

GENERA OF LICHEN PHOTOBIONTS

After Poelt (1969) and Ahmadjian (19__)

Rev. 2/94

This is somewhat incomplete, and may be partly out of date, but it should be adequate for recognizing the genera or groups most frequently used in distinguishing genera or species of lichens.

1. Cell contents \pm blue-green, less often brown, the coloring diffuse; chloroplasts and pyrenoids absent. KEY I. CYANOBACTERIA

1. Cell contents not blue-green, but green or yellow-green, or orange-red to golden due to the presence of carotenoids, with clearly differentiated chloroplasts and sometimes also pyrenoids. 2

2. Motile cells (seen only in culture) with flagella of unequal length. In lichenized state, forming single cells or short compressed filaments; in culture, developing a highly branched filamentous thallus; cells may contain up to 10 or more band-shaped chloroplasts. XANTHOPHYCOPHYTA (YELLOW-GREEN ALGAE): Heterococcus (syn. Monocilia)

2. Motile cells with flagella of equal length. Usually (in most lichen-forming genera) with a single, non band-shaped, chloroplast per cell. KEY II. CHLOROPHYCOPHYTA (GREEN ALGAE)

I. CYANOBACTERIA

1. Cells solitary or in colonies, spherical or ellipsoid, all similar, not in chains (in squash mounts). 2

1. Cells aggregated into filaments, all cells similar or differentiated into vegetative cells and heterocysts. 4

2. Cells aggregated into colonies of 2-4(-16), surrounded by a thin, uniform, rarely obscurely laminated close-fitting sheath. Chroococcus

2. Cells aggregated into colonies of 2-8(rarely more), with loose, lumpy, homogeneous or often clearly layered gelatinous sheaths. Gloeocapsa s. lato. According to Poelt, the sheath color is probably due to the substrate and not to the composition of the lichen, and therefore should not be employed as a taxonomic criterion, and the delimitation of lichen genera on the basis of "Gloeocapsa" vs. "Xanthocapsa" is questionable. 3

3. Sheaths, particularly in the cortex of the lichen thallus, reddish or violet. Above all in lichens on non-calcareous substrates. Gloeocapsa s. str.

3. Sheaths in the lichen cortex yellow or yellow-brown. Above all in lichens on calcareous substrates. "Xanthocapsa"

3a. Upper part of thallus, lying on or just below substrate surface, composed of decumbent, short filaments or groups of cells with a thick gelatinous sheath; lower part of thallus made up of long filaments. Growing in the intertidal zone of the seashore, often on and within mollusk shells. In the lichen Pyrenocollema. Hyella

3a. Thallus not as above. Habitat various, but not on or in mollusk shells. 4

4. Filaments (older parts) composed of cells in 2-4 rows by division in all planes. True branching present. In the lichen genera Ephebe, Spilonema, and the cephalodia of some species of Stereocaulon. Stigonema

4. Filaments of uniseriate cells, these, however, often aggregated, without true branching. 5

5. Filamentous nature of the colonies clearly evident. Cells mostly spherical to cylindrical or disc-shaped. 6

5. Filamentous nature of the colonies obscure. Cells somewhat deformed. Unkeyable unless isolated in culture..... forms of Nostoc, Scytonema, Rivulariaceae

6. Cells isodiametric, rounded, 3-6 um broad. Filaments unbranched, with intercalary heterocysts, either imbedded in a firm gelatinous sheath and forming contorted beadlike chains (in the lichen family Collemataceae) or imbedded in gelatinous masses (e.g., in the lichen family Pannariaceae). Hormogonia common, usually formed by rupture of the filament at a point between a heterocyst and a vegetative cell. Nostoc

6. Cells more than 5 um in at least one dimension, more often angular than rounded, mostly broader than long. 7

7. Filaments with basal or terminal heterocysts, apically attenuate (difficult to see). In various lichen genera, especially in the family Lichinaceae. KEY I-A. Rivularioid algae (Rivularia, Dichothrix, Calothrix)

7. Filaments with intercalary heterocysts, not apically attenuate; with false dichotomous branching. Filaments one cell thick. Branches originating between two heterocysts and extending out from the side of filament, either singly or in pairs. In the lichen genera Coccocarpia, Polychidium, etc. Scytonemoid algae (Scytonema)

