Lichens

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TRICHY-24

LICHENS

- Lichen – an association between a fungus and an alga.
- Mycobiont – the fungal partner in a lichen.
- Photobiont – the photosynthetic partner in a lichen; either a green alga or cyanobacterium.

LICHENS

- One of the most successful mutualistic associations in the world.
- Over 13,500 species based on the mycobiont.
- Early inhabitants of the harsh environments of the Silurian and Devonian.

LICHENS

- Worldwide distribution, often in the most extreme environments, Arctic, Antarctic, deserts and all other habitats.
- Primary colonizers in primary succession.
- Occur on soil, plants, animals, rocks, decorate tombstones, buildings, etc.
- Rare in polluted areas - intolerant of industrial pollutants, especially sulfur dioxide.

LICHENS

- Mycobiont usually takes up about 90% of the thallus and is usually an ascomycete (most are inoperculate discomycetes) or occasionally a basidiomycete (eg. *Omphalina*, *Multiclavula*).
- Photobiont may be a green alga, cyanobacterium or both. Both the algae and cyanobacteria fix carbon and the cyanobacteria fix nitrogen.

What do we mean by fix carbon and nitrogen?

LICHENS

- 1868 - Schwendener hypothesized that lichens are symbiotic associations of fungi and algae.
- 1831-1888 - DeBary believed that the symbionts excrete and benefit from an exchange of metabolites, the alga receiving minerals, water and nitrogen from the fungus, the fungus receiving carbohydrates from the alga.

Photobionts

- 24 genera of green algae are lichenized; *Trebouxia* accounts for >75% of known lichens.

Photobionts

- About 10% of lichens have a cyanobacterium as the only or primary photobiont; most of these belong to *Nostoc*.

Mycobiont/Photobiont Interface

Intercellular haustoria or wall to wall contact.

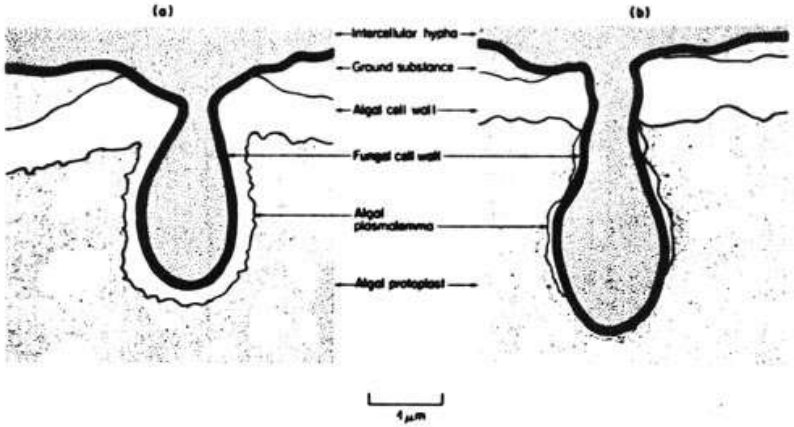

Figure 66 Diagram of mode of penetration of algal cells by hyphae within lichen thalli: (a) invagination but no rupture of host cell wall; (b) rupture of host cell wall and invagination of algal plasmalemma

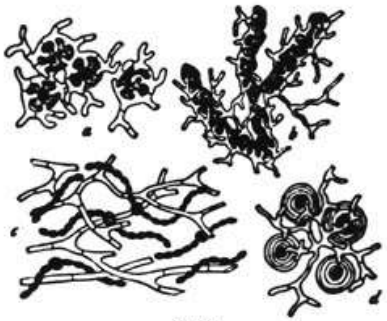

FIGURE 1

Algal types with associated fungal hyphae. *a*, Cystococcus, each cell surrounded by haustoria. *b*, Trentepohlia, showing a branching chain of cells, surrounded by haustorial hyphae. *c*, Nostoc, showing the algal filaments and the intermingled fungal hyphae. *d*, Gloeocapsa, showing the haustoria and the fungal hyphae surrounding the algal cells. *a*, enlarged 750 diameters; *b*, 375 diameters; *c*, 500 diameters; *d*, 650 diameters. From Schneider.

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Mycobiont/Photobiont Interface

Table 21
Types of hypha–algal cell interaction in different genera of lichen algae

	Type of interaction[a]		
	Contact	Invagination	Penetration
Green algae			
Trebouxia	+	+	+
Stichococcus	–	+	+
Myrmecia	–	–	+
Blue-green algae			
Gloeocapsa	+	+	–
Nostoc	+	–	–
Scytonema	–	+	–
Calothrix	+	–	–
Stigonema	+	–	–

[a] + present; – absent.

Advantages to the alga?

- Mechanical protection from injury & high light by being tightly enveloped by hyphae.
- Improved water relations and resistance to desiccation.
- Provides minerals.

Advantages to the fungus?

- Organic nutrients (carbon & nitrogen) provided by photobiont.
- Lichenized fungi have greater longevity.
- Most lichenized fungi are never found free-living in nature.

