Photographic Essay

The Ultrastructure of Lichen Cells Supports Creation, *not* Macroevolution

A Photo Essay and Literature Review — Part II

(A Van Andel Creation Research Center Report)

by Mark H. Armitage and George F. Howe*

Introduction

Lichens are a life-form composed of fungi growing in symbiotic union with algae (Howe and Armitage, 2002). Lichen pigments play many important physiological roles, while their brilliant colors provide considerable aesthetic enjoyment (Howe and Armitage, 2003). The versatile array of lichen asexual reproductive bodies and the other fascinating features of the lichen upper surface have been studied by using scanning electron photomicrography (Armitage and Howe, 2004). Lichen algae and fungi are woven together forming "tissues" that resemble the tissues of unrelated "higher plants" in a general fashion (Armitage and Howe, 2006).

Our previous article (Armitage and Howe, 2007) contains figures showing detailed cross sections of various lichen fungi and alga. This current paper provides more photomicrographs of the cells of lichen fungi (mycobionts) from various lichens, and figure 20 is of a lichen algal cell (phycobiont). We show that lichen cellular ultrastructure yields evidence favoring intelligent design and direct creation. The Bible states that it is possible to gain knowledge about the Creator by studying His work (Romans 1:20). Based on this concept, we hope that readers will learn more about God through the study of lichens, which we believe He created.

Methods

The methods we used in sectioning the lichens and securing the electron photomicrographs are the same as those discussed in previous papers (Armitage and Howe, 2004; 2006).

Lichen Ultrastructure

The Cell Wall Supports the Design Model

There is a magnificent complexity apparent in the layers of fibers present in the cell walls of fungi, algae, and plants.

* Mark H. Armitage, 587 Ventu Park Road #304, Thousand Oaks, CA 91320
George F. Howe, 24635 Apple Street, Newhall, CA 91321-2614
Accepted for publication: March 2, 2007

