CYANOLICHEN KEYS

(After Poelt, 1969, Poelt & Vezda Erg. II, etc.)

Rev. 4/96; still needs a lot of work

1. Ascocarps true perithecia, with ± dark wall. 2
1. Ascocarps apothecia (sometimes perithecioid, but then with pale wall), or thallus sterile. 5

2. Spores muriform. 3
2. Spores simple or 1-septate. 4

3. On moss and soil, mostly above timberline. Spores hyaline to brownish. Thallus grayish, gelatinous; perithecia depressed-globose, ± superficial. .....Microglaena s. lato (see Pyrenolichen keys for more info.)
3. On bark, subtropical. Spores brown-black. Thallus brownish black. ..... Pyrenothrix (nigra)

4. With Nostoc; growing on rock; spores simple. .....Hassea (bacillosa)
4. With Hyella and 1-septate spores, or if with Nostoc or spores simple, then on bark or soil. .....Pyrenocollema (s. lato)

5. Thallus endolithic in calcareous substrates. Apothecia with radiating fissures around a central pore-like disk, ± conical, pale. Algae scytonemoid. .....(Petractis)
5. Thallus growing entirely above the substrate. Apothecia without radiating fissures. 6

6. Thalli large (usually 2 cm or more in diameter, often much larger; lobes mostly 5-10 mm or more wide), not swelling markedly when rehydrated. Corticate over at least the upper surface, with a thick pseudoplectenchymatous cortex, loosely attached to the substrate, Algae (usually Nostoc) tightly aggregated. Underside smooth, cobwebby, or with veins or rhizines or both. Occurring (mostly) in moist climates. .....KEY I
6. Thallus crustose to minutely squamulose, or foliose to dark fruticose and then swelling markedly when rehydrated and black to dark grayish brown. Spores almost always colorless. .....KEY II

I. LARGE CYANOLICHENS

1. Lower side of thallus corticate, with cyphellae, pseudocyphellae, or marginate white bare areas separated by network of channels corresponding to ridges on upper surface. 2

1. Lower surface without cyphellae, or bare white spots (but white papillae occur in Nephroma resupinatum). 4

> **2. Lower surface with obvious cyphellae (sunken into the surface);** thallus gray, gray-brown, or black, frequently sorediate or isidiate and then seldom fruiting. ...Sticta
>
> **2. Thallus without cyphellae, with pseudocyphellae or white bare areas.** 3

3. Lower side with tiny, white or yellow pseudocyphellae. .....Pseudocyphellaria

3. Lower side with coarse, plainly marginate, whitish, hairless spots separated by network of channels. .....Lobaria

> **4. Apothecia present.** 5
>
> **4. Apothecia absent.** 11

5. Apothecia on the morphological lower side of the lobes, which become reflexed so that the apothecia stand vertical to nearly horizontal. Lower side corticate, felty or smooth, light colored. .....Nephroma

5. Apothecia produced on the morphological upper side of the lobes. 6

> **6. Apothecia flush with the surface to deeply immersed, in the center of the lobes, not on the margins.** .....Solorina
>
> **6. Apothecia not deeply sunken; either borne on the lobe margins or constricted at the base.** 7

7. Apothecia not constricted, originating superficially on the lobe margins such that the remains of the cortex are visible beneath the apothecium. .....Peltigera

7. Apothecia constricted at the base, originating near the center of the lobes; cortex on lower side continuous with that of thallus. 8

> **8. Upper side of thallus (at least towards margins) cobwebby-hirsute or scabrid-areolate to verrucose.** 9
>
> **8. Upper side smooth to wrinkled or ridged (or felted-tomentose to pruinose in Pannaria and Parmeliella).** Thallus foliose to squamulose. ... 10

9. Upper surface cobwebby or hirsute margins. Apothecia lecanorine. Thallus foliose. Cortex paraplectenchymatous. Lower side corticate, with veins or only numerous rhizines.
Maritime. .....Erioderma
9. Upper surface scabrid-areolate to verrucose. Apothecia lecideine. ..... Leioderma

