BLUE-GREEN ALGAE

Members of this group (Cyanophytes) form

- floating (planktonic) scums on water – some of these may be poisonous, or cause skin sensitivity
- thin, slippery coatings on rocks and masonry that can be black, green, or red and may dry into flakes (Fig. 1)
- small gelatinous blobs on hard, moist surfaces that may be dark green (Fig. 3)
- fuzzy coatings on water plants or other algae
- velvety lawns, a few mm tall, on moist soil
- crusts, forming on sediments, seen best in the intertidal region at low tide, or on dry soils, especially in the outback of Australia (Fig. 2)
- intimate associations (symbioses) within the tissues of other organisms, some forming a "partnership" with fungi in a compound organism called a lichen (Fig. 4)

Blue-green algae, commonly called "Blue-greens", are only recognizable to the unaided eye when they form populations of enormous numbers of separate individuals or clumps of individuals called colonies. Unfortunately, practically all identification must be undertaken using high power microscopes to ascertain fine cellular details.

The colour of Blue-green algae can be

- dirty green
- dark green, almost black
- reddish or brownish

and depends on the amount of bluish or reddish pigments that are accessory to the green chlorophyll present. The colour contrasts with the grassy-green of Green algae (Chlorophyta) which some of the Blue-greens resemble in shape (Fig. 5).

Under the microscope, individual cells can be bacterial size (1 µm long). Some may approach the size of cells of other algal groups (for example, 10 µm long), which makes separating them from Green algae particularly difficult, ***but***, Blue-green cells usually have few visible bodies inside their cells, and certainly no coloured plastids. This is why they should be called, more correctly, blue-green bacteria.

Fig. 1: slippery, dark-stained granite rock (arrowed) in a zone that is wet from wave surges, at Victor Harbor, S Aust.

Fig. 2: salt crust on Lake Gairdner, S Aust., stained a dirty colour by blue-green algae

Fig. 3: dark green gelatinous blobs in the intertidal, on granite at Victor Harbor, S Aust.

Fig. 4: intricate (fruticose) lichen from Kangaroo Island,, S Aust. – a combination of a fungus and a Blue-green alga

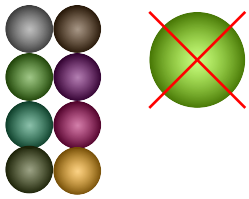


Fig. 5: some colour variations of Blue-greens (left) compared to Green algae (right)

Fig. 6: dot-shaped or coccoidal *Gloeocapsa* colonies, of cells in 2-3s within sheaths

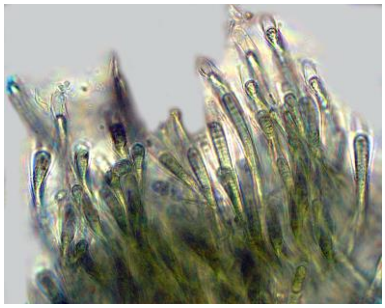


Fig. 7: *Lyngbya* mass of threads (filaments or trichomes)

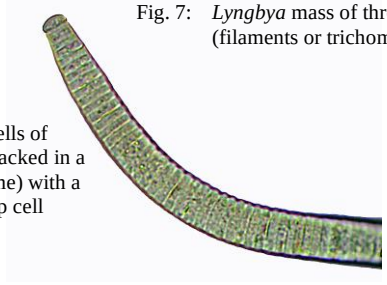


Fig. 8: disc-shaped cells of *Oscillatoria* stacked in a line (a trichome) with a convex tip cell

Most of the cells look similar, but some species have

- larger, thick-walled cells (akinetes) that may spread the organism vegetatively (Fig. 9)
- rounded cells (heterocytes, also called heterocysts) where gaseous nitrogen is fixed into ammonia (Fig. 10)

Cells can be

- single
- strung together in a line (a trichome, Figs 8, 9, 10), and some trichomes can glide backwards and forwards or in a spiraling motion
- clumped together, sometimes in packets (colonies) of 2 or 4 or many. They usually have their own walls, but, also, cells can be wrapped in a sheath or they can be embedded in a gelatinous matrix (Fig.11).

The Blue-greens illustrated below are found in these habitats:-

- freshwater
- saline lakes
- marine, either in calm estuarine situations or, in rough water
- on moist soil
- on rock
- on other plants, including the bark of trees

Blue–greens can often withstand great fluctuations of salinity, temperature and drying (Fig.12). They are even found at the edges of hot-water springs. See for example https://www.ncbi.nlm.nih.gov/pmc/articles/PMC378340/

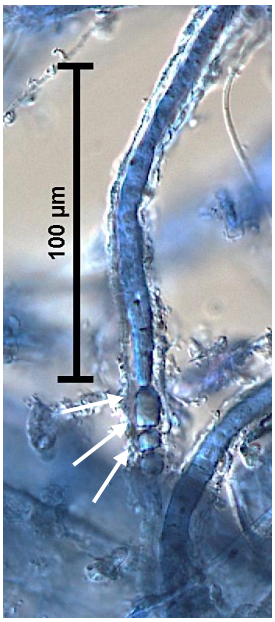


Fig. 9: trichome of *Lyngbya* with a string of akinetes (bracketed)

Fig. 10: trichome of *Calothrix* with a terminal heterocyte (arrowed)

