Photographic Essay

Lichens in Cross-Section: Evidence *for* Design and *Against* Macroevolution

(A Van Andel Creation Research Center Report)

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Abstract

Photomicrographs of lichens show what can be called "tissues." The functions evident in these lichen tissues provide clear support for their origin by divine design. Macro-evolutionary explanations given for lichen origins are demonstrated to be inadequate and unsupported. Lichens, which are not "plants," are seen to possess amazing, anatomical counterparts to the complex tissues found in the "higher plants." Similarities like these, between organisms that are taxonomically quite distant, suggest a "common Designer" rather than an evolutionary "common ancestry."

Introduction

In Romans 1:20 the apostle Paul implied that many of God's attributes, such as His deity and His power, cannot be accessed directly by the human sense organs (Howe, 2003). Paul said it is possible to observe these otherwise invisible dimensions of deity by studying what God has made. The first of our four objectives is that readers understand more about the Creator by viewing the amazing anatomy of the lichens He has created.

Our second goal is to display the various lichen tissues in photomicrographs and to enumerate their functions. These tissues play numerous roles that enable lichens to grow north or south—on land or even in the sea. Although comparatively simple in structure, the functions of the tissues of lichens are nevertheless a tribute to design by their wise Creator.

A third objective is to discuss a few of the peculiar evolutionary comments made by otherwise intelligent lichenologists. Many of these scientists express their personal belief in the evolutionary origin of lichens, without mention of a creationist alternative. We are not criticizing or minimizing the experimental work of the lichenologists involved. Instead, we are demonstrating the vulnerability and futility of their underlying evolutionary origins speculations. A contribution that creation-minded workers can make is to carefully reassess the data in each field, including lichenology. Silence on our part concerning evolutionary blunders would be a disservice to science.

An additional objective is to draw attention to the fact that lichens frequently resemble plants from other biological "kingdoms." Such clear-cut similarities between organisms that are taxonomically "distant" from each other, support a "common Designer" rather than in a "common ancestry." When we describe startling resemblances, we do so to show the fact that

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Accepted for publication:
March 21, 2005

such parallelisms would be unlikely from the vantage of macroevolution. Whenever evolutionists use the term "polyphylogeny" they are tacitly admitting that life had many independent starting points—not just one. Obvious anatomical counterparts in these widely separated groups support intelligent creation rather the neo-Darwinian evolution. This is a "biotic message" from the manufacturer, as ReMine (1993) noted. It would have been well for macroevolution to have produced a carefully designed component once. To ask that it originate similar systems two or more times in distant branches of the much-touted "evolutionary tree" is preposterous. The very idea would be dismissed without giving it a second thought, if evolutionism had not already become an item of reverent contemplation in the minds of so many people.

Materials and Methods

Specimens of *Xanthoparmelia* sp., *Pleiopsidium chlorophana*., *Candelilaria* sp., and *Caloplaca* sp, were processed in a laboratory microwave (Pelco Model 3450 with model 3420 microwave load cooler, Ted Pella, Inc., Redding, CA), according to the protocol outlined by Giberson et al. (1997). Using the microwave procedure reduces processing time for plants and produces better preservation in tissues than the conventional method.

Tissues were fixed in 2.5% glutaraldehyde and postfixed in 2% osmium tetroxide within the laboratory microwave oven. Dehydration was carried out with graded steps of acetone using the microwave protocol described below. Infiltration and embedding were performed in a mixture of 1:1 Epon/Spurr's resin.

Places where there is higher than average microwave energy, called hot spots, exist within the microwave chamber. These were identified by using a neon bulb array, and were eliminated with water loads, which were replaced when the water became warm to the touch. A temperature probe was also used to restrict high temperatures at each step in the fixation, dehydration, infiltration, and polymerization processes (see Table 1 of Giberson et al., 1997). A diamond knife was used to produce silver-colored sections, which were collected on uncoated copper grids were stained in uranyl acetate and lead citrate. Specimens were viewed and photographed on an AEI 801Transmission Electron Microscope (TEM).

Background Considerations about Lichens

How Do Plant Tissues and Lichen Tissues Differ?

Tissues are clusters of cells that work together to fulfill one or more functions. Humans, animals, and "higher plants," like flowering plants, all possess tissues. Complex tissue structure is characteristically absent, however, from the mosses, liverworts, hornworts, fungi, and algae. A tissue in a flowering plant, such as a carrot plant, consists entirely of carrot cells and is thus monogenetic. Each cell in the carrot tissue possesses the same genes and chromosomes because they all have descended from one single cell—the carrot zygote.

Lichen tissues, however, do not develop from a single zygote. Lichens involve a very close symbiotic union between a fungus and an alga (Howe and Armitage, 2002; 2003). The alga, which cannot produce tissues alone, grows in close association with the lichen fungus, which is also unable to form tissues. But lichen tissues develop because fungus genes for producing them respond to signals from nearby lichen algal cells (Brodo et al., 2001). Lichen tissues arise by a complicated interplay between cells of these two very widely diverse genetic sources. Lichen tissues are organized cell clusters, which in both form and function "mimic higher plant tissues very closely" (Hale, 1976, p. 4).

Some workers call the lichen tissues "pseudo-tissues" (meaning "false") tissues because the lichen tissues exist in plants that are taxonomically "distant" from the vascular plants, which also yield true tissues. Tissues should simply be called "tissues" and not "pseudo-tissues," however, wherever they exist. In the creation view, no such distinctions between "true" and "false" tissues are necessary.

When the alga, called the "photobiont" by lichenologists, grows in union with the fungus (the "mycobiont") of a lichen, an entirely new "plant" arises—a "lichen." "When an alga and a fungus unite, they form a plant body entirely different from that formed by either component when grown alone" (Hale, 1961, p. 7). Tissues exist in lichens only because of the effect that the alga bears on the fungus. "Knowledge of the influence of the photobiont on the lichen morphogenesis is important, because only after the establishment of symbiosis is the characteristic thallus of a lichen developed" (Budel and Scheidegger, 1996, p. 38). "One fact is clear—the fungus cannot form a lichen thallus without the photobiont" (Ahmadjian and Jacobs, 1969, p. 52).