> **10. Upper cortex composed of rectanuglar cells formed from periclinally oriented hyphae. Medulla of unbranched periclinal hyphae arranged in the lengthwise direction of the lobes. Lower cortex of rectangular, thick-walled cells formed from periclinal hyphae. Photobiont Scytonema.** 11
> **10. Upper cortex composed of isodiametric cells formed from vertically oriented hyphae. Medulla of loosely woven hyphae intricating in various directions, or if hyphae periclinal along long axis of lobes, then branched. Lower cortex absent. Photobiont Nostoc.** Thallus squamulose, to foliose at the margins, when dry blue-gray to brown or dark and discolored, thick, commonly cartilaginous and rigid. Apothecia sessile, regular in outline, with a visible proper margin; thalline margin absent or present. Paraphysoids long, branched. These two genera are often extremely difficult to distinguish even when fertile (the supposed distinction given below is now rejected by some authors, and I don't understand what other differences there might be), and so are treated together under Pannaria. 12

11. Apothecia adnate, often irregular in outline, without proper and thalline margins. Paraphysoids lacking. Underside densely rhizinate, blue-black. Thallus bluish gray. Apothecia biatorine (with a non-carbonaceous, non-thalloid exciple), black. .....Coccocarpia
11. Apothecia sessile, regular in outline, with a visible proper margin; thalline margin present or absent. Paraphysoids long, branched. ..... Degelia

> **12. Apothecia, at least when young, usually lecanorine, with algae.** .....Pannaria
> **12. Apothecia biatorine, without algae.** .....Parmeliella

13. Lower side felty. 14
13. Lower side corticate, or if appearing felty (e.g., Coccocarpia) then rhizines blue-black. 15

> **14. Lower side with veins.** ..... Peltigera
> **14. Lower side without veins.** ..... Pannaria and Parmeliella

15. Aquatic. With veins on underside. .....Hydrothyria (venosa)
15. Terrestrial. 16

16. Thallus with rhizines. 17
16. Thallus without rhizines. .....Nephroma

17. Upper surface cobbwebby-hirsute (Erioderma) or scabrid-areolate to verrucose (Leioderma). ..... (Erioderma and Leioderma)
17. Upper surface smooth to ridged. These genera probably cannot be distinguished when sterile, and sterile species should be cross referenced in the species keys for both. ..... (Coccocarpia and Degelia)

II-A. SMALL, GELATINOUS CYANOLICHENS WITH NOSTOC

1. Thallus with loosely disposed Nostoc filaments, ± swollen and gelatinous when wet, black to dark brown. 2
1. Thallus with tightly aggregated Nostoc, not swollen or gelatinous when wet. ..... (see KEY II-B)

2. Apothecia present. 3
2. Apothecia absent. 10

3. Spores unicellular. 4
3. Spores 2- or more-celled. 7

4. Spores acicular, spirally coiled. Thallus a rosette of radially arranged, narrow, thin lobes. On bark or rock. .....(see Koerberia)
4. Spores short, not spirally twisted, at the most fusiform. 5

5. Thallus appearing large foliose, with many adventive lobules and isidia, sometimes with elongated lobes. On bark. .....Physma
5. Thallus crustose to squamulose or dwarf fruticose, ecorticate. 6

6. Apothecia lecideine (with a black carbonaceous exciple), the hypothecium dark. Thallus small, mealy, granular, or dwarf fruticose. Growing on moss and plant debris, arctic-alpine. .....Leciophysma
6. Apothecia lecanorine. Thallus crustose to clearly foliose, umbilicate, or dwarf fruticose. Spores simple, subglobose to globose. .....Lempholemma

7. Underside with distinct veins; thallus large, thin and brittle, lead-colored to brownish or blackish, loosely lobed. Growing on rocks submerged in running water. Thallus corticate. .....Hydrothyria (venosa)
7. Underside without distinct veins, but sometimes wrinkled; if growing submerged in water, then thallus small. 8

8. Apothecia biatorine, small. Thallus mealy-pustulate. Photobiont in chains of 2-3 cells or more, often folded, rarely single-celled or forming packets surrounded by individual pale or colored gelatinous sheath. Spores thin-fusiform or vermiform, (5-)7-8(-14)-septate. On moss and humus, arctic and subarctic. .....Arctomia

8. Apothecia lecanorine. Thallus crustose to subfruticose or large and foliose. Photobiont bead-like, in lax chains suspended in a conspicuous, colorless, gelatinous matrix. Spores, habitat and distribution various. 9

9. Thallus, except for the apothecia, ecorticate or almost, very gelatinous (swelling strongly when wet), variable in shape, the surface usually dull, dark green-black, rarely with a reddish tinge. Apothecia lecanorine. Spores mostly 4-celled to sub-muriform, sometimes acicular. .....Collema