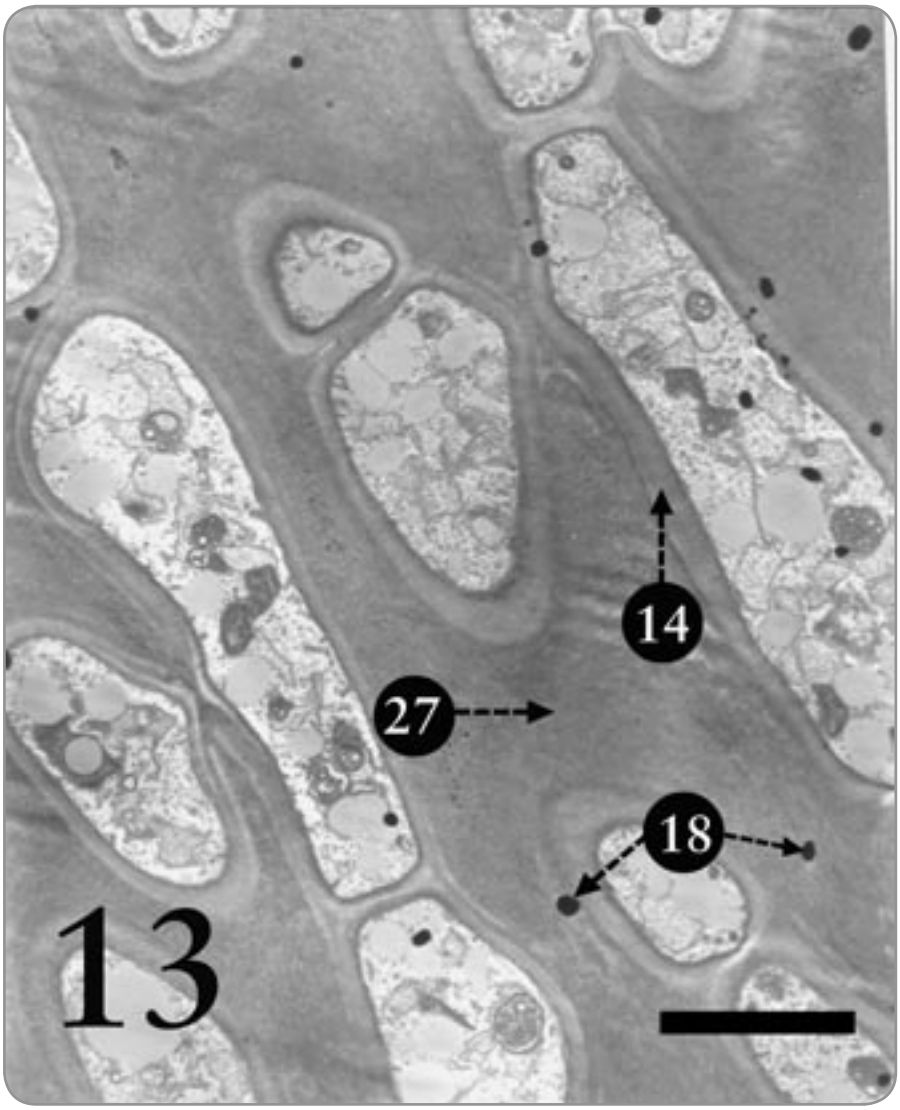


Figure 13. Lichen fungus cells in the medulla region of *Candelariella* sp. The hyphae are suspended in an extracellular matrix, which has been formed by the mycobiont hyphae (27). Cells here may be sexual structures in an early stage. The cell wall is (14). The magnification is 12,000X; the scale bar is 40 micrometers.

Mycobiont cell walls contain chitin, glucans, glucosamine, and amino acids (Ahmadjian, 1993). Animal cells generally lack cell walls, and since animal cells require flexibility, the absence of cell walls appears itself to be an intelligent design for them. Cell walls can be observed in most of our figures, where they are labeled "14." A thick extra cellular matrix suspending mycobiont cells in the medulla is labeled "27" on Figure 13.

The cell wall is able to increase in length and thickness as the cell grows larger. This is an amazing phenomenon because cell walls are composed of fibers, which are themselves nonliving. This would be somewhat like a human shoe, which after being fitted to the foot of a small child, could maintain the same thickness and yet continue to expand as that child's foot enlarges to its adult size (see Howe, 1966, pp. 107–108).

An ingenious feature of cell walls in the lichen mycobionts is that they are relatively thin in mycobiont cells of the algal layer. Fungal cells within the algal layer need to absorb photosynthate molecules from nearby phycobiont cells. But walls of fungi in the medulla are much thicker in this tissue where structural support for the lichen is needed, a design topic we discussed at some length in a previous paper (Armitage and Howe, 2006). Intelligence is evident in fungus cell walls because: "Hyphae of the medulla and cortex have an outer and inner wall layer, while those of the photobiont zone have only one layer" (Ahmadjian, 1993, p. 19). This two-layered structure of mycobiont cell walls in the medulla has been demonstrated by other workers but is not obvious in our figures. Two layers appear to be a design for strength in the medulla and cortex tissues but one layer is more suitable for transmission of photosynthate in the algal zone.

