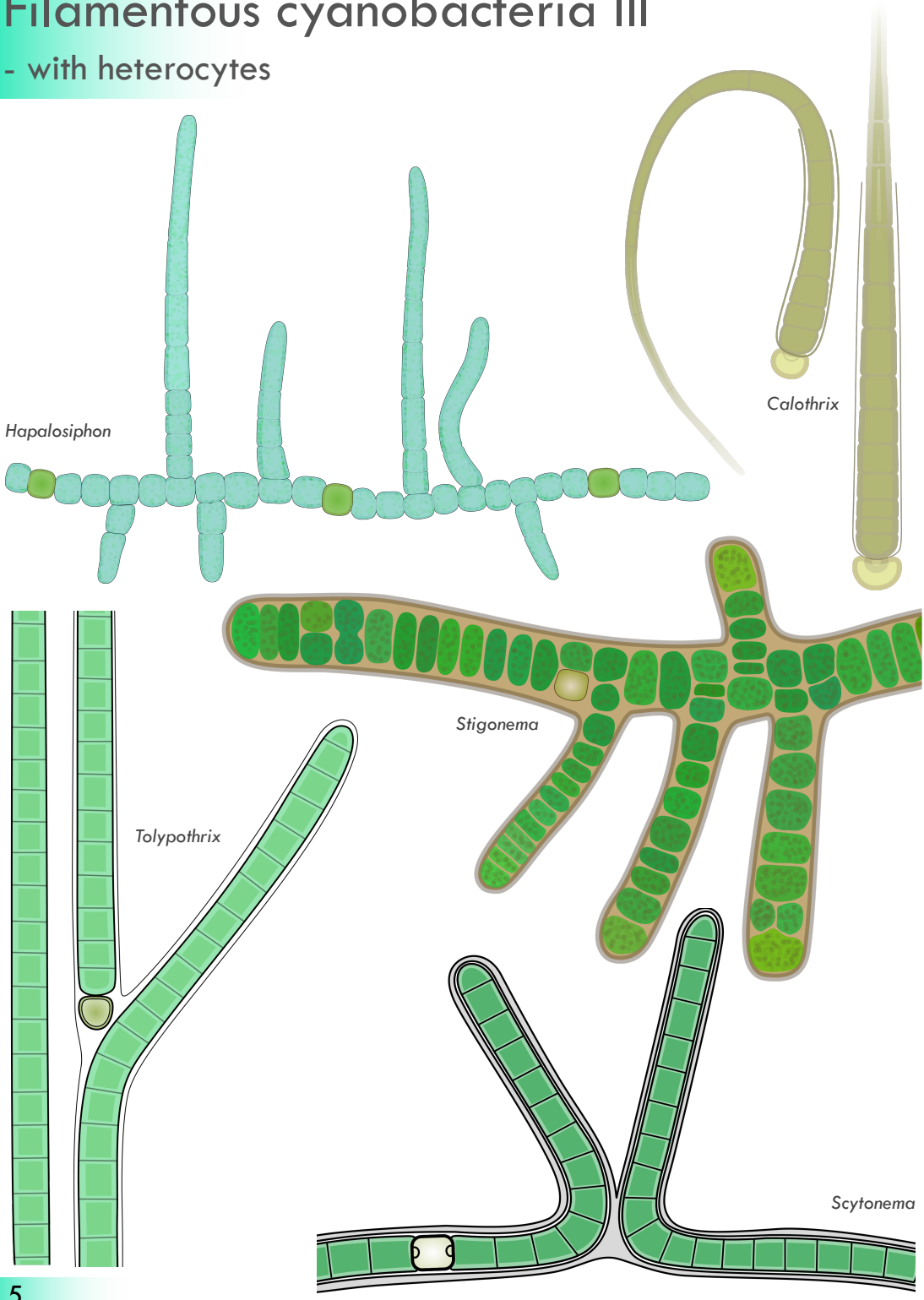




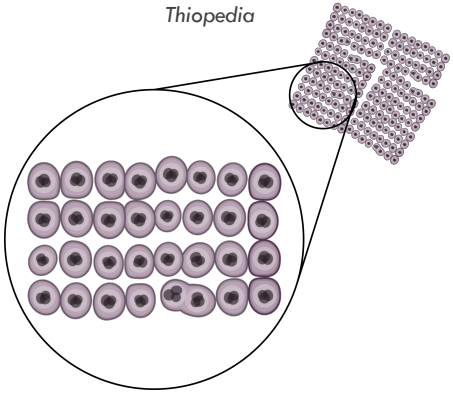


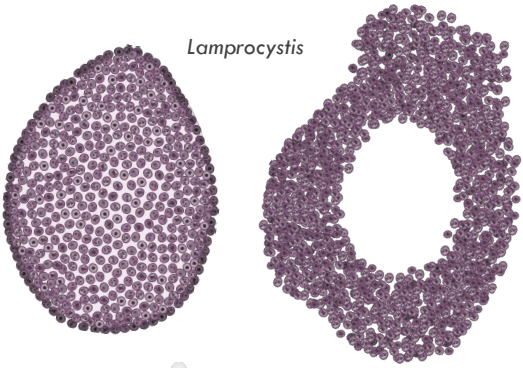
Filamentous cyanobacteria III

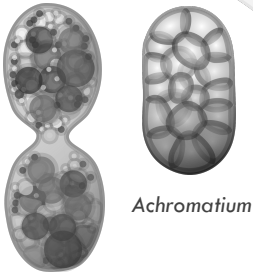
- with heterocytes

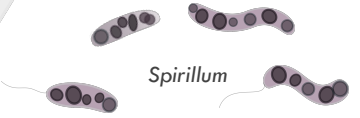


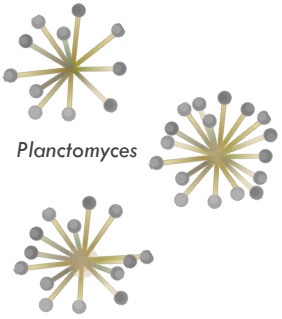
Other bacteria

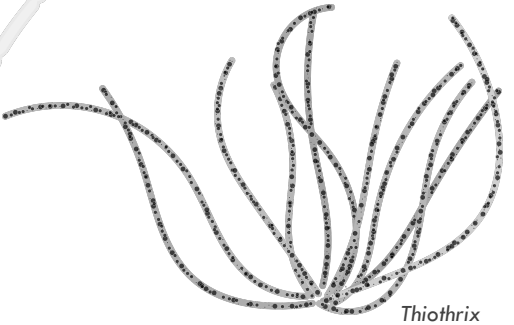












Green euglenoids I

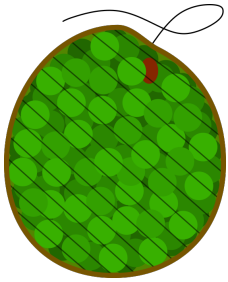


Euglena deses

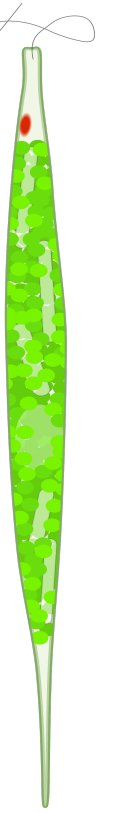




Euglena



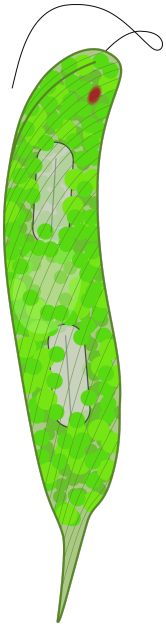
Euglena texta



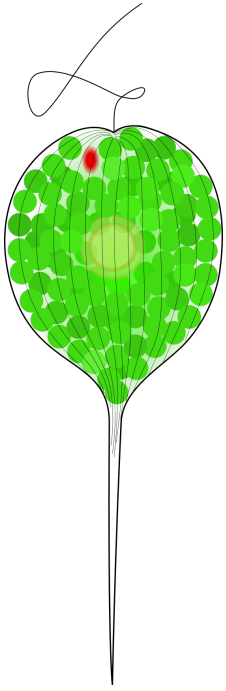
Lepocinclis acus



Lepocinclis spirogyroides



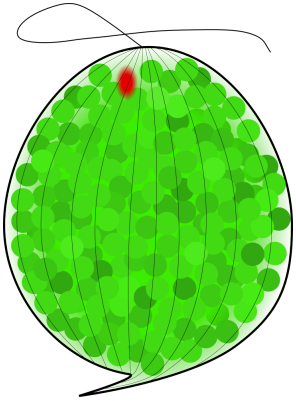
Lepocinclis oxyuris



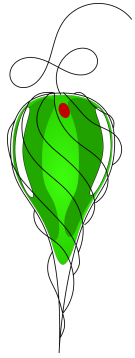
Phacus longicauda



Phacus tortus



Phacus pleuronectes

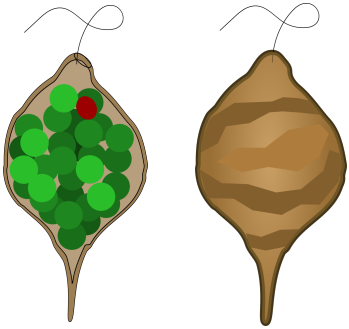


Monomorphina

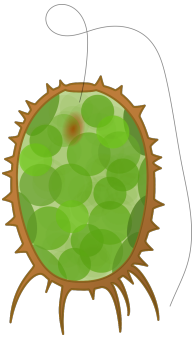


Phacus oscillans

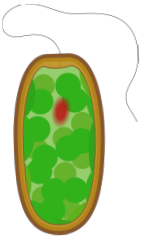
Green euglenoids II



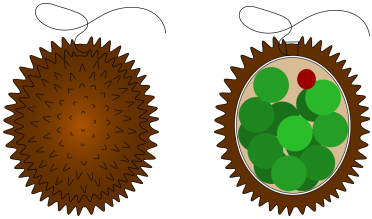
Strombomonas



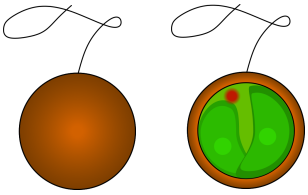
Trachelomonas armata



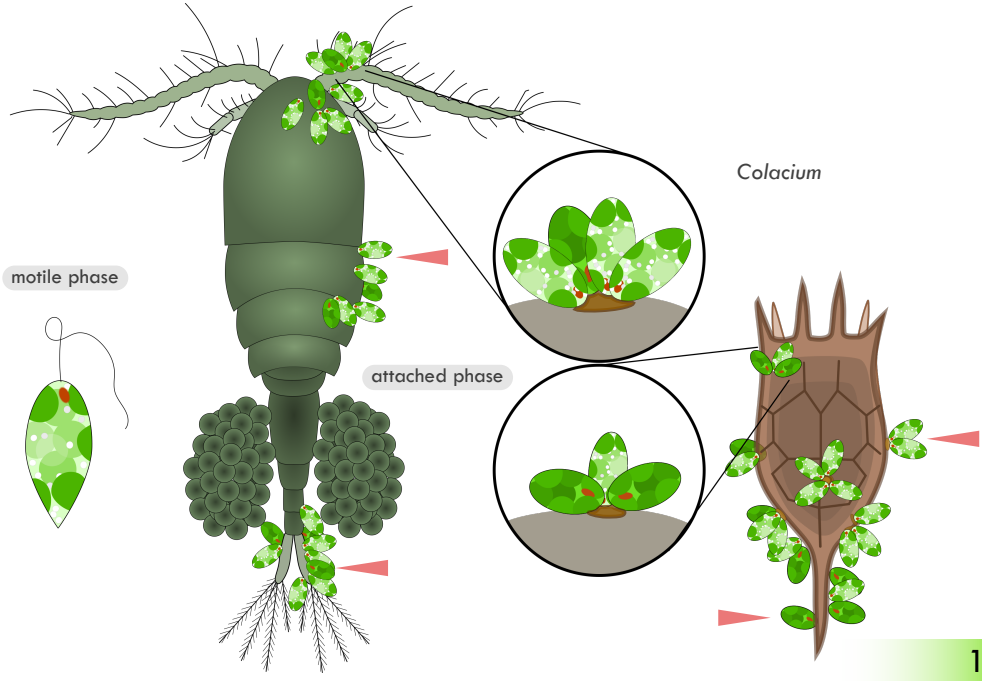
Trachelomonas abrupta



Trachelomonas hispida



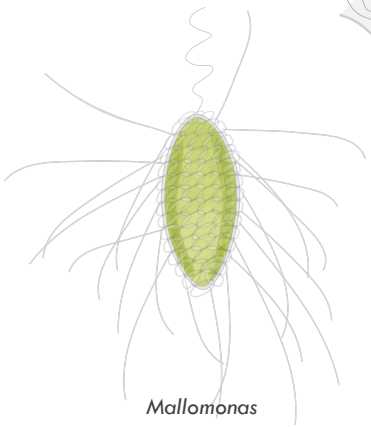
Trachelomonas volvocina



Golden algae



Chrysococcus

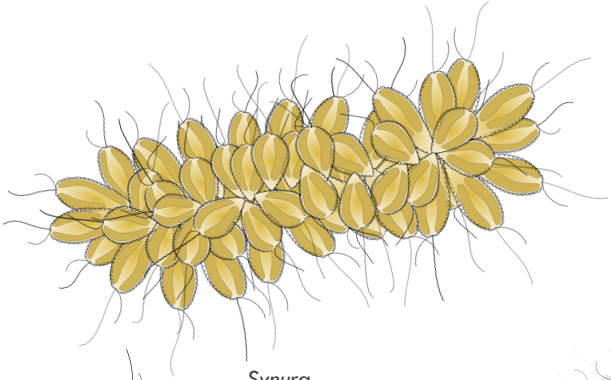


Mallomonas

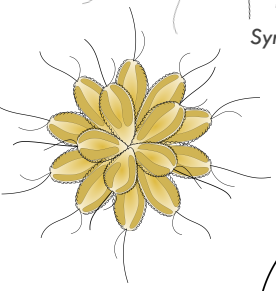


Dinobryon

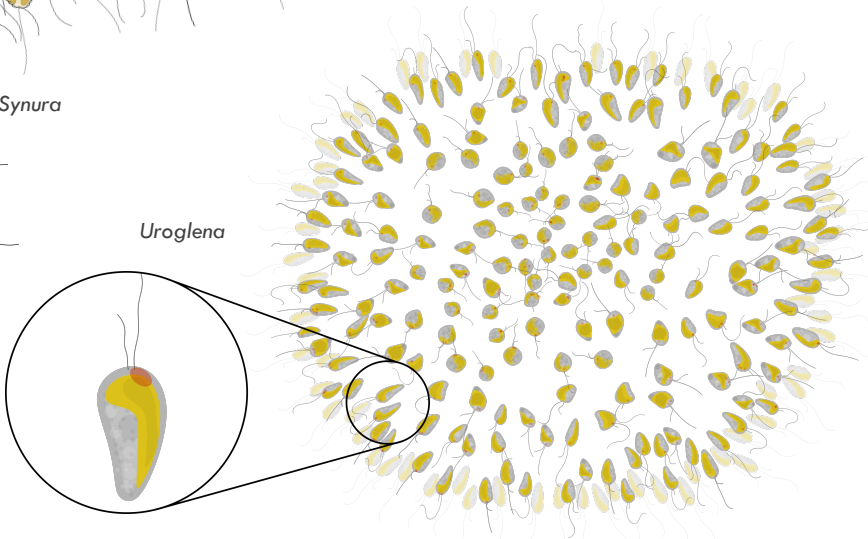
Ochromonas



Synura

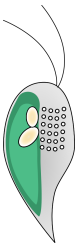


Uroglena

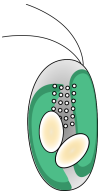


Cryptophytes, dinoflagellates and raphidophytes

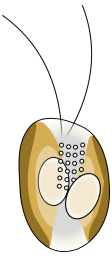
- cryptophytes
- dinoflagellates
- raphidophytes