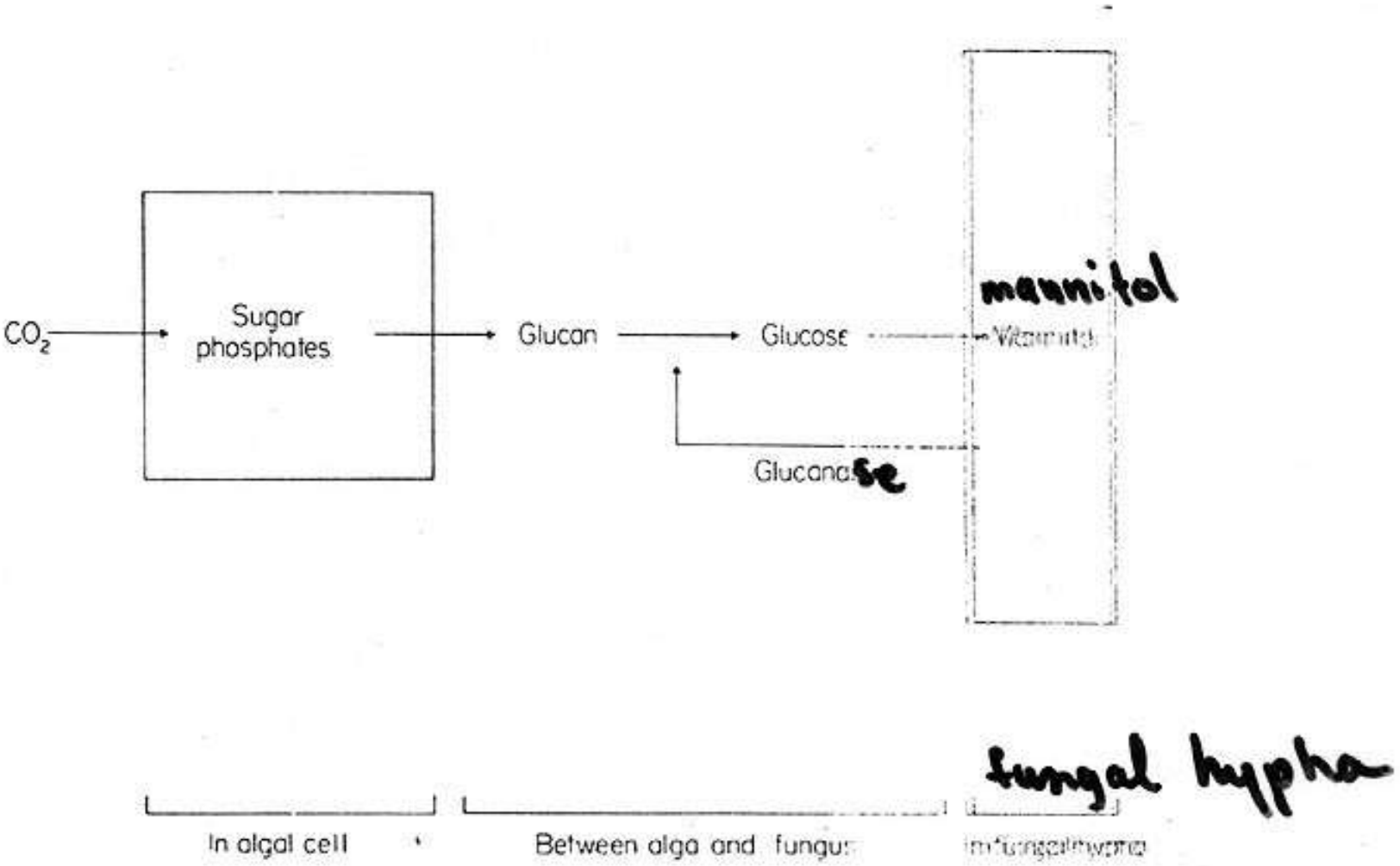


Figure 71 *Peltigera polydactyla*, possible mechanism of transfer of photosynthate from alga to fungus. After Hill, 1972

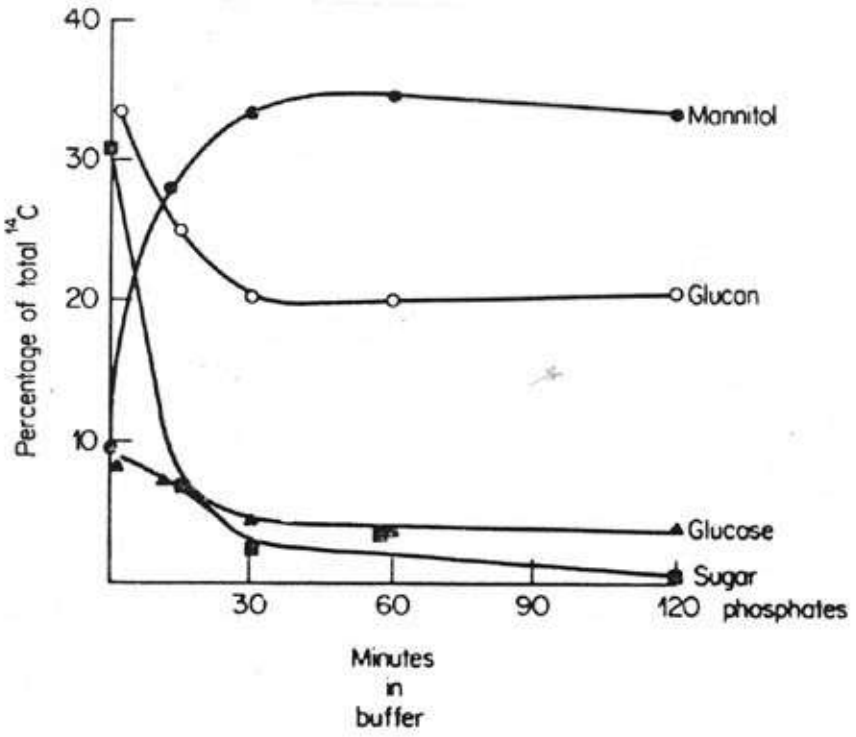


Figure 70 *Peltigera polydactyla*, redistribution of ^{14}C in various fractions after pulse feeding with labelled CO_2 followed by incubation in buffer. Modified from Hill, 1972; by permission of *New Phytologist*

Table 24
Changes in levels of ^{14}C in fractions after pulse feeding with $^{14}CO_2$ (after Hill, 1972)

Fraction	Change in ^{14}C after pulse as percentage of total counts	
Mannitol	+50	
Glucose	−3	total −50
Sugar phosphates	−31	
Glucan	−16	

Some lichens have been taken apart and put back together again but environmental conditions must be just right for reassociation to occur.