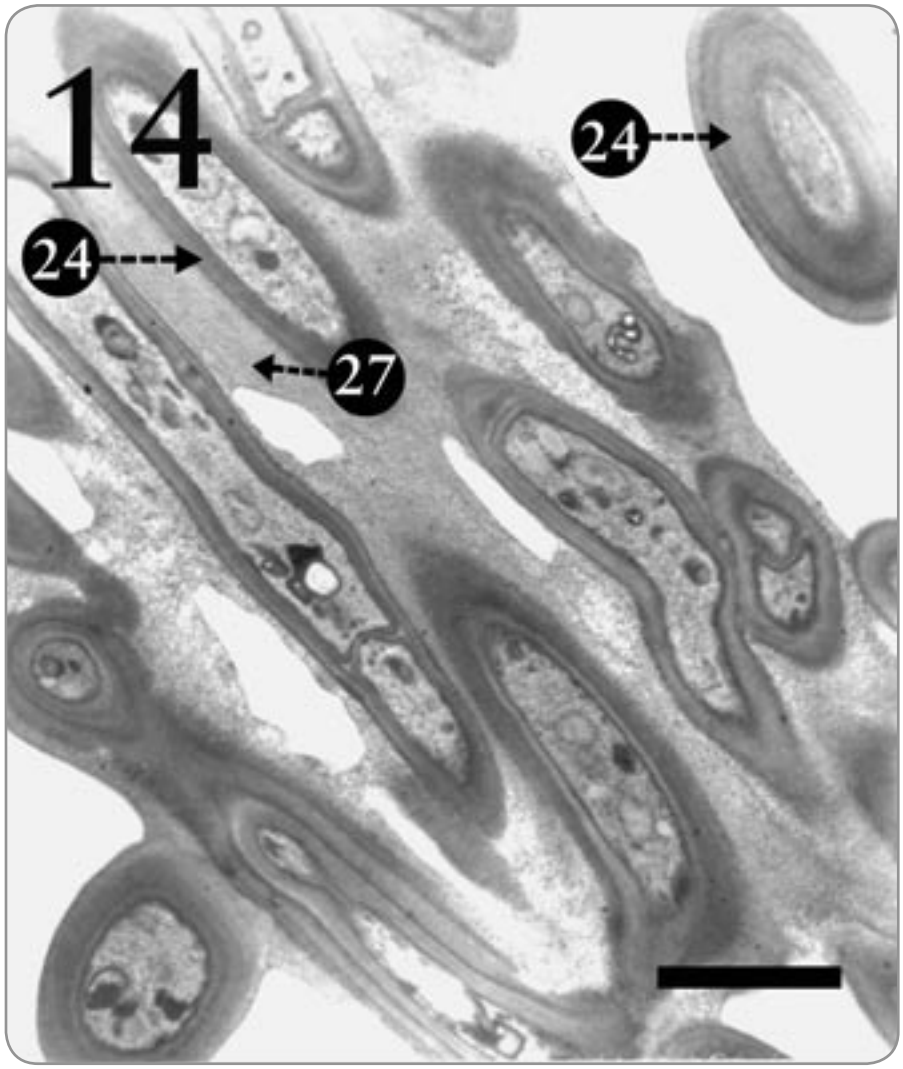


Figure 14. A slanted section crossing through the medullary mycobiont hyphae of *Pleiopsidium chlorophana*: magnification 9,000X with a scale bar of 50 micrometers. Hyphae in the medulla have thick walls (24) and a thick matrix between the cells (27), both of which lend strength to this supporting tissue.

This propensity to produce either thin or very thick cell walls must depend not only on the genetics of the mycobiont, but somehow must be mediated by the presence of the algae. Another design feature is that lichen medulla tissue possessing numerous hyphae usually will have cell walls that are thin, whereas another medulla with few hyphal layers generally has thick hyphal cell walls. Therefore, "by this distribution and differentiation, the stability of a thallus is guaranteed" (Peveling, 1973, p. 165). We think that balanced wall differences like these demonstrate God's handiwork.

The major difference in hyphal cell wall thickness in the algal zone versus the medulla can be seen by comparing fungus cell walls of the same lichen species (*Xanthoparmelia sp.*) from its algal zone (Figure 7, number "14m" in Armitage and Howe, 2007) with those from its medullary tissue (Figure 10, number "24" in Armitage and Howe, 2007). Although the magnification in Figure 10 is slightly greater than Figure 7, both photographs are of the cell wall of the same lichen, and it is obvious that cell wall thickness is much greater in the medulla than in the algal layer. While not promoting creation or intelligent design, Ahmadjian (1993) wrote two sentences about the balance of cell wall properties, which enables lichens to function properly:

> The walls have to be strong enough to withstand the drying and wetting cycles of the thallus and to facilitate these cycles by losing and imbibing water quickly. In addition, they have to be flexible in order to interface with (appressorial) and penetrate into (haustorial) cells of the photobiont. (p. 17)

It cannot be shown that neo-Darwinian evolution furnished these well-adapted cell wall features.