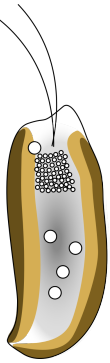


Komma

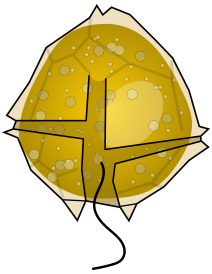


Chroomonas

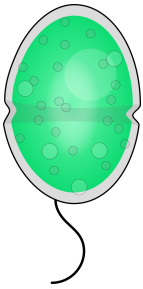




Cryptomonas



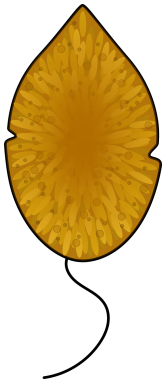
Peridinium

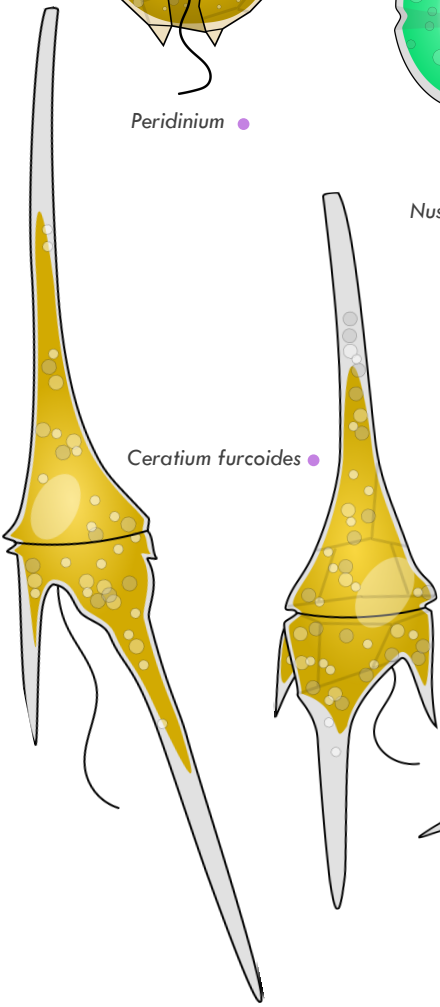


Nusuttodinium

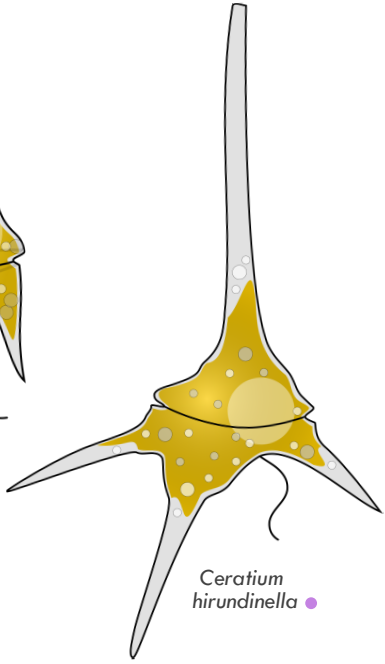


Gymnodinium

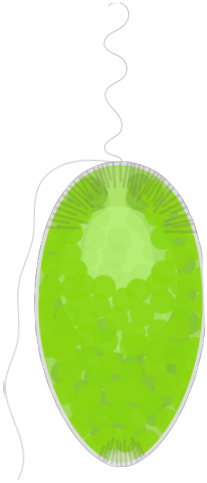




Ceratium furcoides

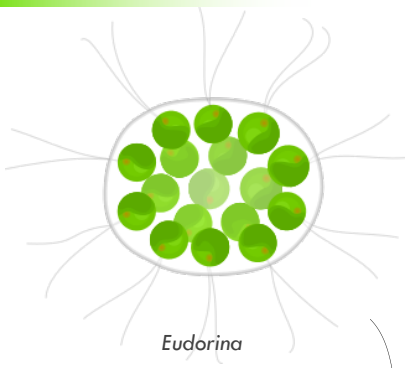


Ceratium hirundinella

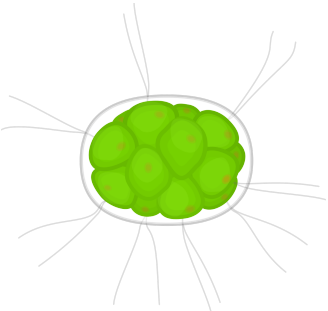


Gonyostomum

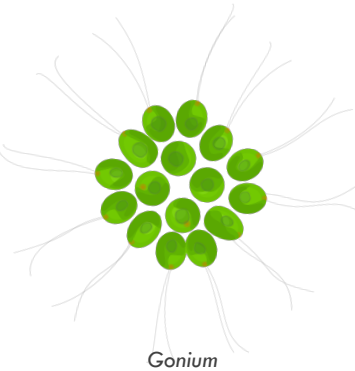
Flagellated green algae



Eudorina



Pandorina

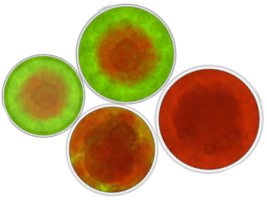


Gonium



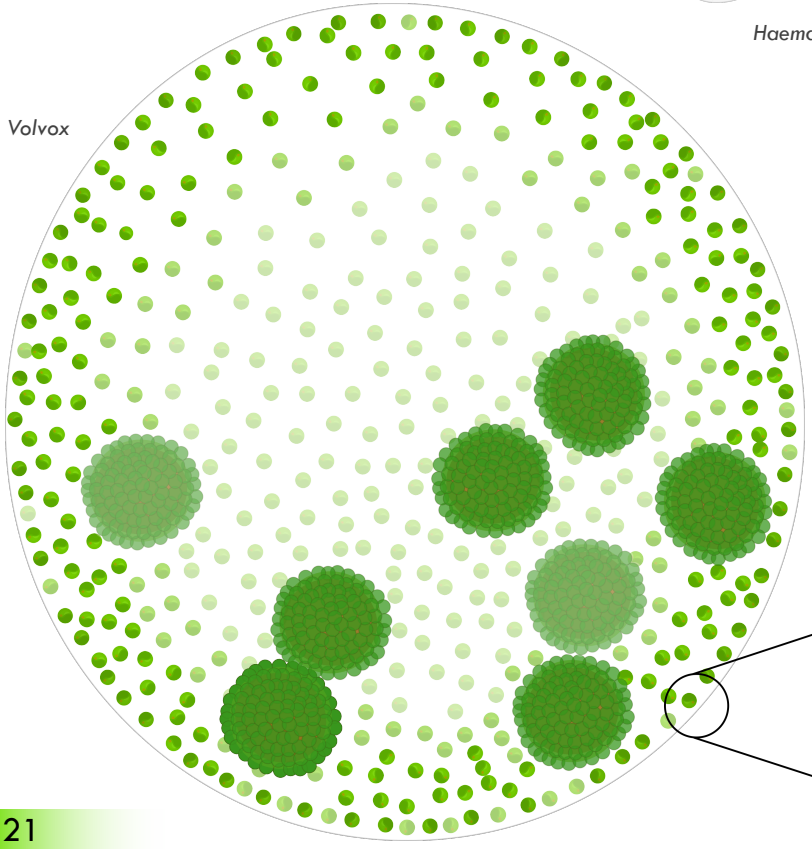
Chlamydomonas

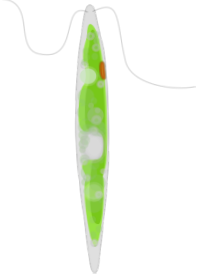




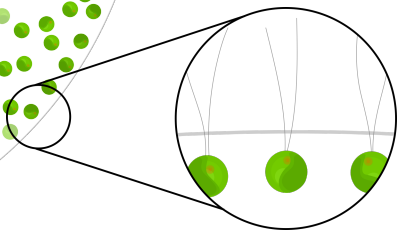
Haematococcus

Volvox

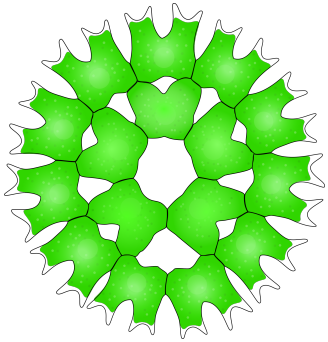




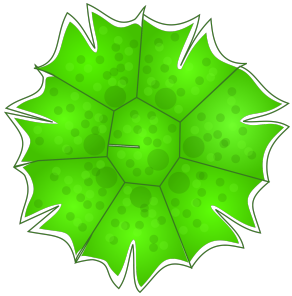
Chlorogonium



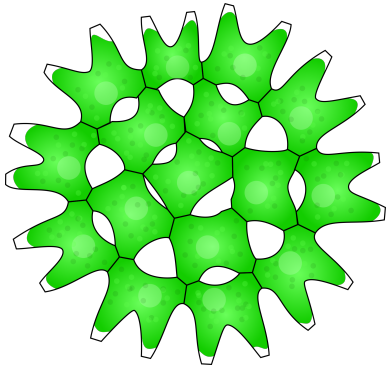
Coccal green algae I



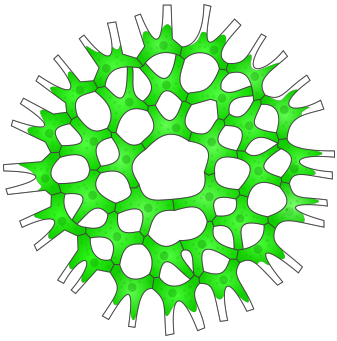
Parapediastrum



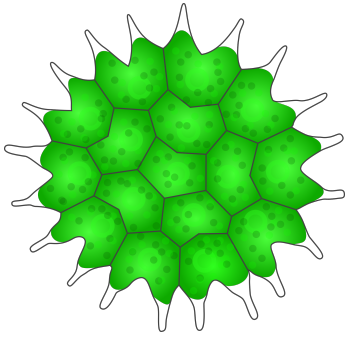
Stauridium



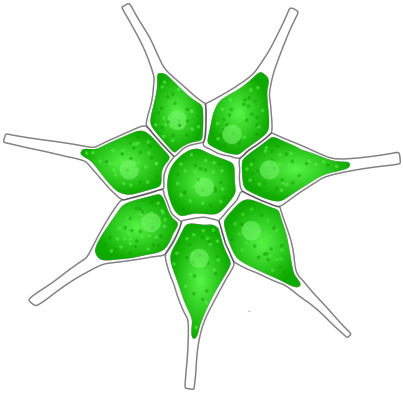
Pediastrum



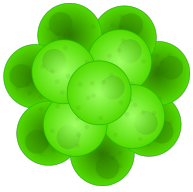
Lacunastrum



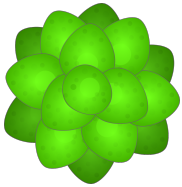
Pseudopediastrum



Monactinus

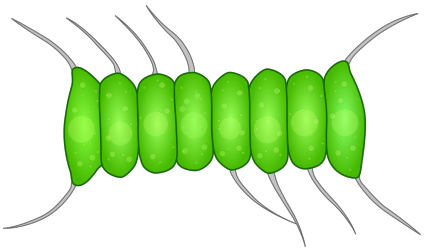


Coelastrum microporum

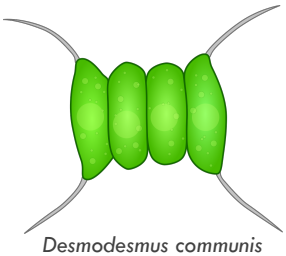


Coelastrum astroideum

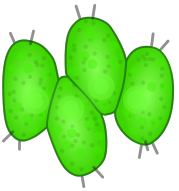
Coccal green algae II



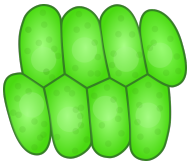
Desmodesmus magnus



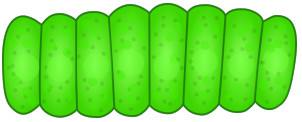
Desmodesmus communis



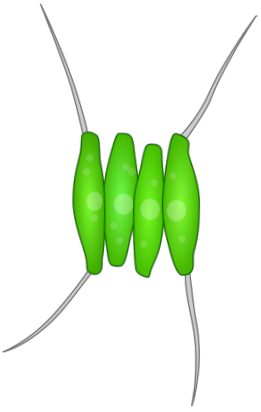
Desmodesmus denticulatus



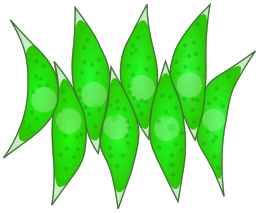
Scenedesmus obtusus



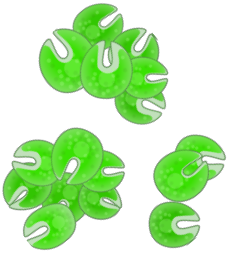
Scenedesmus ellipticus



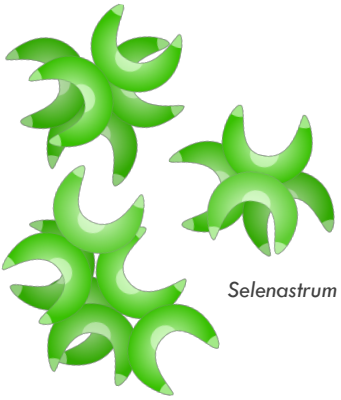
Desmodesmus opoliensis



Tetradesmus



Kirchneriella



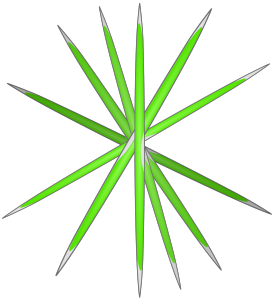
Selenastrum



Lemmermannia



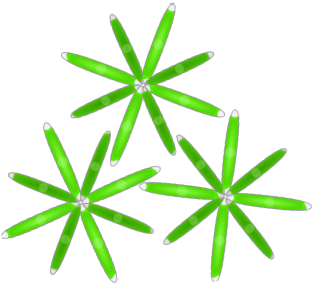
Monoraphidium



Ankistrodesmus falcatus

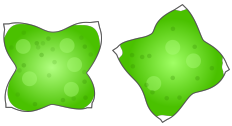


Ankistrodesmus arcuatus

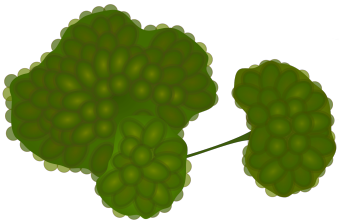


Actinastrum

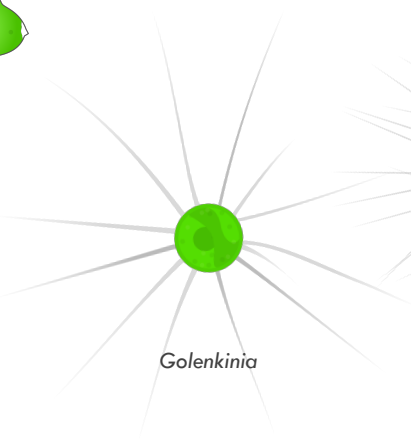
Coccal green algae III



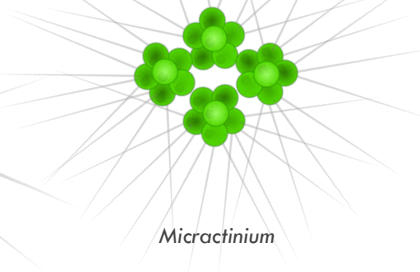
Tetraedron



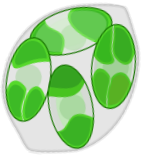
Botryococcus



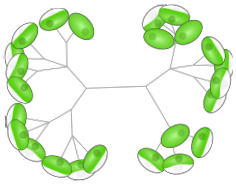
Golenkinia



Micractinium



Oocystis



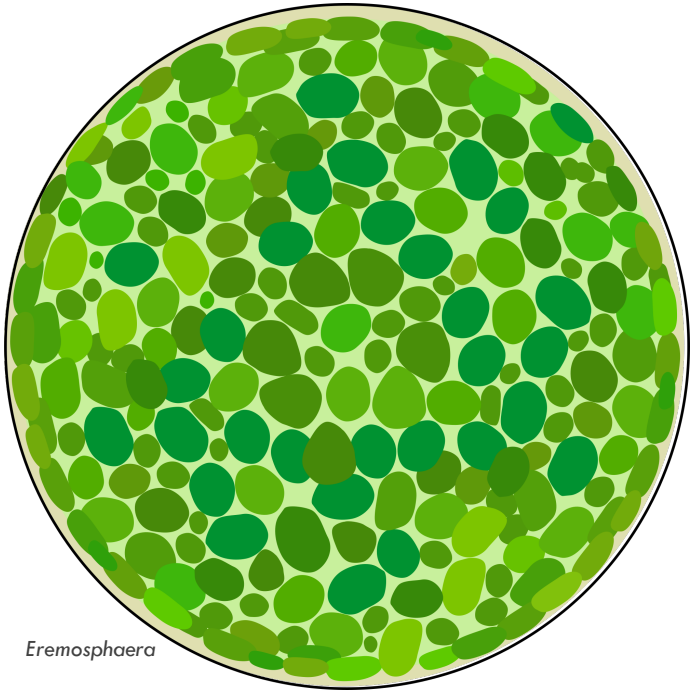
Dictyosphaerium



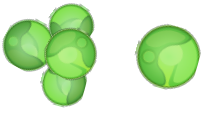
Stichococcus



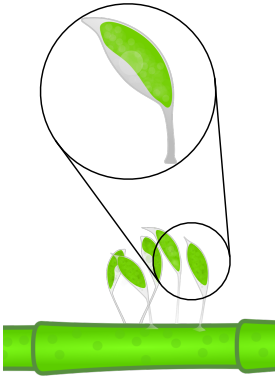
Planktosphaeria



Eremosphaera

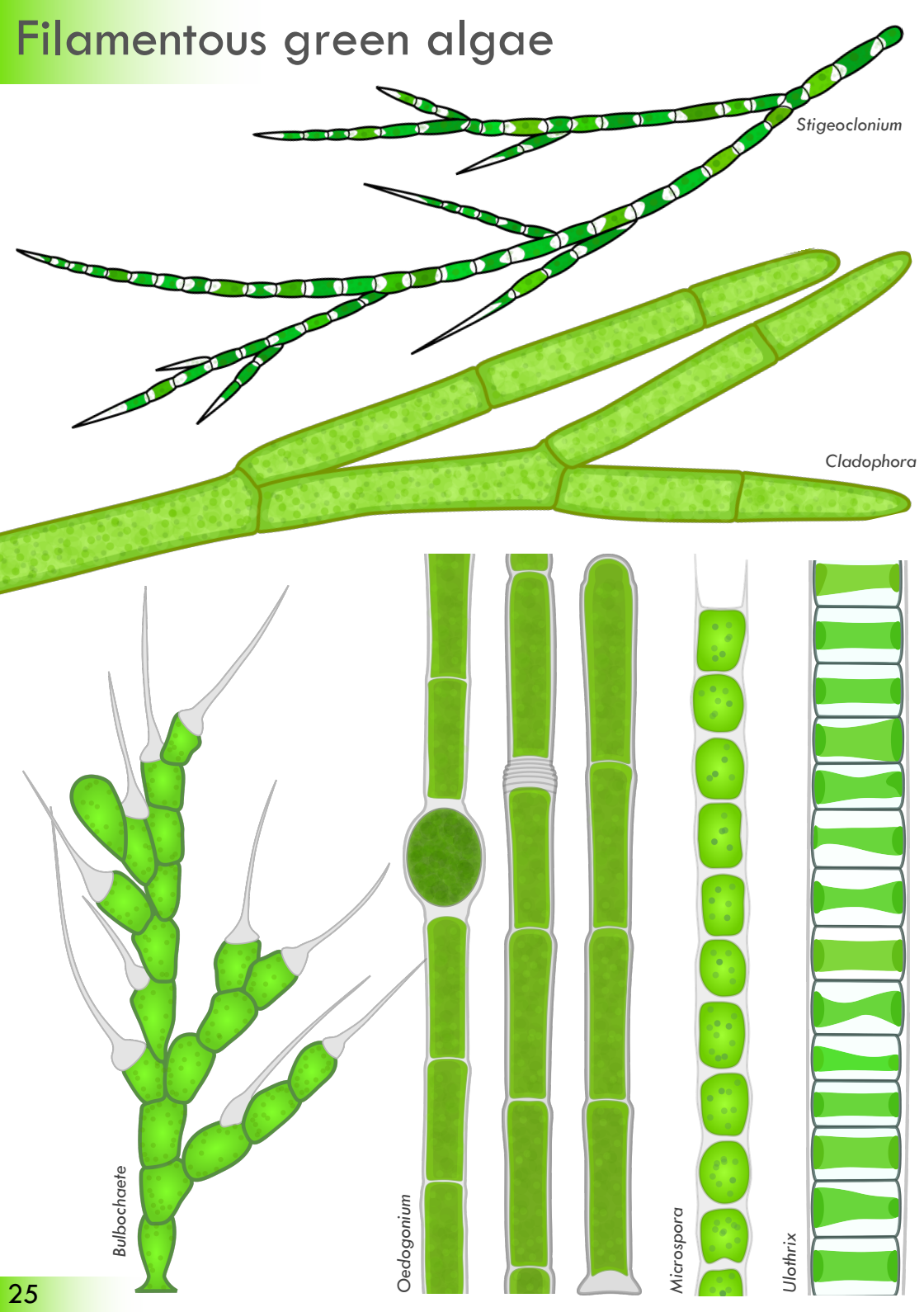


Chlorella



Characium

Filamentous green algae

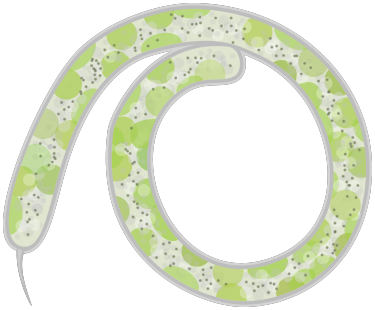


Yellow-green algae



Tribonema

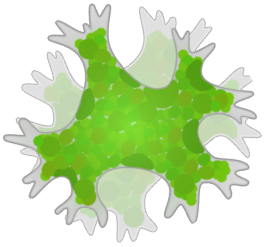
'H-shaped pieces': typical remains of cell wals