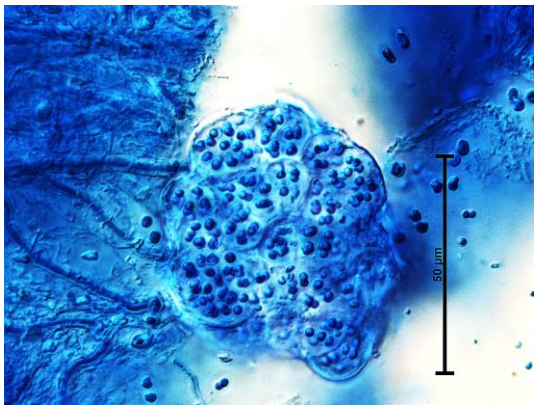
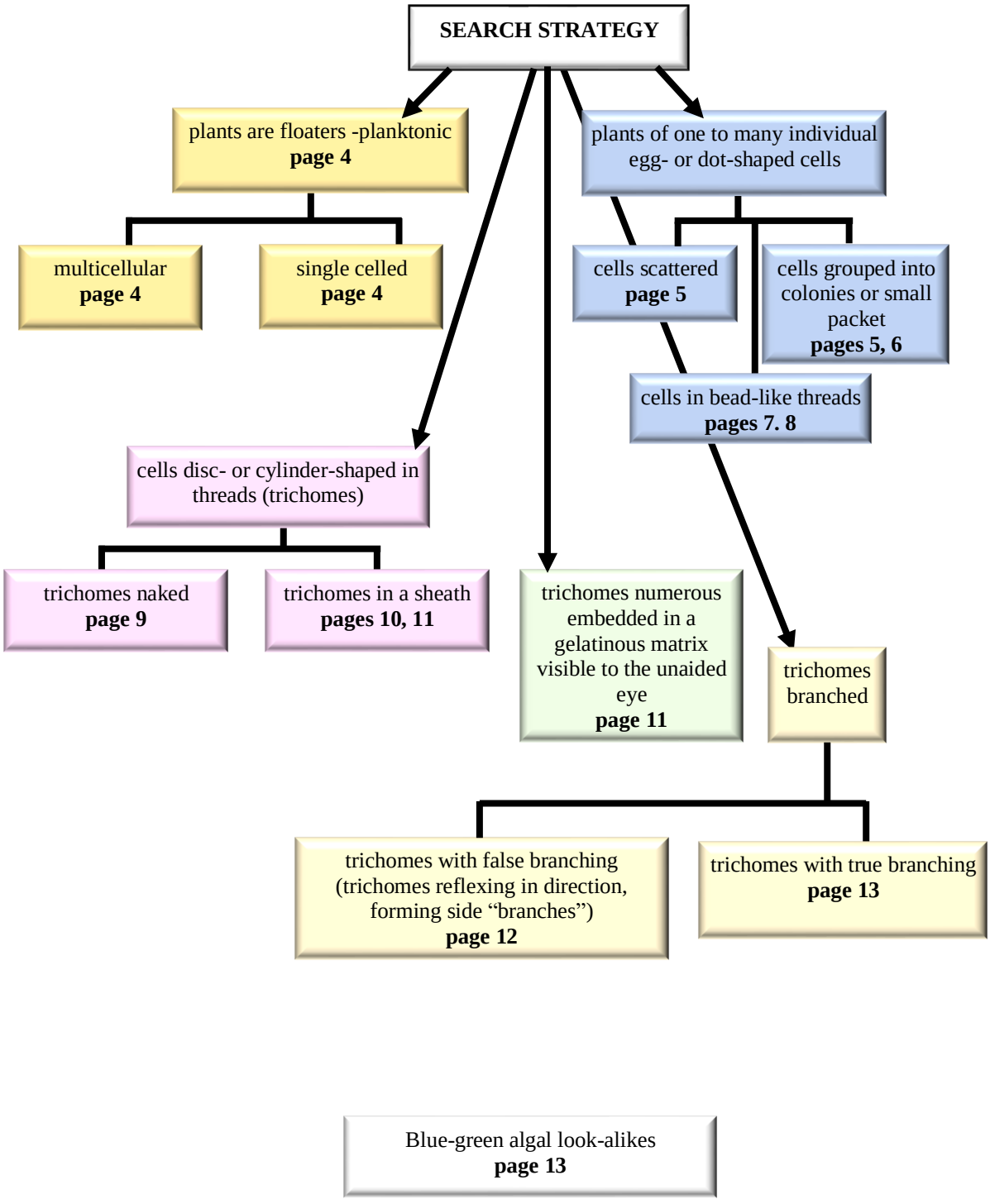


Fig. 11: many colonies of *Chroococcus* adhering into a single mass

Fig. 12: bacterial mat (green Cyanophytes and purple sulfur bacteria) on tidal flats amongst mangrove pneumatophores (arrowed). The organisms in the mat withstand desiccation and fluctuating air temperatures when exposed at low tide, even in summer when this occurs in the hot, middle part of the day. The Cyanophytes "fix" atmospheric nitrogen into organic compounds which then become available for other organisms in the food web, especially small grazing snails. The mat stabilizes the sticky, fine sediments, so limiting erosion by wave action when the tide comes in

REFERENCES:

1. Baker, P. D, & L. D. Fabbro (2002). **A guide to the identification of common blue-green algae (Cyanoprokaryotes) in Australian freshwaters. 2nd edition**. Identification & Ecology Guide No. 25. Albury. Cooperative Research Centre for Freshwater Ecology**.**
2. Prescott, G. W. (1970). **How to know the freshwater algae. Second edition.** Pictured-key nature series. Wm. C Brown Co, USA

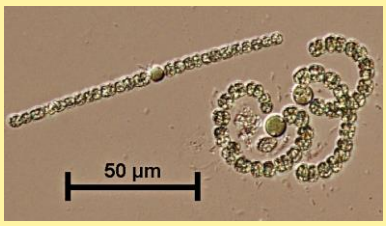

SEARCH STRATEGY
plants are floaters -planktonic
page 4
plants of one to many individual egg- or dot-shaped cells
multicellular
page 4
single celled
page 4
cells scattered
page 5
cells grouped into colonies or small packet
pages 5, 6
cells in bead-like threads
pages 7. 8
cells disc- or cylinder-shaped in threads (trichomes)
trichomes naked
page 9
trichomes in a sheath
pages 10, 11
trichomes numerous embedded in a gelatinous matrix visible to the unaided eye
page 11
trichomes branched
trichomes with false branching (trichomes reflexing in direction, forming side “branches”)
page 12
trichomes with true branching
page 13
Blue-green algal look-alikes
page 13

BLUE-GREEN ALGAE AT A GLANCE

PLANTS PLANKTONIC (FLOATING)

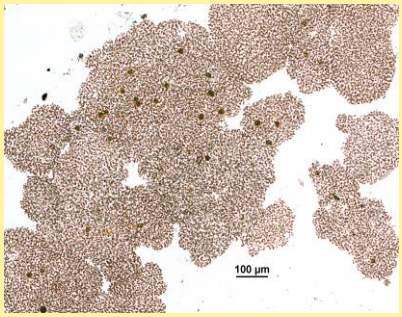
plants multi-cellular

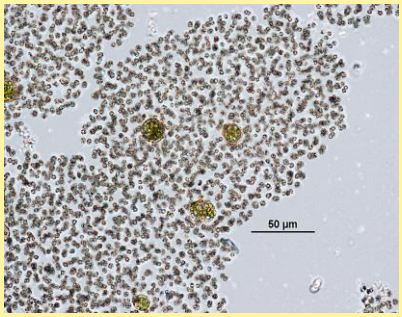
1. *Anabaena circinalis*.
Torrens Lake, S Australia