The lichen is really a "new plant," over and above the identity of either the fungus or the alga: "The lichen thallus is a vegetative plant body of **remarkable complexity** having little resemblance externally to either nonlichenized fungi or algae" (Hale, 1967, p. l, emphasis added). Then Hale added a peculiar remark about origins: "The fungal component…has **succeeded** in establishing a symbiotic relationship with algae" [emphasis ours]. Hale attributed this "remarkable

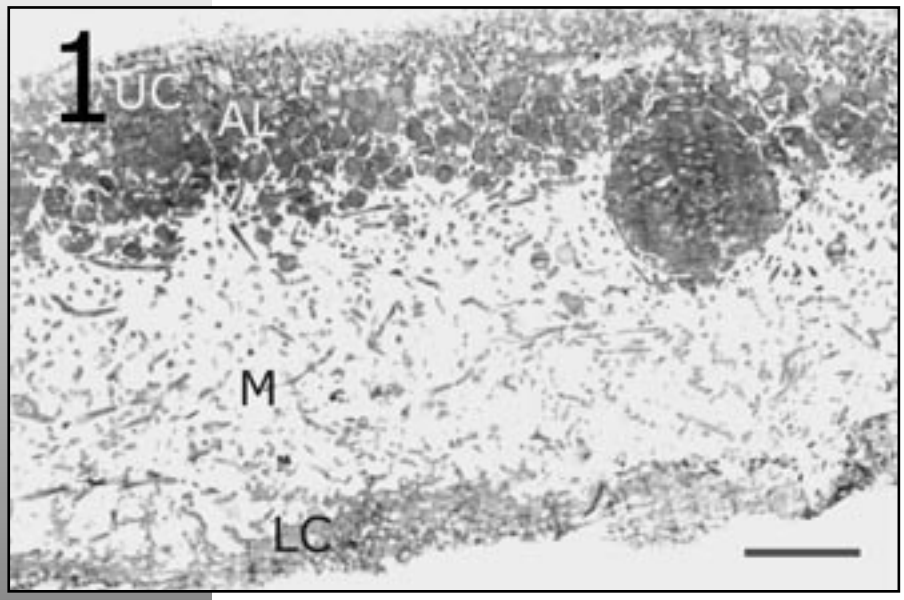

Figure 1. A foliose lichen *Xanthoparmelia*, cross-section, 250X brightfield micrograph. Scale bar = 600 micrometers. The tissue layers discussed in this paper are all visible here: UC—upper cortex, AL—algal layer, M—Medulla, and LC—lower cortex. These tissues work together to control life-giving functions in the lichen. Foliose lichens like this one have a lower cortex, giving protection to the lower surface, which is exposed beneath at many locations. Design and function seen throughout the entire lichen support the creation origins view. We think the ball-shaped object at the right, moving upward from the medulla into the algal layer is an ascocarp—a fungus reproductive structure that produces ascospores.

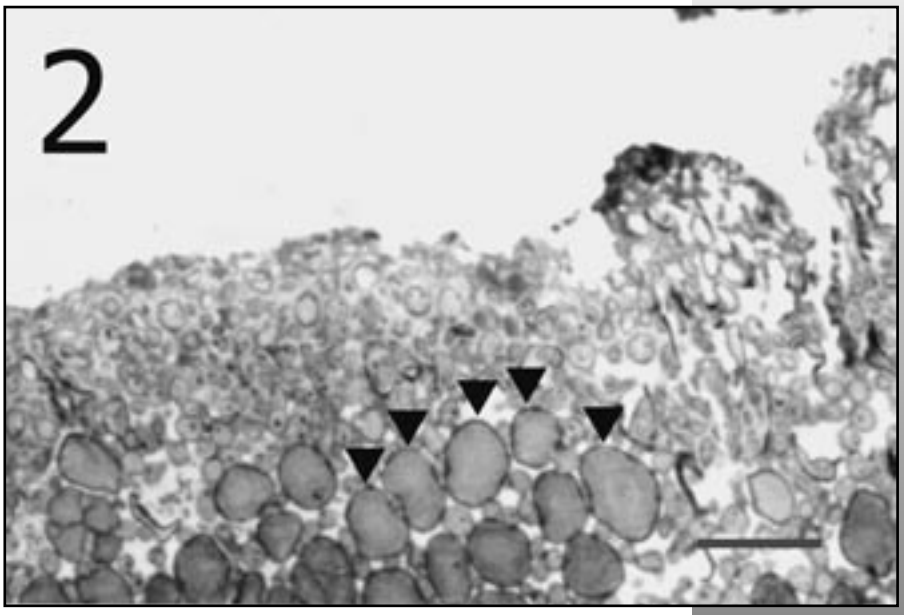

Figure 2. A cross-section of the lichen *Caloplaca*, showing the cortex tissue above and the upper portion of the algal layer, 1000X brightfield micrograph. Scale bar = 250 micrometers. The same fungus that makes thick cell walls for strength and protection in the upper cortex (UC) makes much thinner cell walls in the algal layer (AL). Thin fungus cell walls are important in the algal layer because foods that are produced by photosynthesis in the algae must move through those thin fungus cell walls to enter and nourish the fungus cells. Each of the dark triangles points to a cell of the alga *Trebouxia*.

complexity" in lichens to an ability of the lichen fungus to have ***succeeded*** in bringing about the symbiotic union. This is an example of "teleology"—the act of attributing purpose to the organism itself. Paul noted in Romans 1:20 that it is also bad theology to worship the creature rather than the Creator.

What is Lichen Stratification?

A dermis layer is at the upper surface of some lichens. The dermis is thought to assist in preventing excessive water loss. Photographs of the lichen upper surface layer were previously published (Armitage and Howe, 2004). Scanning electron micrography (SEM) was used to examine many features of the lichen upper surface. Although relatively thin and small to the naked eye, lichen cross-sections demonstrate the complex anatomy of lichens, as seen in Figure 1. Beneath the dermis are four layers or strata, which, in sequence downward are the: 1. Upper cortex, 2.

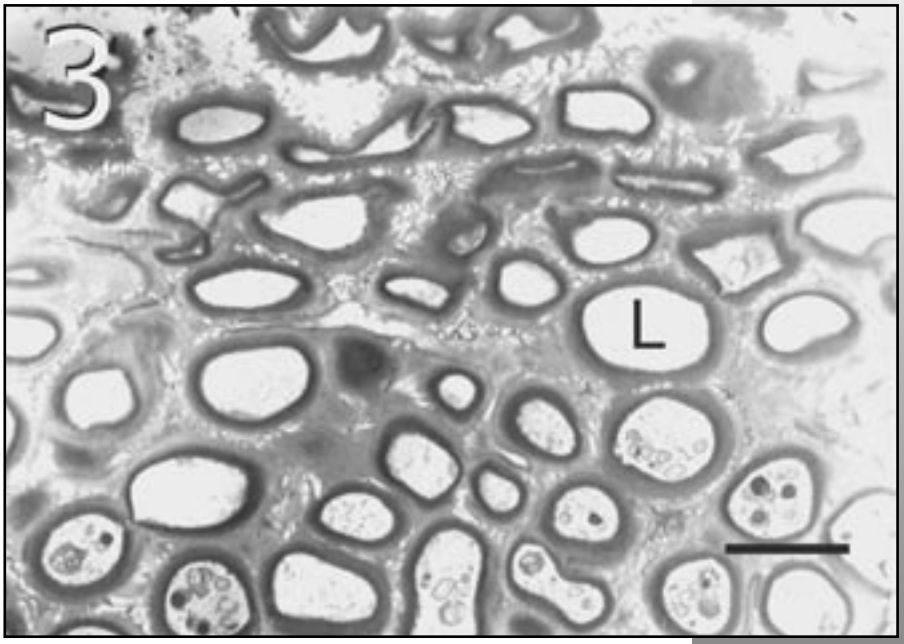

Figure 3. A cross-section of cortex tissue in the lichen *Pleopsidium chlorophana*, 5000X TEM micrograph. Scale bar = 5 micrometers. This is a close up view of fungal hyphae within the lichen cortex. The cell walls have become quite thick. The cells merge with their neighbors, having become "conglutinated." The thick and hardy structure of the cortex provides strength for the lichen at its upper surface. Much of the cytoplasm in the cortex hyphae disintegrates when the cells are mature—see symbol L for lumen inside an empty fungal cell. This lichen fungus tissue, called prosoplectenchyma, is very similar to collenchyma tissues produced in higher plants. Since lichens are believed to be polyphyletic, this magnificent protective tissue would have needed to evolve many times independently in various lichen family trees, if evolution were true.