I-A RIVULARIOID ALGAE

Rivularia

Usually with basal heterocyst. Thallus freely branched, bushy, with false branching; lower parts of filaments (up to 6) often lying in a common gelatinous matrix. Dichothrix

Mostly with terminal heterocysts. Thallus of single or clustered filaments, which are \pm parallel, mostly upright and undivided. Filaments often ending in hair-like projections. Only one trichome within a sheath. Calothrix

II. GREEN ALGAE

1. Cells in definite filaments or sheets, mostly very thick-walled. In fresh material usually orange or golden yellow to reddish brown (often visible by scratching the thallus under a dissecting scope). Starch absent (no iodine reaction). Trentepohlioid algae. 2

1. Cells solitary or clumped, seldom thin-walled and in short chains, or (at least in culture) filamentous or sheet-forming, but in fresh material usually green. Starch present. 3

2. Cells in multilayered sheets which may develop erect filamentous outgrowths, or in radially disposed filaments. Sporangia produced at tips of filaments (even in lichenized state). In the lichen, the fungus sometimes causes the alga to lose its plate-like shape and form irregular, radiating filaments, or rarely, the fungus will separate the algal thallus into single cells. In the foliicolous lichen Strigula. Cephaleuros

2. Cells in uniseriate filaments, in a lichen, sometimes small and irregular or separated into single cells. Cells with thick walls turning deep violet in zinc chloride-zinc iodide solutions. If the cells seem solitary they are cylindrical, barrel-shaped or ellipsoid, 1-3 times longer than wide. The cells are larger than those of most other lichen-forming green algae, 10-20 μm along the long axis. Cells containing droplets of an orange-red pigment (β -carotene) which often obscure the parietal chromatophores. Zoospores quadriflagellate; gametes biflagellate; akinetes present. In many crustose genera, e.g. Gyalecta, Ionaspis, Graphis, etc., and many tropical and subtropical genera. Trentepohlia (Syn. Chroolepis)

3. Thallus of solitary or clumped cells, seldom thin-walled and in short chains. Chlorococcoid algae. 6

3. Thallus (at least in culture) filamentous or plate-like. 4

4. Thallus plate-like, usually one-cell thick, usually retaining this condition in most lichen associations, but sometimes the fungus causes the algal thallus to be non-radiating and slightly irregular. In the lichen genera Arthonia, Mazozia, Opegrapha, Porina, Trichothelium. ULOTRICHALES: Phycopeltis

4. Thallus filamentous or of solitary cells. 5

5. In a lichen, consisting mostly of single cells; when pieces of the lichen thallus are kept in a culture medium, the alga grows out of the fungal tissue and remains in a single-cell condition. Cells which are not in a gelatinous matrix form zoospores (up to 64 per sporangium) which can then give rise to an irregular filamentous thallus. A single pyrenoid is present in young cells,

but up to 3 pyrenoids have been found in older cells. In the lichen genus Thrombium. ULOTRICHALES: Leptosira

5. Forming highly branched, long-celled filaments when free from fungal tissue; cells with parietal chloroplast and pyrenoid. Cells \pm elongated in culture. In the lichen genus Verrucaria. ULOTRICHALES: Pseudopleurococcus

6. Cells mostly apparently cylindrical, ellipsoid, ovoid, or with right-angled edges (examine many cells). 7

6. Cells broad-ellipsoid to round or pear-shaped. It is usually impossible to determine these algae from squash mounts, since classification depends on the reproductive cycle. For keying out lichen genera a further determination is usually not critical. In a wide range of lichen genera. KEY II-A. Protococcoid algae (also called Trebouxoid algae)

7. Cells cylindrical with rounded or obtuse ends; chloroplast parietal, not extending length of cell; without pyrenoid; forming small, simple filaments consisting of cells joined loosely end to end; cells tending to break away from each other such that filaments are rarely more than a few cells long. In many members of the lichen order Caliciales. Stichococcus

7. Cells egg-shaped to ellipsoid or spherical. 8

8. Cells oblong-ovoid to ellipsoid or almost spherical, 7-12 x 4-10 μ m; chloroplasts parietal, flat to dumbbell-shaped or cup-shaped, generally without a pyrenoid. Cell wall often slightly gelatinous (or with a gelatinous sheath). In the lichen genera Peltigera, Solorina, Multiclavula, etc.; also a common epiphyte on lichen thalli. Coccomyxa