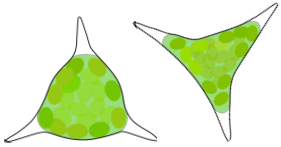
Ophiocytium



Chlorobotrys



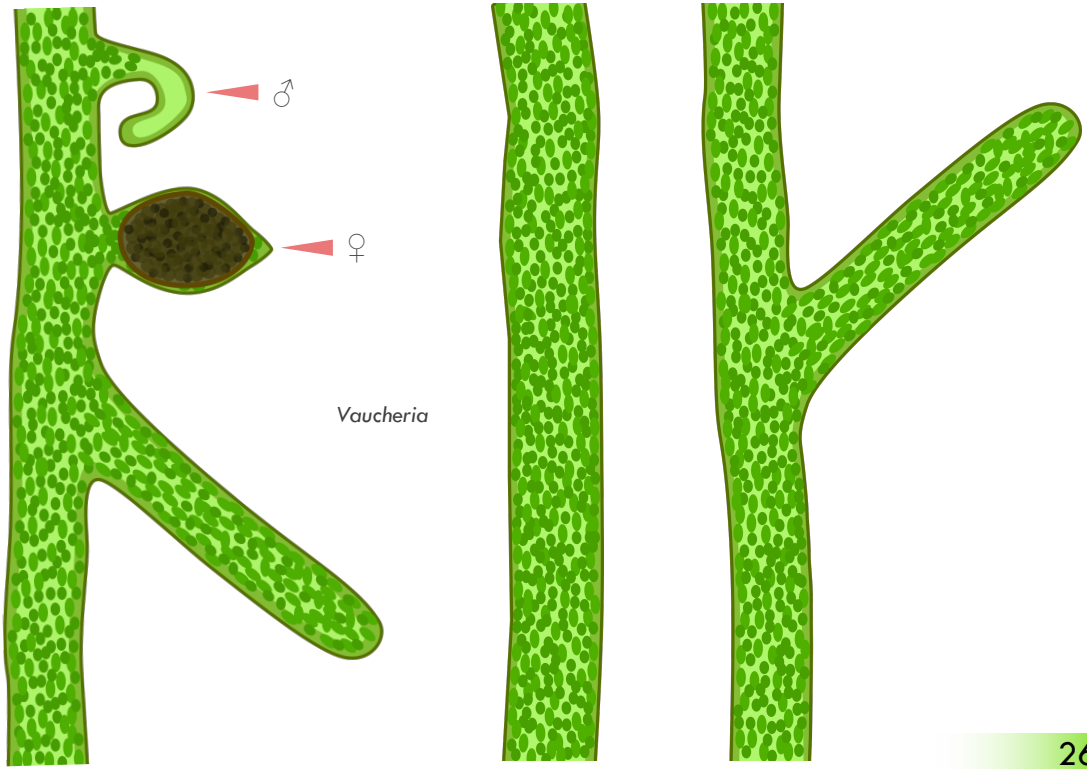
Pseudostaurastrum



Goniochloris

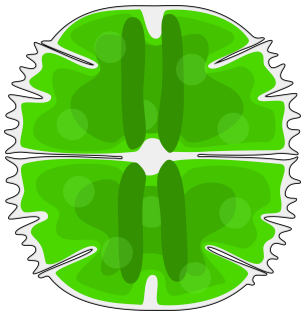


Centritractus

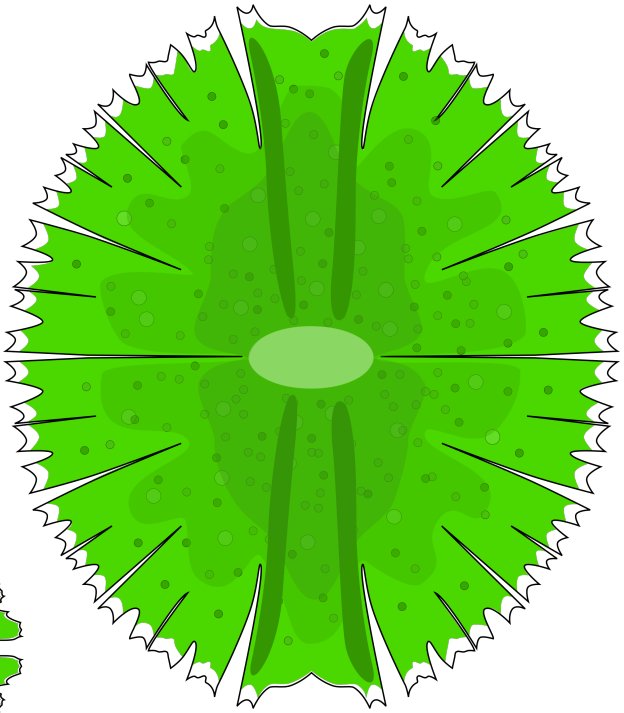


Vaucheria

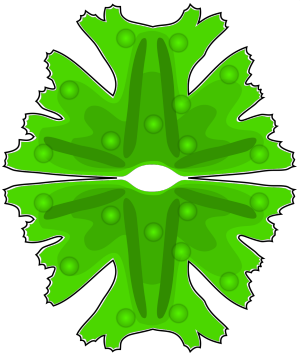
Desmids I



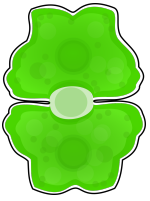
Micrasterias truncata



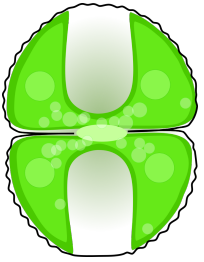
Micrasterias rotata



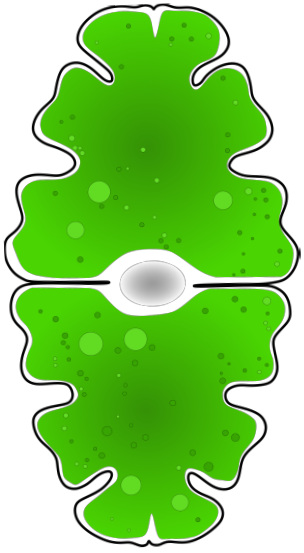
Micrasterias americana



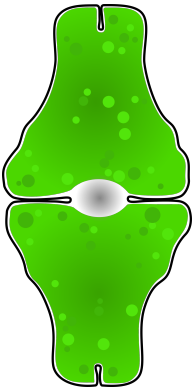
Euastrum binale



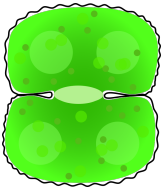
Cosmarium tetraophtalmum



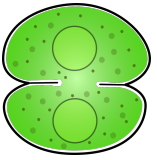
Euastrum oblongum



Euastrum ansatum

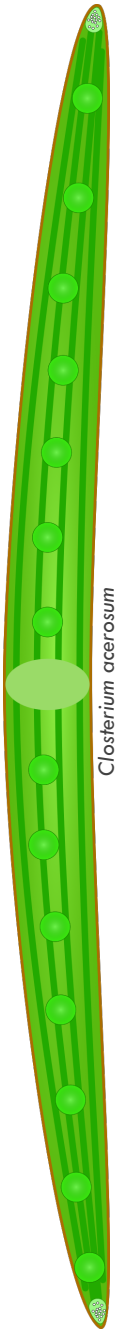


Cosmarium biretum

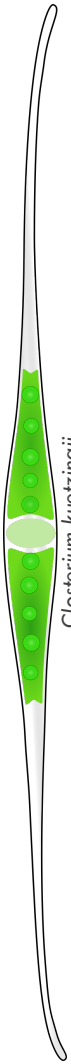


Cosmarium neodepressum

Desmids II



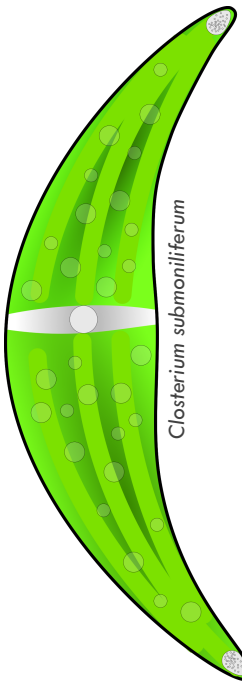
Closterium acerosum



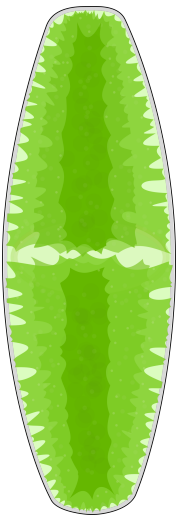
Closterium kuetzingii



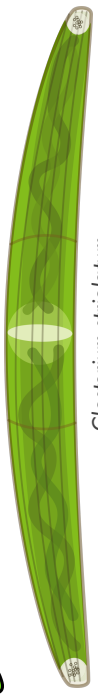
Cylindrocystis



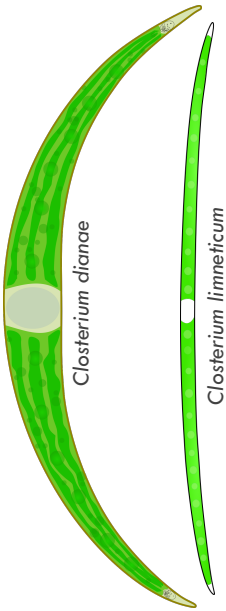
Closterium submoniliferum



Netrium



Closterium striolatum



Closterium dianae

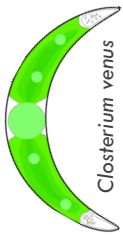
Closterium limneticum



Tetmemorus



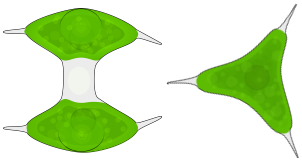
Pleurotaenium



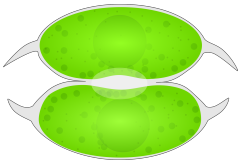
Closterium venus

Desmids III

upper view

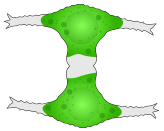


Staurodesmus cuspidatus



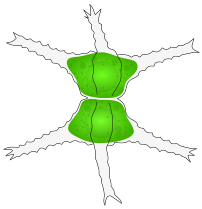
Staurodesmus convergens

upper view

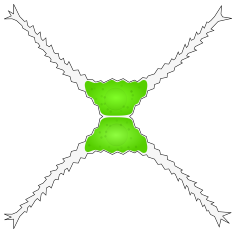




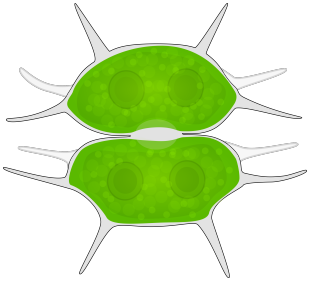
Staurastrum planctonicum



Staurastrum manfeldtii



Staurastrum chaetoceras



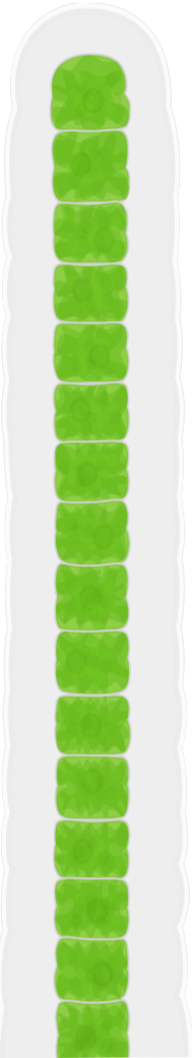
Xanthidium



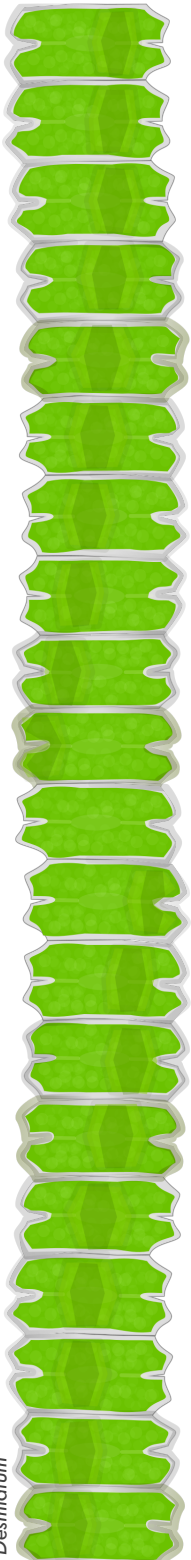
Teilingia



Bambusina

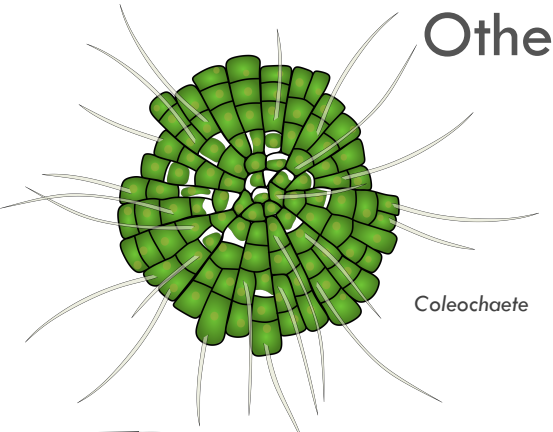


Hyalotheca



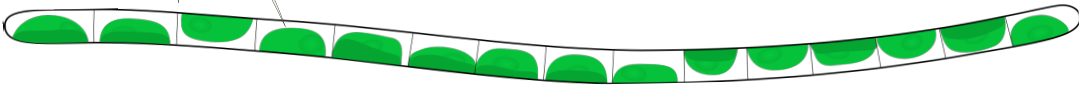
Desmidium

Other streptophyte algae



Coleochaete

Klebsormidium



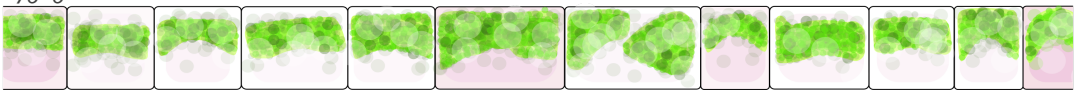
Mougeotia



Zygnema



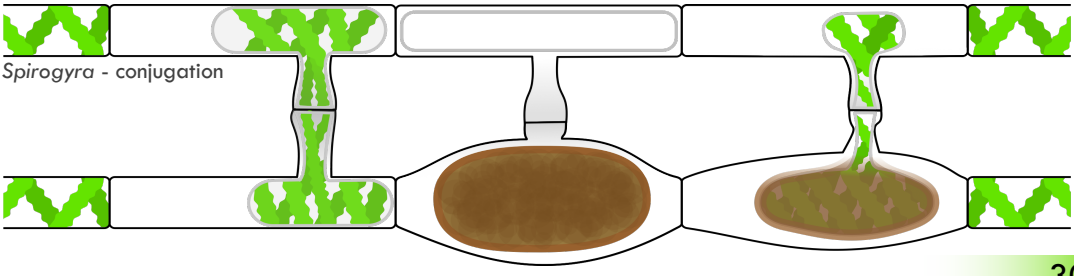
Zygogonium



Spirogyra

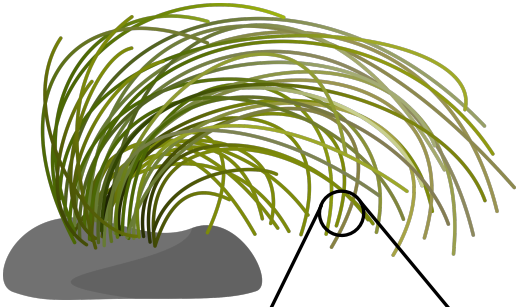


Spirogyra - conjugation

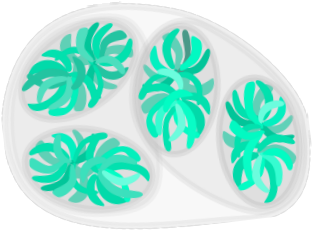


Red algae and Glaucophyta

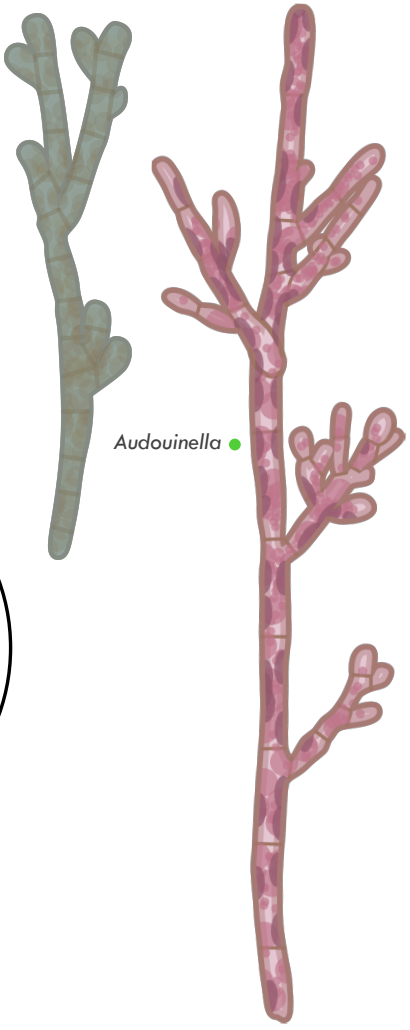
red algae
Glaucophyta



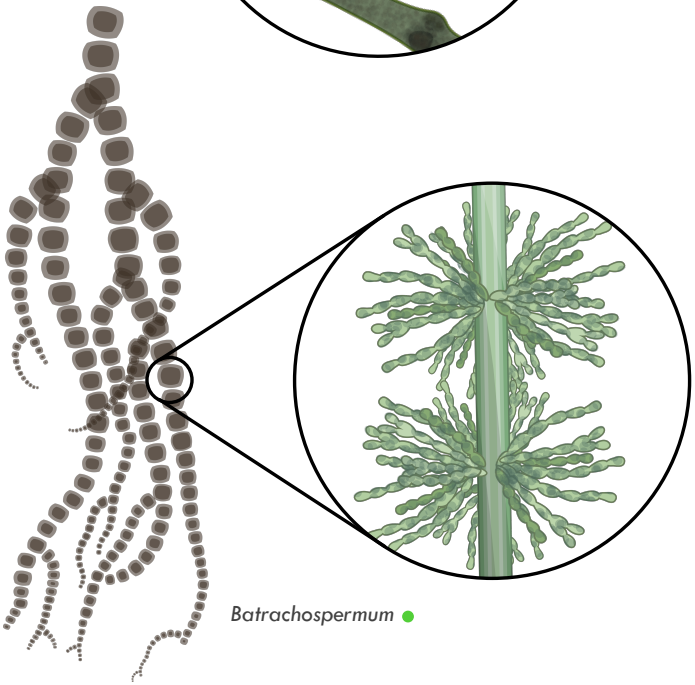
Lemanea



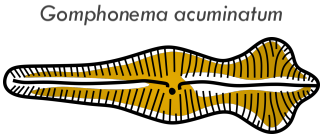
Glaucocystis



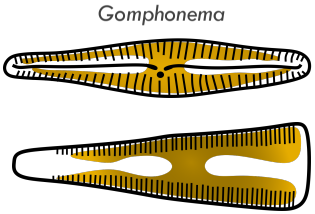
Audouinella

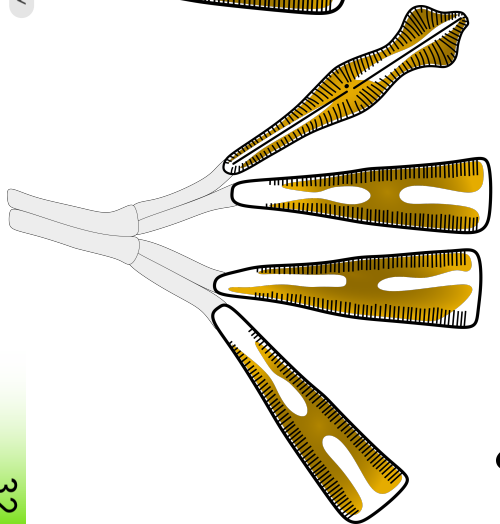


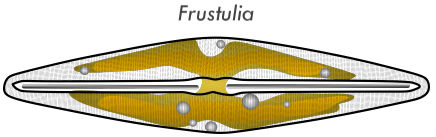
Batrachospermum

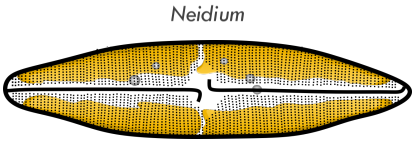

Gomphonema acuminatum

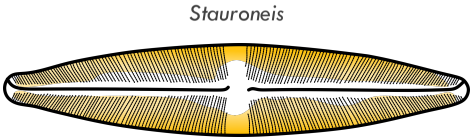

Gomphonema truncatum

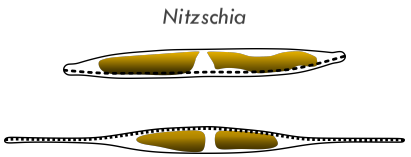

Gomphonema
side view




Frustulia


Neidium


Stauroneis


Nitzschia


Gyrosigma


Pinnularia





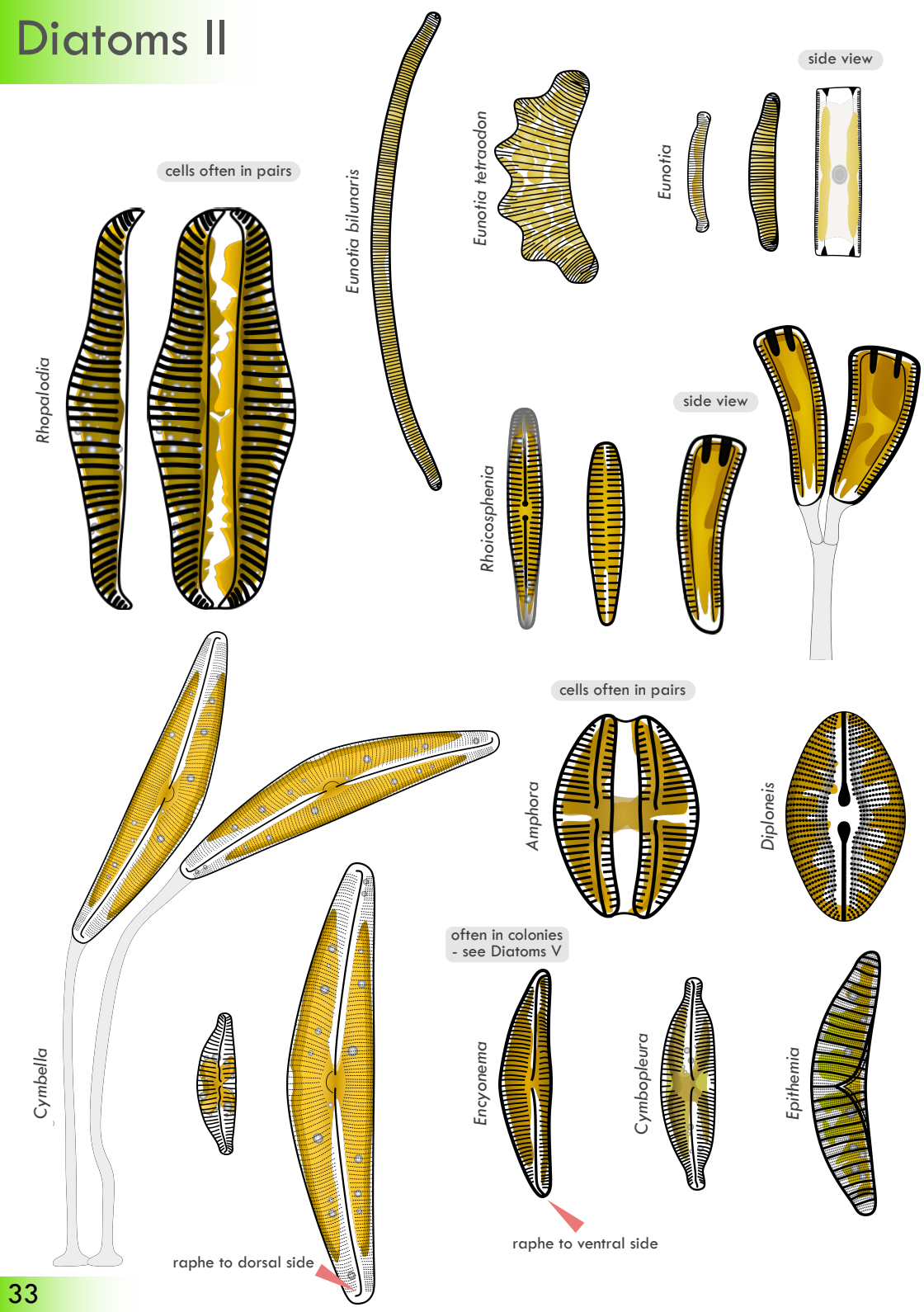

Navicula



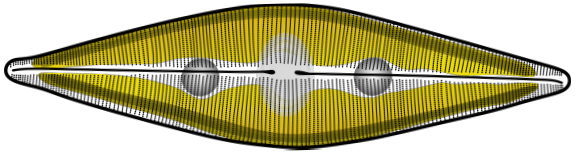




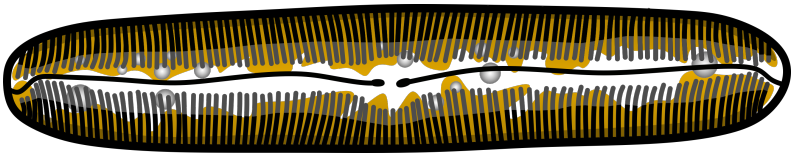
Diatoms II


cells often in pairs
Rhopalodia
Eunotia bilunaris
Eunotia tetraodon
Eunotia
side view
Rhoicosphenia
side view
cells often in pairs
Amphora
Diploneis
Cymbella
raphe to dorsal side
often in colonies
- see Diatoms V
Encyonema
Cymbopleura
Epithemia
raphe to ventral side

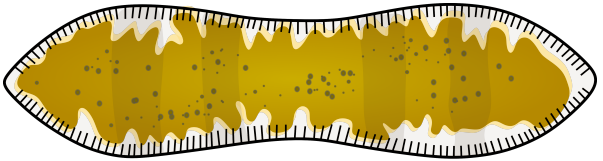
Craticula



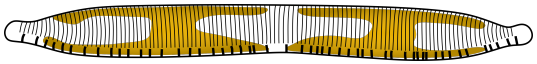
Pinnularia viridis



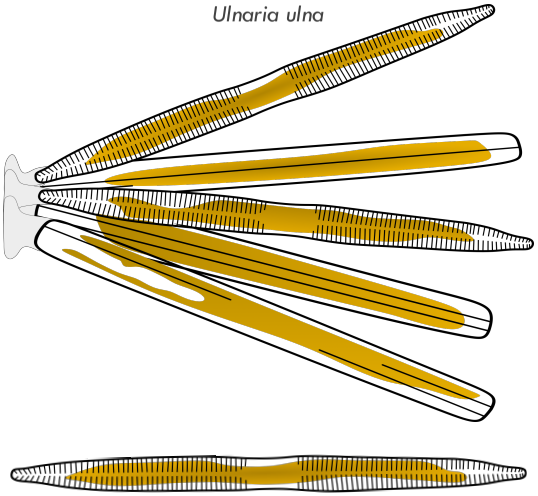
Cymatopleura



Hantzschia

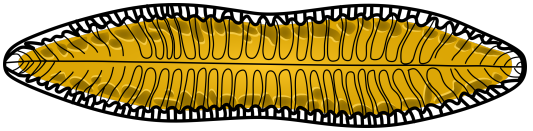


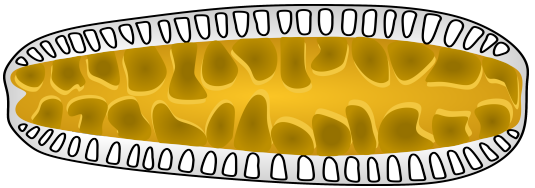
Ulnaria ulna



Surirella







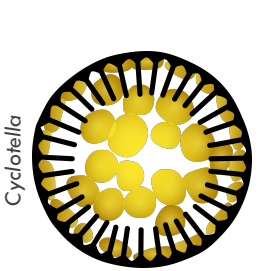
side view

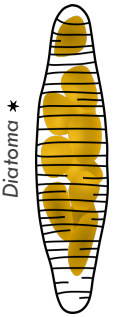
Ulnaria acus

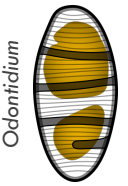


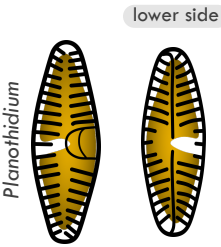
Diatoms IV

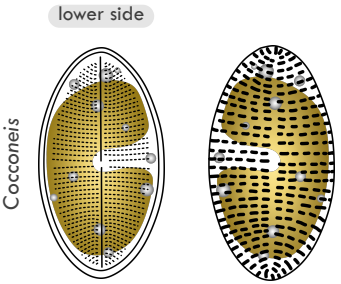
✶ colonies-forming diatoms - see Diatoms V