9. Thallus corticate (usually with a single layer of well-defined, rounded to cuboid cells, sometimes less distinct), less strongly gelatinous, more constant in shape, the surface often shiny, blue-gray to brownish, reddish, or greenish but not black. Thallus sometimes with white hairs or tomentum (usually only on underside). (if white hairs present on upper side, also see Leptochidium albociliatum)
.....Leptogium

10. Thallus corticate. .....(Arctomia, Leptogium, and Hydrothyria)

10. Thallus ecorticate. ....(Physma, Collema, Leciophysma and Lempholemma)

II-B. SMALL CYANOLICHENS WITH FILAMENTOUS, NON-SHEATHED PHOTOBIONTS (GELATINOUS OR NOT, BUT IF NOSTOC, THEN NON-GELATINOUS)

1. Apothecia sunken in, and surrounded by, the thick, appressed-squamulose thallus. Spores 1-celled. Thallus pseudoplectenchymatous. On soil or rock in dry areas. [Solorina spongiosa, with 4 large, brown spores per ascus, will also key out here] 2

1. Apothecia superficial, although frequently with a thalloid exciple, or immersed in a dwarf fruticose thallus.
..... 3

> **2. Thallus of umbilicate, gray-black squamules or lobes, sometimes with marginal soralia. Spores many per ascus.**
> .....Peltula
> **2. Thallus not umbilicate, loosely adnate to free at the margin. Spores 8 per ascus.** .....Heppia

3. Thallus robust, squamulose to nearly foliose, or forming rosettes. Apothecia lecanorine or biatorine, not lecideine and black. Thallus with a paraplectenchymatous cortex. Squamules distinct from the hypothallus, with ± well-differentiated rhizines. [If upper surface of thallus hairy-cobwebby or scabrid-areolate to verrucose, see Erioderma and Leioderma]. 4

3. Thallus crustose-scaly to dwarf-fruticose, or if obscurely squamulose to minutely foliose, then the apothecia are lecideine and black. 9

> **4. Spores 12-16 per ascus. Thallus a closely adnate rosette, stellate-radiate, with pale lower surface and rhizines, with or without isidia. Upper surface longitudinally grooved and striate.** Photobiont Scytonema. In temporary seepage areas on rocks. (If sterile, may be easily confused with Koerberia; if thallus squamulose, not radiating, see Peltula) .....Vestergrenopsis
> **4. Spores 8 per ascus. Thallus with other characters.** Spores simple to 1-septate. [If spores multiseptate, see Arctomia] 5

5. Spores 1-celled, elliptical, rarely 2-celled in Pannaria leucophaea s. l.; thallus blue-gray, pale gray, or black, frequently sorediate to isidiate and then seldom fruiting. 6

5. Spores 2-celled, or 1-celled, acicular and spirally coiled.
..... 7

> **6. Upper cortex composed of rectangular cells formed from**

periclinally oriented hyphae. Medulla of unbranched periclinal hyphae arranged in the lengthwise direction of the lobes. Lower cortex of rectangular, thick-walled cells formed from periclinal hyphae. Photobiont Scytonema. [If Apothecia adnate, irregular in outline, without proper and thalline margins, and paraphysoids lacking, see Coccocarpia]. ..... Degelia

6. Upper cortex composed of isodiametric cells formed from vertically oriented hyphae. Medulla of loosely woven hyphae intricating in various directions, or if hyphae periclinal along long axis of lobes, then branched. Lower cortex absent. Photobiont Nostoc. ..... Pannaria and Parmeliella

7. Thallus with scattered white hairs; undulating imbricate-foliose, blackish or greenish black, On moss and soil. .....Leptochidium albociliatum

7. Thalli without hairs. 8

8. Spores 2-(-4)-celled, elliptic-fusiform. Squamules + overlapping, mostly growing over mosses, over wet, non-calcareous rocks, yellowish to reddish brown (dull green when moist), pale beneath with a few concolorous brown rhizines, the margins mostly with isidia or lobules. Apothecia frequent or not; thalline exciple absent. Photobiont Nostoc. Montane and boreal. .....Massalongia (carnosa)

8. Spores 2-celled, fusiform, or 1-celled acicular and twisted. Thallus a rosette of elongate, twisted to flattened lobes, the upper surface with isidia and lobuli, dark gray to olive, (sometimes?) longitudinally grooved and striate. On bark and non-calcareous stone. .....Koerberia

9. Apothecia lecideine, black. Thallus minutely fruticose, mealy, of closely aggregated filaments, or effigurate-fosettiform with elongate-cylindrical to flattened lobes. .....Placynthium