Algal layer, 3. Medulla, and (in some lichens), 4. Lower cortex (see Figure 3; and Moore-Landecker, 1972, pp. 380–381; Fink, 1935, p. 4; Brodo et al., 200l, p. 4). A few lichens, especially those in which the phycobiont is a blue-green bacterium, have no specific "algal layer," and the phycobiont cells are distributed throughout the other layers. Such lichens are said to be "unstratified" or "homomerous" as opposed to the usual heteromerous or stratified condition in which a distinct algal layer occurs.

This stratification in lichens cannot be explained as having been caused by the lichen fungus living parasitically on algal cells, as Doyle (1965) realized: "…simple parasitism does not explain the extremely stable relationship and longevity of lichens under natural conditions, nor does it explain the resultant highly differentiated internal structure of most lichens" (p. 30). Stability, longevity, and differentiation do not arise as the result of parasitism. Brodo et al. (2001) described the stratified character of a lichen cross-section as follows: "Many lichens *are built* in layers and are said to be 'stratified" (p. 11, italics added). The phrase "are built" actually means constructed or assembled by the combining of parts. Stating that lichens "are built," tacitly affirms the action of a Builder, although Brodo and his coauthors probably did not intend to say that. "For every house is **built** by someone, but God is the **Builder** of all" (Hebrews 3:4).

How Did the Fungi inside Lichens Originate?

Most of the material in a lichen is its fungus (Hale, 1961). The fungi found in most lichens belong to the ascomycete group, which includes fungi that synthesize ascospores in sacs called asci (ascus, singular). There are about 30,000 different species of ascomycete fungi, about half of which are involved as mycobionts in the approximately 5,000 species of lichens. The other ascomycetes are non-lichenized (Brodo et al., 2001).

According to evolutionary theory, it should be possible to find connecting links to show that individual, lichenized, ascomycetes descended from specific, non-lichenized fungus ancestors. But 70 years ago Fink (1935) admitted that the ascomycetes found in lichens are not similar to their non-lichenized counterparts. Fink rationalized and attempted to defend evolution by claiming that the lichenized ascomycetes "…must have become so modified, in many instances, since entering into relationship with the alga that there is little resemblance between them and the ancestral forms" (p. 1). Another way of viewing the lack of links between the lichenized and the non-lichenized fungi may simply be that they are not related—that the Designer created about half of the ascomycetes for bonding with algae and the others for a non-lichenized existence.

Did Symbiosis and Evolution Produce the Vegetative Novelty Seen on Lichen Upper Surfaces?

Armitage and Howe (2004) noted that at least 20 different kinds of asexual or "vegetative" reproductive bodies are produced on the surface (dermis) of various lichens. This wide array found in lichen-associated, ascomycete fungi is not present in the "non-lichen" ascomycetes. To explain this difference, Budel and Scheidegger (1996) asserted that the symbiotic state of lichens must itself have triggered the proliferation of vegetative structures: "Symbiosis is now widely accepted as a source of evolutionary innovation…that has stimulated morphological radiation in ascomycetes" (p. 37).

It is gratuitous and unwarranted to assume that the reproductive novelties found in the lichen mycobionts arose by evolution and symbiosis. Scientific work simply shows that variety in fungi correlates with symbiosis; it does not prove that the variety was caused by symbiosis. To assume causality is invalid because correlation does not prove causality. For example, two phenomena may correlate not because either one caused the other but because a third factor controls them both. Changes in the price of eggs may correlate with changes in the price of beef, not because one causes the other but because of changes in the climate—a third factor controlling them both. Morphological variety and symbiosis might correlate in fungi because of design (a third factor) and not because the symbiosis somehow produced the morphological variety!

Lichen Layers

How Does the Top Layer, the Lichen Upper Cortex, Function?

The lichen upper cortex usually consists of "thick walled cells closely packed in a common, gelatinous, often tough matrix. The cortex serves the lichen as a protective skin" (Brodo et al., 2001, p. 13; see also Hale, 1976, p. 4). Although composed of elongated fungus filaments lying in various directions, the filaments "are so compressed as to appear cellular…" (Hale, 1961, p. 7). The cortex tissue is rigid because the fungus cells become conglutinated—heavily gelatinized, compressed, and stuck together (Figure 3) so that their walls actually unite (Hale, 1967). The cortex functions like epidermis tissue in other plants, conserving water, protecting the cells beneath, and ventilating the inner tissues. The gelatinous nature of cortex cells helps in water conservation.

Some lichen species have pores in the polysaccharide layer of the upper cortex "…exposing the underlying cortical hyphae and providing passageways to the algal layer for gas exchange" (Hale, 1973, p. 4). Fink (1935) noted that: "…these pores are to be looked for, in the most part, in the thinnest portions of the cortex, especially over areas where the algal cells are numerous" (p. 12). The functional value of such a relationship between pores, thin parts of the thallus, and algal cells beneath is obvious. The cortex and its pores allow the ready diffusion of carbon dioxide and oxygen gases involved in photosynthesis of the algal layer (Hale, 1976)

The multi-celled fungal cortex also serves as a light shield protecting the algae below from excessive solar radiation (Brodo et al., 2001). This protection results in part from the fact that certain "…orange and yellow pigments…are usually deposited only in the cortex" (Hale, 1967, p. 5).

Conserving water is achieved not only by the cortex, but sometimes also by asexual reproductive bodies known as isidia (Armitage and Howe, 2004). Jahns (1973) reported that isidia in the lichen *Parmelia saxatilis* "…grow into new thallus scales on the older part of the lichen" (p. 18). The isidia are effectively converted into thallus scales, which in turn become a stack of thalli, one on top of the other. The upper thallus in this stack remains alive, and the lower layers "…are used for water storage" (Jahns, 1973, p. 18). *P. saxatilis* does not exercise this water storage procedure when it grows where water is readily available. Where there is high relative humidity, "…no isidia and therefore no secondary thalli develop" (Jahns, 1973, p. 18). This self-regulated evaporation-control system is an amazing example of design.

Budel and Scheidegger (1996) also viewed the cortex as a line of defense against herbivores, blocking their immediate access to softer inner tissues. They maintained that the cortex modifies the energy budget of lichens. They found that in "sun-adapted" individuals of the lichen *Peltigra rufescens* there was a "decreased transmission of incident light" (p. 48) through the cortex, thus preventing overexposure of the algal layer to sunlight. Reduction of light penetration to the algae was not achieved by simply thickening the cortex, but by the synthesis of air spaces that reflect excess light, another novel feature.

Cortex structure in lichens "… makes possible an unlimited growth" (Bessey, 1971, p. 216). The manner in which the cortex and other tissues are arranged is ideal for expansion, allowing some lichen species to reach sizeable lateral dimensions. Lichens generally have a lobed shape because "initial cells" that cause lateral expansion are more active in some locations than others (Fink, 1935, p. 12).