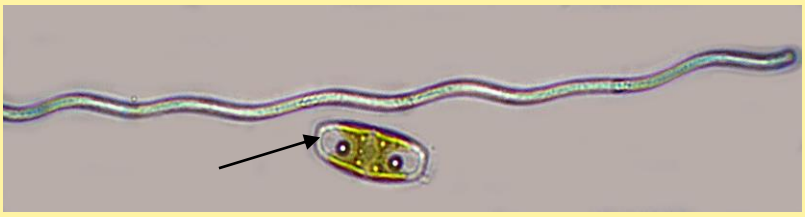
2. *Anabaena circinalis*. West Lakes pond, S Australia
beadlike chain of cells, heterocytes lying within the chain

3. *Microcystis aeruginosa*
Torrens Lake, S Australia
mass of minute cells





4. *Arthrospira* sp
St Kilda mangroves, S Australia, in detritus, seen witha yellowish diatom for comparison (***arrowed***)
Plants move in a slow spiral motion.
They are many-celled, but the cross partitions are difficult to see, and so the plant can be mistaken for the next genus, *Spirulina*



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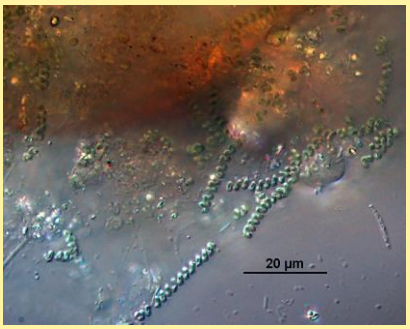
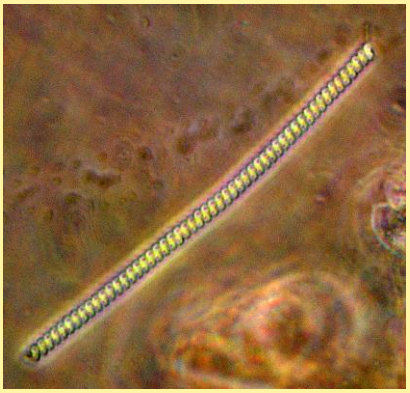
plants large, single-celled

5. *Spirulina* sp, outfall at Kangaroo Island, S Australia

Plants move relatively quickly in a spiral motion

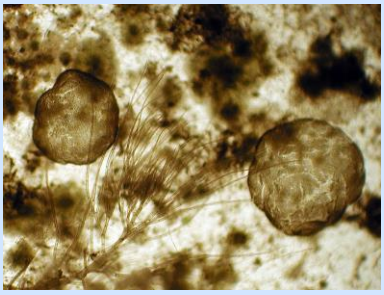


6. *Spirulina*,
in detritus of a mangrove swamp, St Kilda, S Australia

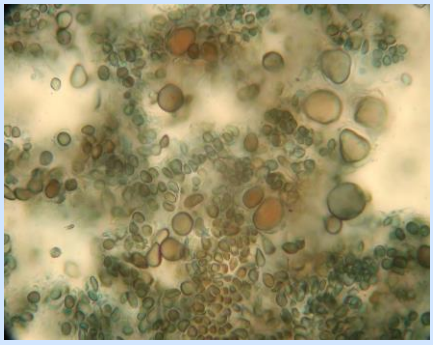


PLANTS OF ONE to MANY INDIVIDUAL *EGG- OR DOT-SHAPED* CELLS

CELLS *SCATTERED*



7. *Microcystis* sp on a settlement plate, Whyalla, S Australia
hollow, papery colony ≈ 3 mm across

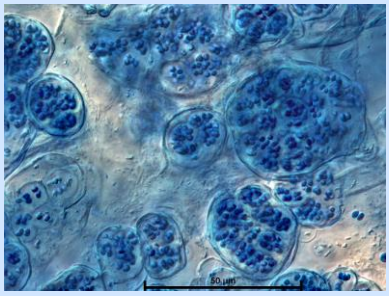


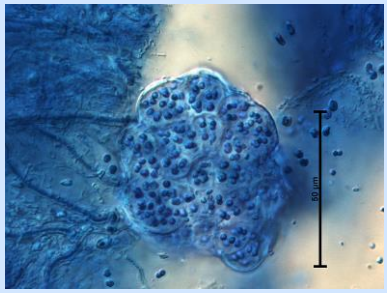
8. *Synechococccus* sp on a settlement plate,
Whyalla S Australia
scattered pinkish cells 2-8 µm across with rigid cell walls

CELLS *GROUPED* INTO COLONIES OR SMALL PACKETS

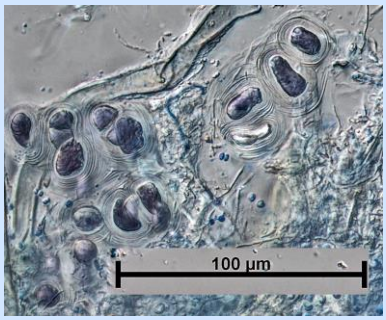
9. *Chroococcus* sp near Mt Gambier, S Australia

Cells minute, both small clusters and larger aggregates of clusters are surrounded by sheaths



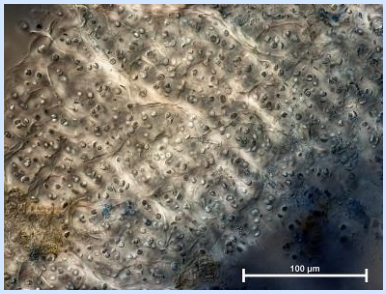


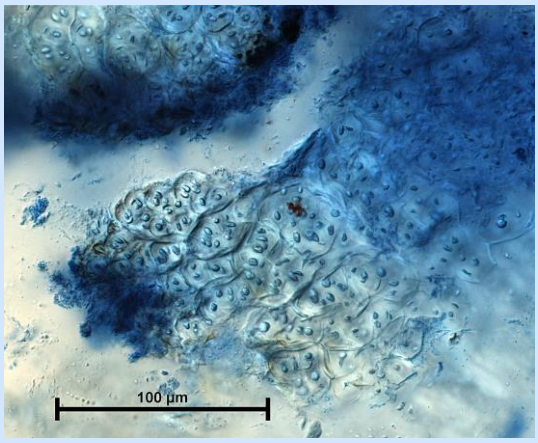
10. *Gloeocapsa* sp on soil mixed with moss rhizoids and lichen
1-3 cells grouped in common lamellate (layered) sheaths and covered in jelly