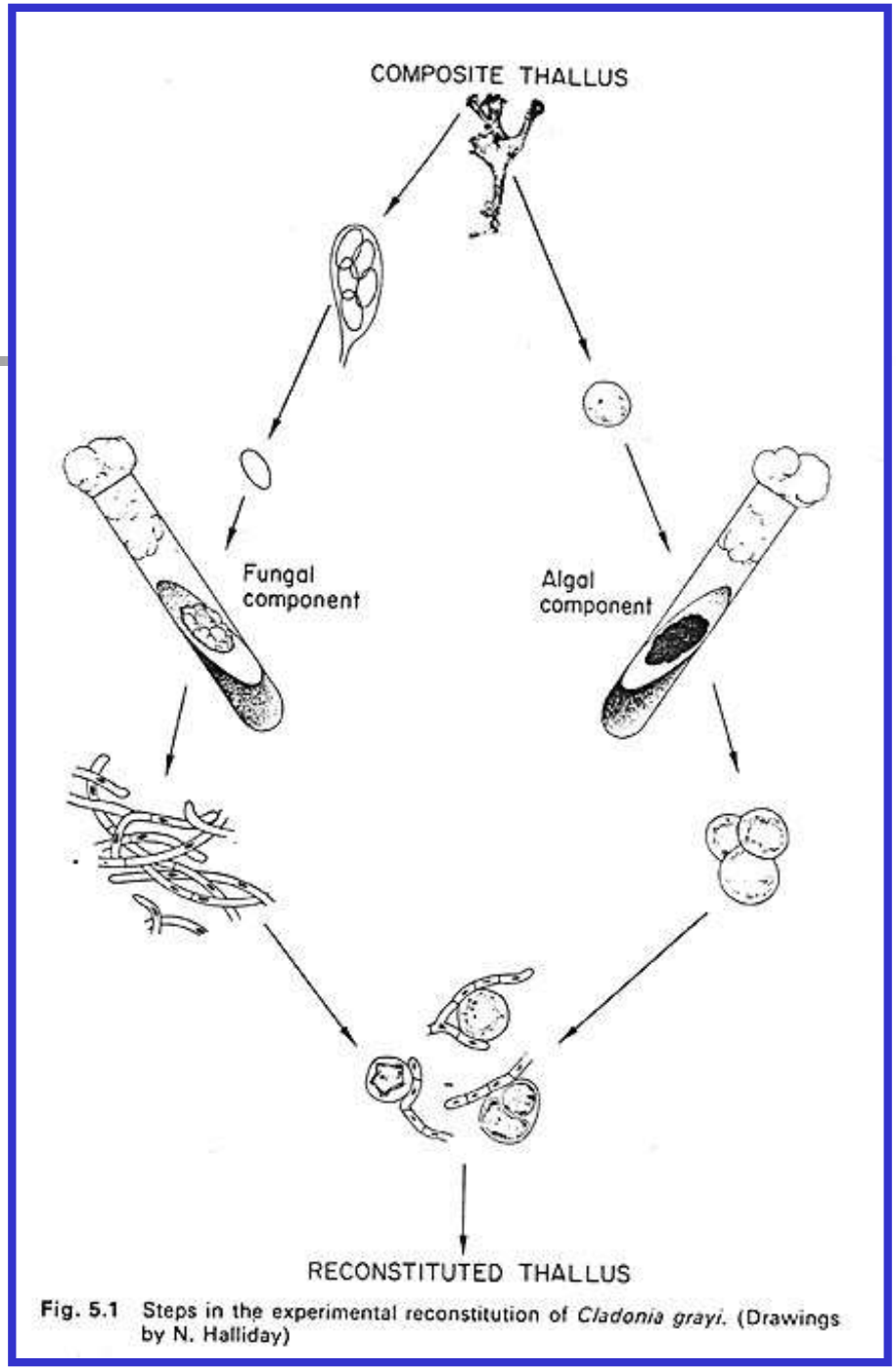


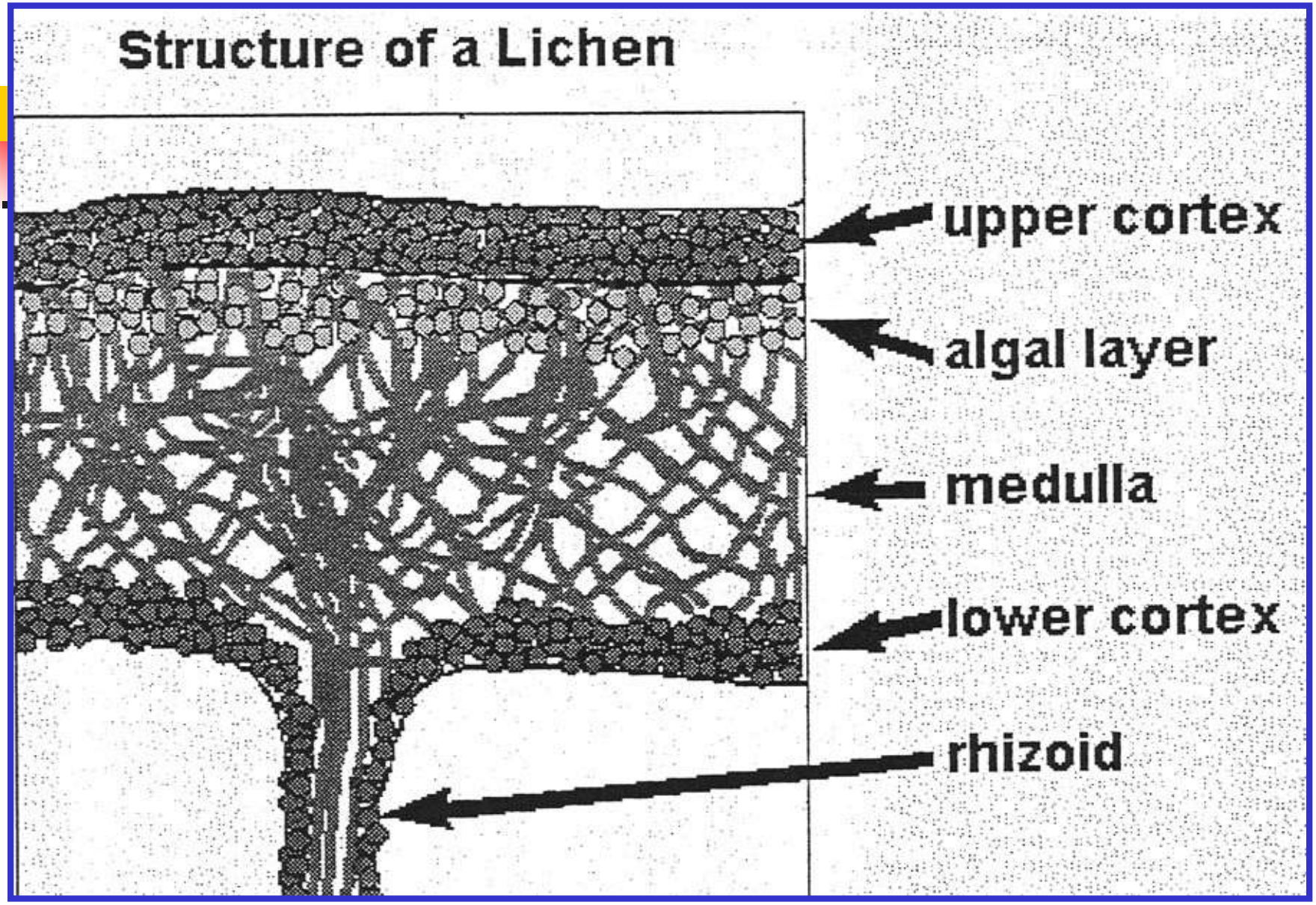
Fig. 5.1 Steps in the experimental reconstitution of *Cladonia grayi*. (Drawings by N. Halliday)

LICHENS

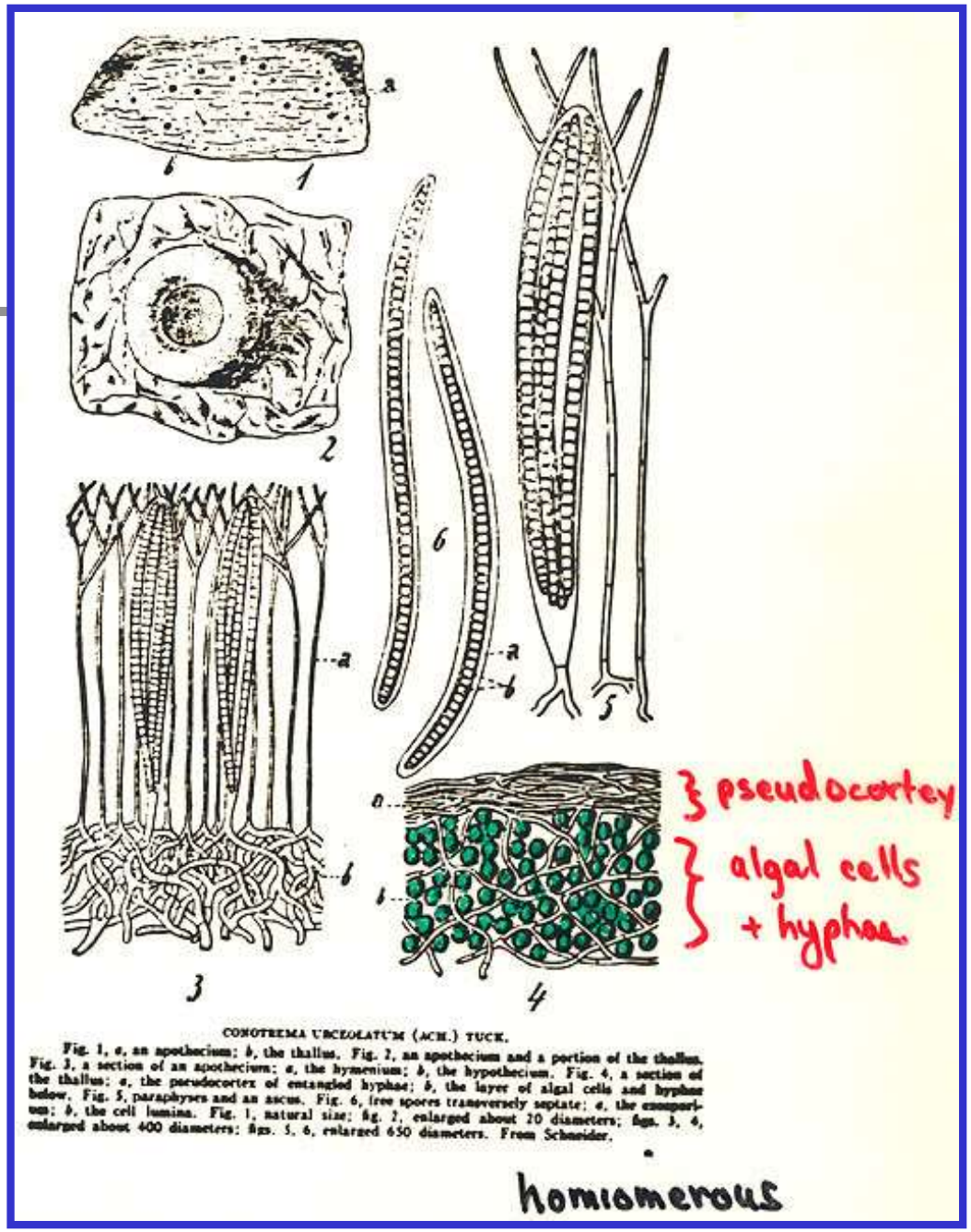
- Are composite organisms that have a different morphological appearance than either of the symbionts.
- Consist of a
  - Cortex (upper and/or lower).
  - Medulla (fungal layer).
  - Algal layer.