9. Apothecia lecanorine or biatorine, not black. Spores 1- or seldom 2-celled. Thallus usually mealy crustose to dwarf fruticose. [If spores multiseptate, see Arctomia]. 11

10. On bark or on moss over rock. Thallus corticate, the medulla without algae. Thallus much-branched and bushy, or prostrate, green, gray or brownish to brown-black, often shiny. Photobiont Nostoc or Scytonema. .....Polychidium

10. Growing directly on rock or soil. 11

11. Spores 1-celled, many per ascus. .....Peltula

11. Spores 2-celled. 12

12. Algal filaments (Stigonema) with true branching. 13
12. Algal filaments simple or with false branches. 14

13. Lobules with blue-green rhizines. Filaments erect, circinate, densely aggregated, very thin. On non-calcareous rock. .....Spilonema
13. Lobules without rhizines, more loosely organized, often thickish. On seepage areas on cliffs. .....Ephebe

14. Thallus of delicate branches, with Scytonema. 15
14. Thallus mealy to strongly dwarf-fruticose, with Calothrix or Dichothrix. 16

15. Thallus resembling an unlichenized Scytonema colony. Algal sheaths sparsely colonized by hyphae. Branching often unilateral. Apothecia lateral, biatorine. Photobiont Scytonema. On dry calcareous and wet non-calcareous cliffs. .....Thermutis velutina
15. Thallus definitely lichenized, made up of filaments branching dichotomously in all directions, the filaments corticate below withh several layers of straplike hyphae. Apothecia lateral, lecanorine. Spores 16-24 per ascus, elliptical. .....Zahlbrucknerella

16. Thallus strongly dwarf-fruticose. .....Lichina
16. Thallus mealy-squamulose and amorphous, or indistinctly placodioid. .....Porocyphus

II-C. SMALL, NON-GELATINOUS CYANOLICHENS WITH UNICELLULAR PHOTOBIONTS WHICH OFTEN FORM COLONIES

1. Algae of the Chroococcus type. Algal cells large, isodiametric, with a thick gelatinous sheath. Sheaths not concentrically arranged. Algal cells not at all aggregated into filaments. 2

1. Algae of the Gloeocapsa type, the algae building larger colonies with concentric sheaths, or aggregated into false filaments. 4

> **2. Thallus foliose, umbilicate, the upper surface reticulately veined. Apothecia sunken and remaining closed.** On non-calcareous stone which is sometimes wet, boreal and montane. .....Phylliscum
>
> **2. Thallus crustose. Apothecia sessile, with a punctiform or expanded disc.** 3

3. Apothecia with an exposed hymenium, appearing lecanorine. ..... Cryptothele (syn. Pyrenopsidium according to Henssen & Büdel, 1984)

3. Apothecia with a punctiform disc, appearing perithecia-like. ..... Pterygiopsis (syn. Forsellia)

> **4. Thallus dwarf-fruticose.** Apothecia superficial. ...3
>
> **4. Thallus foliose, squamulose, or crustose.** Spores unicellular. 5

3. Filaments to 180 um thick, 1-3 mm long, rigidly erect, thick. Apothecia rare, superficial, lecanorine. Algae present in epihymenium. Spores mostly 48, oval. On periodically wet non-calcareous rocks. .....Lichinella

3. Branches much thicker, and up to 3-4 mm long. 4

> **4. Algal sheaths red or violet toward the cortex (of the lichen) (Gloeocapsa s. str.).** .....Synalissa (symphorea)
>
> **4. Algal sheaths yellowish toward the cortex ("Xanthocapsa").** .....Peccania

5. Algal sheaths reddish in the cortex, K± purplish. Apothecia lecanorine. Spores unicellular, usually 8 per ascus. 6

5. Cortical algal sheaths yellow to yellow-brown (or colorless?), K-. (Some Pyrenopsis spp. will also key out here). 7

> **6. Apothecia narrowly opened, ± perithecia-like or urceolate; paraphyses non-septate (?), ± swollen and moniliform above.**

Ascus with wall I- but apical dome I+ blue.
.....Pyrenopsis

6. Apothecial discs broadly open from an early stage, lecanorine; paraphyses septate, slender, not swollen and muriform above. Asci with inner wall I+ blue but apical dome I-. .....Euopsis