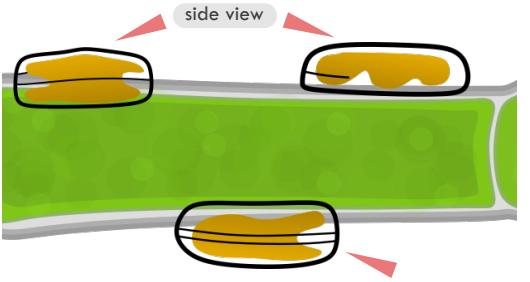




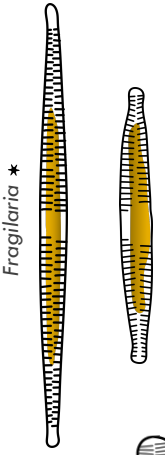




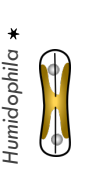


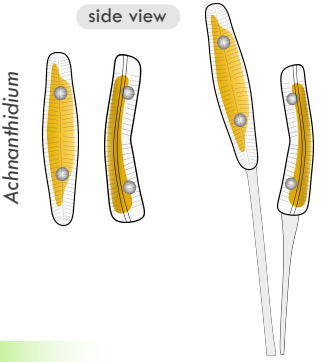






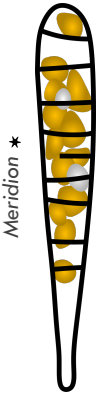






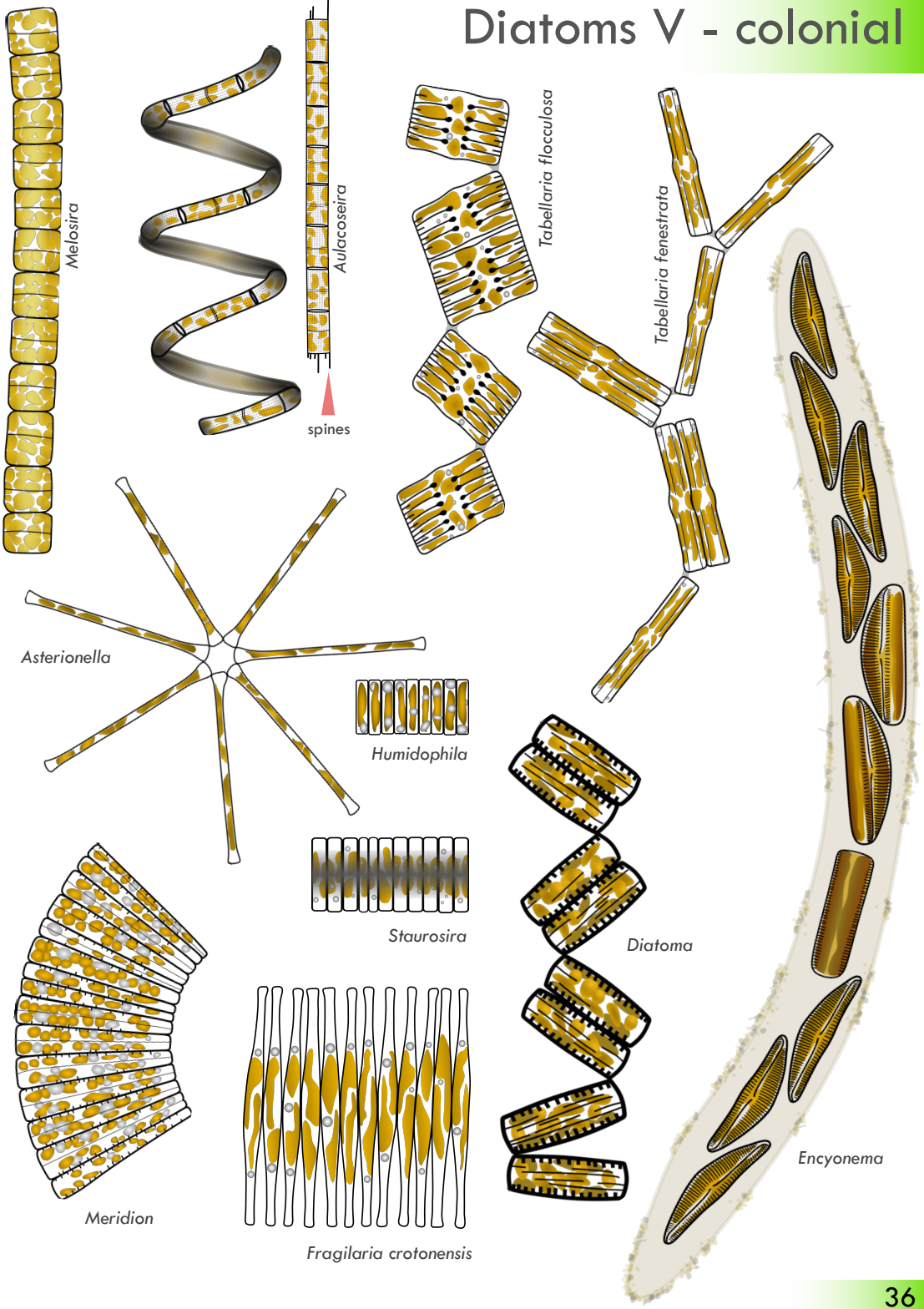




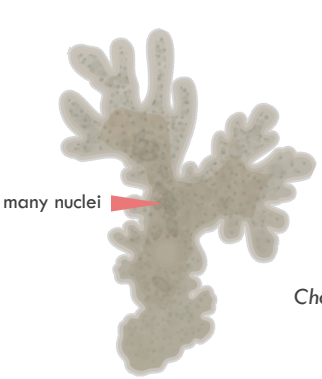




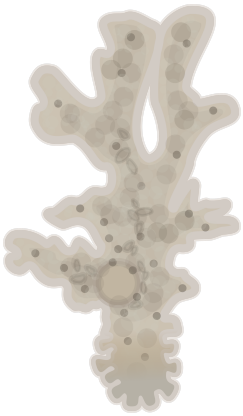
Diatoms V - colonial

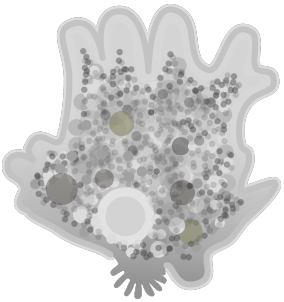


Naked amoebae I

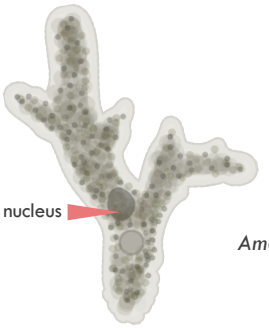


Chaos



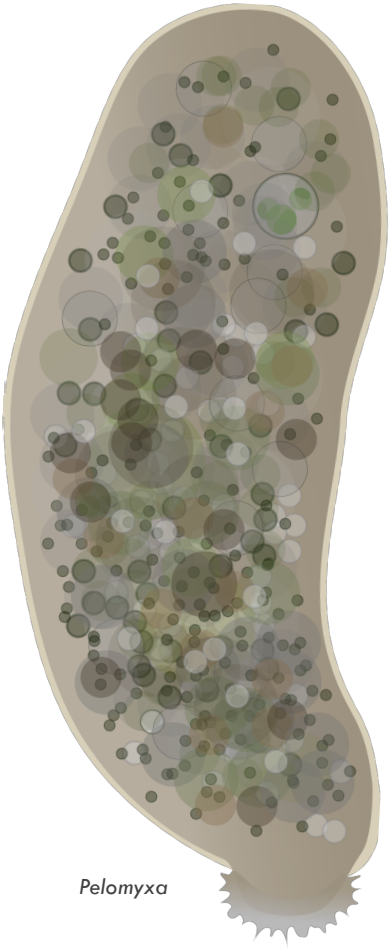


Deuteramoeba



Amoeba

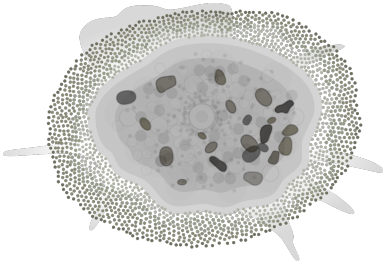




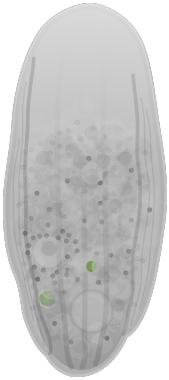
Leptomyxa



Pelomyxa



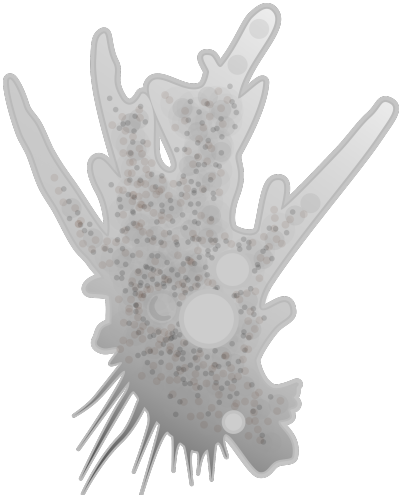
Cochliopodium



Thecamoeba



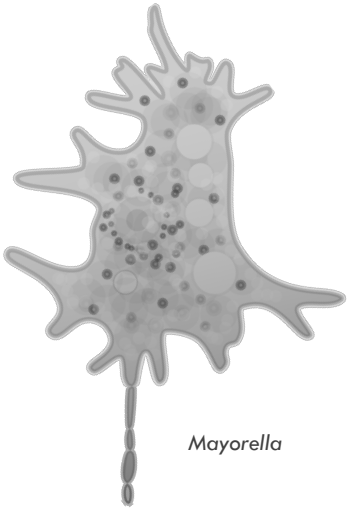
Saccamoeba



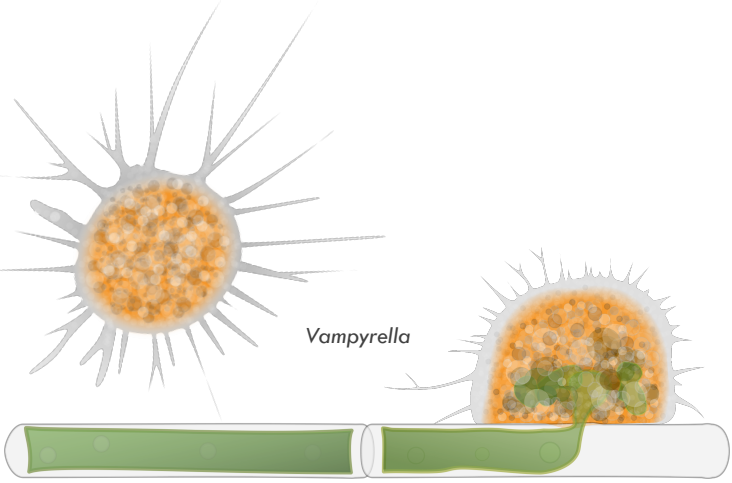
Rhizamoeba



Vahlkampfia



Mayorella



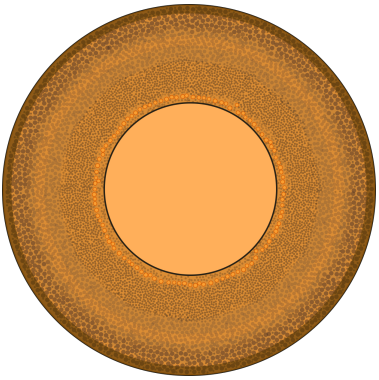
Vampyrella

Testate amoebae I - lobose

Arcella *and* ***Galeripora*** *can be easily identified via pores around the aperture.* ***Galeripora*** *has them,* ***Arcella*** *doesn't.*



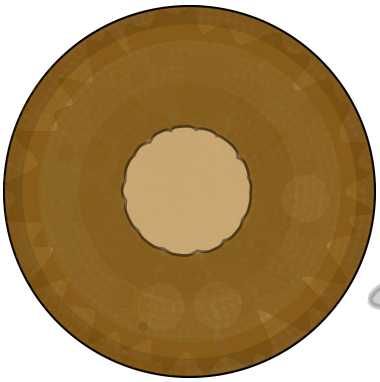
Galeripora dentata



Galeripora

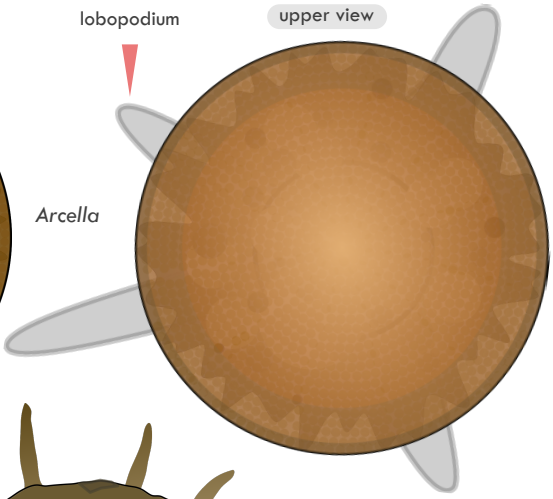
upper view





lobopodium

upper view



Arcella

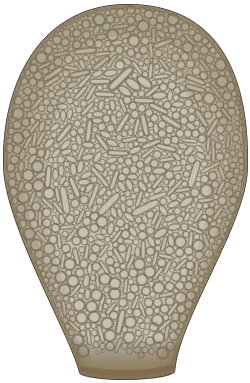


Centropyxis constricta

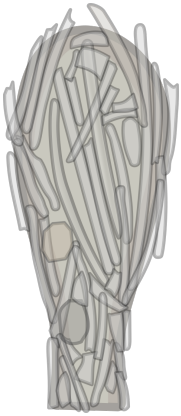


Centropyxis aculeata

Testate amoebae II - lobose



Nebela



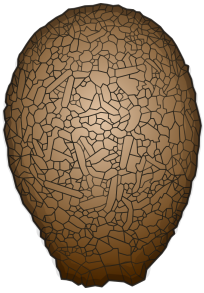
Difflugia bacillifera



Difflugia gigantea



Cylindrifflugia



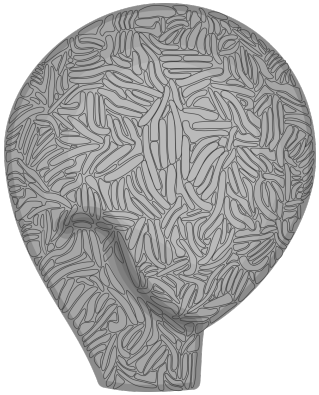
frontal view



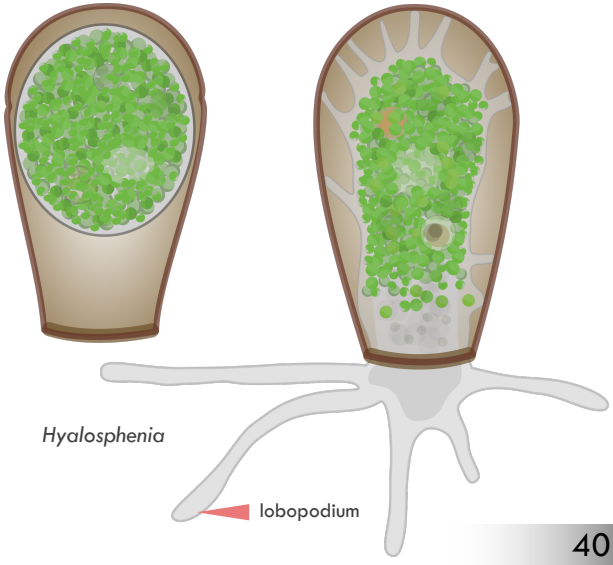
Netzelia



Cryptodifflugia



Lesquereusia

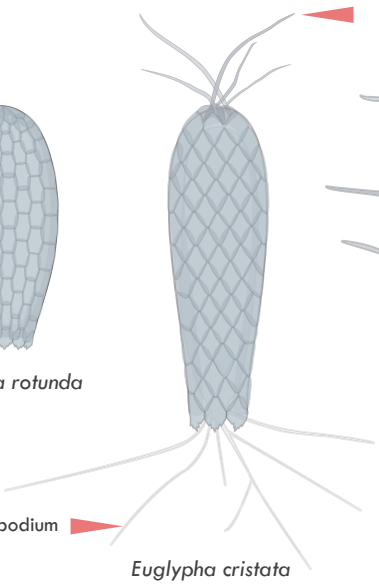


Hyalosphenia

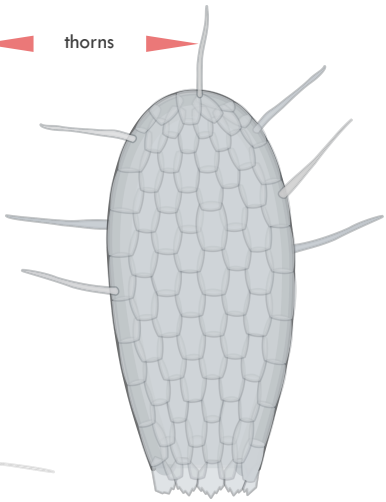
Testate amoebae III - filose



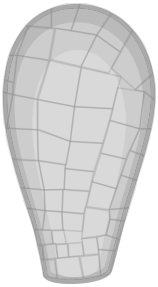
Euglypha rotunda



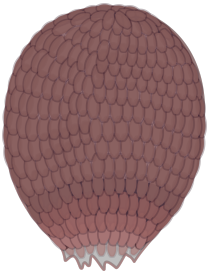
Euglypha cristata



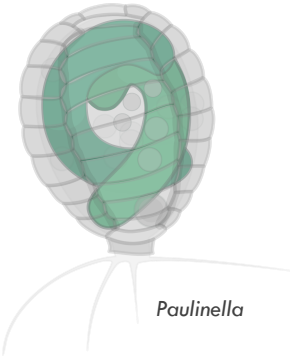
Euglypha filifera



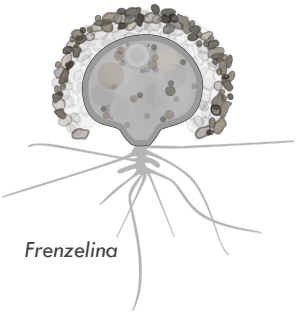
Quadrulella



Assulina



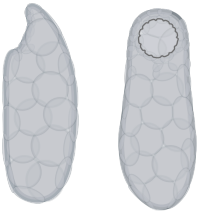
Paulinella



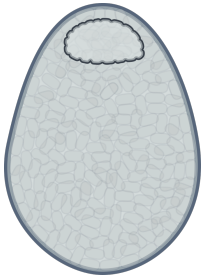
Frenzelina



Cyphoderia

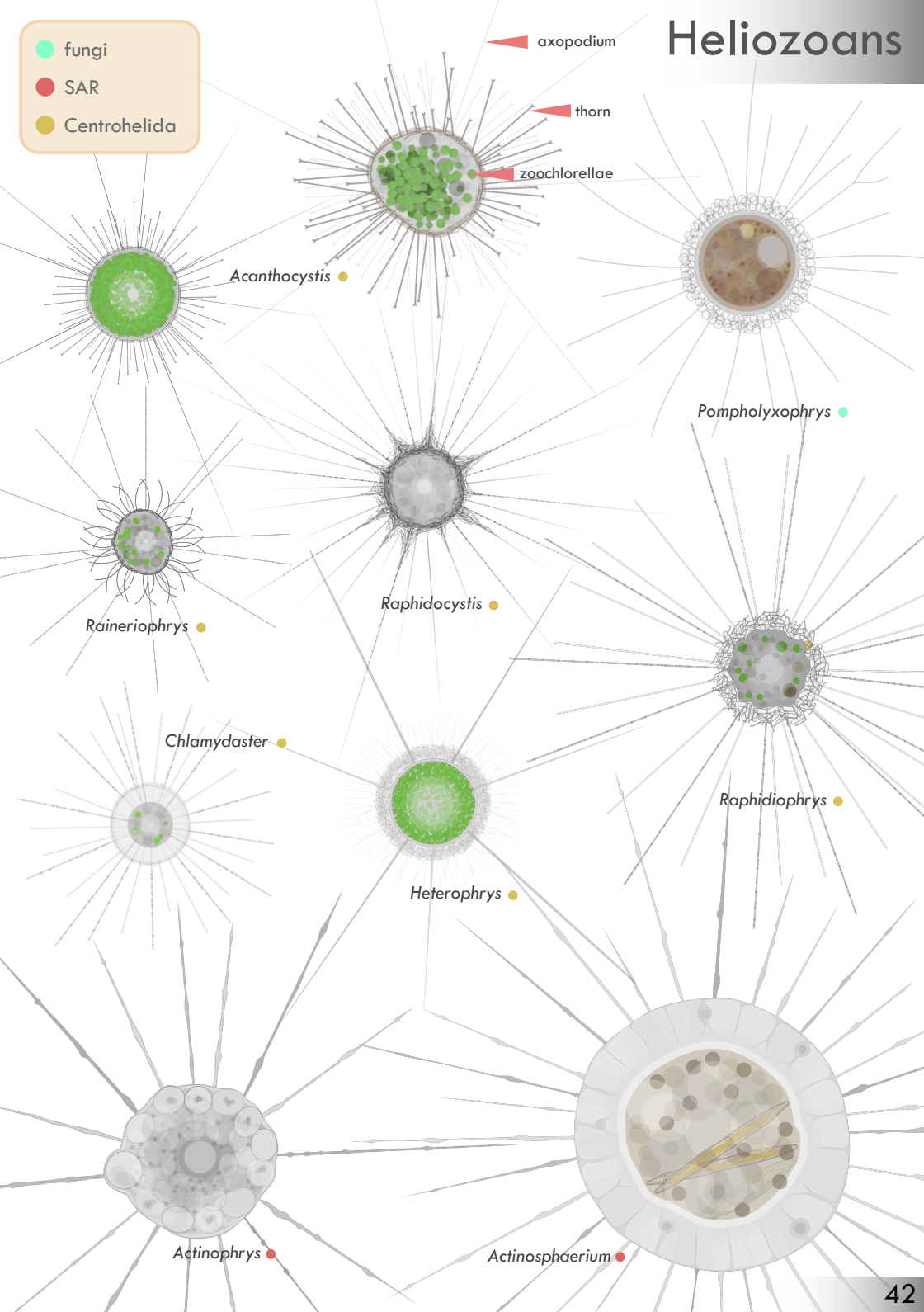


Trinema



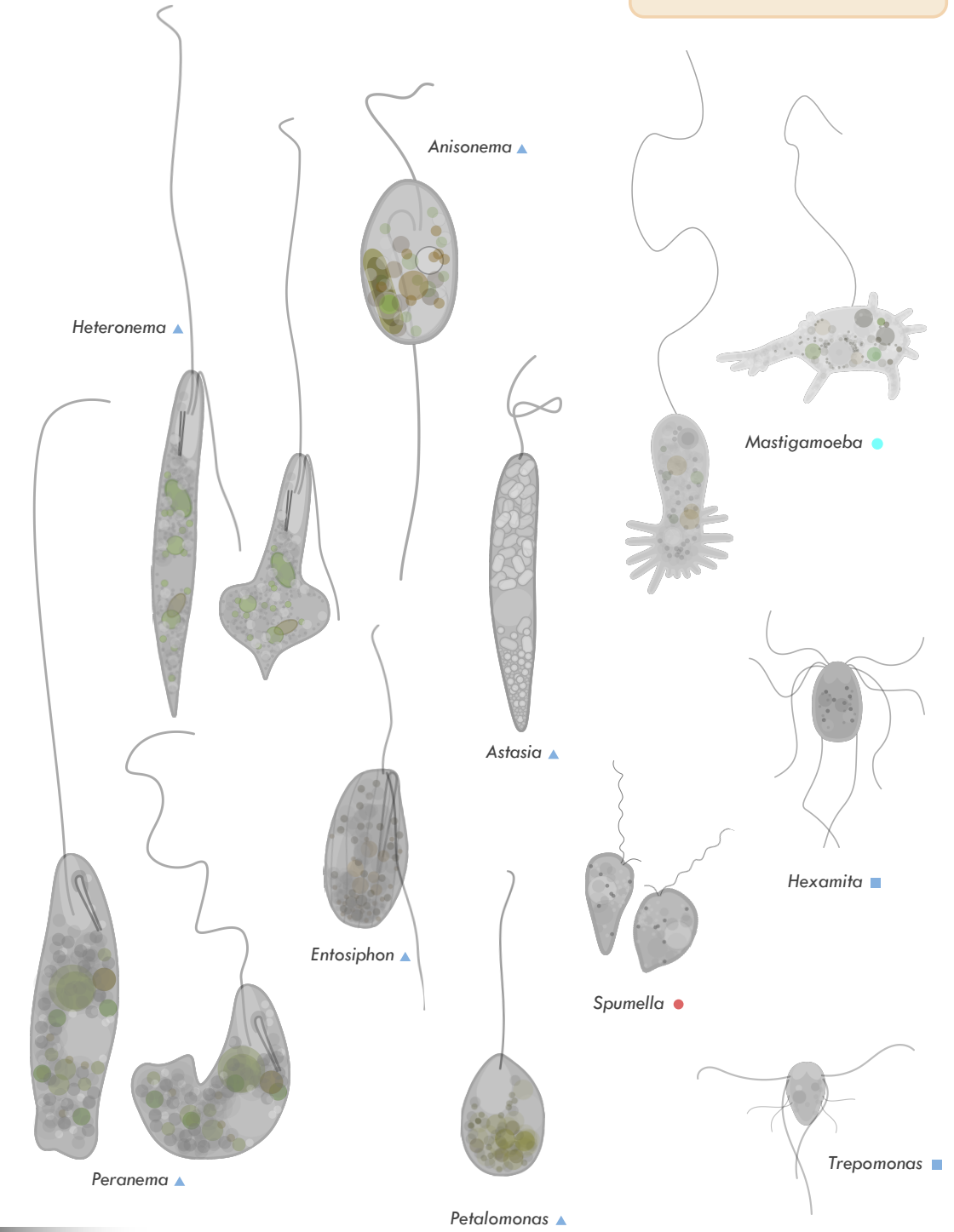
Corythion

Heliozoans


fungi
SAR
Centrohelida
axopodium
thorn
zoochlorellae
Acanthocystis
Pompholyxophrys
Raphidocystis
Raineriophrys
Chlamydaster
Raphidiophrys
Heterophrys
Actinophrys
Actinosphaerium