8. Cells short-ellipsoid, pear-shaped or spherical. (see KEY II-A)

II-A. PROTOCOCCOID (TREBOUXIOID) GREEN ALGAE

1. Gelatinous sheaths thick, non-confluent (each cell with its own sheath). Cells in small colonies, rounded to pear-shaped; chloroplast goblet-shaped with a basal pyrenoid. Individual cells becoming motile or dividing to form 4-8 biflagellate zoospores. Gloeocystis

1. Gelatinous sheath thin or absent. 2

2. Cells with a large central convoluted chloroplast and 1-3 pyrenoids. 3

2. Cells with parietal goblet-shaped or flattened chloroplasts which apparently occupy the entire cell lumen. 4

3. Cell wall with wart-like projections in localized parts (rarely seen in lichenized state). Cells spherical. Chloroplast irregularly star-shaped. Trochiscia

3. Cell wall not ornamented. Cells spherical to ellipsoidal or pear-shaped; vegetative cells to 34 um diam. Central pyrenoid usually clearly visible in lichenized algal cells, not as clear in cultured cells. Nucleus lying near cell wall between folds of outer margin of chromatophore. Colonies on agar are of various shapes and consistencies, often granular and elevated above the agar surface. In many lichen genera, particularly the majority of conspicuous foliose and fruticose lichens. Two main groups: 1) (usually in fruticose lichens) with margin of chloroplast finely divided into narrow lobes which extend to the cell wall, and segments of the chloroplast during division are band-shaped and parietal; 2) (usually in foliose or crustose lichens) margin of chloroplast smooth or not finely divided, and segments during division retaining central position and not band-like. Trebouxia (including Pseudotrebourgia)

4. Cells aggregated into small clumps by their confluent gelatinous sheaths. 5

4. Cells without sheaths. 6

5. Chloroplasts cup-shaped; pyrenoids present; cells not forming pseudofilaments. Cells spherical to ellipsoidal. Chloroplast parietal. In a lichen the cells have a more folded chloroplast with several pyrenoids. In the lichen genus Lecidea, for example. Chlorosarcina

5. Chloroplasts flattened; pyrenoids absent; cells forming pseudofilaments (irregular filaments with slightly elongated end cells, breaking down easily into single cells). Cocobotrys

6. Cells at least partly aggregated or forming short, irregularly filamentous groups. Cells spherical to ellipsoidal, in packets of 2-4 or sometimes clustered into large groups. Chloroplast parietal, cup-shaped, with pyrenoid. Reproduction by vegetative division only (no

spores). Particularly in the lichen family Verrucariaceae sensu lato; also in Lecidea; often free-growing on bark or rock, or epiphytic on lichens. Protococcus auct. (including Pleurococcus and Desmococcus)

6. Cells mostly solitary (?). 7

7. Cells with polar thickenings in older cells and very large, cup-shaped chloroplast (often lacking in symbiosis) lining almost all of the internal cell surface. Cells globose when young, to pear-shaped when older, 2.5-16(-31) um across; mature cells (presporangial) sometimes having a lateral wall thickening; cells with large central nucleus and nucleolus. In the lichenized state, the chromatophore is highly folded and resembles the large central chromatophore of Trebouxia, from which it can be distinguished by the lack of a pyrenoid. Myrmecia

7. Cells not as above, short ellipsoid or spherical. Chloroplast thin, cup-shaped. Pyrenoid present. Reproduction by aplanospores, up to 16 per cell, usually fewer. Chlorella

ADD (UNDER GREEN ALGAE, PROBABLY UNDER PROTOCOCCOIDS):

Thallus single-celled or forming short, irregular filaments:

Cells irregularly rounded (average size 3 x 5 um), often elongated at one end, with pale green parietal plate-like chloroplast without pyrenoid; packets breaking apart as individual cells assume variety of shapes. In the lichen Dermatocarpon. CHLOROSPHAERALES: Hyalococcus

Cells spherical (to ellipsoidal), to 12 um diam.; chloroplast plate-like or bowl-shaped, with pyrenoid; cells sometimes forming gelatinous sheath, which may be confluent. In the lichen genus Lecidea. CHLOROCOCCALES: Pseudochlorella (Syn. Chlorellopsis, Jaagia)