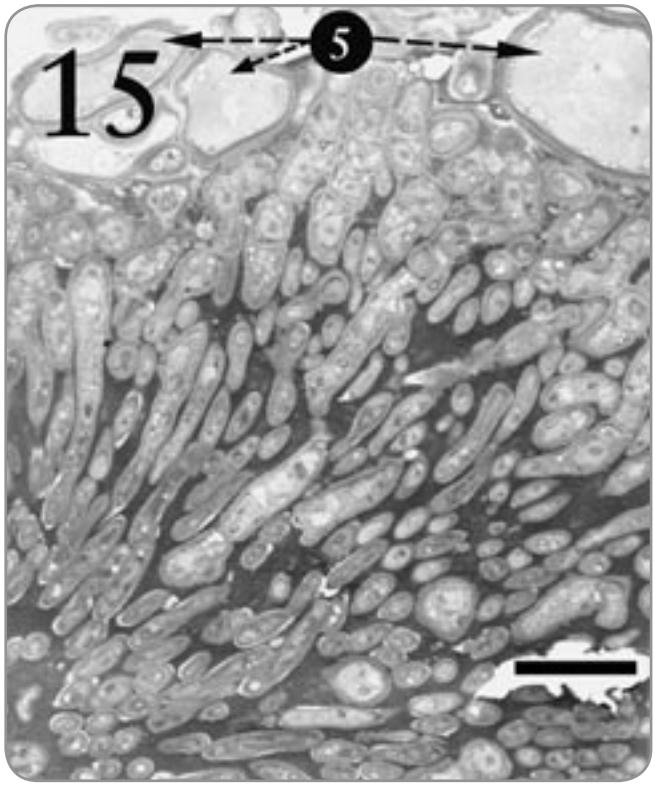


Figure 15. A section of a developing apothecium, which is pushing upward through the algal layer of the lichen *Xanthoparmelia sp.* 5,000X magnification and scale bar is 150 micrometers. These hyphae are inside item 5 of Figure 1. They are fungus filaments in a developing apothecium and they were growing upward, pushing their way through the phycobiont cells (5) of the algal layer. Ultimately, they will form a cup-shaped apothecium on the lichen's upper surface. The apothecium contains asci [spore sacs] in which ascospores are produced, spores that can germinate after liberation, as has been shown in culture experiments.

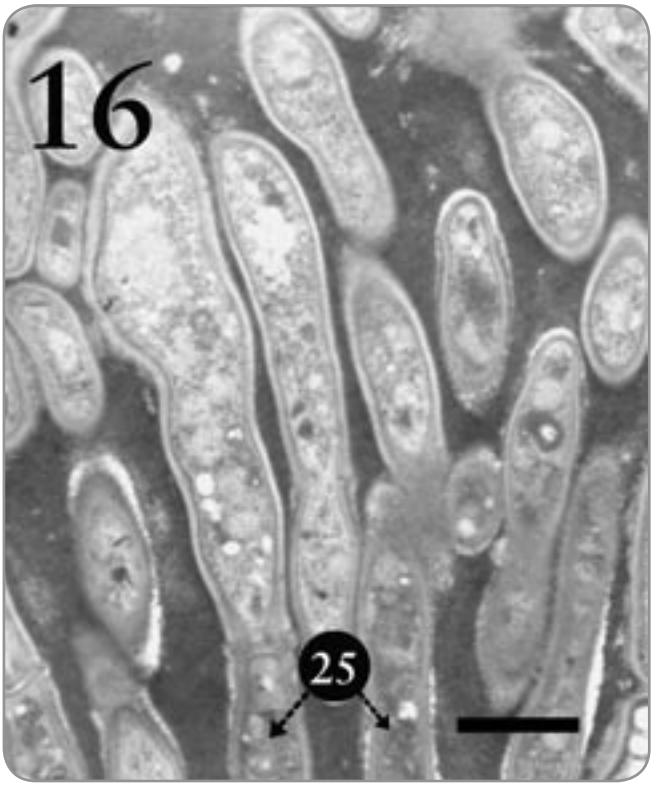


Figure 16. A closer view of cells in the developing apothecium of *Xanthoparmelia sp.*: magnification of 11,000X; the scale bar is 90 micrometers. Items labeled (25) are myelin-like structures.

The Developing Ascocarp Moves Upward in the Thallus

Figures 15 and 16 are highly magnified micrographs of hyphae in the circular developing ascocarp that had been ascending (item "5" in Figure 1 in Armitage and Howe, 2007). Our micrographs in Figures 15 and 16 closely resemble hyphae in sketches of developing asci drawn by Hale (1967, p. 35, Figures d–i). The hyphae that actually produce the ascus sacs "remain non-septate and are much richer in protoplasm than the others [hyphae]" (Fink, 1935, p. 17).