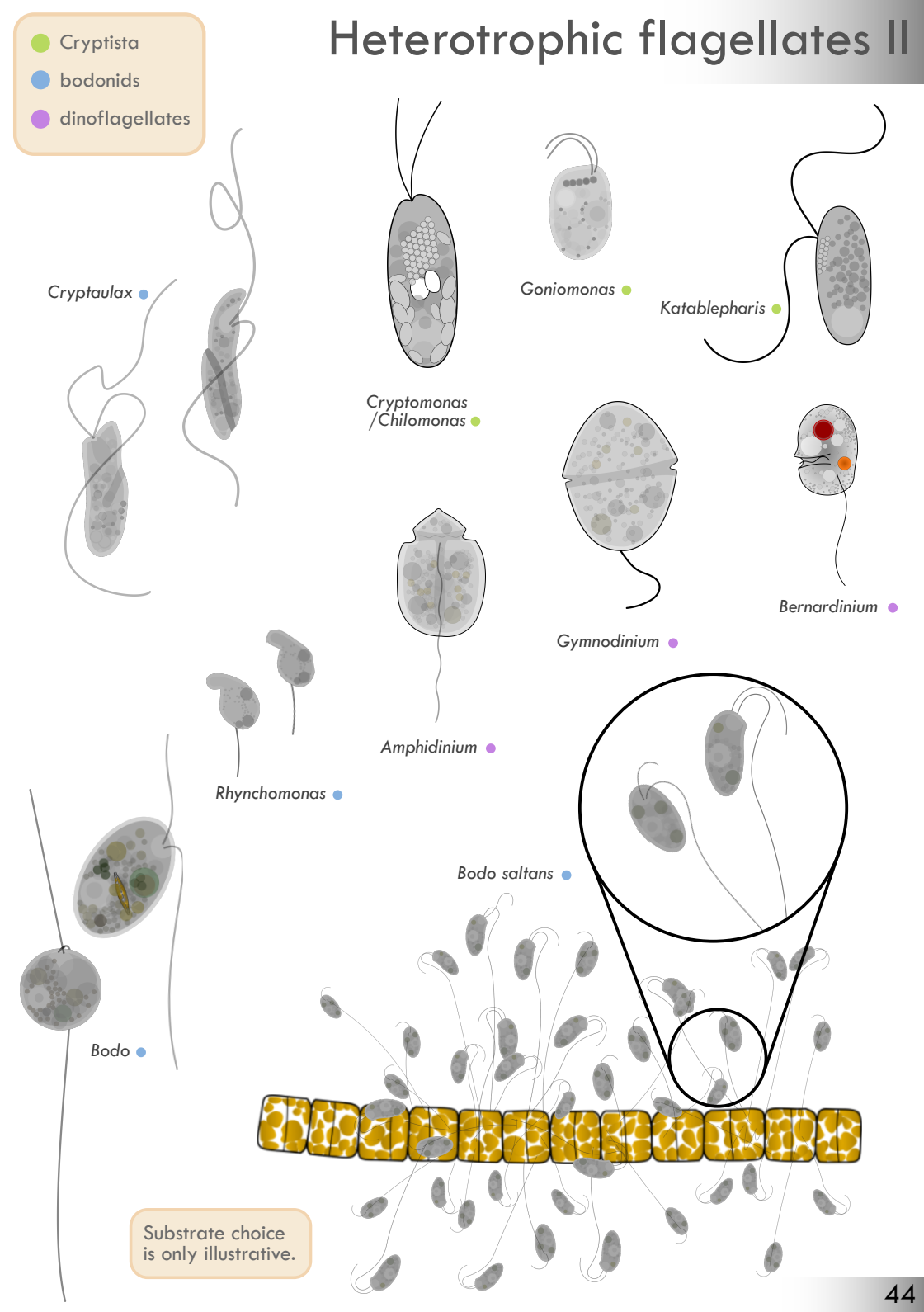
Heterotrophic flagellates I

amoebae
golden algae
euglenoids
metamonads



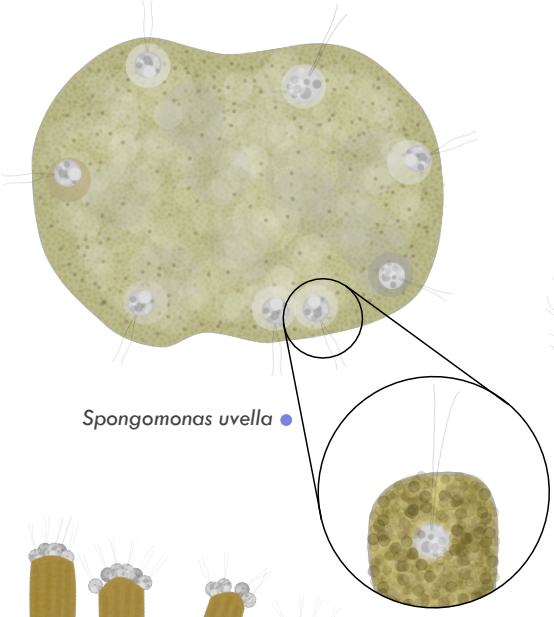
Heterotrophic flagellates II

- Cryptista
- bodonids
- dinoflagellates

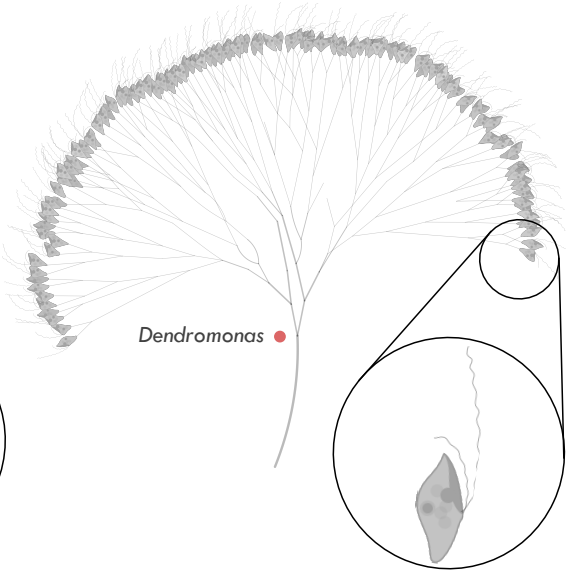


Heterotrophic flagellates III

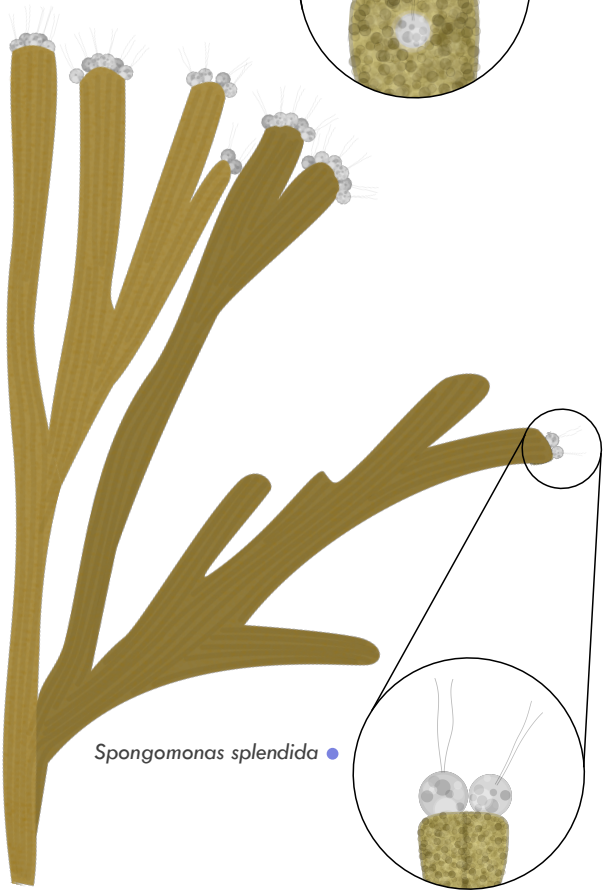
golden algae
Cercozoa



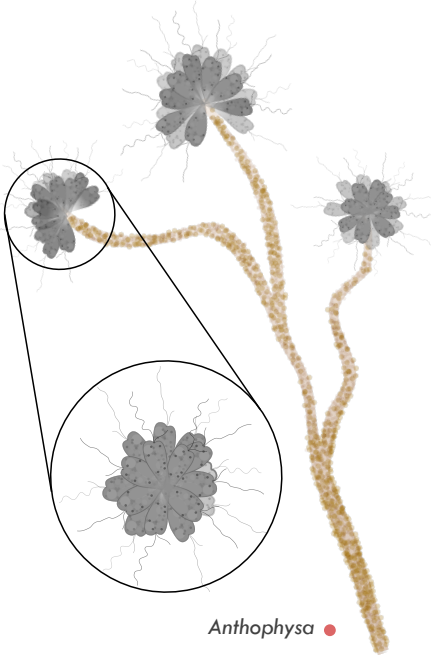
Spongomonas uvella



Dendromonas



Spongomonas splendida

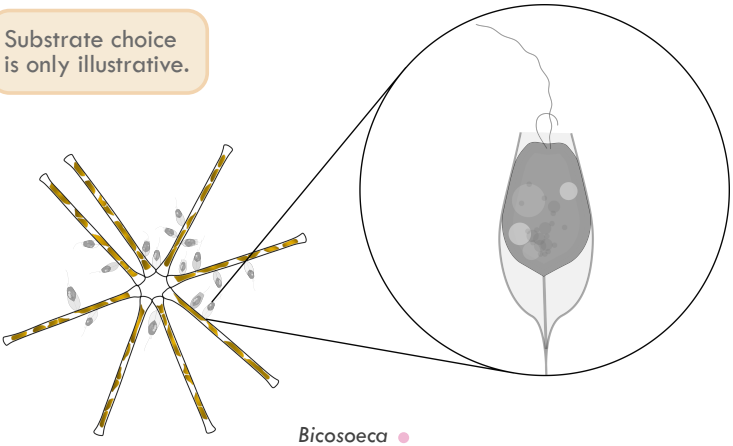


Anthophysa

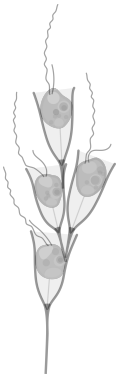
Heterotrophic flagellates IV

- Bicosoecida (no collar)
- choanoflagellates (collar)

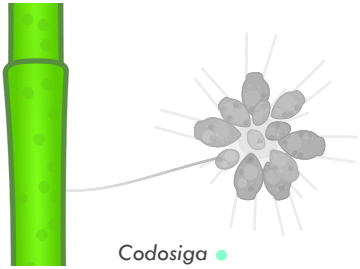
Substrate choice is only illustrative.



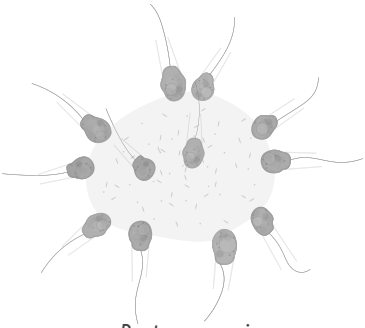
Bicosoeca



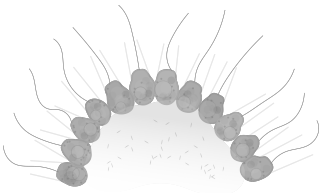
Bicosoeca petiolata



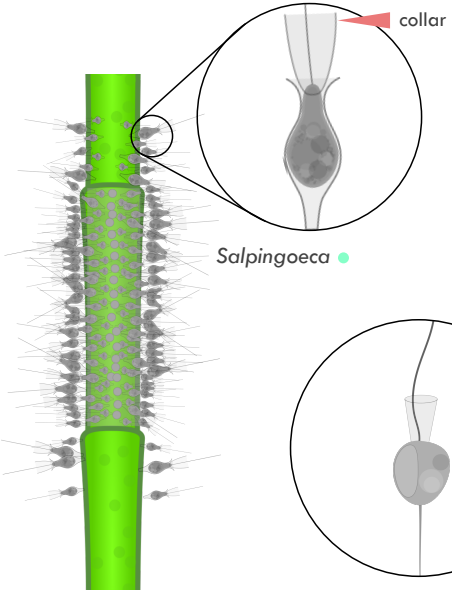
Codosiga



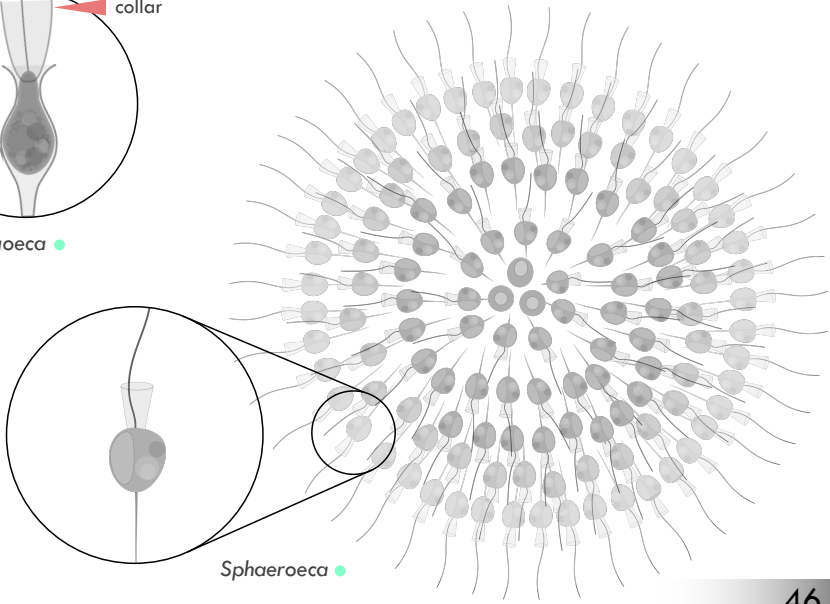
Proterospongia



Desmarella

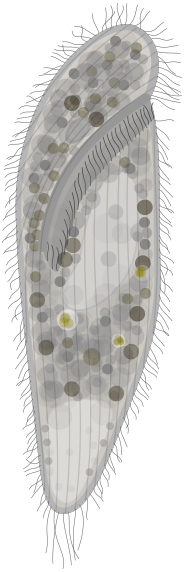


Salpingoeca

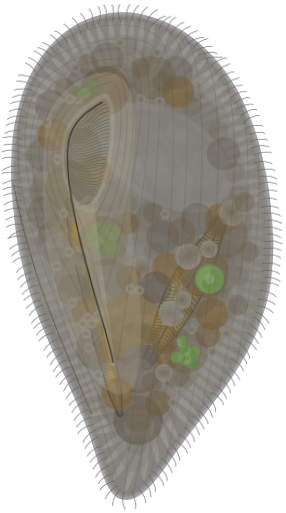


Sphaeroeca

Ciliates I



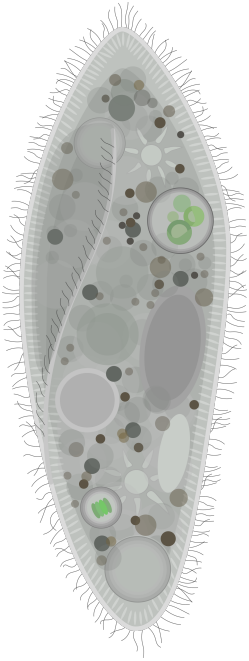
Metopus



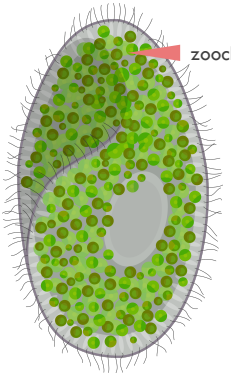
Frontonia atra



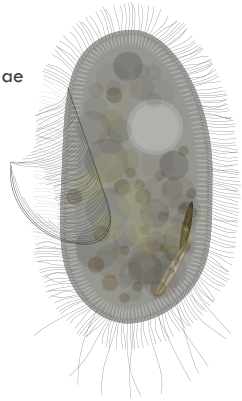
Frontonia leucas



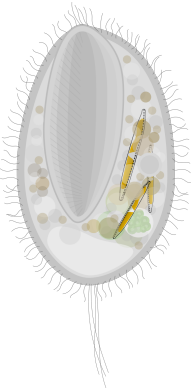
Paramecium caudatum



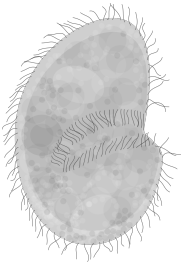
Paramecium bursaria



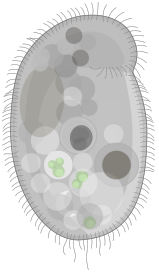
Pleuronema



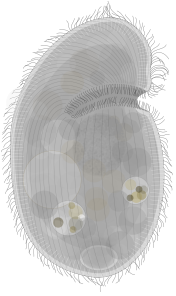
Lembadion



Colpoda



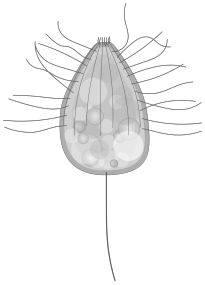
Colpidium



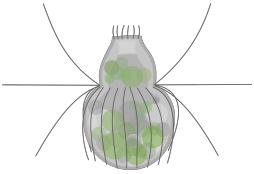
Plagiopyla



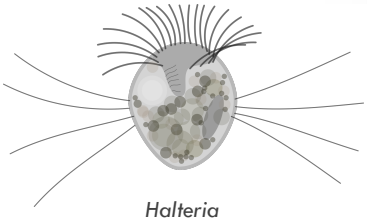
Chilodonella



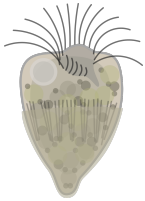
Urotricha



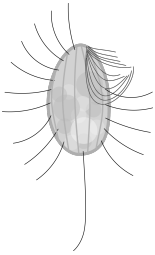
Mesodinium



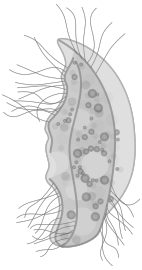
Halteria



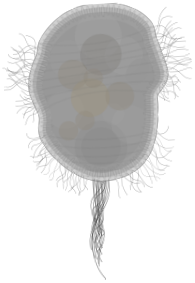
Strombidium



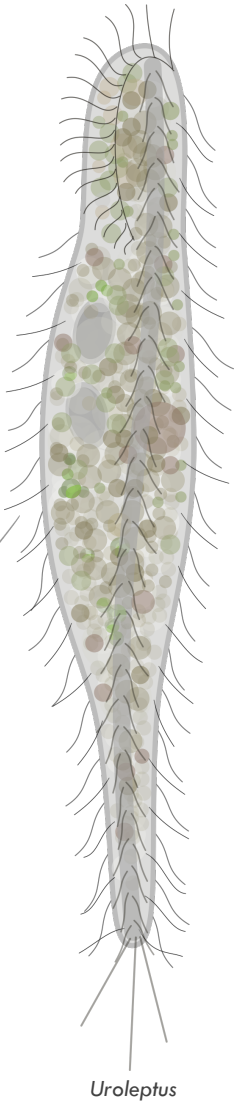
Cyclidium



Drepanomonas



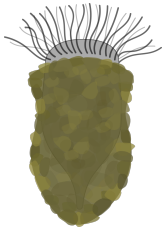
Urocentrum



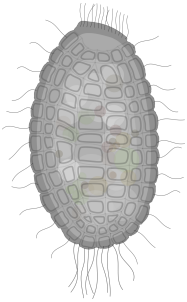
Uroleptus



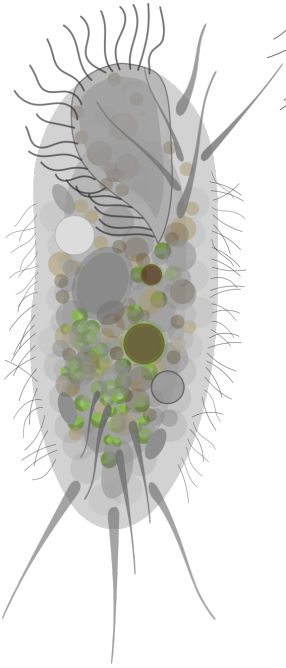
Tintinnidium



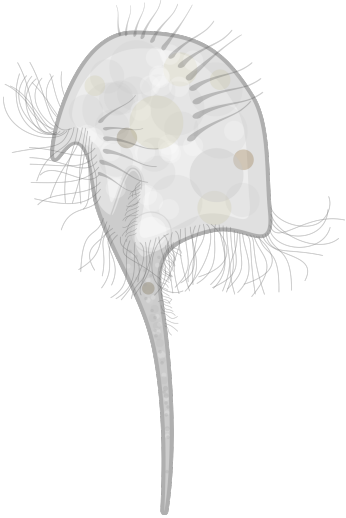
Codonella



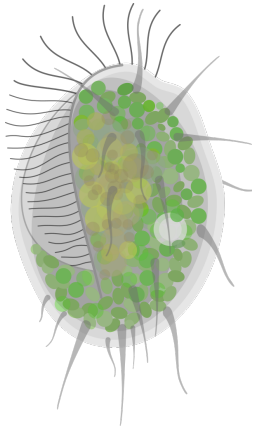
Coleps



Stylonychia

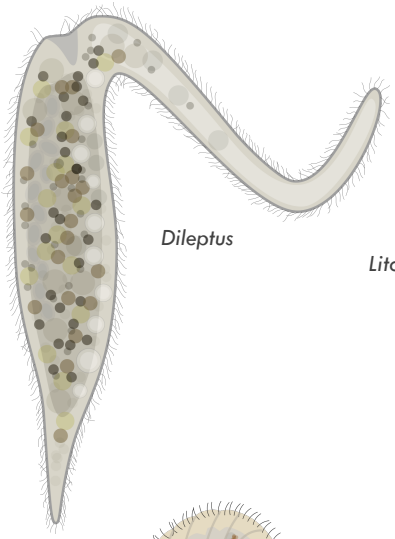


Caenomorpha

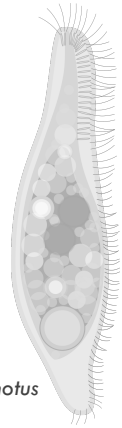


Euplotes

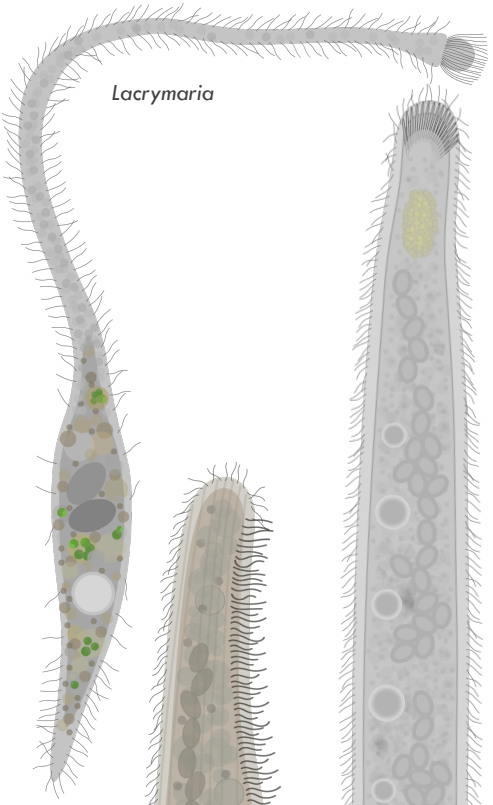
Ciliates III



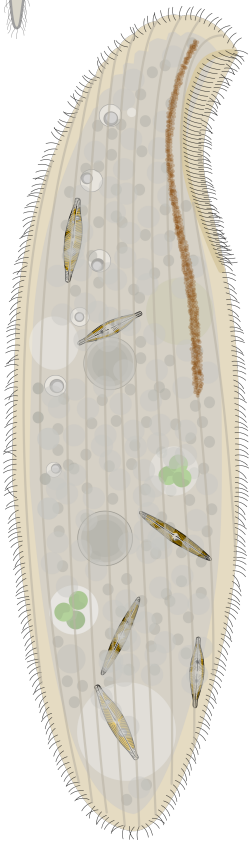
Dileptus



Litonotus



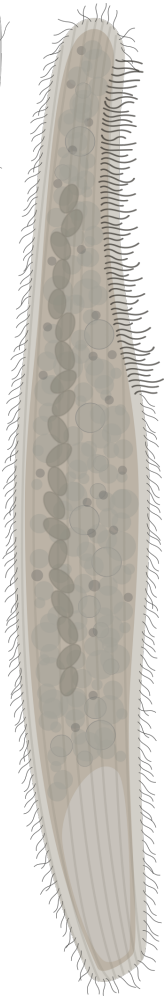
Lacrymaria



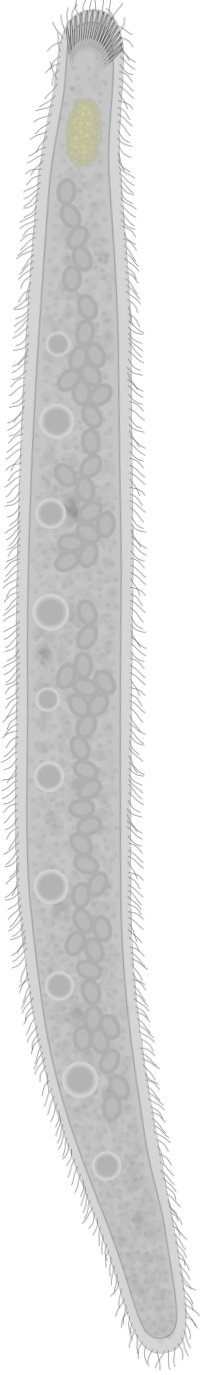
Loxodes



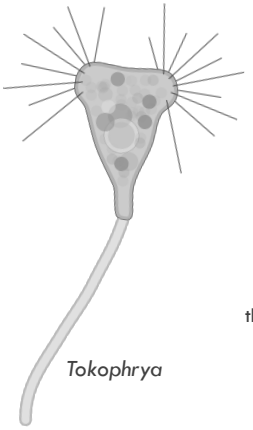
Loxophyllum



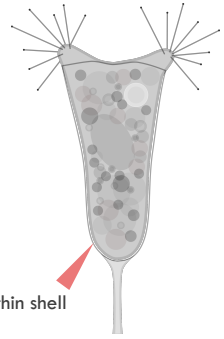
Spirostomum



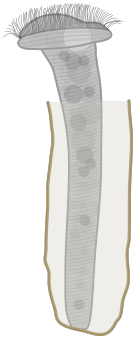
Homalozoon



Tokophrya



Acineta



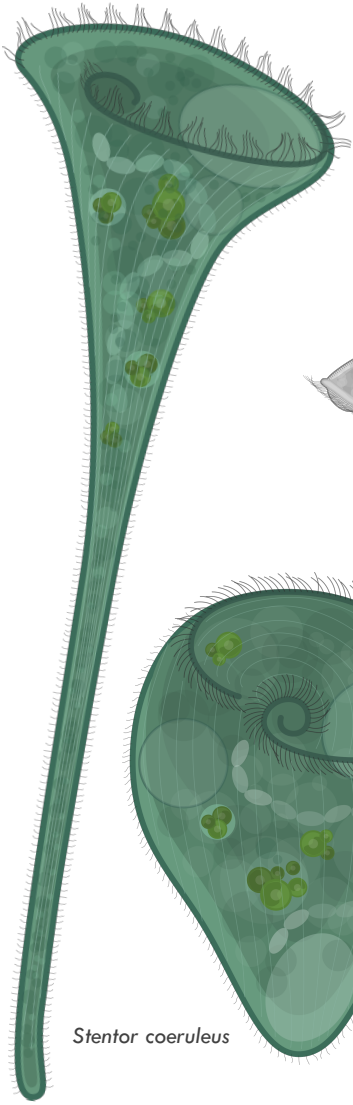
Vaginicola



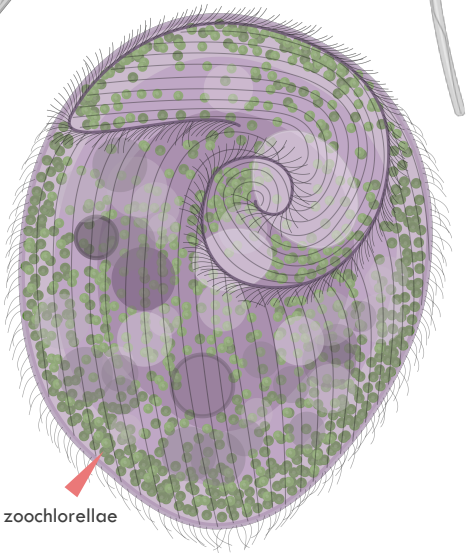
Vorticella



Carchesium



Stentor coeruleus

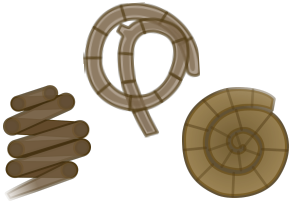


Stentor amethystinus

Identification by conidia requires experience,
the genera depicted are for illustrative purposes only.