In What Ways Is the Lichen Cortex Like a Plant Epidermis?

On the outer cortex of various lichens there are diverse features such as tiny hairs composed of fungal hyphae, crys-

tals of lichen acids, and even pores that expedite gas exchange (Moore-Landecker, 1972; Fink, 1935; Ahmadjian and Hale, 1973). Each of these surface phenomena has its own functional counterpart on the epidermal layer of higher plants (Armitage and Howe, 2004) These are obvious parallelisms found in very different living systems and they deserve an origins explanation. Evolutionary lichenologists assert that many different lichens and their pseudo-tissues evolved on numerous separate, independent occasions. They believe furthermore that the flowering plants independently produced tissues hundreds of millions of years later. Purvis (2000) believed that the lichen tissue structure "…evolved independently numerous times (polyphyletic)…" (p. 46) and he concluded that lichenization occurred independently in at least three different basidiomycete fungus lines as well as four times in various ascomycete groups.

To believe in the macroevolutionary origin of tissues, one must assume that lichen origins occurred repeatedly, requiring hundreds or even thousands of different events, yielding the many thousands of separate lichen species groups. In each of the parallel cases it would have been necessary for the two symbionts to have also yielded the same tissue structure. One must also assume that at a much later time, the flowering plants independently proceeded to evolve very similar tissues. Lichenologists usually do not mention the improbability of this scenario.

Lichens generally fall into one of three morphological categories, or somewhere between them: crustose, foliose, or fruitcose (Howe and Armitage, 2002). In addition to these, certain foliose lichens have only a single, stout, central peg of tissue (called a "holdfast") attaching the thallus to the substrate—resembling an umbilical cord, a mushroom, or an umbrella. These "umbilicate" lichens are connected to the substrate only at their center. Ordinary foliose lichens randomly bend upward from the substrate, connecting to it randomly at various points. Brodo et al. (2001) reported that: "…umbilicate growth form occurs in a number of quite unrelated lichens…" (p. 14). Hale (1976) wrote that the umbilicus "… developed independently in several totally unrelated parallel groups…" (p. 16). Again evolutionists rely on the unlikely prospect of polyphyletic parallelism.

Would Lichens Have a Greater Chance of Survival if they Possessed a Cuticle on their Cortex Surface?

The lichen cortex resembles the epidermis tissue that covers the leaves and other organs of higher plants. But the plant epidermis usually has an outer cuticle layer composed of a waxy substance called cutin, which is effective in preventing excess evaporation. Hale (1976) made the following wistful claim about the absence of a cuticle on lichens that serves to illustrate the misleading comments made by some lichenologists: "Cutin is not produced by lichens and most species have not evolved any means of protection other than that provided by the outer layer of closely packed cortical cells…" (p. 8). Hale should have simply stated that cutin is the protective substance covering higher plant organs, while cortical cells protect lichens. By drawing evolution into the discussion, Hale committed the *petitio principi* logical fallacy of "begging" or bypassing the main question demanding proof—whether or not evolution had anything to do with producing the cortex covering lichens or the cuticle on higher plants. The global "success" enjoyed by lichens shows that no other feature except the cortex is either necessary or desirable for survival. Hale's remarks are irrelevant and misleading, as evolutionary comments can so often be in scientific discussions. Hale (1976) added that some lichens do possess "…a very thick polysaccharide layer…" (p.8) on their upper surface—a feature that provides additional protection against water loss.

Cortex Photographs Explained

The cortex of three different lichens is visible in Figures l, 2, and 3—*Xanthoparmelia sp.* (Figure 1), *Caloplaca sp.* (Figure 2), *and Pleopsidium chlorophana* (Figure 3). The empty lumens (cell cavities), where the protoplasm of fungal cells has disintegrated (Figure 3), are visible. The term prosoplectenchymatous (Greek *proso*=elongated, *plektos*=twisted, and *en chein*=poured into) is applied to cortex tissues like these, wherein the fungal cell walls are thickened, appearing to have been poured into place and glued together. These lichen tissues "…mimic higher plant tissues very closely" (Hale, 1976, p. 4; Hale, 1976; Hale, 1961, p. 4; Hale, 1967, p. 4). Fungus filaments in this prosoplectenchymatous tissue have a cellular appearance in cross-section.

The prosoplectenchyma of a lichen cortex is very similar in appearance and function to collenchyma (Greek *kollan*=to glue, and *en chein*=poured into), a support tissue commonly found in stems and other organs of higher plants. In it, cells likewise appear to have been glued together. The resemblance between the cortex of the lichen *Pleopsidium chlorophana* (Figure 3) and the collenchyma of a higher plant stem (Figure 4) is very close. Both supporting tissues look and function alike, although they arise in different taxonomic groups and by means of different developmental sequences, observations supporting creation, not neo-Darwinian evolution.

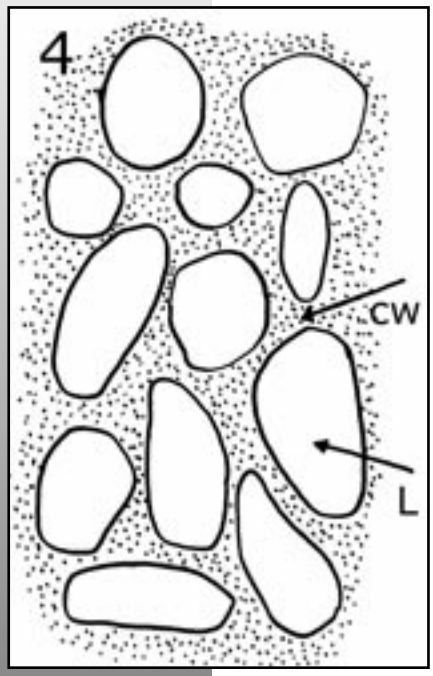

Figure 4. A sketch of collenchyma tissue from a flowering plant stem. Compare this sketch of collenchyma from the stem of a flowering plant with the prosoplectenchyma of the lichen cortex, Figure 3. They have a structure that is almost identical. But since lichens are assumed to have evolved millions of years before higher plants, this type of protective tissue would have needed to have originated independently to give strength in flowering plant organs as well—an unlikely proposition. (Sketch by Patrick Armitage, after Figure 7.15 D, Robbins et al., 1964, p. 84.)

The Algal Layer: The Photosynthetic "Action" Occurs Here

The photobiont cells in many lichens are confined to a zone directly beneath the cortex (Figures 1, 2, and 5). This is the algal layer and numerous fungal hyphae are also present. In fact clumps of algal cells are loosely interwoven with the fungi surrounding the algal cell and often piercing them with haustoria. These are thin tubes through which photosynthetic products move from the alga to the fungus (Figure 7).

The positioning of photobiont cells below the cortex fungus layer is important to the success and survival of certain lichens. If the algae were located too close to the surface, they would be inadequately protected and would be in danger of drought, overheating, and overexposure to solar radiation. But if photobiont cells were buried too deeply in the thallus, they would receive insufficient light for optimum photosynthesis, thereby threatening the food supply of the lichen. This is true even though many lichens are "homoeomerous," with their algae distributed throughout the entire medulla layer and some in the cortex too.