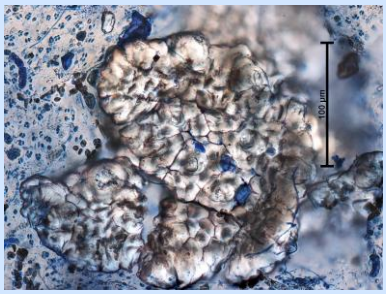


9. *Gloeocapsa sp* near Mt Gambier, SA, 14.xii.1977,
cells with conspicuous concentric rings in sheaths; mixed with *Chroococcus* sp, above;

11. *Chondrocystis* sp in a deep, saline lake, Innes Conservation Park, S Australia, heavily encrusted with lime. A tough, cushion-shaped mass of many colonies, each with their individual sheaths







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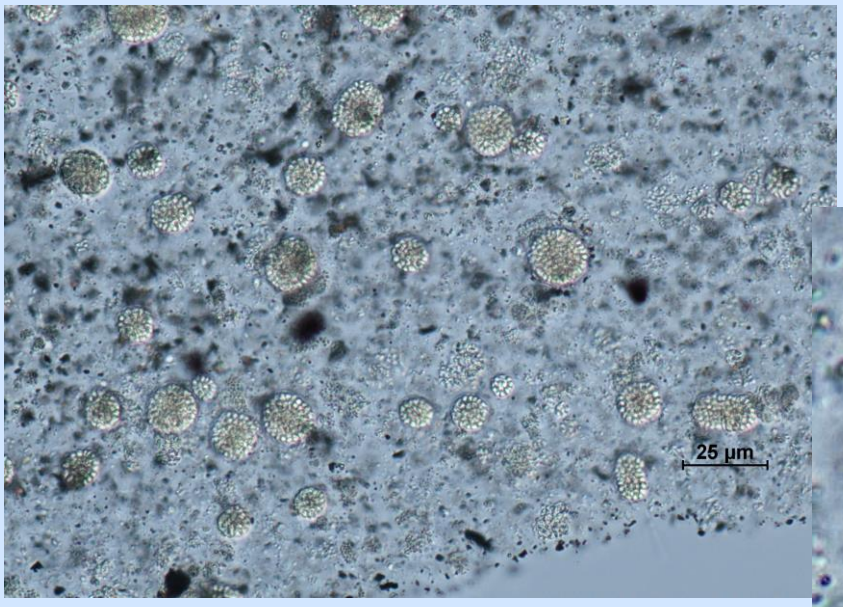
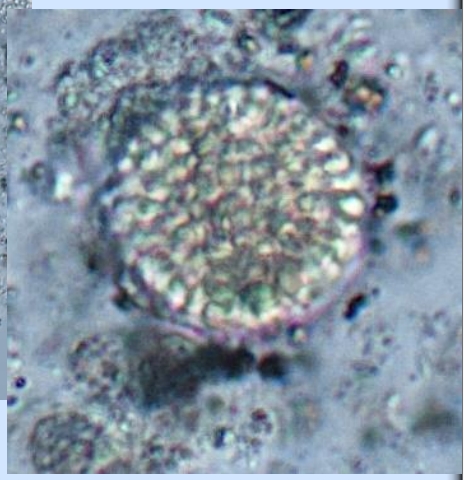


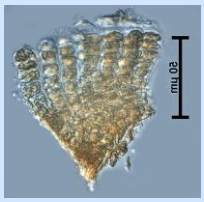
12. *Coelosphaerium* sp taken from a from a waterpipe.
A hollow ball of oval shaped cells, found in still, fresh water



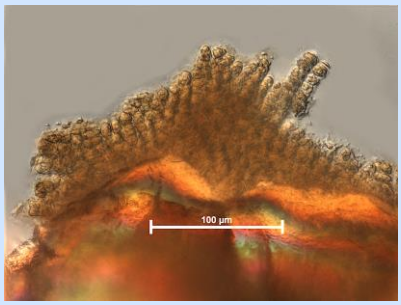
13. *Entophysalis* coating rock in the mid-intertidal, Apollo Bay, Victoria

cells in erect rows, fanning out from a base ("pseudo-branching"), forming cushion-shaped masses

Above: dried colony forming a dark patch on siliceous rock



Right: dissected cells showing pseudo-branching



Above: profile view of a colony appearing above large crystals of the substrate

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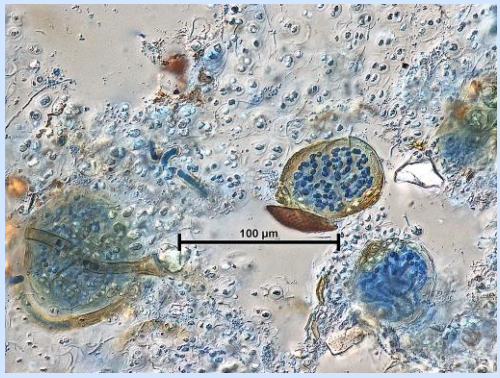
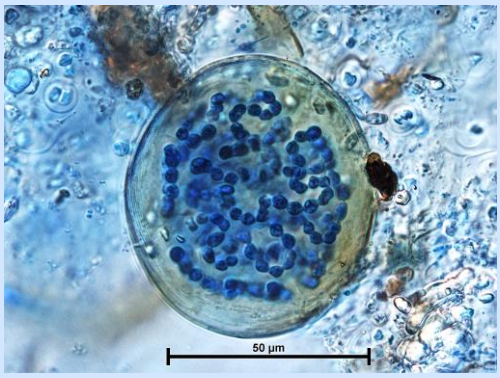
CELLS IN *BEAD-LIKE* THREADS