7. Hymenium with an entire to cracked epithecium containing algae. .....Lichinella (syn. Gonohymenia)

7. Apothecium without a true epithecium, or at least upper hymenium not containing algae. 8

8. Thallus umbilicate or foliose. 9

8. Thallus crustose and ± areolate, to squamulose or coralloid.
.....Psorotichia

9. Hyphae short-celled, forming a loose, small-meshed paraplectenchymatous network. .....Anema (dodgei)

9. Hyphae not paraplectenchymatous.
.....Thyrea

Gloeheppiaceae
(Lichinales)

After Henssen, 1995

1. Thallus peltate, broad-lobed, 5-9 mm diam., pruinose on both surfaces, attached by a broad umbilicus, intenally completely gelatinous. Mexico. ..... Gudelia mexicana
1. Thallus not with those characters, internally with cavities and/or interstices. Without internal cephalodia. 2

> **2. Apothecia of simple structure.** Thallus inflated, surface smooth. Asci mainly 16-spored. Mexico. ..... Gloeoheppia polyspora
> **2. Apothecia of complex structure.** Mexico. ..... Pseudopletula (P. myriocarpa and P. heppioides)

ALTERNATIVE KEYS TO SMALL CYANOLICHENS

The growth form of many cyanolichens is very plastic and difficult to describe, and often ranges from crustose to foliose or fruticose within the same genus. Likewise the substrate can be rather variable. However, the following is an attempt to group genera according to somewhat field-oriented characteristics. For more info., see the earlier keys.

ALT-1 THALLUS DWARF FRUITCOSE, APPRESSED TO ERECT

1. On bark. ..... Polychidium
1. On other substrates. 2

> **2. On soil, moss, or plant remains.** Photobiont filamentous. 3
> **2. On rock.** Photobiont filamentous or not. 6

3. Photobiont loosely arranged Nostoc. Thallus gelatinous. 4
3. Photobiont not Nostoc, or if so then thallus not gelatinous. Spores simple, short, not spirally twisted, at the most fusiform. 5

> **4. Spores 2- or more-celled.** Thallus corticate (Leptogium) or ecorticate (Collema). ..... (Collema and Leptogium)
> **4. Spores simple.** Thallus corticate (Leciophysma) or ecorticate (Lempholemma). ..... (Leciophysma and Lempholemma)

5. Spores many per ascus. Apothecia immersed. In desert areas. .....Peltula
5. Spores 8/ascus. Apothecia adnate to sessile. In moist climates. .....Polychidium

> **6. Growing in the intertidal zone of the seashore (Atlantic coast).** ..... Lichina
> **6. Not in the intertidal zone, but may be in the spray zone.** 7

7. Photobiont of the Gloeocapsa type, unicellular but building larger colonies with concentric sheaths, or aggregated into false filaments. Apothecia superficial. 8
7. Photobiont filamentous, with or without sheaths. 10

> **8. Filaments to 180 um thick.** On periodically wet non-calcareous rocks. .....Lichinella
> **8. Branches much thicker,** and up to 3-4 mm long. [Note: species of Pyrenopsis are crustose, but may have coralloid branches and then

also key out here]. 9

9. Algal sheaths red or violet toward the cortex (of the lichen) (Gloeocapsa s. str.). .....Synalissa (symphorea)
9. Algal sheaths yellowish toward the cortex ("Xanthocapsa"). [Note: species of Psorotichia are crustose, but may have coralloid branches and then also key out here]. .....Peccania

10. Thallus with loosely arranged Nostoc, + swollen and gelatinous when wet, black to dark brown. 11
10. Thallus without Nostoc, or else not swollen or gelatinous when wet. 12

11. Spores unicellular, short, not spirally twisted, at the most fusiform. Apothecia lecanorine. Spores simple, subglobose to globose. On rocks or mortar. ..... (Lempholemma)
11. Spores 2- or more-celled. ..... Collema and Leptogium

12. Spores many per ascus, simple. Apothecia immersed. .....Peltula
12. Spores 8 per ascus, or if more (Zahlbrucknerella) then apothecia adnate to sessile. 13

13. Apothecia lecideine, black. Thallus minutely fruticose. On flat, level rock surfaces which are sometimes wet, calcareous or not. .....Placynthium
13. Apothecia lecanorine or biatorine, not black. Spores 2-celled. 14

14. Algal filaments (Stigonema) with true branching. 15
14. Algal filaments simple or with false branches. 16

15. Lobules with blue-green rhizines. Filaments erect, circinate, densely aggregated, very thin. On non-calcareous rock. .....Spilonema
15. Lobules without rhizines, more loosely organized, often thickish. On seepage areas on cliffs. .....Ephebe