For a discussion of the spherical nature and upward movement of the developing ascocarps, see Armitage and Howe (2006, pp. 262–263). The possible roles of mycobiont ascocarps and their ascospores also were discussed in Howe and Armitage (2002). Furthermore, we have discussed the apparent non-utility of ascocarps and ascospores of mycobionts, whereby lichens generally employ alternative asexual means to reproduce the whole thallus (Armitage and Howe, 2006).

Mycobiont Ascocarps Are Not Useless Remnants of Evolution

In portions of our previous papers, we discussed the concerns of Ahmadjian regarding the fact that ascospores seem to play little or no role in the reproduction of most lichens. One might assume at first thought that ascospores

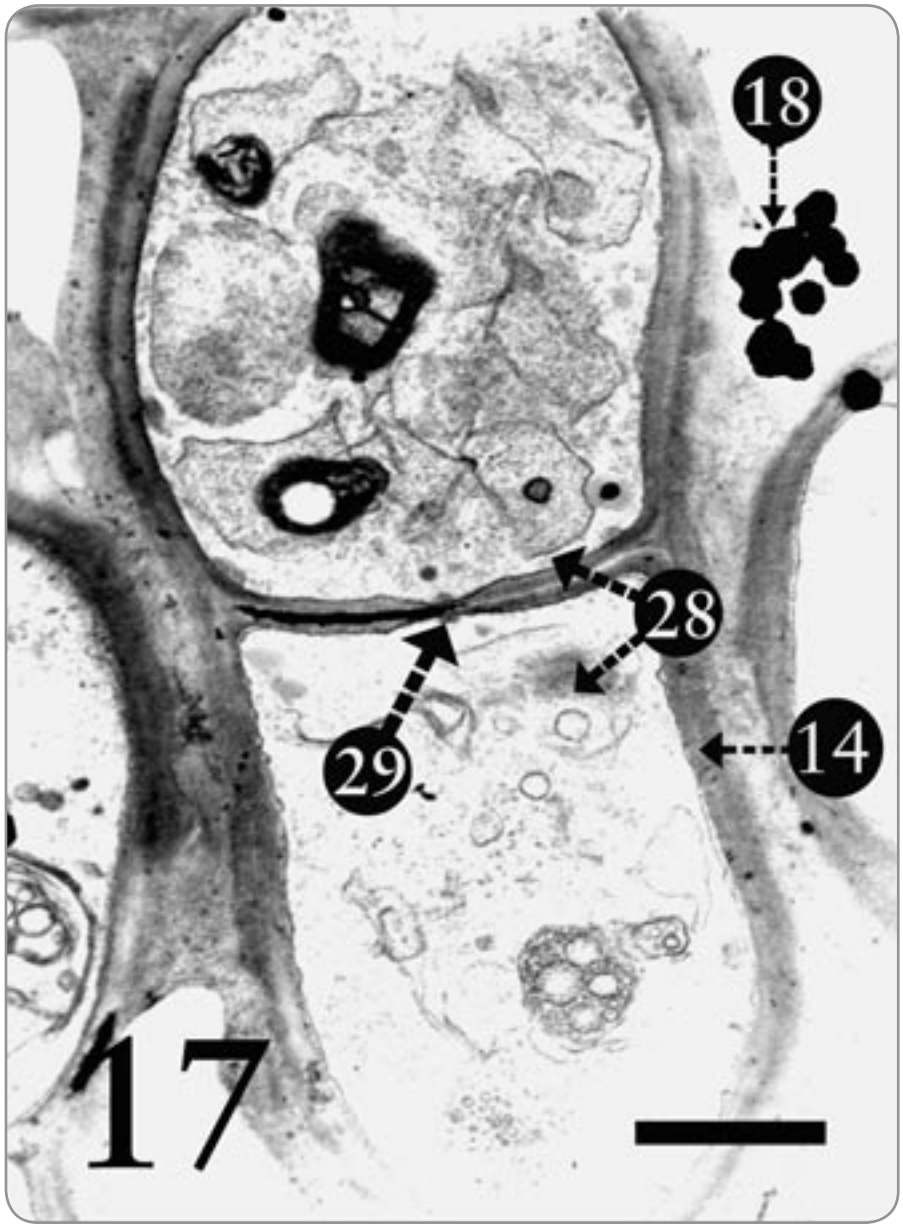
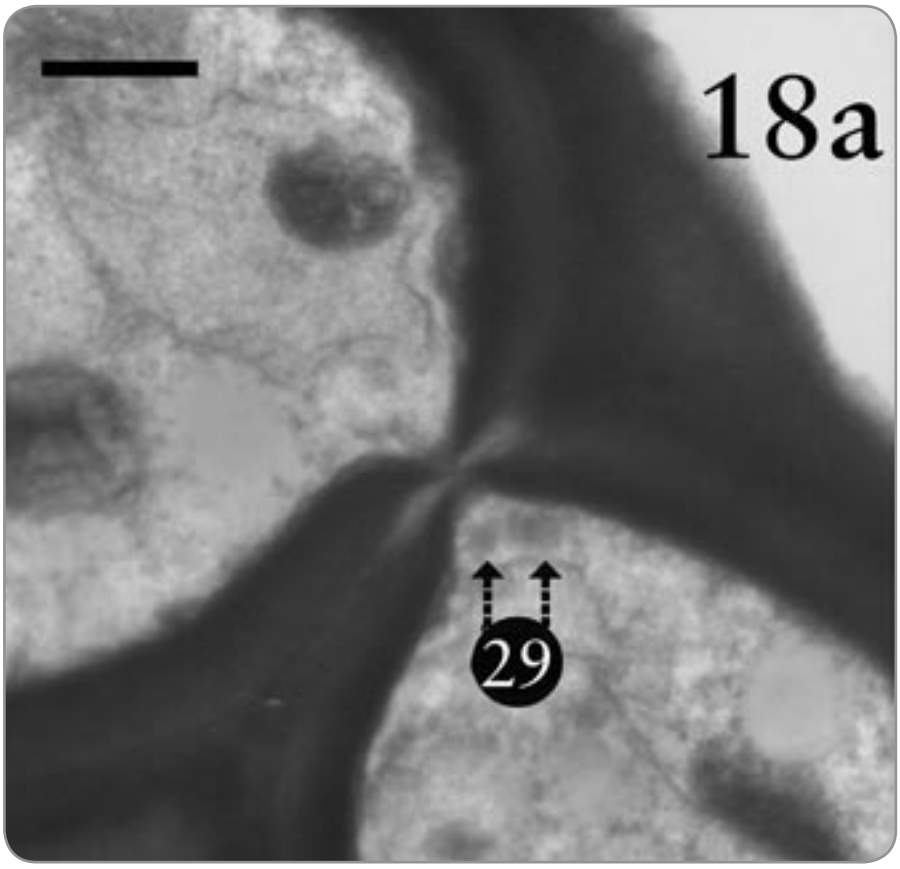