The same lichen fungus that develops thick-walled, protective tissue in the cortex (Figure 3) has relatively thin cell walls in the algal layer (Figures 5 and 6 and Hale, 1961, pp. 7–8). Thinness of fungal cell walls in the algal layer fits their role of absorbing photosynthetic products from nearby photobiont cells. The fact that the fungus synthesizes thin walls in the algal layer facilitates the nourishment of the rest of the lichen. If it were to form walls as thick as in the cortex, movement of photosynthate from alga to fungus would be retarded. But if thin walls were made in both locations,

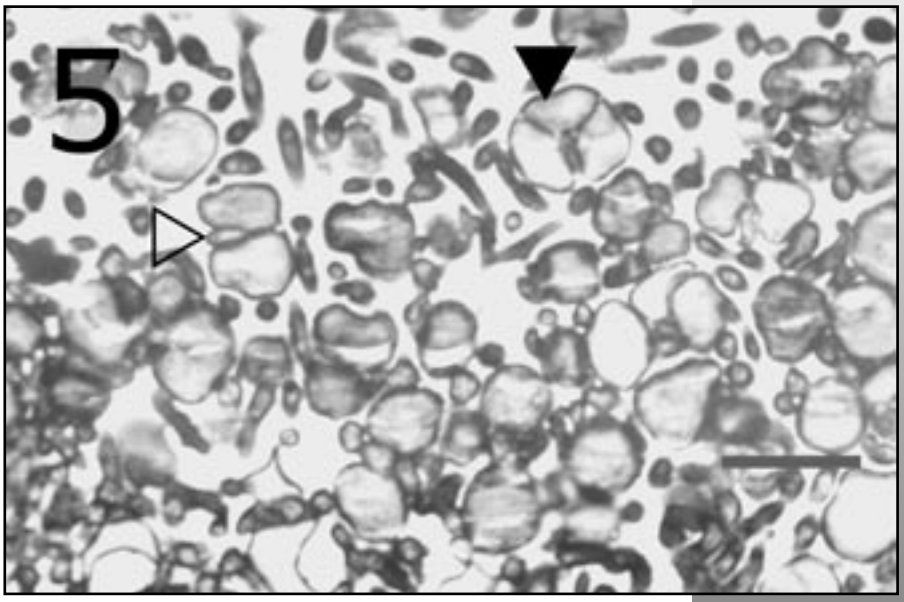

Figure 5. A cross-section of the algal layer in the lichen *Xanthoparmelia*, 1000X brightfield micrograph. This is a close up view of the highly protected algal layer. The smaller, thin walled fungus cells can be seen in both cross and longitudinal-section surrounding and protecting the larger cells of an alga—presumably *Trebouxia*. The y-shaped algal cell (black arrowhead) has recently divided. Many fungus cells are closely appressed to algal cells (white arrow). Scale bar = 250 micrometers.

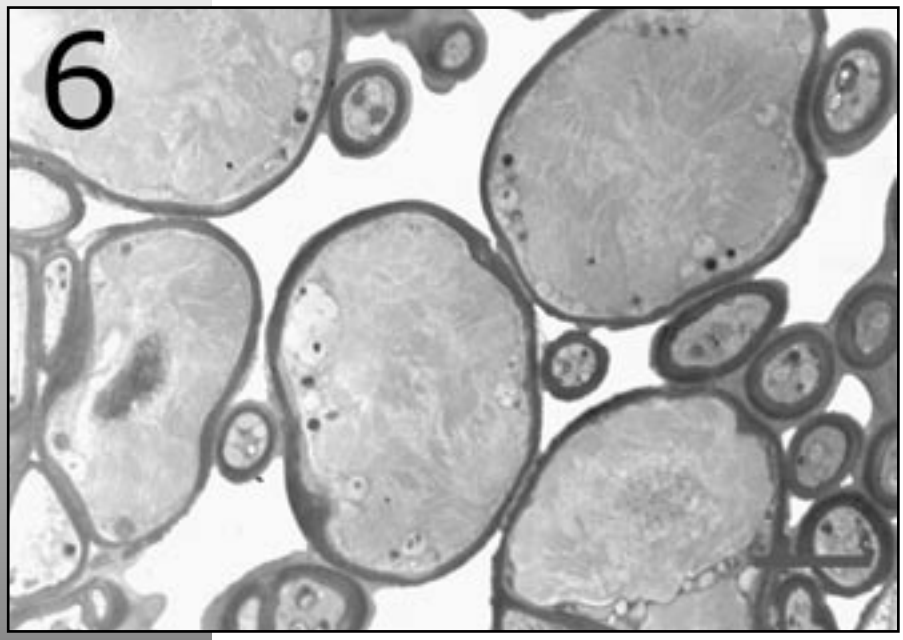

Figure 6. A cross-sectional close up view of algal and fungal cells in the algal layer of the lichen *Pleopsidium chlorophana*, 7000X TEM micrograph. The smaller cells (fungus filaments) are closely associated with the larger algal cells. Products of photosynthesis carried out in the algal cells can pass readily into the thin-walled fungus hyphae—an excellent design. The details of algal cell structure, such as pyrenoids, nuclei, and other features will be discussed in a future paper. Scale bar = 50 micrometers.