16. Photobiont Scytonema. 17
16. Photobiont Calothrix or Dichothrix. On periodically inundated or spray-drenched cliffs. .....Lichina

17. Thallus resembling an unlichenized Scytonema colony. Algal sheaths sparsely colonized by hyphae. Branching often unilateral. Apothecia lateral, biatorine. On dry calcareous and wet non-calcareous cliffs. .....Thermutis velutina

17. Thallus definitely lichenized, made up of filaments branching dichotomously in all directions, the filaments corticate below withh several layers of straplike hyphae. Apothecia lateral, lecanorine. Spores 16-24 per ascus, elliptical. Photobiont Scytonema. .....Zahlbrucknerella

ALT-2 THALLUS ± COARSELY FOLIOSE OR UMBILICATE, NOT RADIATE, MOSTLY ± LOOSELY APPRESSED OR ASCENDING

1. Underside with distinct veins; thallus large. Growing on rocks submerged in running water. Thallus corticate. .....Hydrothyria (venosa)

1. Underside without distinct veins, but sometimes wrinkled; if growing submerged in water, then thallus small. 2

> **2. Thallus with white hairs or tomentum, at least on lower surface.** ..... (see Leptochidium and Leptogium)
>
> **2. Thallus without hairs or tomentum.** 4

3. Thallus with loosely disposed Nostoc filaments, ± swollen and gelatinous when wet, black to dark brown. 2

3. Thallus with tightly aggregated Nostoc, not swollen or gelatinous when wet. 7

> **4. Thallus corticate.** Spores 2- or more-celled. ..... Leptogium
>
> **4. Thallus ecorticate.** 5

5. Spores unicellular. 6

5. Spores 2- or more-celled. On various substrates. ..... Collema

> **6. On bark.** Thallus appearing large foliose, with many adventive lobules and isidia, ecorticate. Apothecial exciple pseudoplectenchymatous. .....Physma
>
> **6. On rocks, mortar, bryophytes or soil.** Apothecia lecanorine. Thallus clearly foliose, umbilicate. Spores subglobose to globose. .....Lempholemma

7. Photobiont filamentous. 8

7. Photobiont unicellular, forming colonies. 12

> **8. Apothecia, if present, immersed. Spores many per ascus. Thallus umbilicate-squamulose, tightly appressed, not lobed at margins. Growing in deserts (but sometimes in moist microhabitats).** (If spores 8 per ascus see Heppia). ..... (see Peltula)
>
> **8. Apothecia adnate to sessile. Spores 8 per ascus. Thallus foiliose, not umbilicate. Growing in moist climates.** 9

9. Upper side of thallus (at least towards margins) cobwebby-hirsute (Erioderma) or scabrid-areolate to verrucose (Leioderma). ..... Erioderma and Leioderma

9. Upper side smooth to wrinkled or ridged (or felted-tomentose to pruinose in Pannaria and Parmeliella). 10

10. Upper cortex composed of rectanuglar cells formed from periclinally oriented hyphae. Medulla of unbranched periclinal hyphae arranged in the lengthwise direction of the lobes. Lower cortex of rectangular, thick-walled cells formed from periclinal hyphae. Photobiont Scytonema. 11

10. Upper cortex composed of isodiametric cells formed from vertically oriented hyphae. Medulla of loosely woven hyphae intricating in various directions, or if hyphae periclinal along long axis of lobes, then branched. Lower cortex absent. Photobiont Nostoc. ..... Pannaria and Parmeliella

11. Apothecia adnate, often irregular in outline, without proper and thalline margins. Paraphysoids lacking. .....Coccocarpia

11. Apothecia sessile, regular in outline, with a visible proper margin; thalline margin present or absent. Paraphysoids long, branched. ..... Degelia

12. Algae of the Chroococcus type. Algal cells large, isodiametric, with a thick gelatinous sheath. Sheaths not concentrically arranged. Algal cells not at all aggregated into filaments. .....Phylliscum

12. Algae of the Gloeocapsa type, the algae building larger colonies with concentric sheaths, or aggregated into false filaments. Spores unicellular. Cortical algal sheaths yellow to yellow-brown (or colorless?), K-. 13

13. Hymenium with an entire to cracked epithecium containing algae. Spores (8 or?) many per ascus. On rocks. .....Lichinella (syn. Gonohymenia)