Anatomy of Lichens

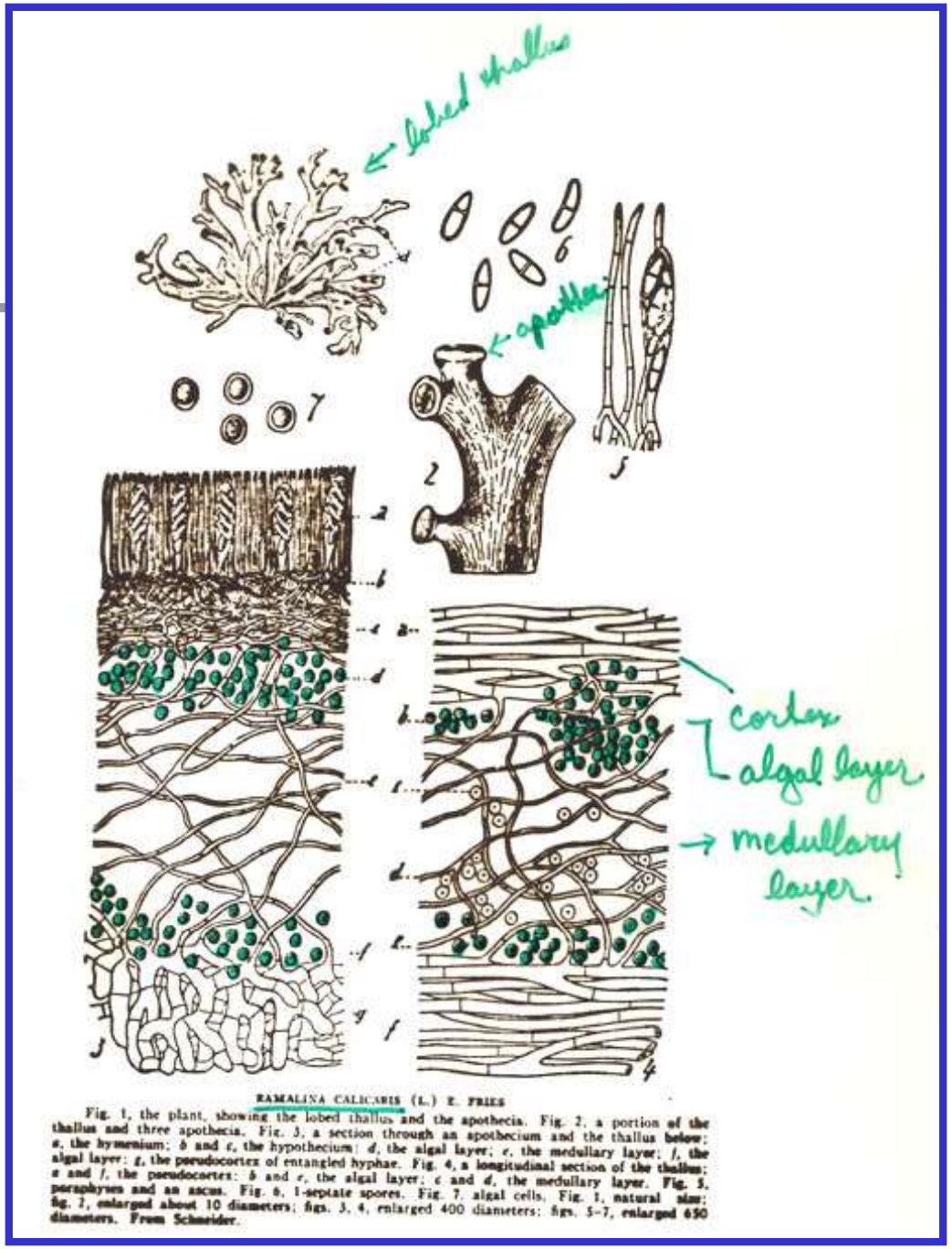
- Stratified - differentiated into cortex (upper and/or lower) and medulla with the photobiont cells forming a discrete layer.
- Non-stratified - photobiont cells evenly distributed throughout thallus.


Structure of a Lichen
upper cortex
algal layer
medulla
lower cortex
rhizoid

Non-stratified, algal cells distributed throughout.



Stratified lichen.



RAMALINA CALICARIS (L.) R. FRIES

Fig. 1, the plant, showing the lobed thallus and the apothecia. Fig. 2, a portion of the thallus and three apothecia. Fig. 3, a section through an apothecium and the thallus below: *a*, the hymenium; *b* and *c*, the hypothecium; *d*, the algal layer; *e*, the medullary layer; *f*, the algal layer; *g*, the pseudocortex of entangled hyphae. Fig. 4, a longitudinal section of the thallus: *a* and *f*, the pseudocortex: *b* and *e*, the algal layer; *c* and *d*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, 1-septate spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5–7, enlarged 650 diameters. From Schneider.

LICHEN THALLI

- Dust/leprose - Lack both upper & lower cortex, medulla attached directly to substrate.
- Crustose - Lack a lower cortex, attached directly to the substrate by medullary hyphae.
- Squamulose - Lack a lower cortex, composed of scale-like segments, often forming erect podetia.

LICHEN THALLI

- Foliose - Flattened,leaf-like thalli with an upper and lower cortex, often with rhizines.
- Fruticose - Strap or thread like, often attached to substrate by holdfast.