13. *Nostoc* trichomes germinating in a thick walled resting spore (akinete)



thick walled resting spores (akinetes) on a background of *Gloeocystis*

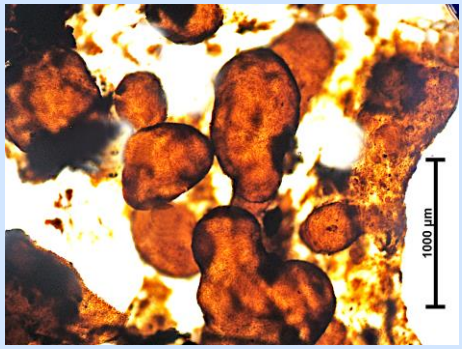


detail of bead-like threads within the thick-walled akinete

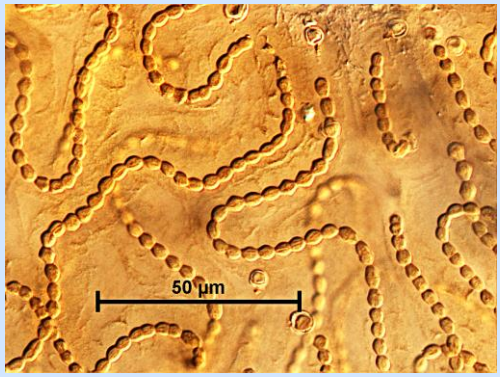
14. *Nostoc* on wet soil, Warrawong Park, Adelaide Hills, S Australia

bead-like chains of cells, basal heterocyte

15. *Nostoc pruniforme* Coorong, S Australia



microscopic trichomes are embedded in a rubbery, reddish, gelatinous matrix



trichomes consist of bead-like strings of > 20 cells all of the same shape

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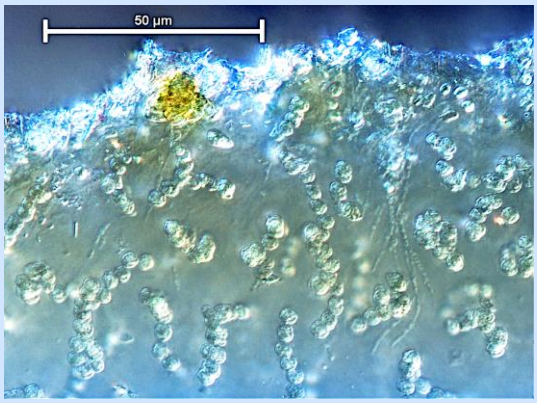
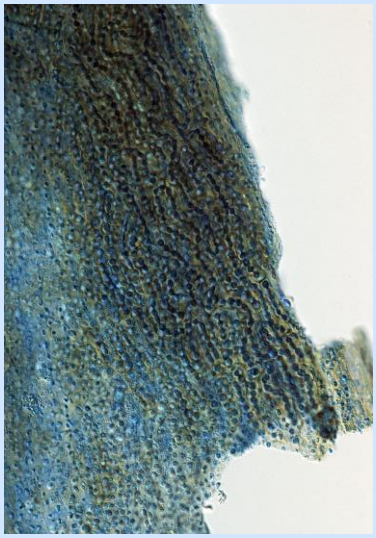
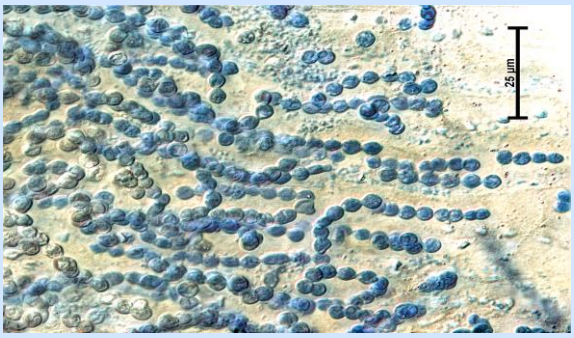


16. *Nostoc commune* arid NW of S Australia, in ephemeral watercourses
Rubbery, strap-like colonies in a drying watercourse (far left), colonies reconstituted in water in the lab. (above, centre), edge of the colony (above, right) with bead-like strings of < 20 cells seen under the microscope

17. *Nostoc flagelliforme*, arid NE of S Australia, on wet soil amongst saltbush shrublands

visible, dark, wiry threads with numerous, microscopic, bead-like chains of cells in a tough, gelatinous sheath

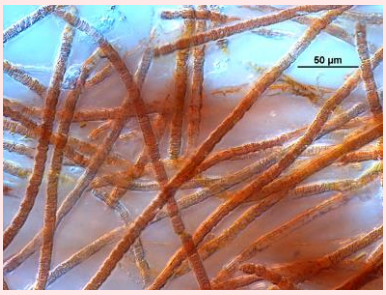




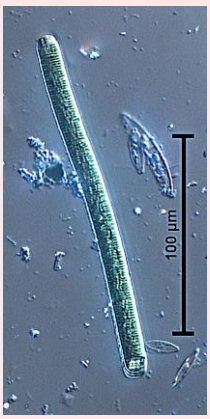
CELLS DISC- OR *UNBRANCHED*, CYLINDER-SHAPED IN THREADS (TRICHOMES)

TRICHOMES NAKED (NOT LYING IN A SHEATH OR GELATINOUS MATRIX)

trichomes ***glide slowly back and forth*** when alive, trichomes ***not*** tapering apically - *Oscillatoria*

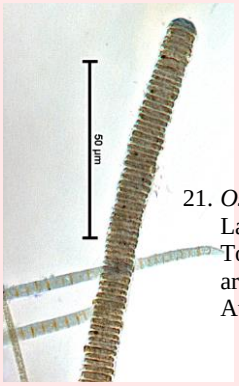


18. *Oscillatoria* sp Kangaroo Island, S Australia, estuary
mass of gliding trichomes (above), detail of numerous disc-shaped cells in the trichome (right)



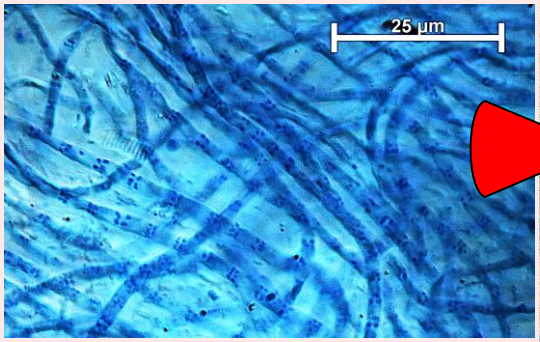
19. Left: *Oscillatoria* sp West Lakes, S Australia

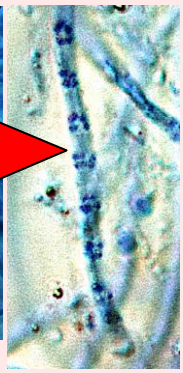
20. Right: *Oscillatoria* sp, pond in the Botanic Gardens Adelaide, with distinctive apical cell



21. *Oscillatoria* Lake Torrens, arid S Australia

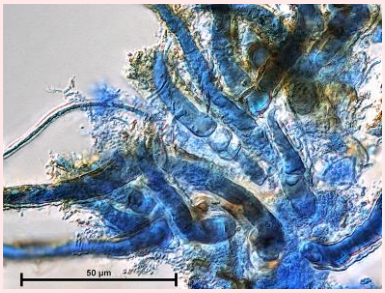
22. *Jaaginema pseudogeminatum* Portland, Victoria, trichomes very thin, 2-3 prominent granules either side of end walls