Figure 17. Mycobiont cells of the lichen *Caloplaca sp.*: magnification 12,000X; the scale bar is 30 micrometers. A perforated septum (28) separates the upper and lower cells (28). The unnumbered hole between them can become clogged by a pluglike structure known as a Woronin body (29). Woronin bodies can plug damaged hyphae, serving to prevent further loss of cytoplasm from the cells. The cytoplasm of the upper cell here is fragmented (as in certain cells of Figure 17), perhaps indicating the synthesis of spores, if this is in fact a developing ascus in an apothecium.

are routinely able in nature to capture free-living phycobionts, thereby reestablishing the lichens *de novo*. As we have discussed in our previous papers, however, Ahmadjian (2002, pp. 2–3) has asserted that such a resynthesis of lichens rarely if ever occurs, and is somewhat of a lingering "myth."

We shall discuss evidence in conflict with Ahmadjian's idea, but even if he is correct in stating that lichen resynthesis does not occur in nature, ascocarps and their ascospores should not be considered "vestigial." The spores have been shown to germinate, forming hyphae in culture experiments. Having endowed lichens with various means of asexual reproduction, the Creator perhaps refrained from canceling the fungus subroutines for producing ascospores and other sexual cells. Germinating ascospores and free-living *Trebouxia* have in fact been reported to resynthesize lichens in nature. Thus, the sexual process still may be involved in the reproduction of lichens.