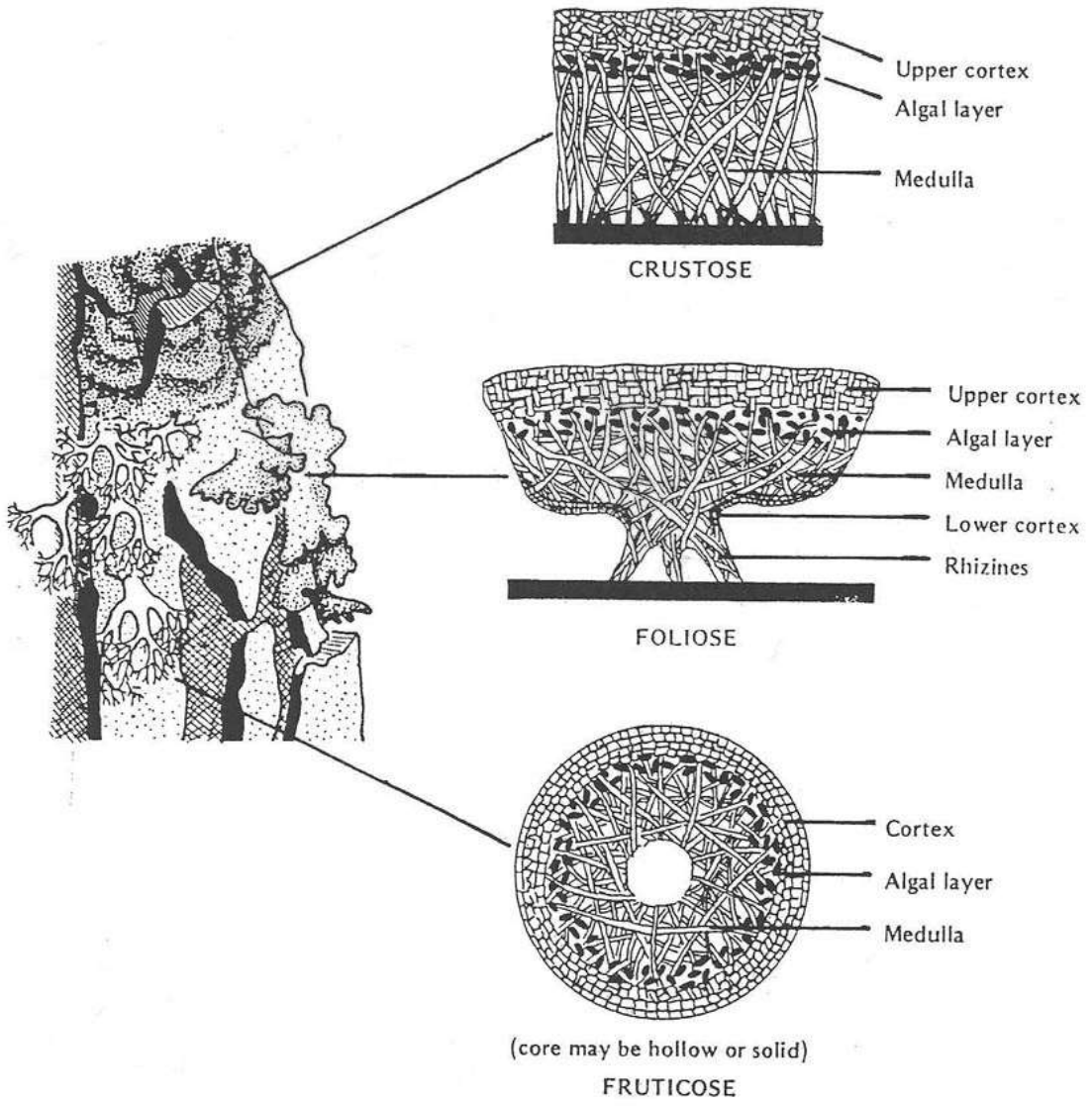
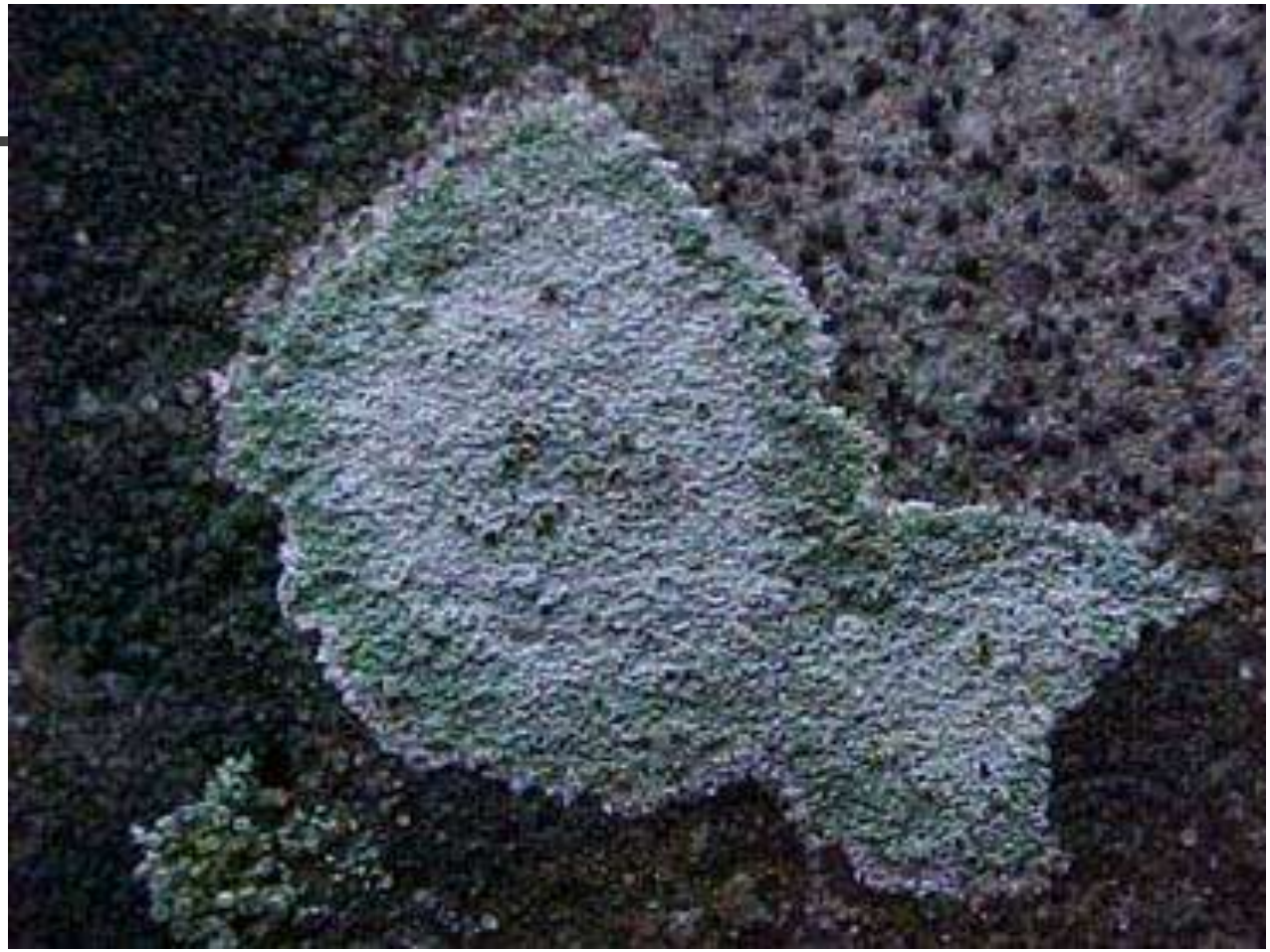
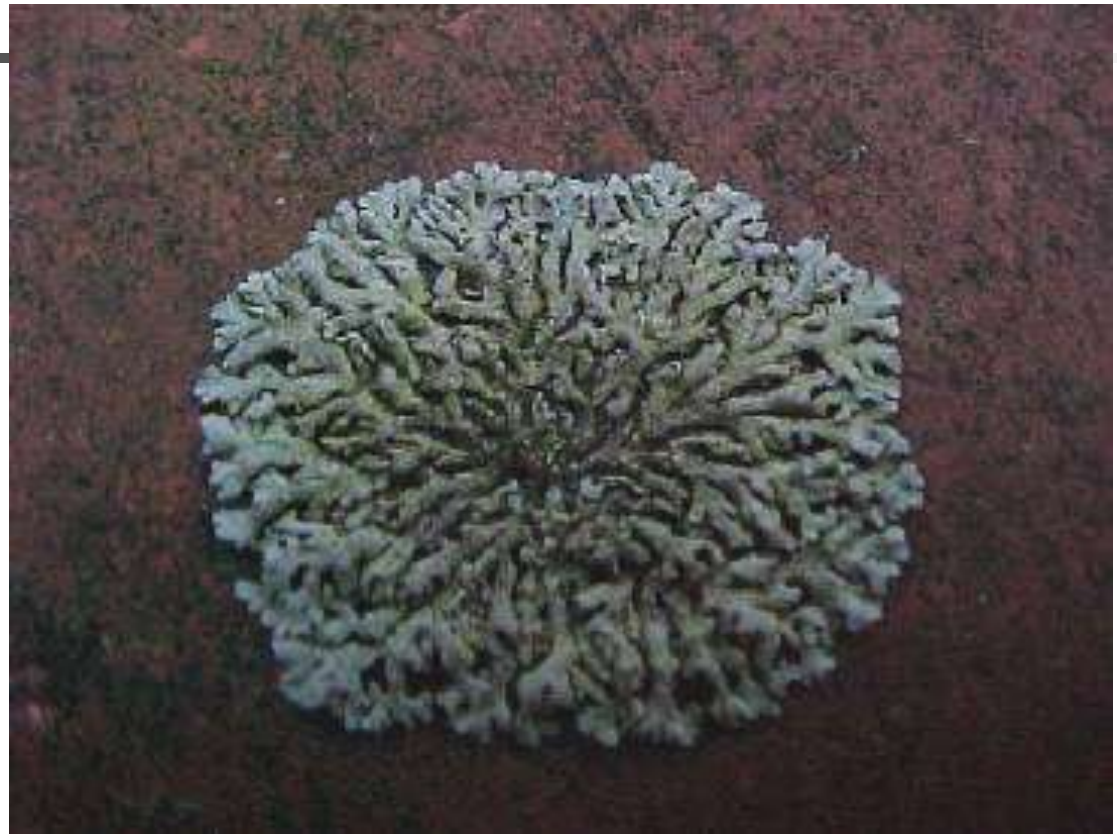