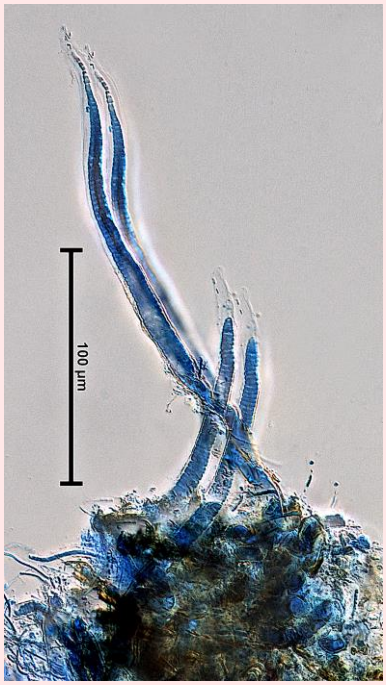


trichomes usually solitary, ***tapering apically***, heterocyte, if present, ***basal*** - *Calothrix*

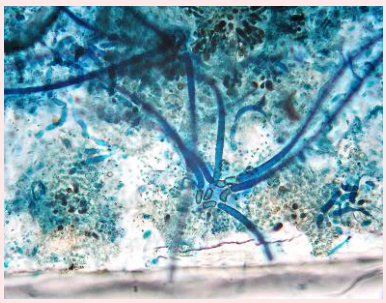
23. *Calothrix fasciculata* West Island, Victor Harbor, S Australia
zone (arrowed) staining a wave-swept granite boulder



Above: trichomes, massed, some with a basal heterocyte



25: *Calothrix fasciculata*: Cape Leeuwin, WA
trichomes, tapering apically



24. *Calothrix* sp (left & right)
Stony Point, upper Spencer Gulf, S Australia
on a plastic settlement sheet

CELLS DISC- OR CYLINDER-SHAPED IN *UNBRANCHED*, THREADS (TRICHOMES) – continued

trichomes extremely thin and ***spirally wrapped*** around other algae and waterplants

26. *Leibleinia epiphytica* Botanic Gardens Adelaide, S Australia, recycle-water ponds (arrowed) wrapped around the Green alga *Oedogonium* (*Oed*)

27. *Leibleinia* sp Pearson Island S Australia, (arrowed) on trichomes of another Blue green alga attached to the Brown alga *Cystophora*

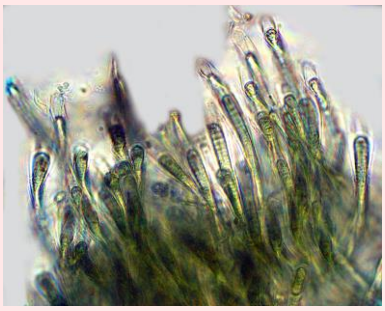
TRICHOMES LIE IN A SHEATH

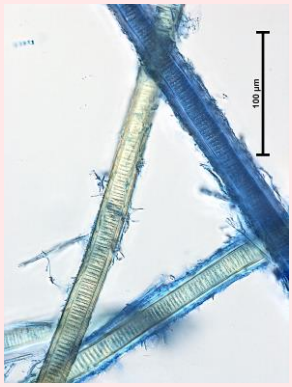
sheath ***firm,*** often extending beyond the trichome, trichome may ***glide*** within the sheath –§*Lyngbya* spp

Left: 28. *Lyngbya* sp Pt Pirie, S Australia trichomes densely clumped

Right: 29. *Lyngbya* sp Lake Woolpooloo, S Australia, detail of thick sheaths

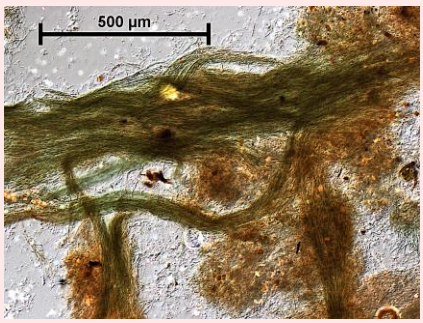
Far right: sheath extending beyond the trichome

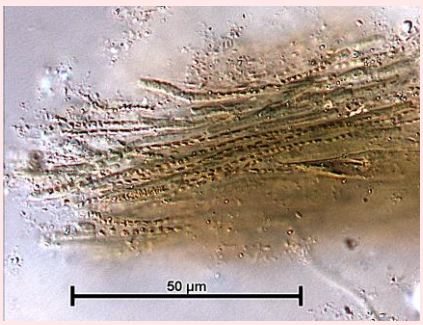




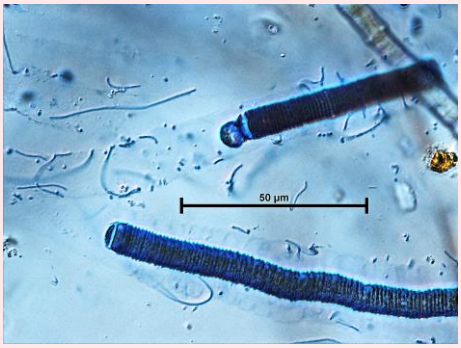
sheath ***diffuse***, ***sticky*** and about the ***same length*** as the trichome - §*Phormidium*

30. §*Phormidium* sheath is diffuse but sticky, filaments cling together, there are no erect filaments and cells are rectangular





31. §*Phormidium* West Lakes Adelaide, S Australia the sheath is hard to detect, but sticky, and the end cell of the trichome is semicircular or bulbous

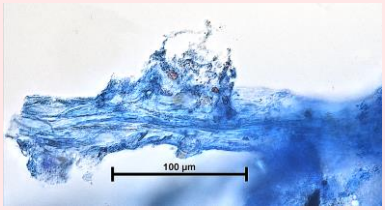


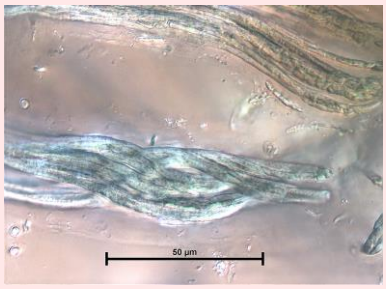
§ some modern works merge *Lyngbya* and *Phormidium* into *Oscillatoria*

continued next page

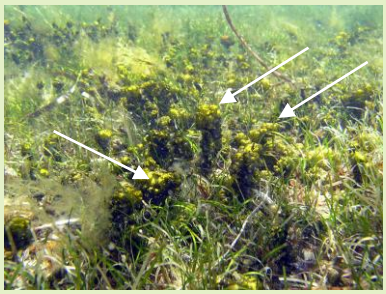
trichomes numerous, ***wrapped together*** into strands