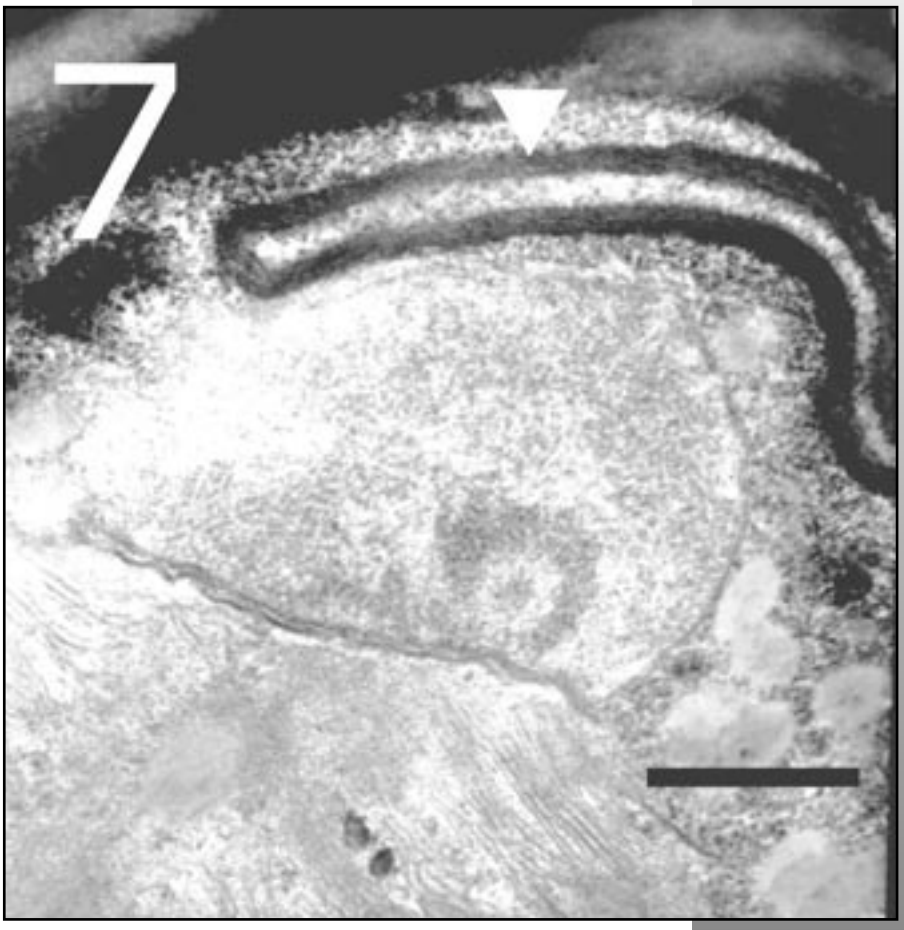

Figure 7. A fungal haustorium (haustoria, plural) located inside an algal cell, lichen *Candelilaria*, 8500X TEM micrograph. The nucleus, cell division, and the pyrenoid can each be seen in this algal cell—features to be discussed in a subsequent paper. Fungus hyphae are able to absorb photosynthetically produced foodstuffs not only by being closely appressed to the outside of algal cells but also by sending nutritive branches called haustoria inside the algal cells. A haustorium (white arrowhead) is visible here.

the cortex would be poorly equipped to protect the upper lichen surface. Fungus wall thickness in each layer fits its functions in that particular tissue. Attributing the origin of such detailed design features to the action of mutations and natural selection over long time periods, as evolutionists do, is tautological sophistry. Until the proper wall thickness had been developed, the lichen could not have lived and reproduced.

Hale (1976) indicated that some lichen tissues resemble the palisade layers of leaves in flowering plants (see also Hale, 1973). Photosynthesis of the lichen algae does occur in the algal layer, which is the counterpart of the palisade mesophyll leaf tissue. The algal layer in lichens is similar to the palisade photosynthetic tissue in another way—both are surrounded by non-photosynthetic layers, above and below.

As far as we can determine, the photobiont found in each of the lichens studied in the VACRC collection is a species of *Trebouxia*, a green algal genus. There is no handbook telling which alga is present in each species of lichen. Brodo et al. (200l) noted that "The photobiont of only 2 to 3 percent of all lichens have been identified to the species level" (p. 4). Perhaps this paucity of information occurs "…because the algal colonies have been modified by the fungus to the point of being unrecognizable" (Hale, 1967, p. 8). By "modified" he was not referring to a genetic modification by evolution but to a phenotypic algal modification caused by the adjacent symbiotic fungus.

Hale (1961) reported that 30 different algae have been identified from lichens, but that the "…majority of lichens contain the green alga *Trebouxia* (phylum Chlorophyta)" (p. 3). In a subsequent paper, we intend to illustrate and discuss some of the amazing features visible in *Trebouxia* cells and in the lichen fungi at high magnifications.

The presence of *Trebouxia* in so many lichens is evidence favoring creation. *Trebouxia* is "…rarely found in the free-living state in nature" (Moore-Landecker, 1972, p. 30). There are three characteristics of *Trebouxia*, which are disadvantageous for life in the free state and yet actually equip it for growing inside lichens: l. *Trebouxia* requires very low light intensities for optimum photosynthesis, 2. *Trebouxia* has a relatively slow growth rate, and 3. *Trebouxia* cells have an unusual "preference" for organic nitrogen sources [carbon-containing molecules that have nitrogen as part of the molecule] instead of the prevailing inorganic ones. These peculiarities favor it for growth in association with a lichen fungus (Moore-Landecker, 1972).

First, concerning the requirement for low light intensities, *Trebouxia* cells grow beneath the lichen cortex where light intensities are relatively low. Second, the slow growth rate of *Trebouxia* cells correlates well with the slow overall growth rate of most lichens. And third, nitrogen supplies inside the lichen are normally in the form of organic nitrogen, which *Trebouxia* cells favor—another trait helping *Trebouxia* to live inside lichens. Likewise, the production of asexual reproductive bodies called aplanospores is suppressed in the *Trebouxia* cells growing in lichens (Moore-Landecker, 1972; Bessey, 1971). This ensures that the algal aplanospores will not routinely unite with fungus filaments to form lichens *de novo*. This maintains a stability of each lichen species and also conserves cellular energy that would otherwise be spent forming useless algal reproductive bodies. The very "deficiencies" of the alga *Trebouxia* pre-"design" it for symbiosis.

The Lichen Medulla Layer and the Roles It Plays

The medulla is a large, loosely woven, center region of lichens where food, water, and acids are stored—see Figure 8 and consult Hale, 1967. Fungal cell walls in the medulla (Figure 9) are thick, which affords a firm but relatively open framework below the algal zone. In their loose arrangement, thick walled medullary hyphae provide a strong center support while simultaneously supplying space for air and water. Wall thickening in the medulla results from the secretion of microfibrillar polysaccharide layers.

In many of these medulla cells, the cell cavity inside the cell wall, known as the lumen, has been all but obliterated by the deposition of secondary cell wall layers (Figure 9). Cells with greatly thickened cell walls are known in higher plants as "sclerenchyma" (*sclera*=hard and *enchein*=poured into, Greek). The walls cells in medulla cells closely resemble sclerenchyma cells of the taxonomically distant flowering plants—another puzzling, "long distance" parallelism that suggests design.

The lichen medulla is up two-thirds or more of the lichen thallus thickness and most of its bulk (see Figures 1 and 8) (Hale, 1961). Loosely packed filaments in the medulla are metabolically active, making it the ideal area for food storage. Some of its filaments are so closely involved in storage that they are called "fat cells." Crystals of lichen substances may also be conspicuous in the medulla (Hale, 1973).

In contrast, the mesophyll cells of higher plants contain chloroplasts; medulla filaments do not. Nonetheless, the medulla organization resembles the spongy mesophyll tissues located below the palisade tissues in leaves of higher plants. It strains scientific credibility to continually suggest that these

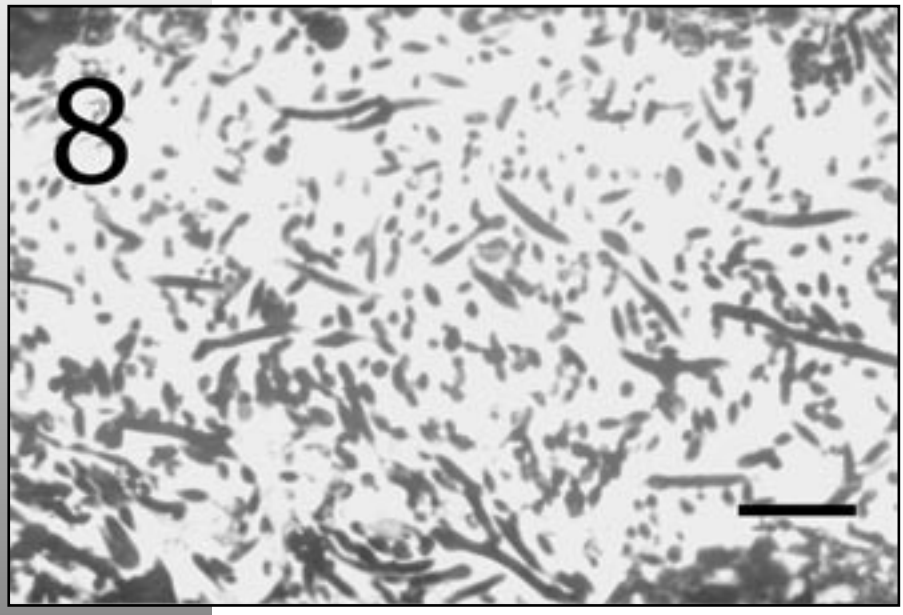

Figure 8. A cross sectional view of the medulla in the lichen *Xanthoparmelia*, 500X brightfield micrograph. The medulla is a massive center tissue in the lichen, a tissue which provides support and structure while allowing much space for water, air, and storage. Scale bar = 400 micrometers.