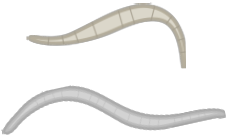
Conidia of ascomycetes

Helicospores



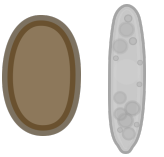
Helicodendron

Scolecospores



Anguillospora

Amerospores



Acrocalymna

Didymospores



Didymocyrtis

Fragmospores



Microsporum



Curvularia



Xylomyces

Dictyospores



Alternaria



Canalisporum

Staurospores



Lemmoniera



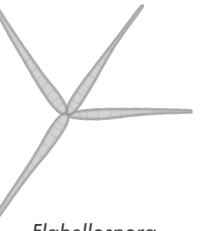
Tripospermum



Clavariopsis



Alatospora



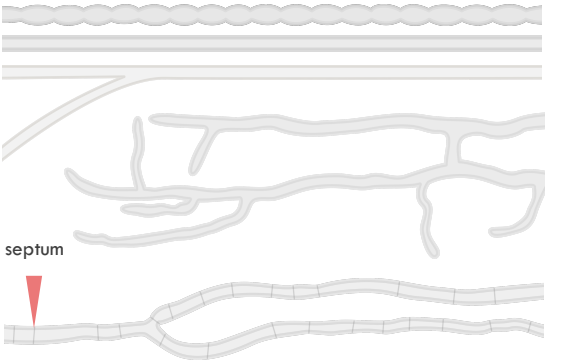
Flabellospora

Hyphae

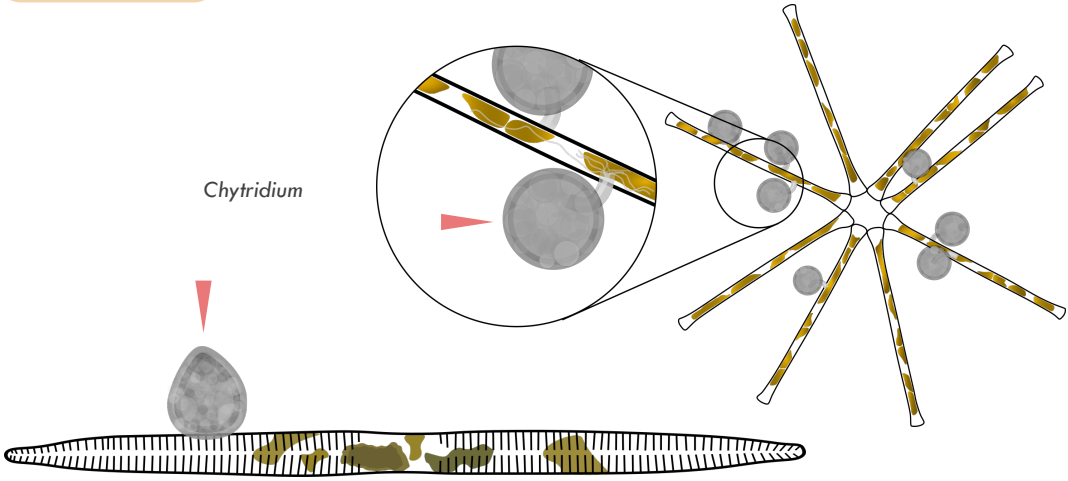
Ascomycetes and basidiomycetes have septate hyphae.

Developmentally less advanced groups and fungi-like organisms lack septa.

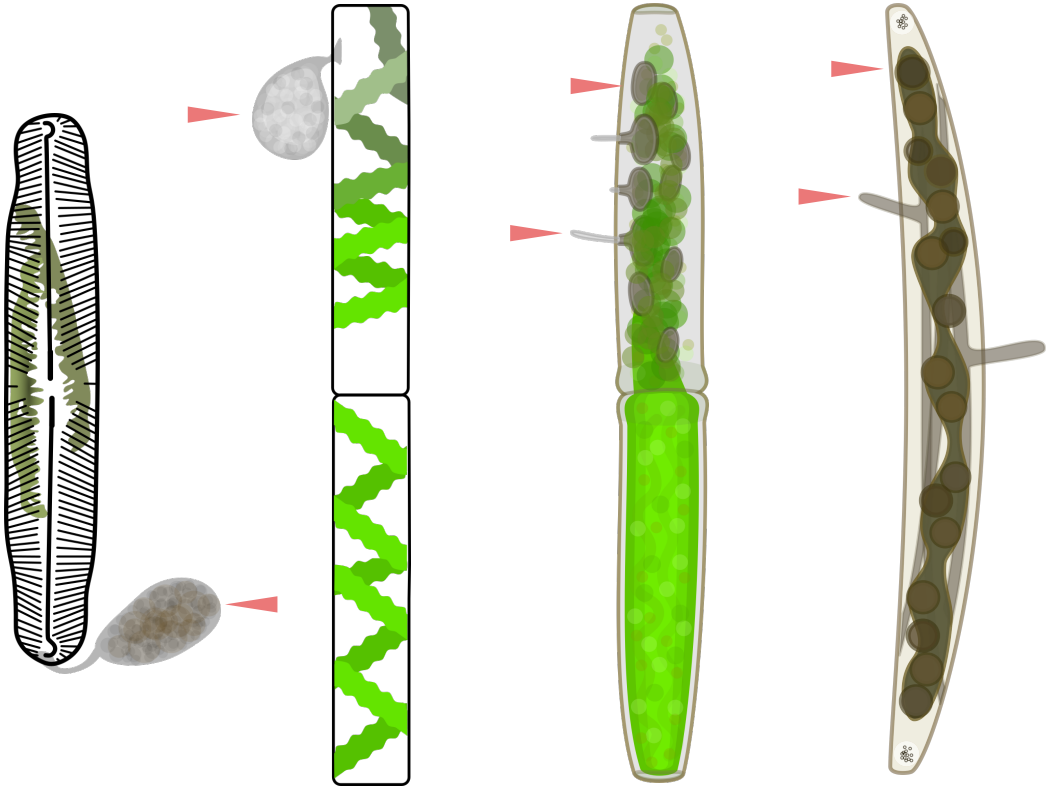
A more detailed identification based on hyphae is not possible.



Host choice is only illustrative.



Chytridium

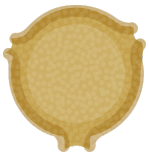


Rhizophydium

Olpidium

Ancylistes

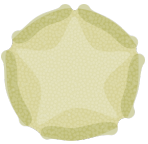
Plants I - pollen



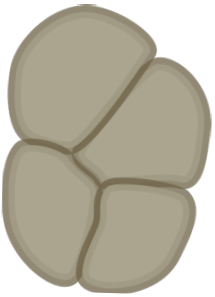
Betula
(birch)
20–30 µm



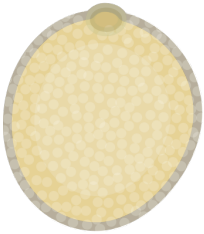
Salix
(willow)
20–30 µm



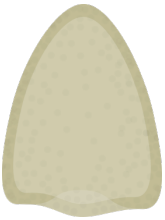
Alnus
(alder)
20–30 µm



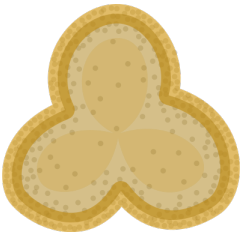
tetrads
e.g. *Typha*
(cattail)
40–100 µm



Poaceae
(grass)
20–60 µm



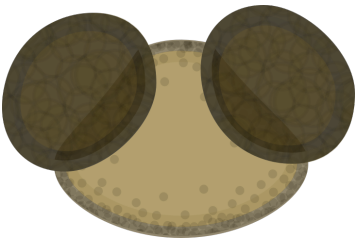
Cyperaceae
(sedges)
30–40 µm



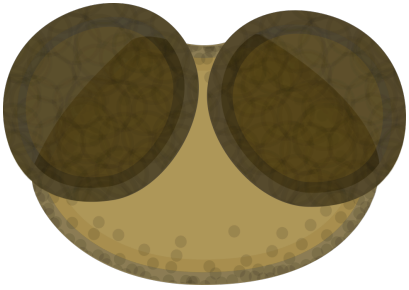
triads
e.g. *Juncus*
(rushes)
20–50 µm



Abies
(fir)
75–200 µm



Pinus
(pine)
50–110 µm



Picea
(spruce)
110–150 µm

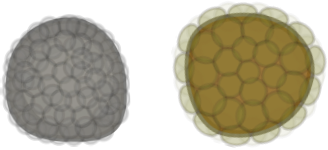
Plants II - ferns and bryophytes



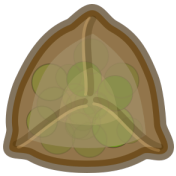
Pteridophyta
(fern spores)



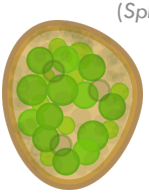




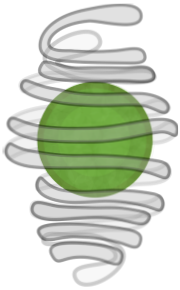
Marchantiophyta
(liverworts spores)



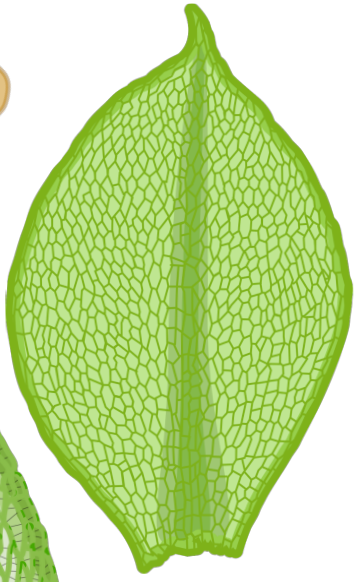
Sphagnum
(*Sphagnum* spore)



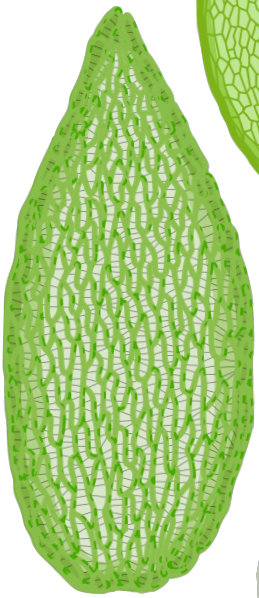
moss spores



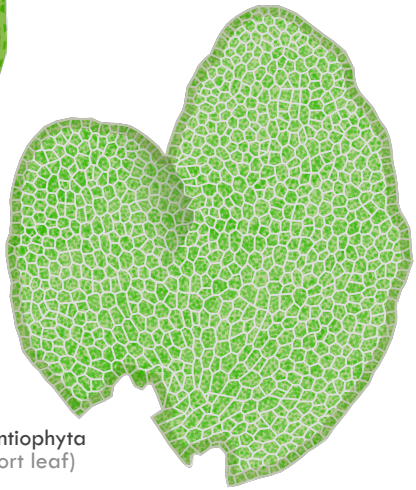
Equisetum
(horsetail spores)



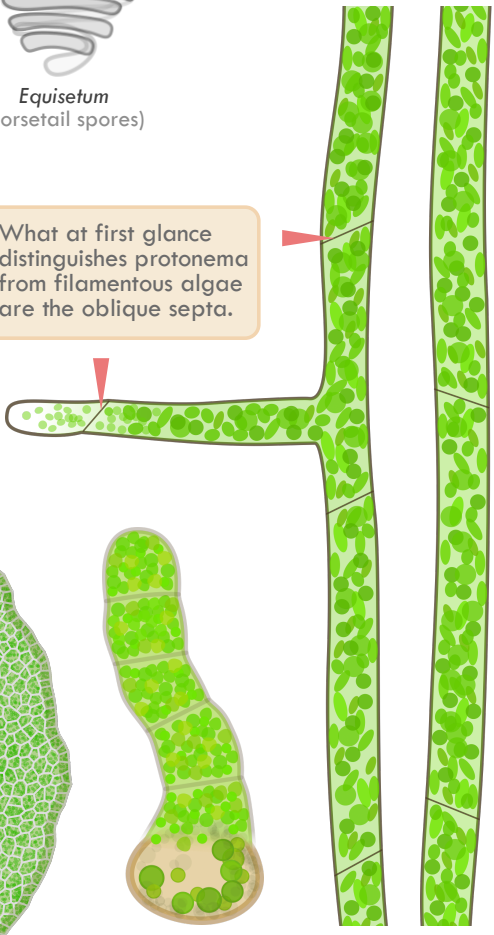
moss leaf with a rib



Sphagnum
(*Sphagnum* leaf)



Marchantiophyta
(liverwort leaf)



protonema
(moss)

Plants III - plant parts

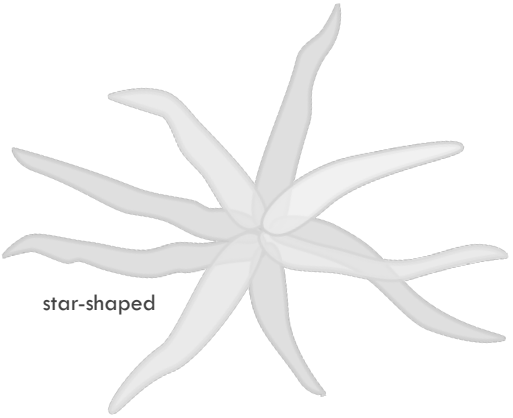
Trichomes from the plant surfaces

unicellular filiform



multicellular filiform

adhesive

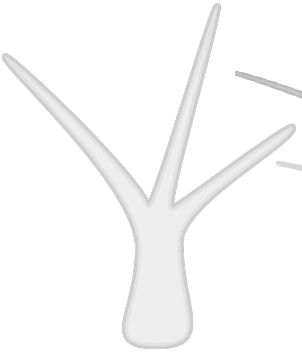


star-shaped

unicellular glandular



multicellular glandular

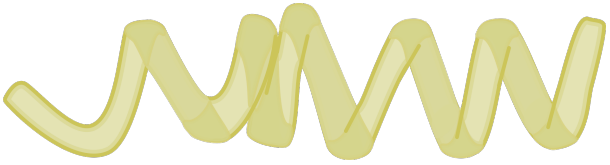


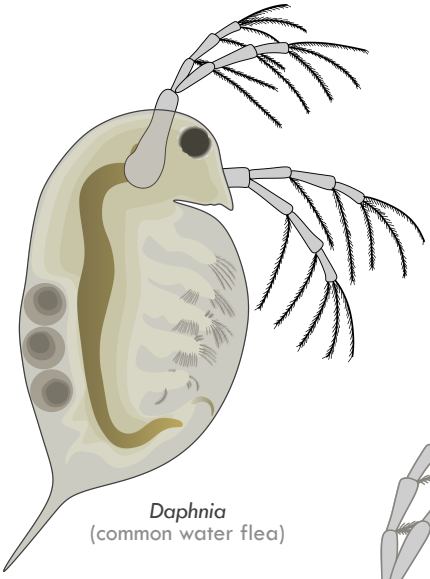
unicellular branched



whorled branched

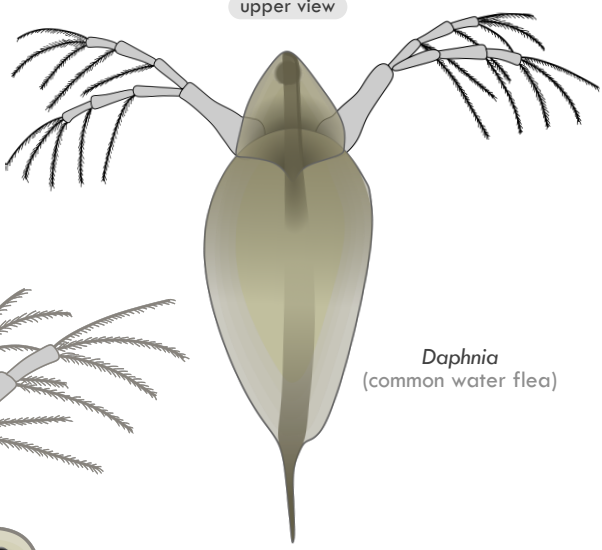
Parts of the xylem of vascular plants





Daphnia
(common water flea)

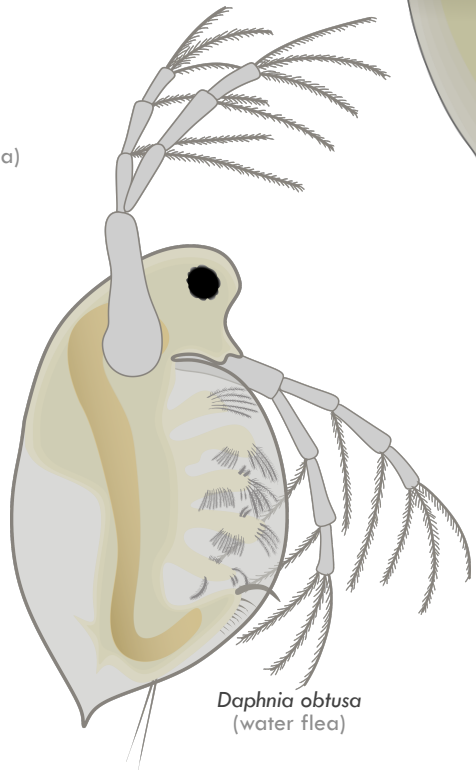
upper view



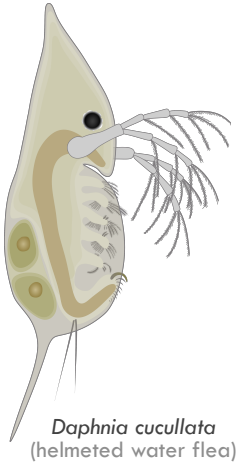
Daphnia
(common water flea)



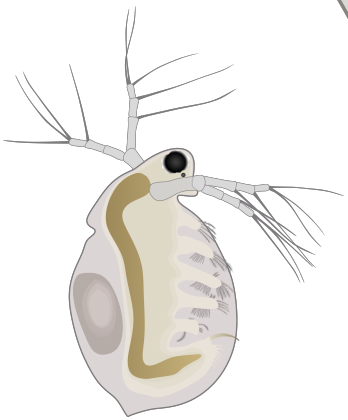
ephippium
(dormant stage of water flea)



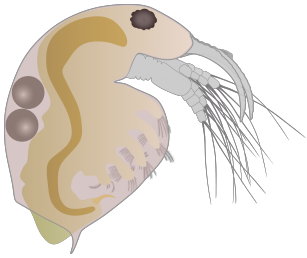
Daphnia obtusa
(water flea)



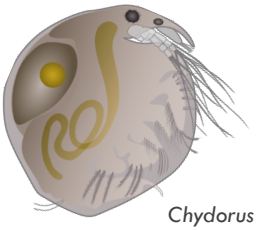
Daphnia cucullata
(helmeted water flea)



Ceriodaphnia
(water flea)

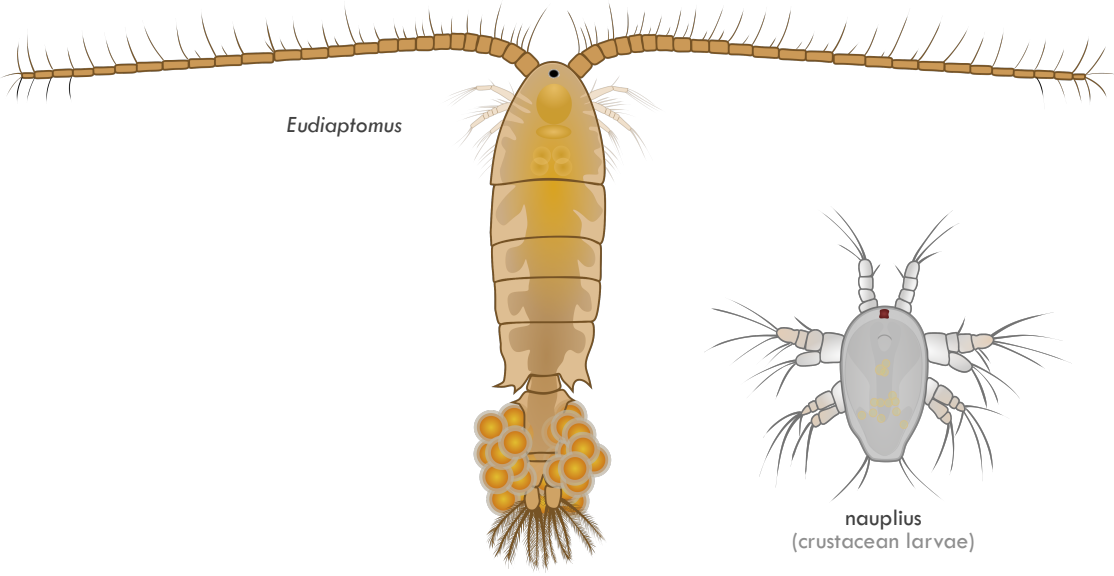


Bosmina
(water flea)



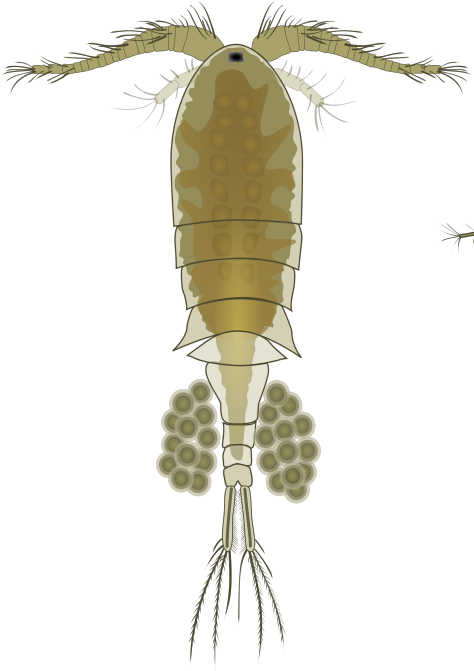
Chydorus

Crustaceans II



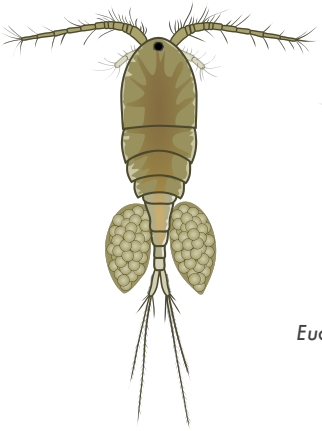
Eudiaptomus

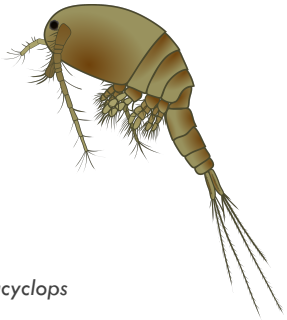
nauplius
(crustacean larvae)



Cyclops

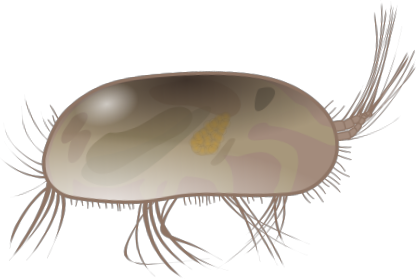
side view



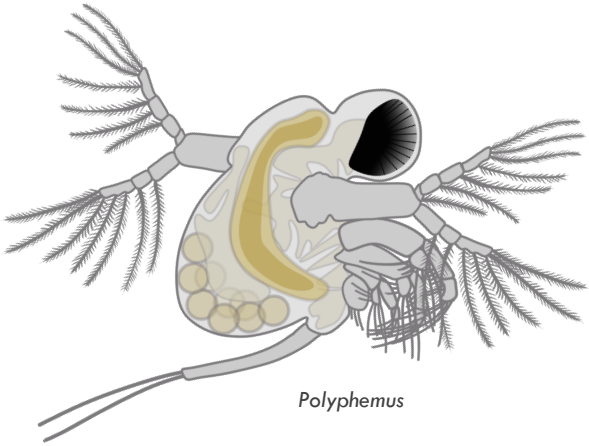


Eucyclops

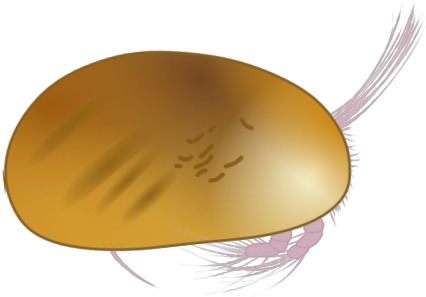
The size shown does not correspond to reality, *Leptodora* can reach a size of up to 20 mm, while *Polyphemus* is about 1 mm.