Fig. 2. Three main types of lichen thalli (i.e., crustose, foliose, and fruticose, and their different layers). [From Ahmadjian and Paracer, 1986. University Press of New England.]

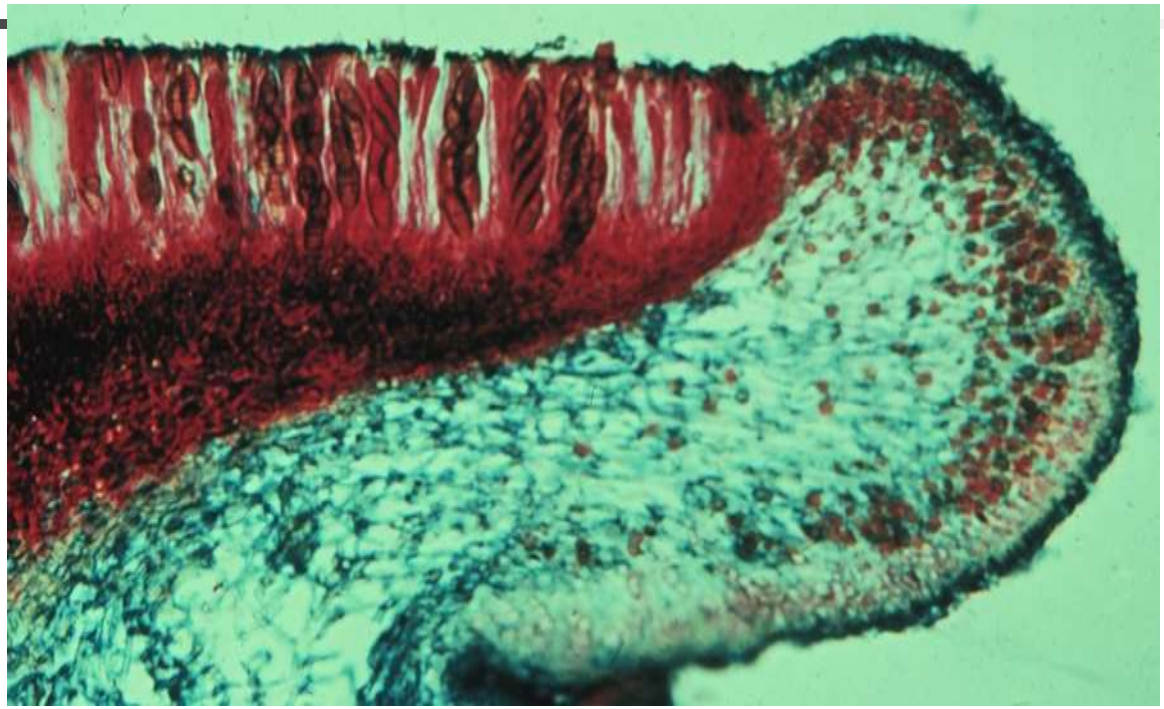


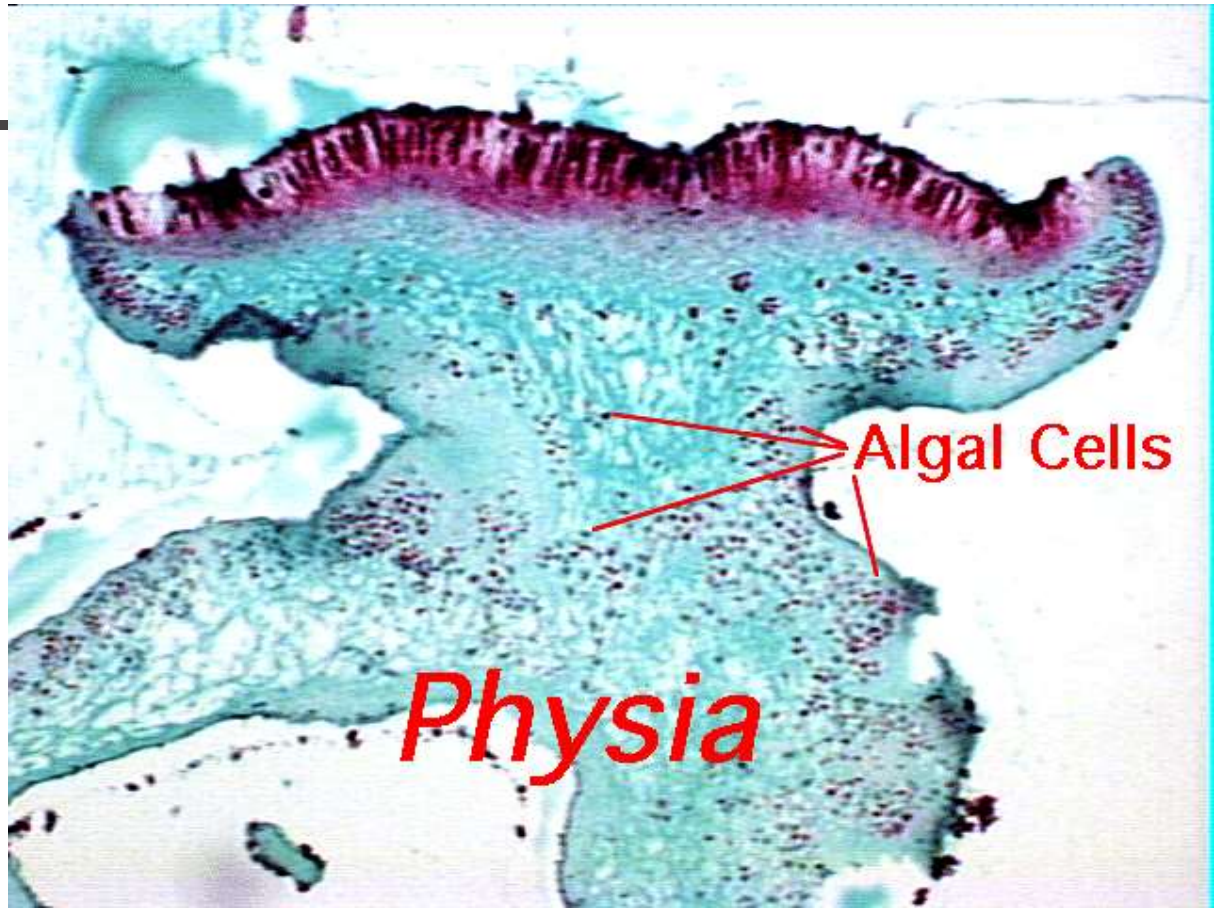


From Sylvia and Stephen Sharnoff (See web site below)

REPRODUCTION

- Meiospores (ascospores & basidiospores).
- Conidia
- Vegetative propagules
  - Cephalodia - gall-like swellings containing cyanobacteria on or in thallus with algal photobiont; primary function is nitrogen fixation, but may also be a propagule.
  - Isidia - small, cortex-covered protuberances containing fungal and algal cells.
  - Soredia - A few algal cells surrounded by fungal hyphae formed in small, pustule-like breaks in cortex called soralia.