13. Hymenium without a true epithecium, or at least without algae. 14

14. Hyphae short-celled, forming a loose, small-meshed paraplectenchymatous network. .....Anema (dodgei)

14. Hyphae not paraplectenchymatous. .....Thyrea

ALT-3 THALLUS RADIATING, PLACODIOID TO FINELY LOBED-FOLIOSE, CLOSELY APPRESSED

1. Thallus with loosely disposed Nostoc filaments, + swollen and gelatinous when wet, black to dark brown. On various substrates. ..... see Leptogium, Collema, and Lempholemma
1. Photobiont not Nostoc, or thallus not gelatinous. 2

2. On bark. 2
2. On other substrates. 3

3. Spores 1-celled, elliptical, rarely 2-celled in Pannaria leucophaea s. l.; thallus blue-gray, pale gray, or black, frequently sorediate to isidiate and then seldom fruiting. (If photobiont unicellular, in colonies, see Thyrea girardi). ..... (see Degelia, Pannaria and Parmeliella)
3. Spores 2-celled, fusiform, or 1-celled acicular and twisted. Thallus a rosette of elongate, twisted to flattened lobes, the upper surface with isidia and lobuli, dark gray to olive, (sometimes?) longitudinally grooved and striate. .....Koerberia (biformis)

4. On soil, moss, or plant remains. ..... Pannaria and Parmeliella
4. On rock. 5

5. Upper surface of lobes longitudinally striate (lens). Lobes very thin, narrow and tightly appressed. These two genera are difficult to distinguish when sterile (which is frequently the case in the saxicolous, isidiate species); Koerberia is mostly temperate, while Vestergrenopsis is mostly arctic, but there may be some overlap. 6
5. Upper surface of lobes not striate. 7

6. Spores 8 per ascus. ..... Koerberia (sonomensis)
6. Spores 12-16 per ascus. ..... Vestergrenopsis

7. Apothecia sunken in, and surrounded by, the thallus. On rock in dry areas. Spores many per ascus, unicellular. .....Peltula (placodizans)
7. Apothecia superficial, although frequently with a thalloid exciple. 8

8. Apothecia (if present) lecanorine or biatorine, not lecideine and black. Thallus frequently sorediate to isidiate and then seldom fruiting. ..... (see Erioderma and Leioderma, Coccocarpia and Degelia, and Pannaria and Parmeliella, in key to foliose genera)
8. Apothecia lecideine and black. .....Placynthium

ALT-4 THALLUS CRUSTOSE TO SQUAMULOSE, NOT RADIATING. ON BARK, SOIL, MOSS, OR PLANT DEBRIS.

1. **On bark.** 2
1. **On other substrates.** (if on wood, see Euopsis?). 3

2. Thallus with loosely disposed Nostoc, gelatinous. ..... Collema and Leptogium
2. Thallus not gelatinous. ..... Pannaria and Parmeliella

3. Photobiont Gloecapsa, unicellular, forming colonies. ..... (see Euopsis pulvinata)
3. Photobiont filamentous. 4

4. Thallus with loosely disposed Nostoc filaments, ± swollen and gelatinous when wet, black to dark brown. (Solorina spongiosa will also key out here; the thallus contains green algae but is frequently reduced, and the apothecia frequently rest on a spongy cushion of partially buried coralloid cephalodia containing Nostoc; the spores are 4 per ascus, over 30 um long, and brown) 5
4. Thallus with tightly aggregated Nostoc, not swollen or gelatinous when wet. 9

5. Thallus corticate. Spores 2- or more-celled. 6
5. Thallus ecorticate. Spores simple or septate. 7

6. Apothecia biatorine, small. Thallus mealy-pustulate. Photobiont in chains of 2-3 cells or more, often folded, rarely single-celled or forming packets surrounded by individual pale or colored gelatinous sheath. Spores thin-fusiform or vermiform, (5-)7-8(-14)-septate. On moss and humus, arctic and subarctic. .....Arctomia
6. Apothecia lecanorine. Thallus crustose to subfruticose Photobiont bead-like, in lax chains suspended in a conspicuous, colorless, gelatinous matrix. Spores, habitat and distribution various. ..... Leptogium

7. Spores unicellular. 8
7. Spores 2- or more-celled. ..... Collema

8. Apothecia lecideine (with a black carbonaceous exciple), the hypothecium dark. Thallus small, mealy, growing on moss and plant debris, arctic-alpine. .....Leciophysma
8. Apothecia lecanorine. Thallus crustose. Spores subglobose to

globose. .....Lempholemma

9. Apothecia sunken in, and surrounded by, the thick, appressed-squamulose thallus, or apothecia absent, and squamules with sorediate margins. On soil in deserts. Spores 1-celled. 10