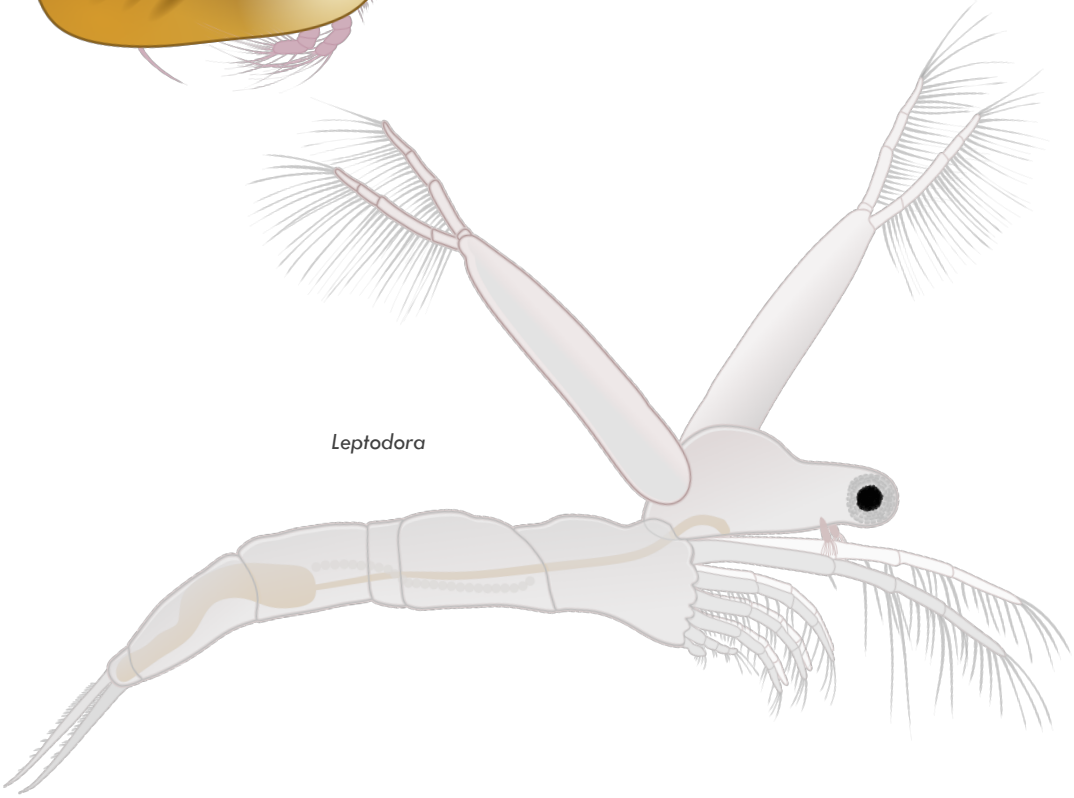


Ostracoda



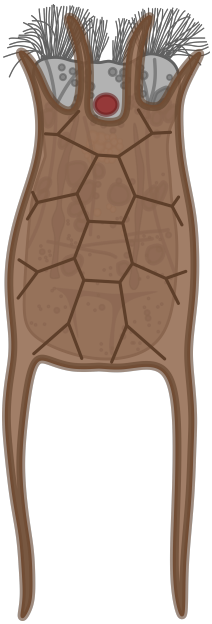
Polyphemus



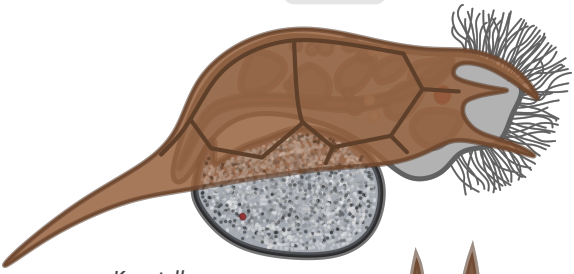


Leptodora

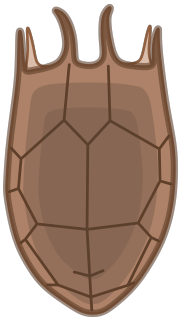
Rotifers I

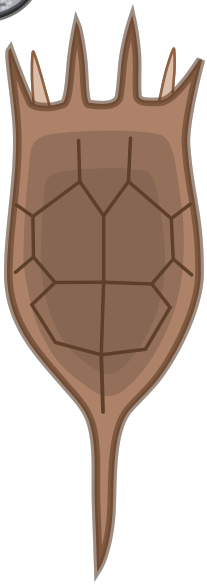


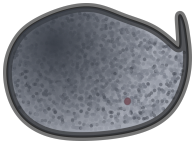
side view



Keratella



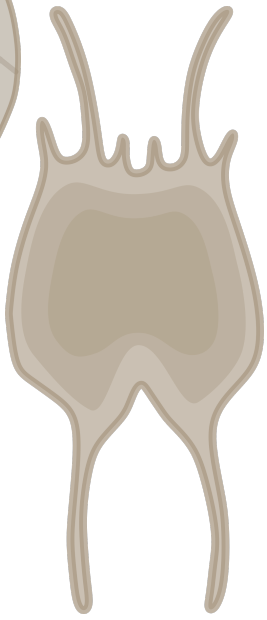


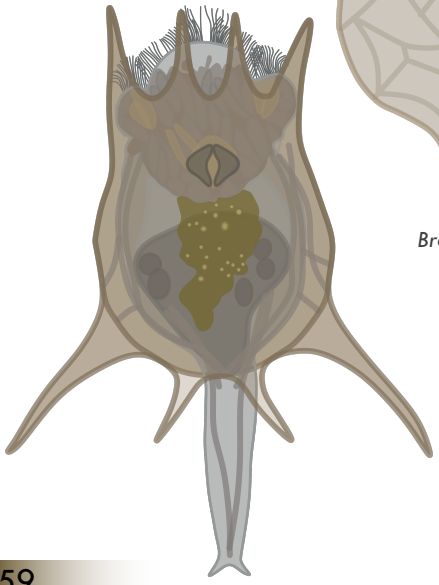


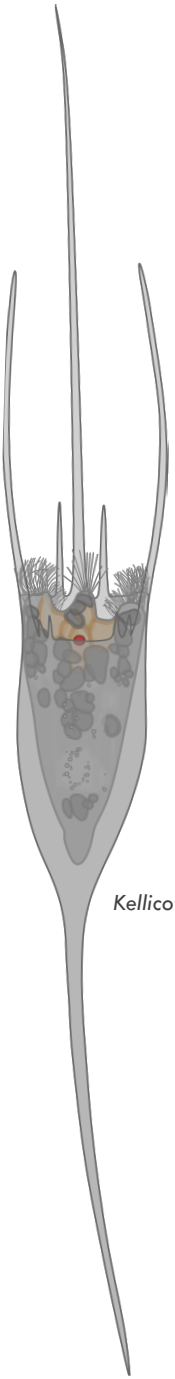
Keratella
(egg)



Brachionus

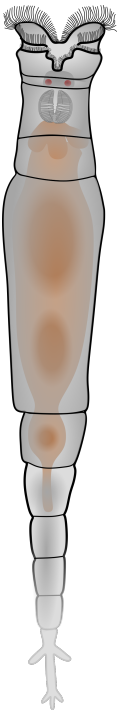




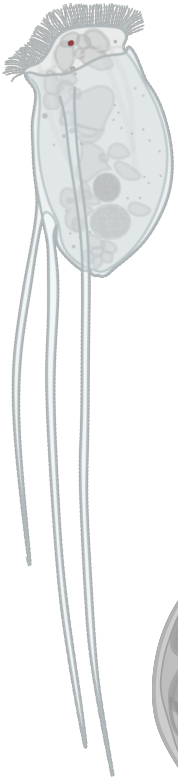


Kellicottia

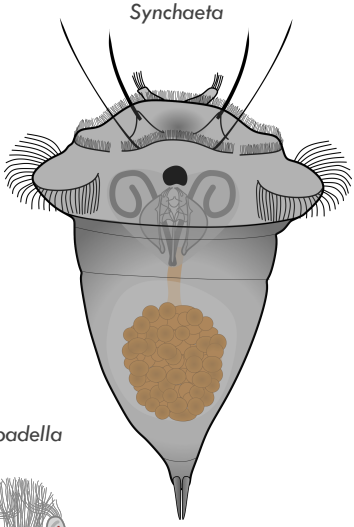
Bdelloidea



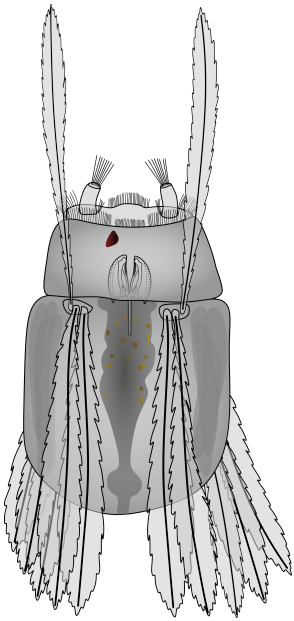
Filinia



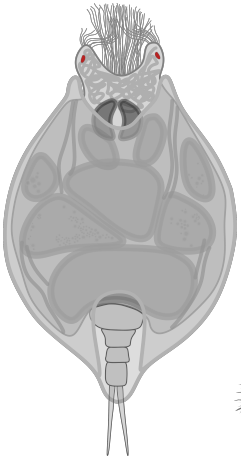
Synchaeta

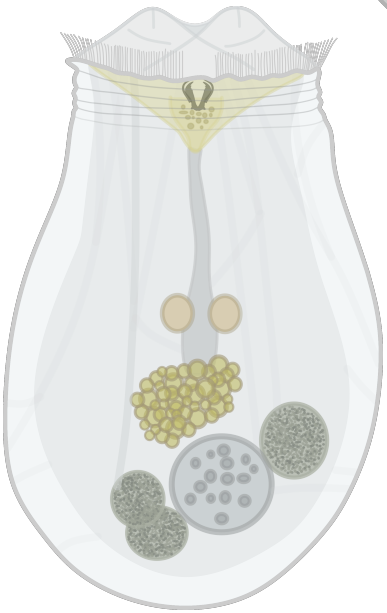


Polyarthra

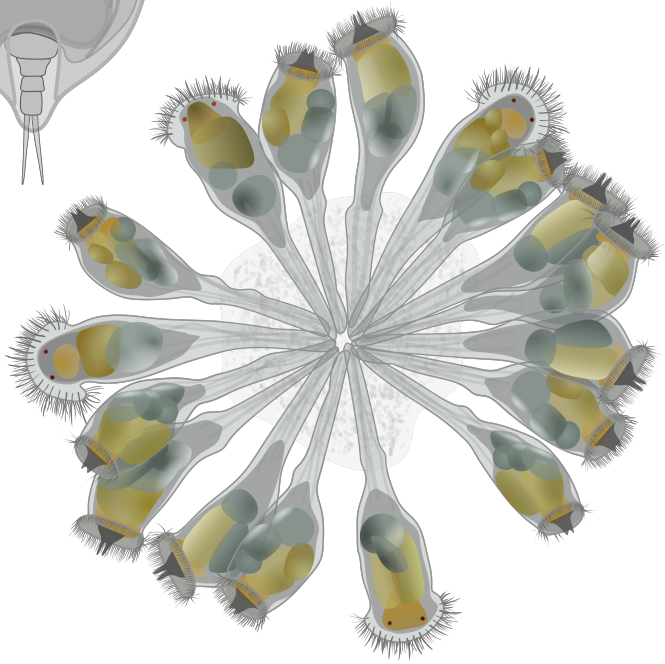


Lepadella





Asplanchna

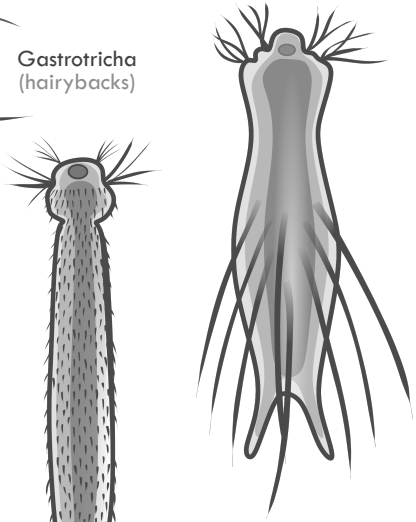


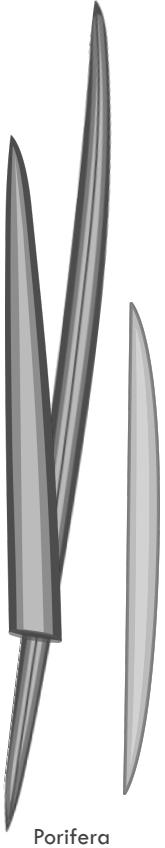
Conochilus

Other animals I

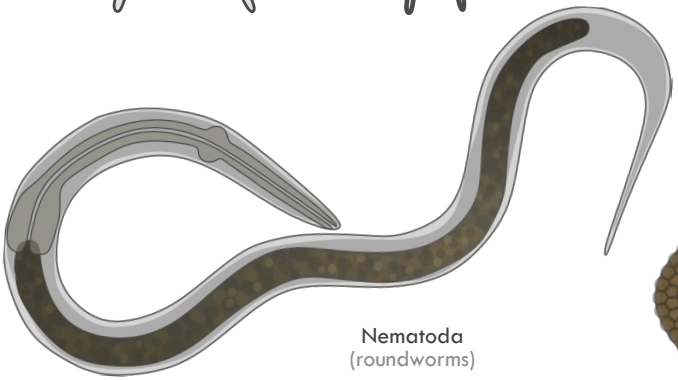


Gastrotricha
(hairybacks)

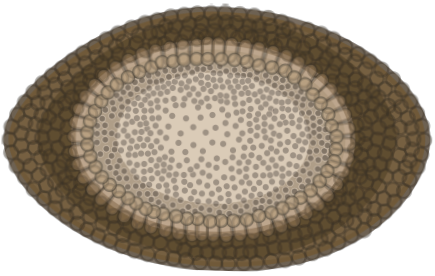




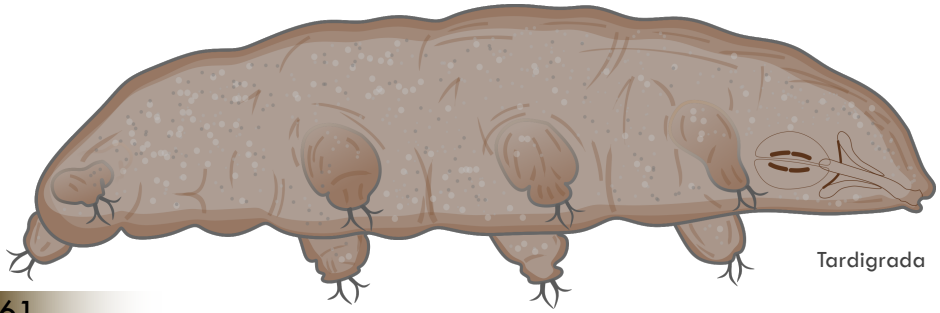
Porifera
(needles)



Nematoda
(roundworms)



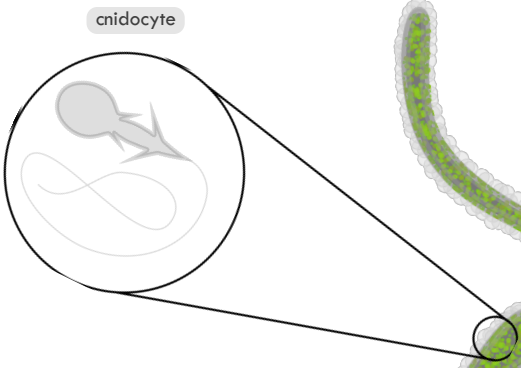
Bryozoa
(statoblast)

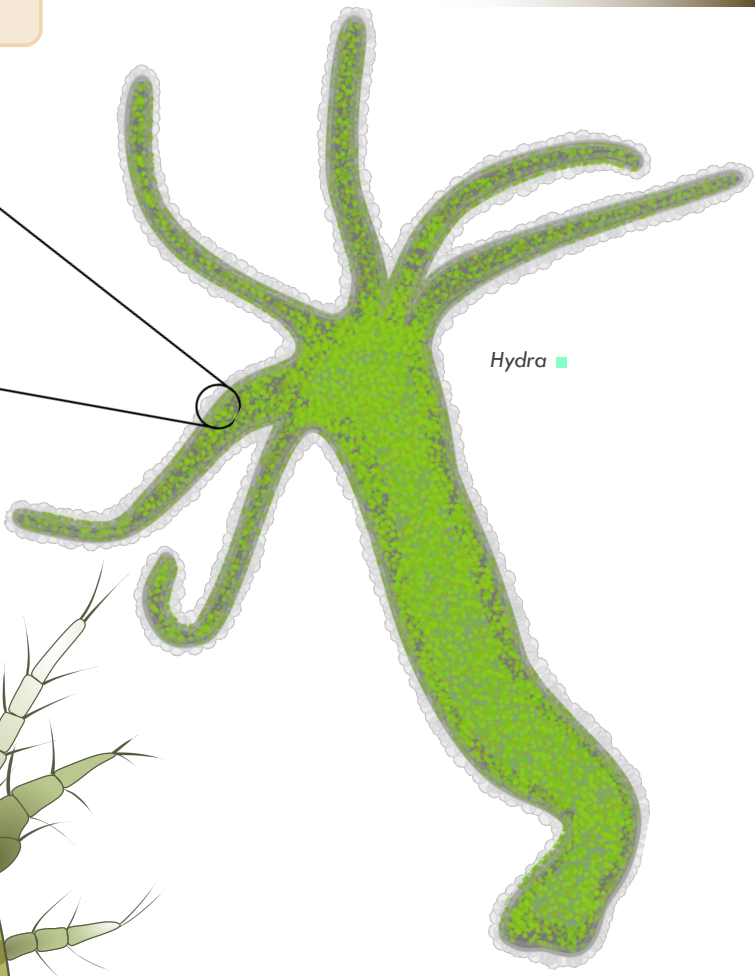


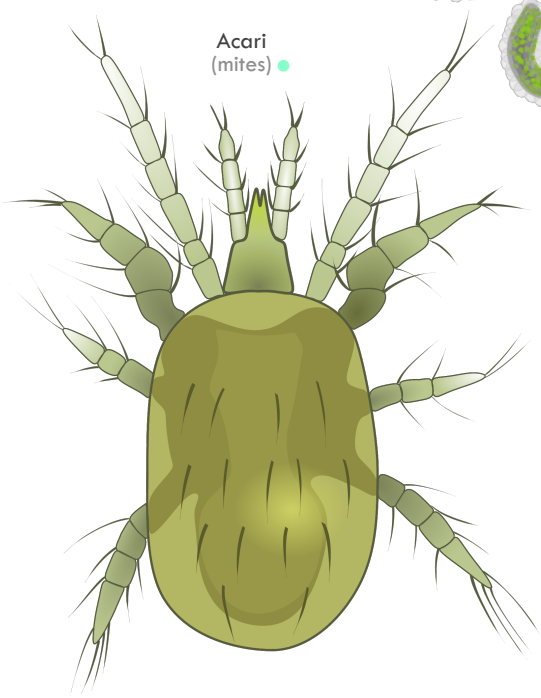
Tardigrada

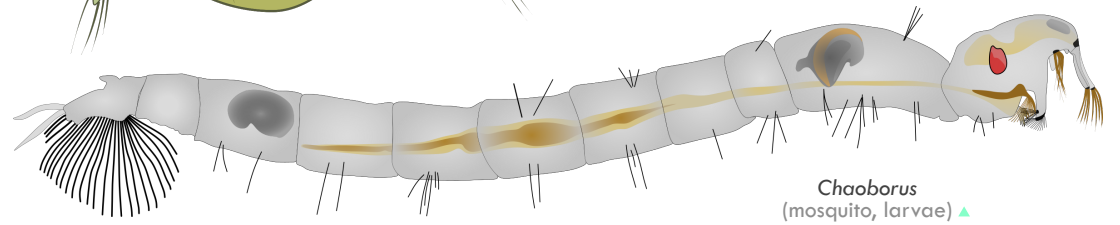
Other animals II

■ cnidarians ● arachnids
▲ insects



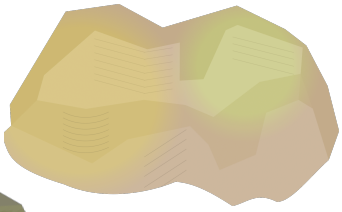


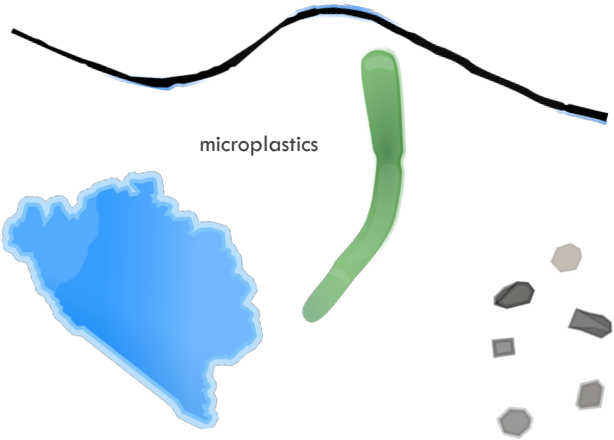




Abioseston

The term abioseston refers to inanimate particles of organic and inorganic origin (remains of bodies, products of their metabolism, precipitates, crystals, etc.).