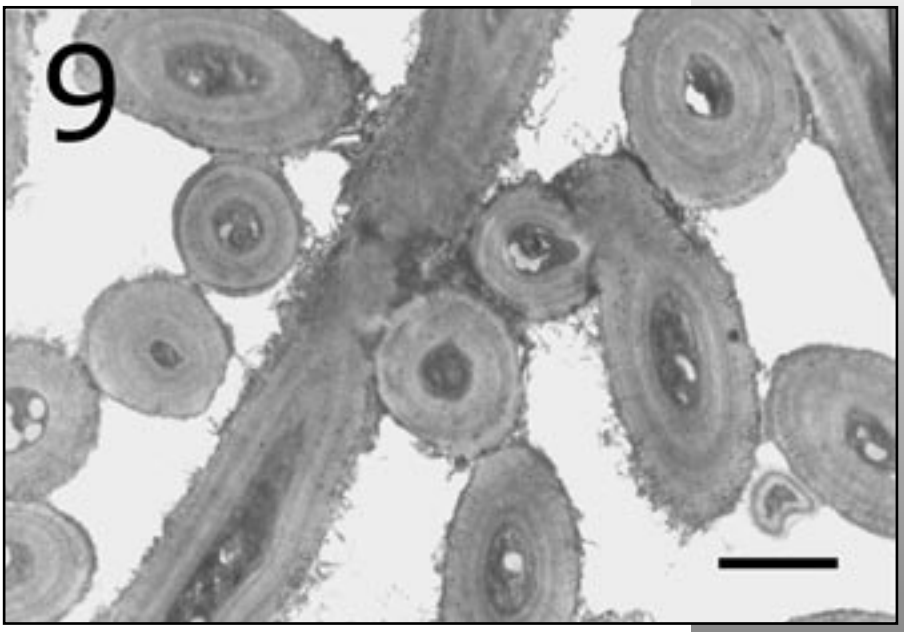

Figure 9. A close up view of cross and longitudinal-sections of fungal hyphae within the cortex of the lichen *Xanthoparmelia sp.*, 5000X TEM micrograph. Although there is much space between fungus hyphae in the medulla, the very thick walls provide a strong, central structure for the lichen. The secondary cell walls are quite thick so that very little space remains in the cell lumen for the cytoplasm or the nucleus. Such ultra-differentiation turns these inner fungal filaments into firm rods that closely resemble sclerenchyma fibers produced independently in the vastly distant flowering plants. Striking resemblances between tissues of widely different organisms support creative design rather than evolutionary common ancestry. The same fungus produces thick cell walls, as needed in the upper cortex and in the medulla but it produces thin cell walls for absorption of food in the algal layer. Cell wall design matches function in each lichen layer. Scale bar = 5 micrometers.

tissue similarities have evolved many times independently in the origin of many different lichens and that they arose once again in flowering plants!

The medulla also transports minerals from beneath to the algal and cortex tissues above. Foods move downwards from the algal layer, through the medulla, and into the lower cortex (Fink, 1935).

The Lower Cortex Layer—Is It Present or Absent?

The presence or absence of a lower cortex usually correlates with the type of the lichen: foliose versus crustose (Fink, 1935). The only lichens needing a lower cortex (the foliose ones) have one. Foliose lichens are somewhat wrinkled and unattached to the substrate over much of their lower

surface. Were it not for a lower cortex, much of that lower surface would be exposed to the atmosphere and subject to desiccation (Figure 10).

While the lower cortex plays a role in foliose lichens, its absence from most crustose lichens is likewise evidence of design. Crustose individuals are attached at all points to the substrate, obviating the need for a protective lower layer (Hale, 1967).

The lower cortex resembles the upper cortex except that it is thinner (Fink, 1935) and frequently has hair-like rhizines (Hale, 1961). Rhizines are compacted strands of hyphae that foster absorption and attachment (Hale, 1967). They are not to be confused with "rhizomes," which are horizontal stems found in certain flowering plants.

In addition to rhizines, some lichens possess other hair-like structures known as cilia—appendages that originate from the thallus margins. Hale (1967) wrote that the cilia "appear to be related to rhizines although in view of their diversity they may well have originated in several ways" (p. 23). This is another example of the independent, polyphyletic origin of a parallel feature (cilia) in different lichens. The presence of cilia in otherwise unrelated lichens supports creation, not macroevolution.

The thinness of the lower cortex is likewise a profitable design. If it were thick, like the upper cortex, the lower one would hinder absorption from beneath. Its thinness is a good design for both the roles it plays—absorption and attachment.

The lower cortex has no gas exchange pores (Hale, 1973), similar to those found on the lichen upper cortex. They would be of no value and might even cause harm. Each tissue is fitted for its functional requirements.

Genetic controls are required to govern these various differences between the lower and the upper cortex. The same genes that cause the upper cortex to be a thick, conglutinated mass of cells (Figure 3) with gas exchange pores present, must direct the lower cortex to be thinner, to produce rhizines, to not make pores, and to facilitate the absorption of minerals and water (Figure 10). The ability of the same genome to produce tissues with such distinct variations requires design engineering, which has not been shown to originate by natural selection working on gene mutations.

What Is the Ball Seen in Lichen Sections?

We think the large, circular object visible in our photograph of *Xanthoparmelia* (Figure 1) is an ascocarp reproductive structure of the ascomycete fungus. Lichen ascocarps originate in the medulla (Fink, 1935), where fungus hyphae grow together to form a spherical structure. Gradually a developing ascocarp moves upward from the medulla, through the algal layer, and into the upper cortex. The one in Figure 1 is partly in the medulla and partly in the algal layer where it is displacing some of the algae and fungus filaments. Fink (1935) noted that young ascocarps going through development "may scarcely be discernible in any way except in sections of the thallus" (p. 4). Fink (1935)