Algal Cells
Physia

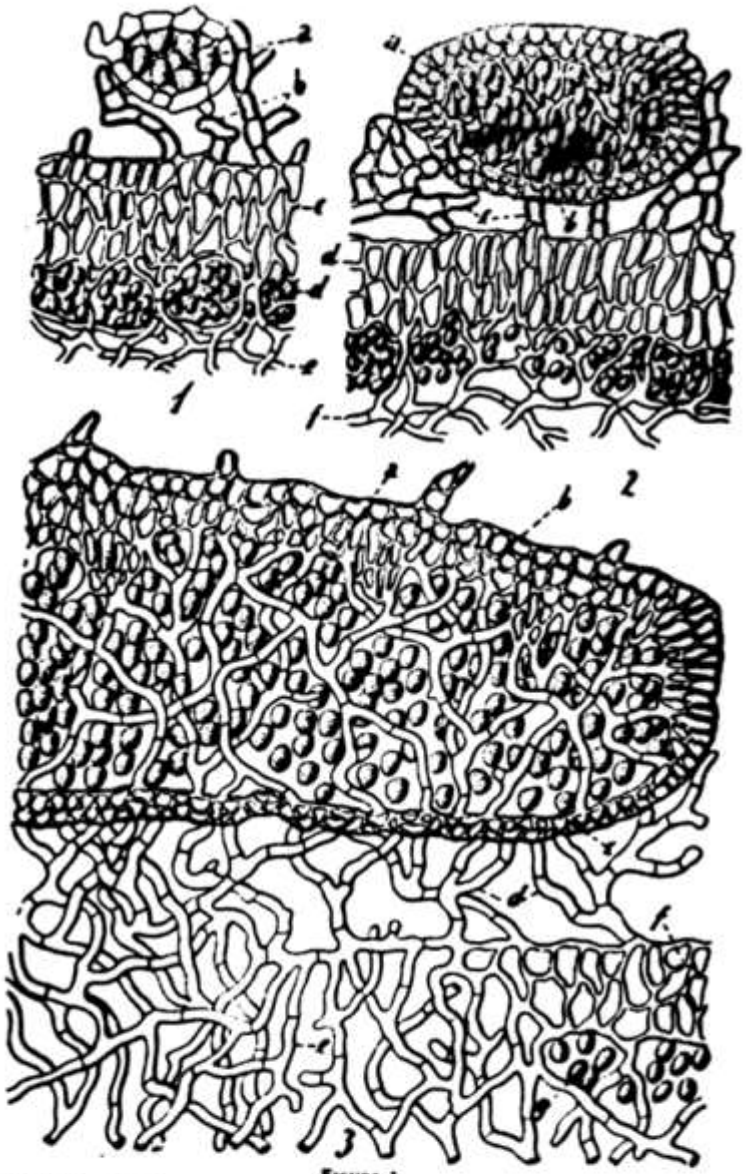
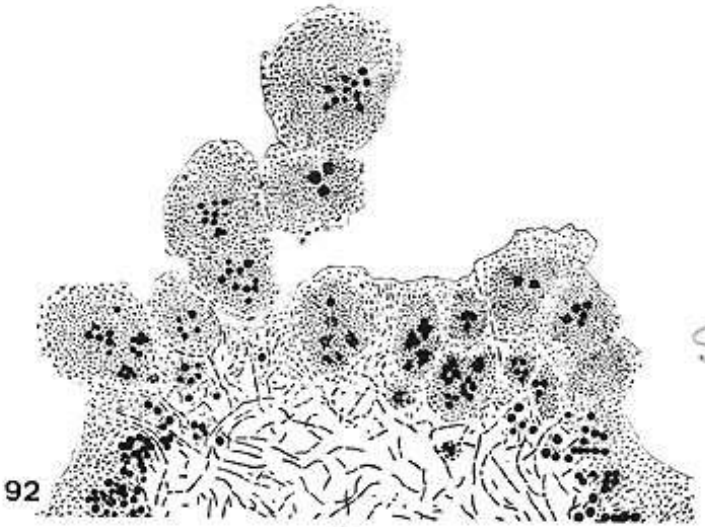
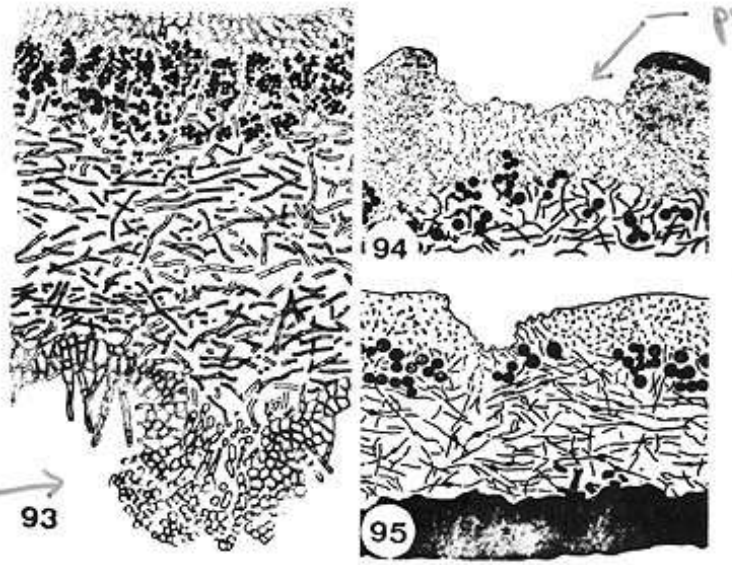


FIGURE 3

Cephalodia of *Peltigera aphthosa*: Diagram 1, *a*, a young cephalodium; *b*, the trichomatic hyphae holding the cephalodium. Diagram 2, an older cephalodium; *a*, the internal hypae and algal cells; *b*, the well-developed cortex; *c*, the supporting trichomatic hyphae. Diagram 3, a mature cephalodium; *a*, the internal hyphae and algal cells; *b*, the upper cortex; *c*, the lower cortex; *d*, the supporting hyphae; *e*, the thallus below the cephalodium, where the algal cells have disappeared and the cortex is transformed into hyphal tissue; *f*, the cortex; *g*, the algal layer of the supporting thallus. Diagram 1, enlarged about 100 diameters; diagram 2, enlarged 400 diameters; diagram 3, enlarged 200 diameters. From Schneider.





FIGS. 92–95. Fig. 92, soralium of *Lobaria pulmonaria*; Fig. 93, respiration pore of *Nephroma resupinatum*; Fig. 94, pseudocyphellae of *Cornicularia divergens*; Fig. 95, pseudocyphellae of *Cetrelia cetrarioides* (Figs. 92–94 from Henssen and Jahns, 1973.)