9. Apothecia, if present, superficial, although frequently with a thalloid exciple. In moist climates. 11

10. Thallus of umbilicate, gray-black squamules or lobes, sometimes with marginal soralia. Spores many per ascus. .....Peltula

10. Thallus not umbilicate, loosely adnate to free at the margin. Spores 8 per ascus. .....Heppia

11. Spores multiseptate. Thallus crustose-scaly. Cortex one cell thick. ..... (Arctomia)

11. Spores simple to 1-septate. Thallus usually robust, squamulose (but sometimes entirely granular, in Parmeliella cyanolepra). Cortex usually 3-4 or more cells thick. The following genera are very difficult to distinguish when sterile. 12

12. Spores 1-celled, elliptical, rarely 2-celled in Pannaria leucophaea s. l.; thallus blue-gray, pale gray, or black, frequently sorediate to isidiate and then seldom fruiting. Upper cortex composed of isodiametric cells formed from vertically oriented hyphae. Medulla of loosely woven hyphae intricating in various directions, or if hyphae periclinal along long axis of lobes, then branched. Lower cortex absent. Photobiont Nostoc. ..... Pannaria and Parmeliella

12. Spores 2-(-4)-celled, elliptic-fusiform. Squamules ± overlapping, mostly growing over mosses, over wet, non-calcareous rocks, yellowish to reddish brown (dull green when moist), pale beneath with a few concolorous brown rhizines, the margins mostly with isidia or lobules. Apothecia frequent or not; thalline exciple absent. Montane and boreal. .....Massalongia (carnosa)

ALT-5 THALLUS CRUSTOSE TO SQUAMULOSE, NOT RADIATING. ON ROCK.

1. Thallus of loosely arranged Nostoc, gelatinous. ..... (Collema, Leptogium, and Lempholemma)
1. Thallus not gelatinous, or not with Nostoc. 2

2. Photobiont filamentous. 3
2. Photobiont unicellular, forming colonies. 6

3. Apothecia lecideine, black. Thallus mealy, of closely aggregated filaments. .....Placynthium
3. Apothecia (if present) lecanorine or biatorine, not black. Spores 1- or seldom 2-celled. Thallus usually mealy crustose. 4

4. Spores 1-celled (rarely 2-celled in Pannaria leucophaea); or apothecia absent. 5
4. Spores 2-celled. .....Porocyphus

5. Growing in deserts. Apothecia, if present, immersed. Spores many per ascus. [If spores 8 per ascus, see Heppia lutosa] .....Peltula
5. Growing in moist climates. Apothecia, if present, adnate to sessile. Spores 8 per ascus. ..... Pannaria and Parmeliella

6. Algae of the Chroococcus type. Algal cells large, isodiametric, with a thick gelatinous sheath. Sheaths not concentrically arranged. Algal cells not at all aggregated into filaments. Thallus crustose. Apothecia sessile, with a punctiform or expanded disc. 7
6. Algae of the Gloeocapsa type, the algae building larger colonies with concentric sheaths, or aggregated into false filaments. Spores unicellular. 8

7. Apothecia with an exposed hymenium, appearing lecanorine. .....Pyrenopsidium
7. Apothecia with a punctiform disc, appearing perithecia-like. ..... Pterygiopsis

8. Hymenium with an entire to cracked epithecium containing algae. .....Lichinella (syn. Gonohymenia)
8. Apothecium without a true epithecium; upper hymenium not containing algae. 9

9. Algal sheaths reddish in the cortex, K+ purplish. Apothecia lecanorine. Spores unicellular, usually 8 per ascus. 10
9. Cortical algal sheaths yellow to yellow-brown (or colorless?), K-.

(Some Pyrenopsis spp. will also key out here). 11

10. Apothecia narrowly opened, ± perithecia-like or urceolate; paraphyses non-septate (?), ± swollen and moniliform above. Ascus with wall I- but apical dome I+ blue.
.....Pyrenopsis
10. Apothecial discs broadly open from an early stage, lecanorine; paraphyses septate, slender, not swollen and muriform above. Asci with inner wall I+ blue but apical dome I-. .....Euopsis

11. On non-calcareous rock. Asci with distinctly thickened apices, I-, but with an I+ blue apical dome. ..... Pyrenopsis
11. On usually calcareous rock. Asci uniformly thin-walled, entirely I-. .....Psorotichia