32. *Microcoleus* sp
"Deep Lake", Innes CP, S Australia.
On limestone in saline water

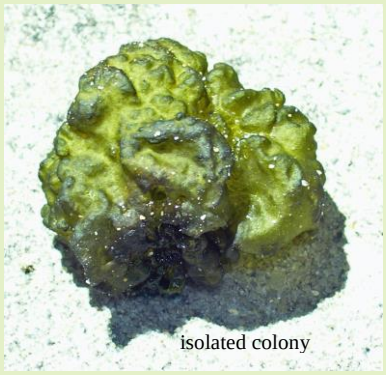




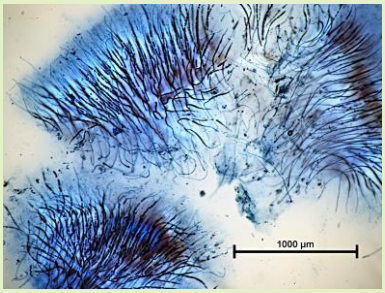
TRICHOMES NUMEROUS, EMBEDDED IN A GELATINOUS MATRIX VISIBLE TO THE UNAIDED EYE



33. *Rivularia polyotis* Encounter Bay, Victor Harbor, S Australia, 11.xii.2005

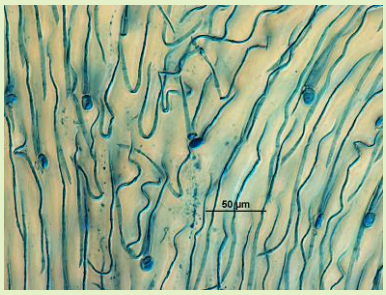


isolated colony



dissected pieces of the matrix with numerous embedded, hair-like trichomes

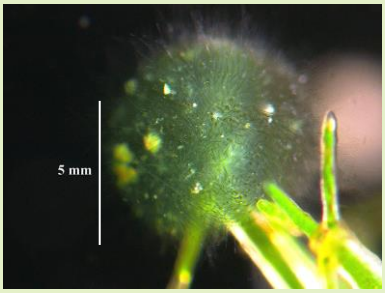
34. *Rivularia* §*firma* The Bluff, Victor Harbor, S Australia, 26.iii.2006



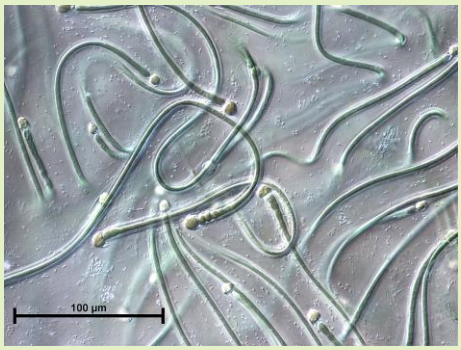
Right: on granite rock in wave surge
Far right: highly magnified view of hair-like trichomes embedded ***in parallel rows*** in the gelatinous matrix

§ a name to be changed to *Rivularia australis*

35. *Gloeotrichia* sp
Middle Point Swamp
lower SE, S Australia
05 xii.2017



Right: soft colony epiphytic on *Lamprothamnion*
Far right: hair-like trichomes embedded ***irregularly*** in a soft gelatinous matrix



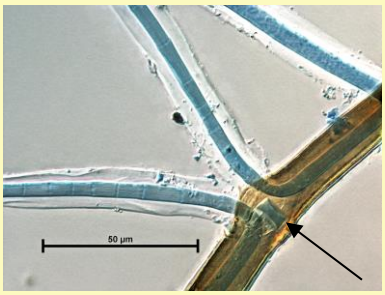
PLANTS WITH *BRANCHED* THREADS OR FILAMENTS

THREADS *FALSELY* BRANCHED (threads that reflex in direction, forming side-branches)

36. *Scytonema* sp Bridgewater Lakes, Portland, Victoria

Right:
floating in great numbers

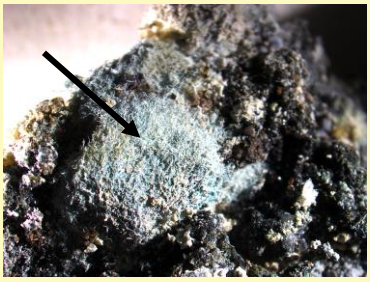
Far right:
false branching produced by reflexing of a ***pair*** of filaments when they meet at the site of a heterocyte (arrowed)

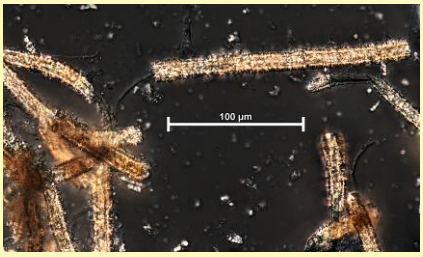


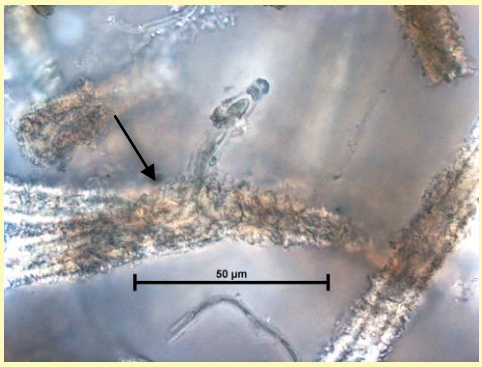
37. *Scytonema* sp Snake Hill, Myora Forest near Mt Gambier, S Australia, near sinkholes

Right:
patch (arrowed) about 2 mm across of a mass of bluish, calcified filaments lying on black lichen on soil

Far right:
filament with encrusting aragonite crystals on the surface of the sheath, making the trichomes brittle, and break into pieces when handled

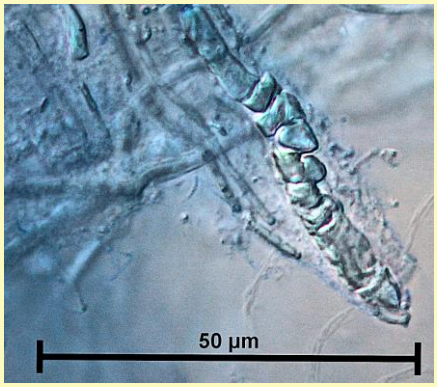






(*Scytonema* Snake Hill, continued):
Left:
pseudo-branches emerging from highly calcified trichome sheaths (arrowed)