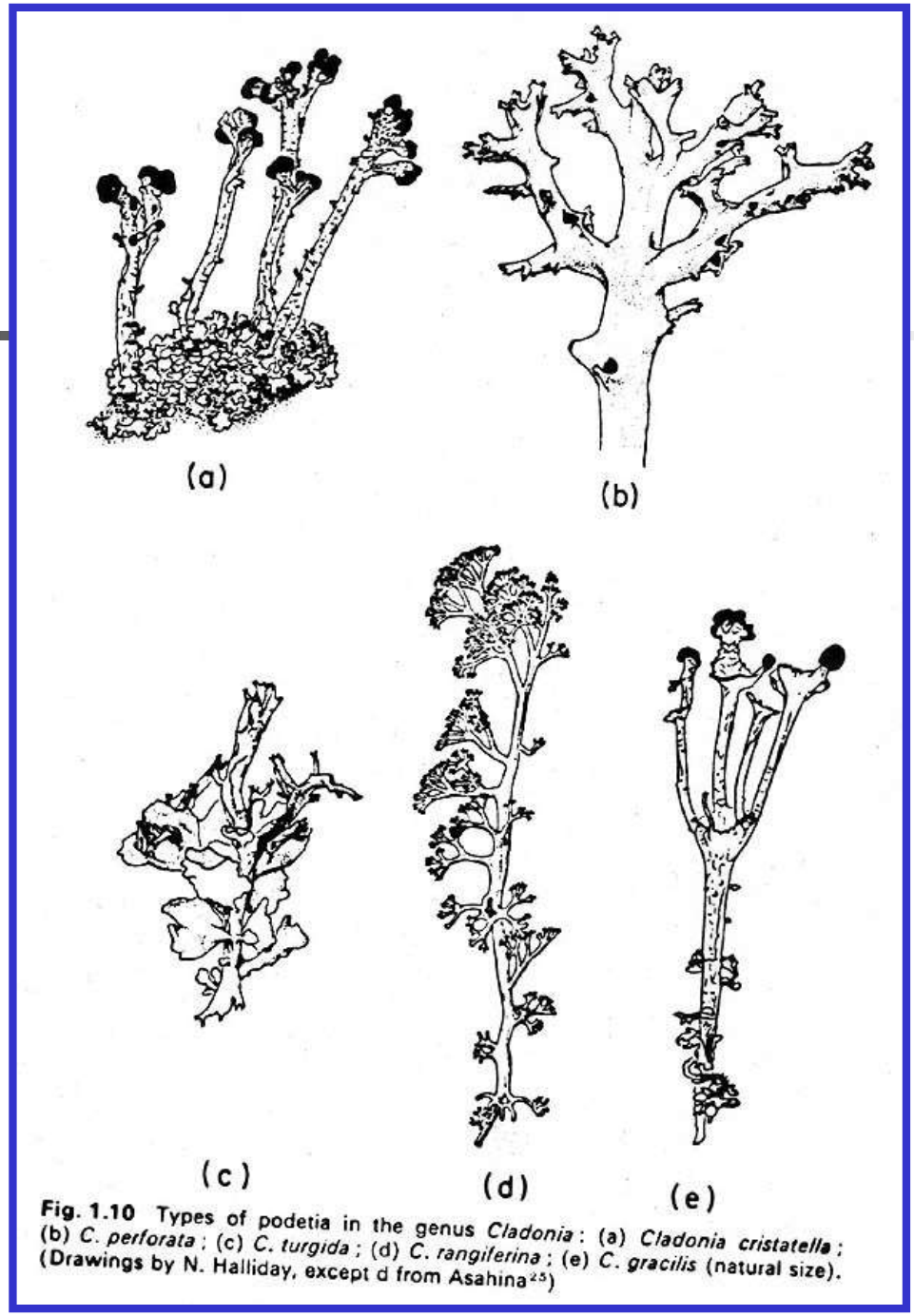
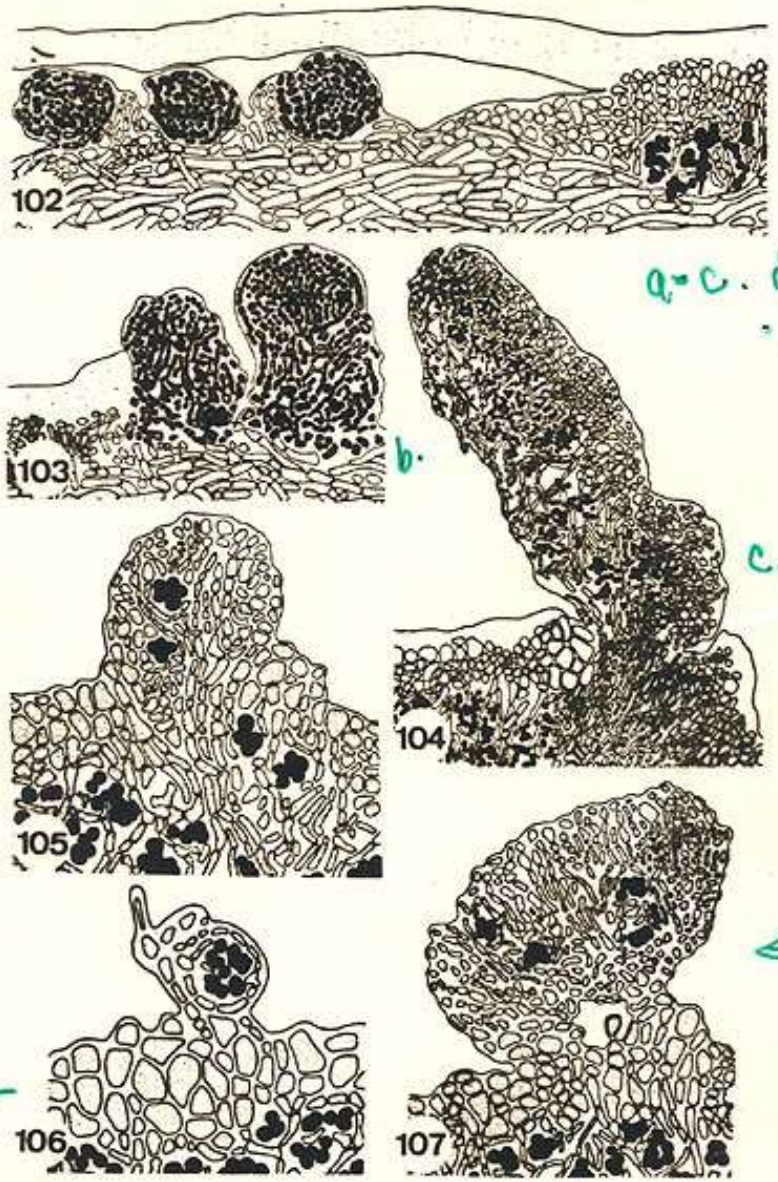


Fig. 1.10 Types of podetia in the genus *Cladonia*: (a) *Cladonia cristatella*; (b) *C. perforata*; (c) *C. turgida*; (d) *C. rangiferina*; (e) *C. gracilis* (natural size). (Drawings by N. Halliday, except d from Asahina[25])



FIGS. 102–107. Figs. 102–104, development of isidia in *Peltigera praetextata*; Fig. 105, development of an isidium of *Peltigera lepidophora* by growth of medullary hyphae; Fig. 106, development of an isidium in *Peltigera lepidophora* by trapping of algae; Fig. 107, older isidium of *Peltigera lepidophora*. (Figs. 102–107 from Henssen and Jahns, 1973.)

LICHEN GROWTH

- Slow growing - most 1 mm/yr, a few up to 4 mm/yr.
- Growth favored by high humidity, cool temperatures & low light.
- Long-lived - Alpine-arctic lichens may be 1000-4500 yrs old.
- Longevity attributed to ability to withstand long periods of drought and resume growth when water becomes available.

USES OF LICHENS

- Food
- Dyes (litmus paper, Harris tweed)
- Essential oils for perfumes, soaps
- Bioactive compounds (antiviral, antibacterial)
- Nesting/bedding material
- Poisons