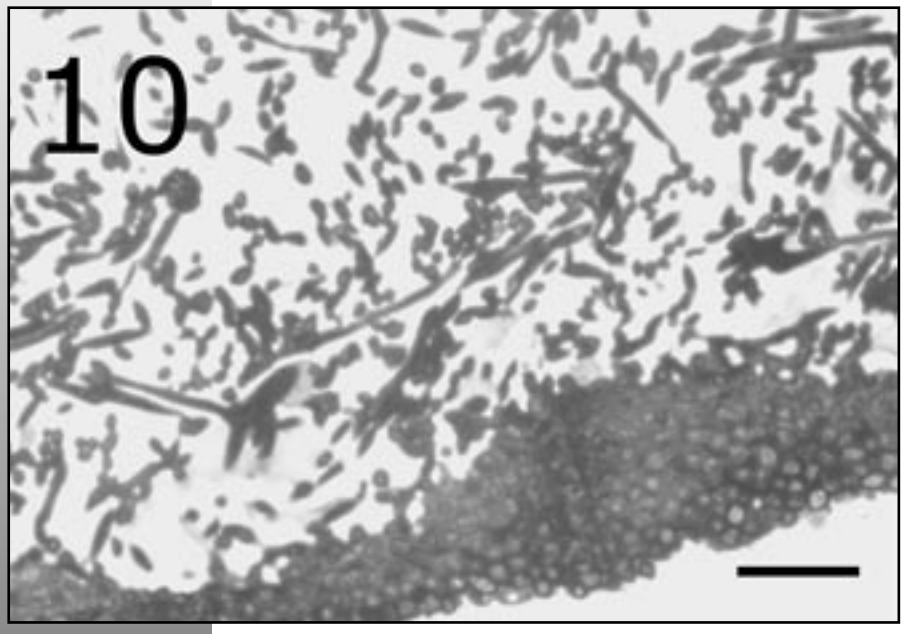

Figure 10. A cross-section of the lower thallus of the lichen *Xanthoparmelia*, 500X brightfield micrograph. It is profitable that the lower cortex (LC) be present on the bottom of a foliose lichen like this species, to prevent desiccation from beneath. But it is also advantageous that crustose lichens have little or no lower cortex because they make total contact with the substrate beneath. Fortunate design features like this one favor the creation origins scenario rather than a chance-based evolution theory. Scale bar = 400 micrometers.

also described the appearance of one type of ascocarp, an apothecium, in a section of a thallus: "…the outline of transverse section of the apothecium, when young, would usually be very nearly a perfect circle; but the form may become very irregular as growth proceeds, so that at maturity this outline is quite irregular" (p. 4).

Most ascocarps ultimately open to the exterior at the upper surface, forming a small pore or a broad cup (Howe and Armitage, 2003, Figure 6). When it is mature, an ascocarp produces sacs called asci (ascus, singular). Inside each ascus, meiosis cell division occurs in the production of four or eight ascospores, depending on the species of ascomycete involved (Hale 1961). Why the lichen fungi produce these ascocarps, asci, and ascospores when they appear to be of no value either to the lichen itself or in the synthesis of new lichens, is a puzzle to both creationists and macroevolutionists (Howe and Armitage, 2003; Ahmadjian, 2002).

Does the Medulla Send Dead Cells Upward?

Only one of the dozens of lichenologists whose writings we have studied discussed cell movement upward. It has a possible bearing on functions of lichen tissues, however, and it should either be substantiated or clearly refuted in the literature. There is an upward movement of fungal cells and dead algal cells into the dermis above. Fink (1935) noted that by this gradual upward passage of tissues, dead, "...entangled algal cells are at length carried off by the abrasion of the upper surface" (p. 8). This upward movement converts the cortex cells into filaments of the dermis tissue, ultimately ridding the lichen of dead algal cells at the top. Hale (1973 and 1976, p. 10) made only a brief mention of atranorin as being a substance that is apparently synthesized near the algal layer, and "…seems to migrate into and through the cortex and eventually becomes deposited on the surface of the epicortex" (1976, p. 10). This comment also suggests a general upward movement.

If a sloughing of old cells does occur in lichens, it would be the counterpart of a cork cambium found in the taxonomically distant flowering plants, a tissue divides to form new cells under the bark, thereby replacing outer ones that die and fall off. The ability of a lichen to repair itself from inside out by continually removing dead cells, would be yet another evidence of intelligent creation. This needs further study.

Conclusion

Some of the tissue systems in lichens have a close functional and structural similarity to tissues of flowering plants, which are so distant in plant classification that they are in different kingdoms. Haunting resemblances between plants in widely separated corners of the botanical world support creation by a common Designer, not macroevolution from a common ancestry.

Lichenologists periodically refer to neo-Darwinian evolution in their analyses of lichen anatomy, but in so doing, they often demonstrate how useless and meaningless evolutionism is in these scientific discussions. Many aspects of lichen tissue structure and physiology require further research; ideally, creation scientists will carry many of those future studies out.

Lichen tissues display a great complexity of structure and function. Such design strongly supports the existence of an extremely intelligent Designer who played a very active role in the origin of lichens. The study of lichens themselves gives us a view of the capabilities of the Creator.

Acknowledgments

We are responsible for the contents of this photographic essay, but we gratefully acknowledge the help of the following people who supplied input and/or technical assistance in various ways: Peg Westphalen, Lane Lester, Cindy Blandon, Patrick Armitage, Jerry Bergman, Stephen B. Austin, and Emmett Williams. We also thank the people who contributed to the CRS Research Fund and the Van Andel Creation Research Center Fund, interest from which has helped support various phases of our research.

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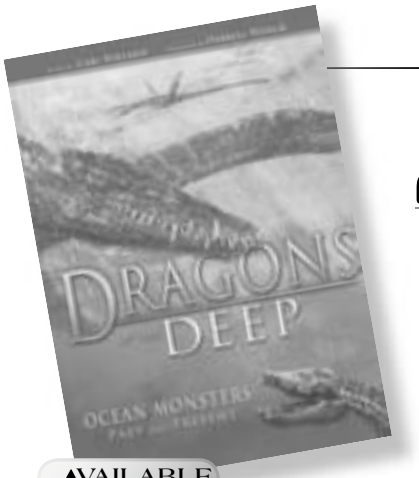

AVAILABLE THROUGH CRS BOOKS!

Book Review

Dragons of the Deep by Carl Wieland

Master Books, Green Forest, AR, 2005, 80 pages, $16.00.

This fully-illustrated book is written for children. It is filled with pictures of marine reptile monsters from the past so kids will love it. The words used will add to the vocabulary of all readers from age 5–95, including behemoth, coelacanth, ichthyosaur, kronosaurus, mesonychoteuthis, ophtalmosaurus, turbidity currents, and xiphoctinus. Author Wieland concentrates on the large creatures of the sea, both past and present. A *sarcosuchus* fossil was found in the deserts of North Africa in 2001. It was a 40 foot long "super croc" twice as big as living saltwater crocodiles (pp. 44-47). This fearsone beast may be the leviathan described in Job 41. *Archelon* was a sea turtle weighing five tons and 16 feet long, larger than a car (pp. 60-63). Its fossils are found in the mid-northern U.S. *Mesonychoteuthis* is thought to still live in deep Antarctic waters, a colossal squid twice the size of the better known giant squid (pp. 30-32). Body parts of the impressive squid have been found inside whales. With the tentacles, its length exceeds two school buses.

The list goes on with creatures that were armor-plated, some with eyes as large as dinner plates, others carrying over 100 pounds of gizzard stones, and a tarpon-like fish weighing 800 pounds. Some of these creatures, thought to be extinct, may still be with us. The case is made that all sea creatures were at on time vegetarian in agreement with Genesis 1:30. The book is in full color and includes a helpful index. Thanks to author Wieland for reminding us of the dramatic living treasures of the sea.

Don B. DeYoung