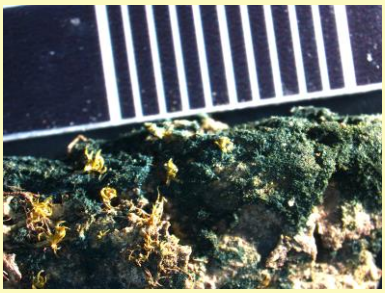
Right:
stack of akinetes at the apex of a trichome exposed by dissolving the calcified coating with acid

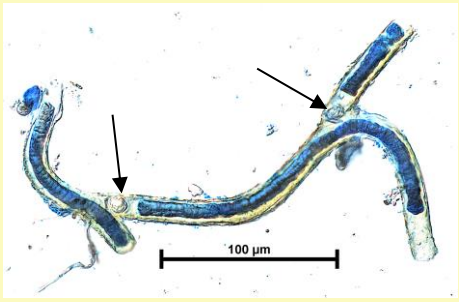


38. *Tolypothrix* sp Meningie, S Australia. on cherry tree bark

Right:
Carpet of filaments on bark (graduations on scale = 1 mm)

Far right:
false branches produced by the reflexing of ***one*** filament at the site of a heterocyte (arrowed)

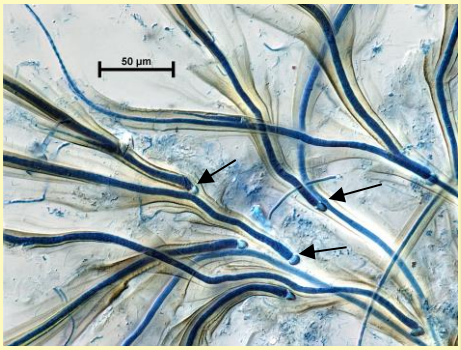




39. *Sacconema rupestre* Borzi *ex* Bornet & Flahault, Bridgewater Lakes, Portland Victoria

Right:
tufts (arrowed) on dead sticks

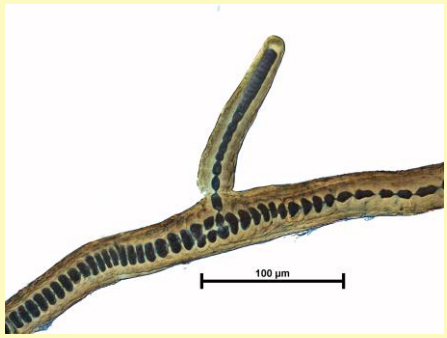
Far right:
filament forming the false branch has a ***basal heterocyte*** (arrowed); ***frayed*** tips are used as a diagnostic feature (not shown)



THREADS WITH *TRUE* BRANCHING

40. *Stigonema* sp
Bogong High Plain, Falls Creek, Mt Beauty area, Victoria

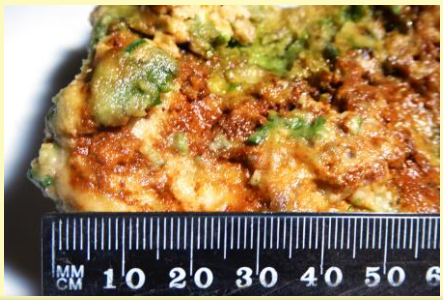
filaments frequently with a single row of cells, ***coloured sheaths***, cells ***discoid***, connected by a protoplasmic strand similar to that in the Red algae. Heterocytes are rare and inconspicuous.



41. *Nostochopsis* sp 
in a small saline spring, Lake Torrens, arid S Australia

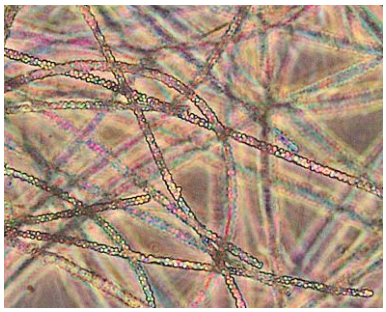
Right:
sediment stained green with the alga

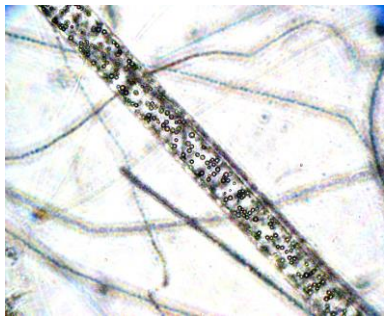
Far right:
cylindrical cells, filaments branched



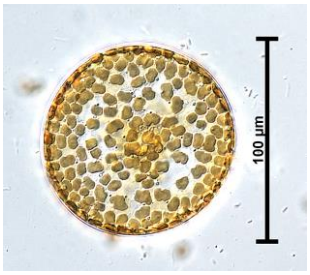
BLUE-GREEN ALGAE LOOK-ALIKES

Sulfur bacteria: from black, odorous sediments at St Kilda intertidal, S Australia. Colourless microscopic threads with bright dots (sulfur particles) may glide backwards and forwards





Keriochlamys styriaca
A Golden-brown alga consisting of several small cells in a thick sculptured sheath



Coscinodiscus
A Golden-brown diatom with plastids similar to encapsulated cells of Blue-green algae

Gloeocystis gigas
A Golden-brown alga with golden plastids. pairs of cells within common sheath. Individuals larger than similarly shaped Blue-greens such as *Gloeocapsa*

LIST OF GENERA ILLUSTRATED

genus	page	genus	page	genus	page/s	genus	page
Anabaena	4	*Entophysalis*	6	*Lyngbya*	10	*Rivularia*	11
Arthrospira	4	*Gloeocapsa*	5	*Microcoleus*	11	*Sacconema*	12
Calothrix	9	*Gloeocystis*	13	*Microcystis*	5	*Scytonema*	12
Chondrocystis	5	*Gloeotrichia*	11	*Nostoc*	7, 8	*Spirulina*	4
Coelosphaerium	6	*Jaaginema*	9	*Nostochopsis*	13	*Stigonema*	13
Chroococcus	5	*Keriochlamys*	13	*Oscillatoria*	9	*Synechococcus*	5
Coscinodiscus	13	*Leibleinia*	10	*Phormidium*	10	*Tolypothrix*	12