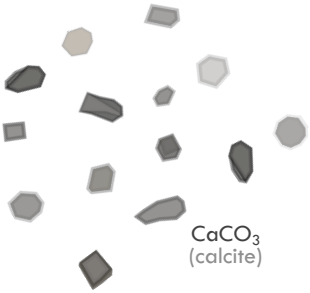


microplastics

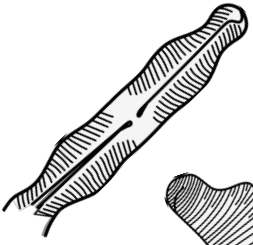


SiO_2
(sand)



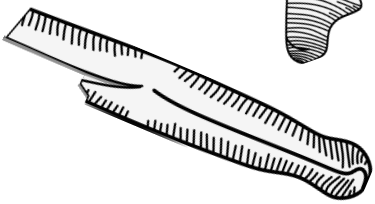


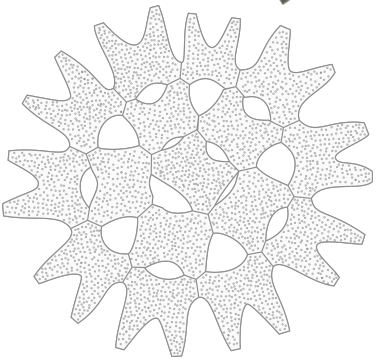
$CaCO_3$
(calcite)



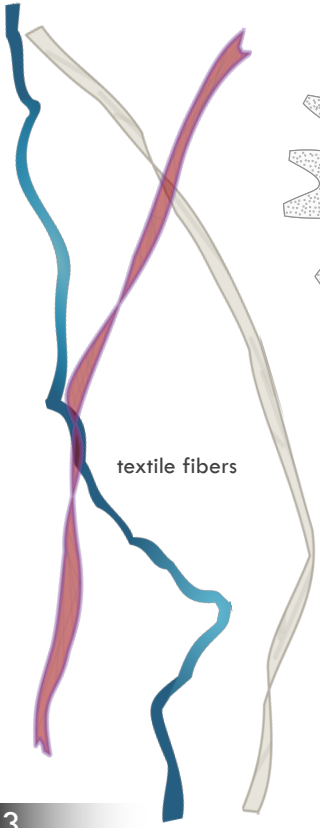


empty and broken
frustules of diatoms

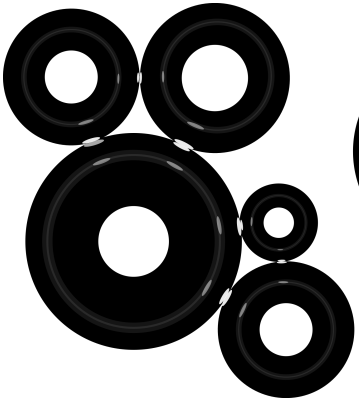


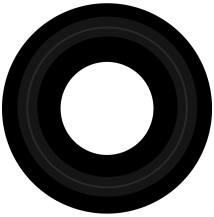


empty cell walls of algae



textile fibers





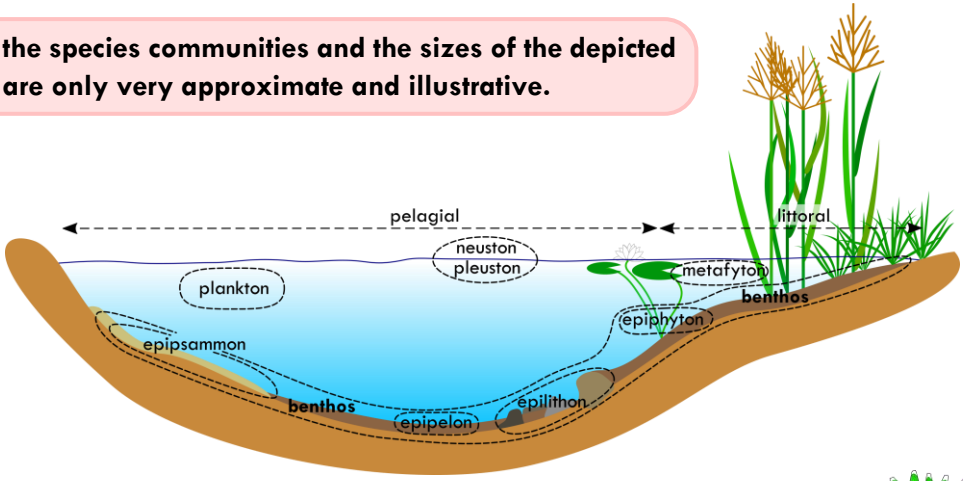
air bubbles

Sample examples

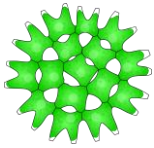
On the following pages you will find **examples** of what samples of different communities from different habitats might look like. In order to understand the following pages correctly, it is important to keep in mind that:

Trophic state of an ecosystem simply means its ***nutrient content***. The main **nutrients** are dissolved **phosphorus** and **nitrogen**. ***Eutrophic*** bodies are those that have an **excess** of nutrients (most ponds), ***mesotrophic*** are at an **intermediate** level of nutrient content (e.g., some reservoirs, better quality ponds), and ***oligotrophic*** have only a **minimum** of nutrients (this includes peat bogs, preserved flooded sand pits and quarries, lakes, etc.). Intermediate stages are called combinations of the names of both stages (e.g., meso-eutrophic, oligo-mesotrophic). The trophic status of a biotope is also closely associated with the taxonomic composition of the community inhabiting it.

Both the species communities and the sizes of the depicted taxa are only very approximate and illustrative.



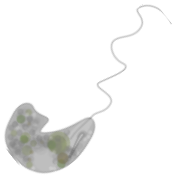
Plankton is a community of organisms floating freely in the water mass. The term **phytoplankton** refers to cyanobacteria and algae, while the term **zooplankton** refers to heterotrophic protozoa, crustaceans, rotifers, etc.





Periphyton, or ***growths***, is a community of organisms living sessile on submerged substrates. Depending on the type of substrate, we distinguish different types of growths: ***epipelon*** between fine particles of mud or sand, ***epiphyton*** on plants, ***epilithon*** on stones, ***epipsammon*** on sand and ***epizoon*** on animals. The main group of periphyton is **diatoms**.

Benthos is traditionally referred to as a community of bottom-dwelling organisms. It is mainly composed of the epipelon. It is difficult to define it precisely and distinguish it from the periphyton, which is why both communities are very similar – **diatoms** also play a major role here. Since a lot of organic matter settles to the bottom, there are many **heterotrophs** in the benthos.

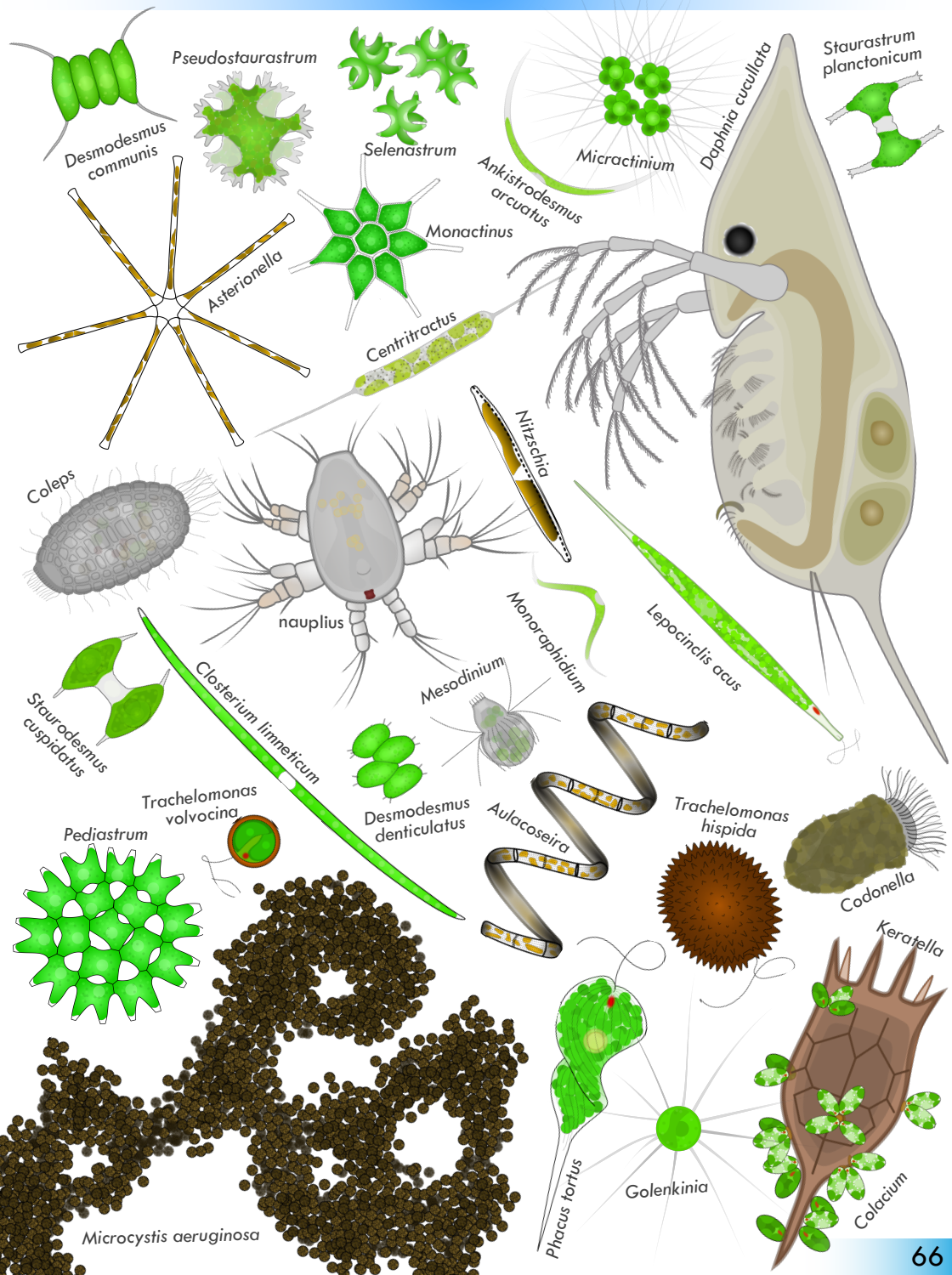


Example of water bloom

A water bloom is a biomass of phytoplankton visible to the naked eye, which is formed as a result of an overgrowth of cyanobacteria (with an admixture of algae). Water blooms occur in highly nutrient-rich water bodies, such as ponds.



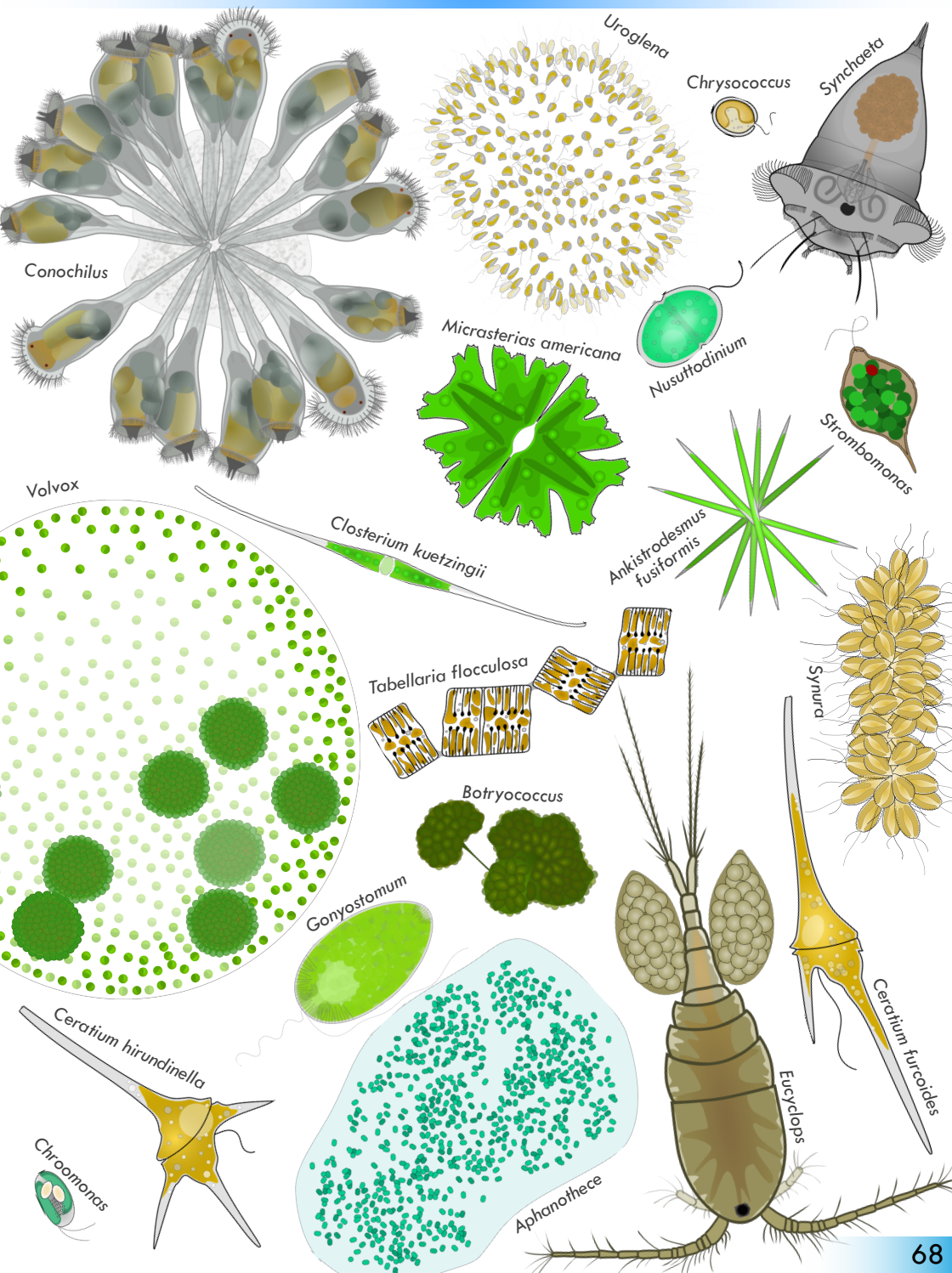
Example of eutrophic plankton



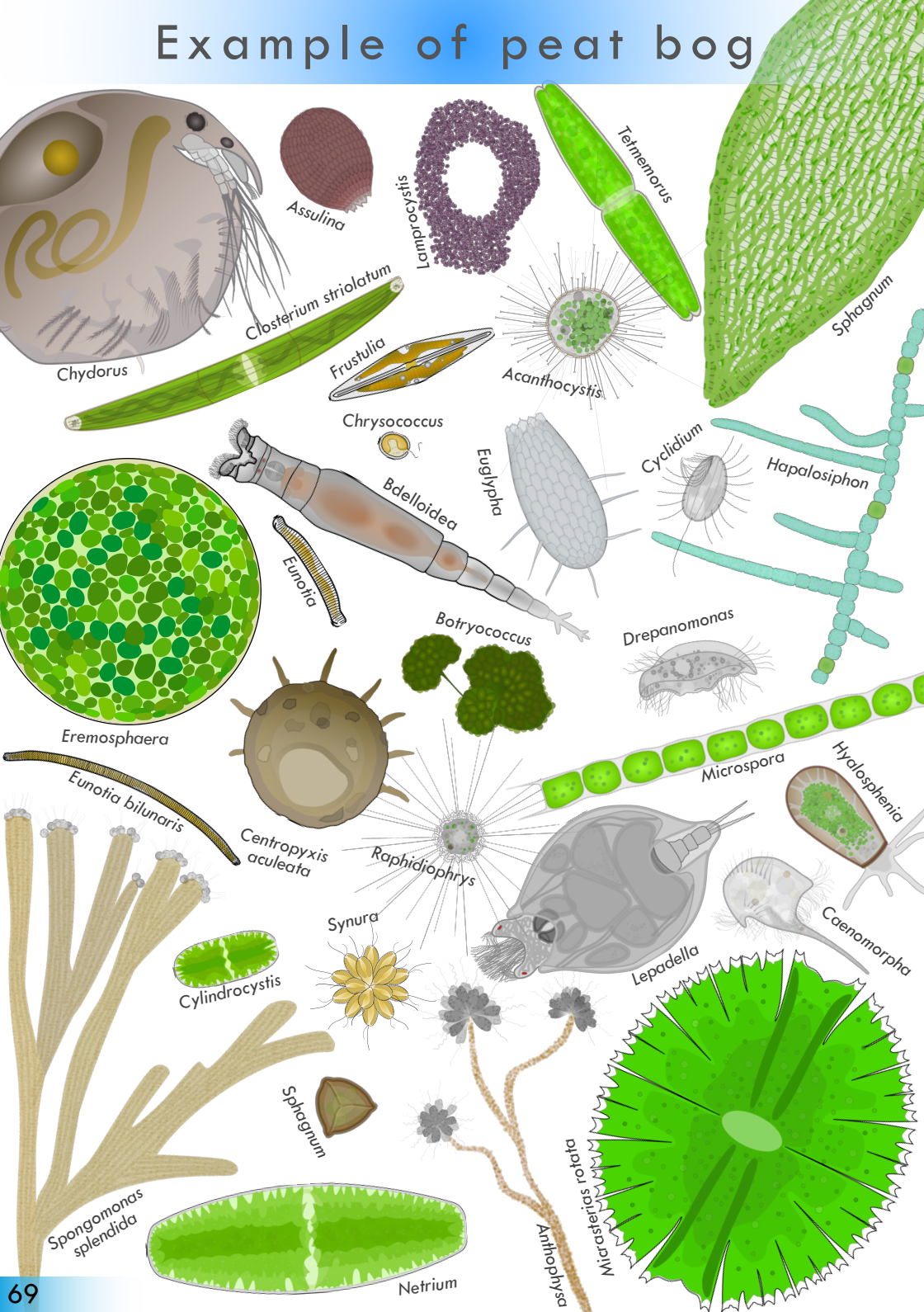
Example of meso-eutrophic plankton



Example of mesotrophic plankton



Example of peat bog



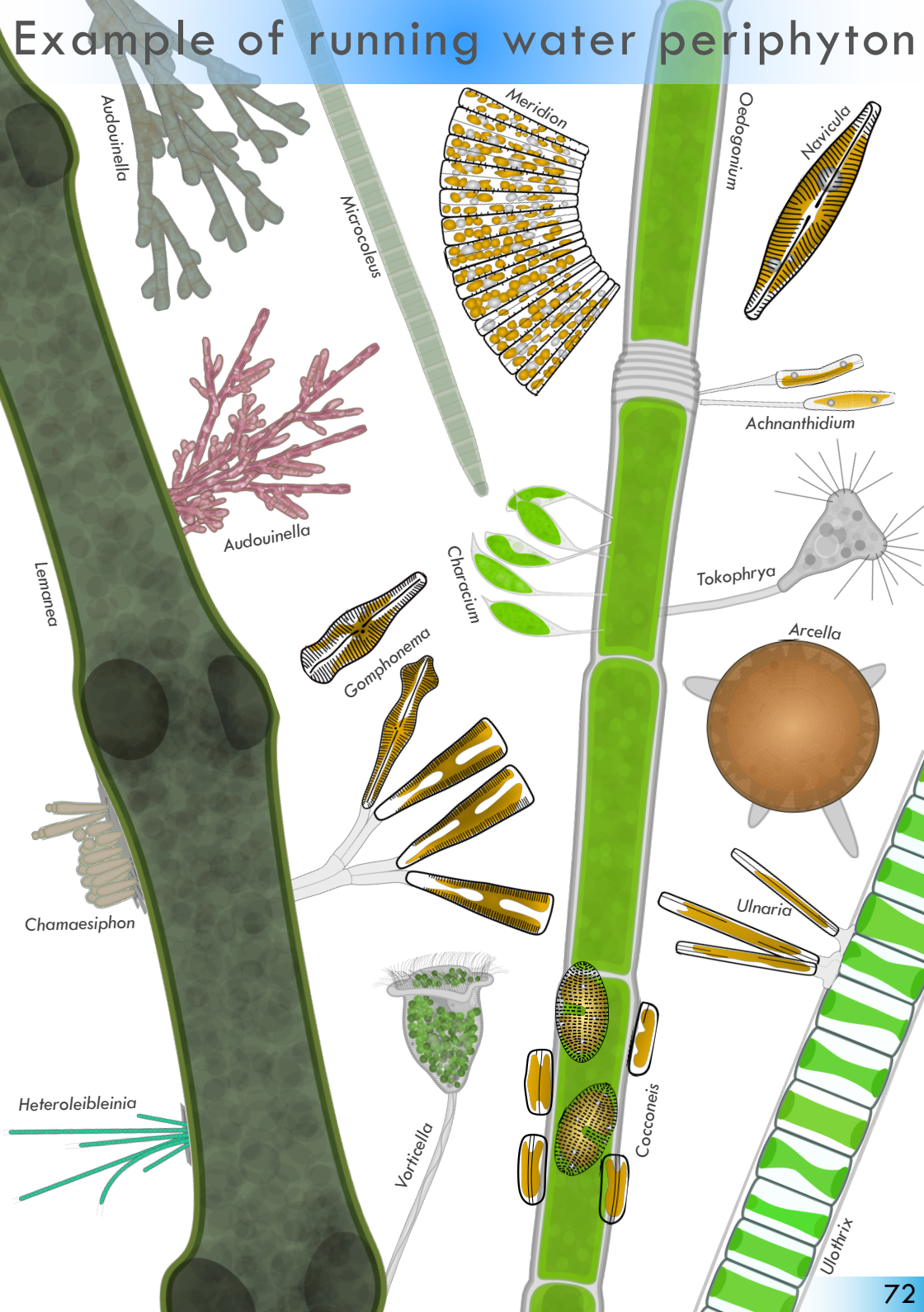
Example of pool or puddle



Example of standing water periphyton



Example of running water periphyton

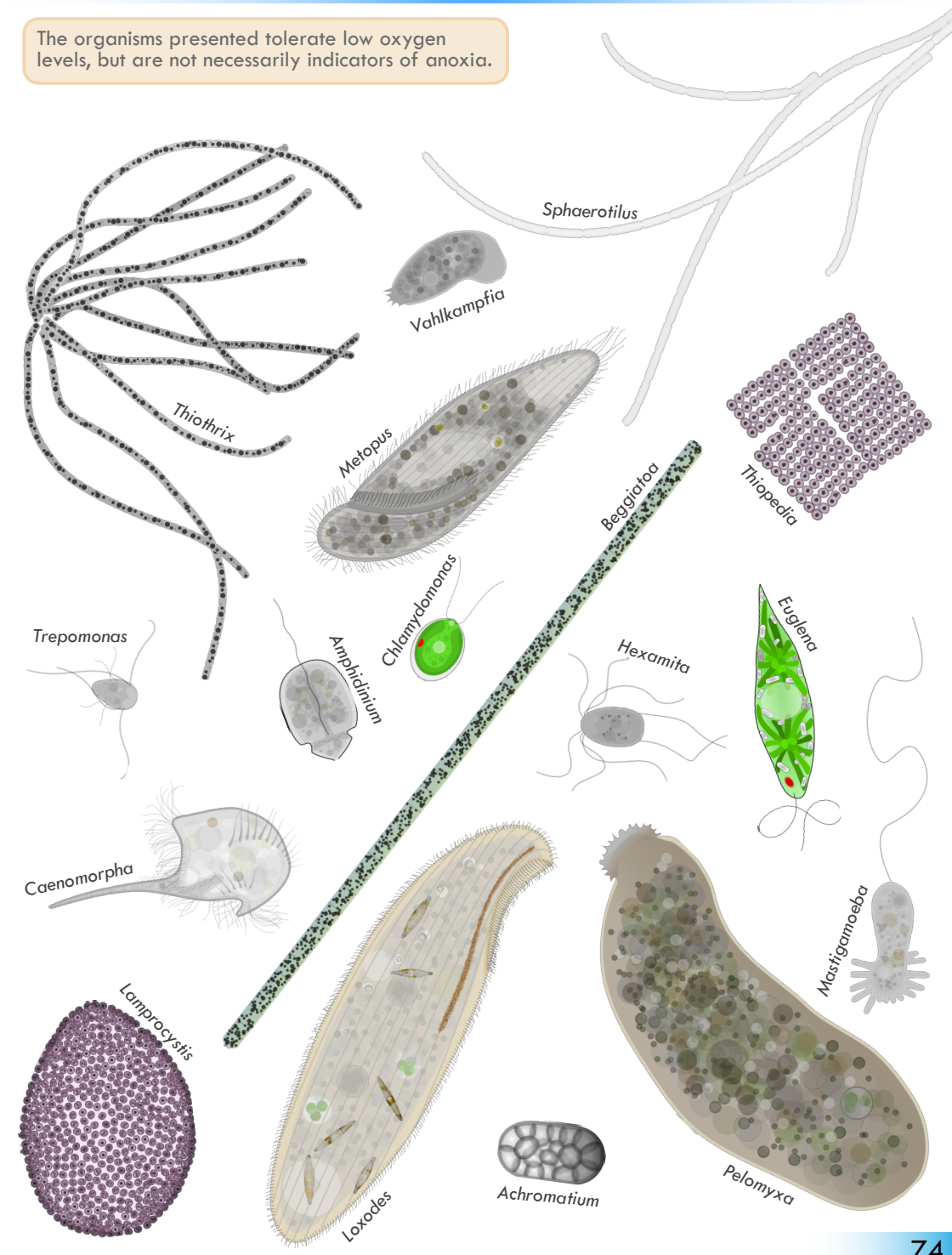


Example of benthos



Example of anaerobic sediment

The organisms presented tolerate low oxygen levels, but are not necessarily indicators of anoxia.



DON'T



PANIC