Ott (1987) showed that ascospores are not vestigial in the lichen *Xanthoria parietina*. *Pseudotrebouxia*, the phycobiont of this lichen, sometimes (but rarely) is able to exist in a free-living condition. Sexual reproduction can and does take place in the mycobiont because ascospores grow and produce new hyphae in nature. Ott reported that these hyphae made contact with various



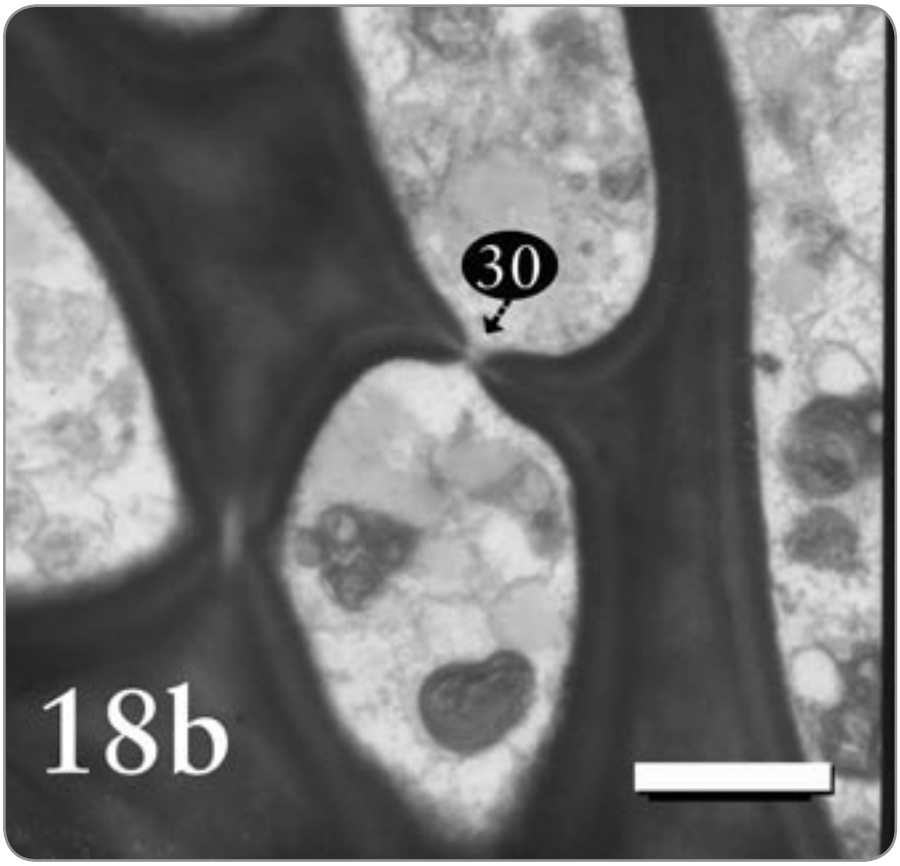


Figure 18. (A) This TEM of two adjacent mycobiont cells from *Candelariella sp*. shows the septum pierced by a pore, which connects them. In the lower cell, two Woronin bodies (29) are faintly visible, hovering near the pore. (B) Here is another view of the hole or pore (30) in the septum between two adjacent fungal cells in *Candelariella*. The cells make direct contact through this pore. The magnification of 18A is 20,000X (scale bar 8 micrometers) and 18B is 10,000X (scale bar 20 micrometers).

algae and, by a rather involved stepwise interplay, finally produced a new X. *parietina* lichen thallus. Other studies show that even the lichens having *Trebouxia* as a phycobiont can be resynthesized in nature.

Myelin-like Structures

Some objects possessing alternating layers of electron dense and electron non-dense material are labeled "25" on Figures 16 and 19, and on Figure 11 of Armitage and Howe (2007). Although usually small, some of these objects like the one in Figure 19 are much larger. Their layered appearance resembles nerve cells and thus we are adopting the term "myelin-like" to describe them, an adjective employed by other workers for similar structures found in both mycobionts and phycobionts (Jacobs and Ahmadjian, 1971; Peveling, 1973, p. 158). Current literature does not appear to provide possible functions of myelin-like bodies. Holopainen and Karenlampi (1984) reported an increase in the number of myelin-like bodies in lichens as one of the injuries resulting from sulfur dioxide fumigation.

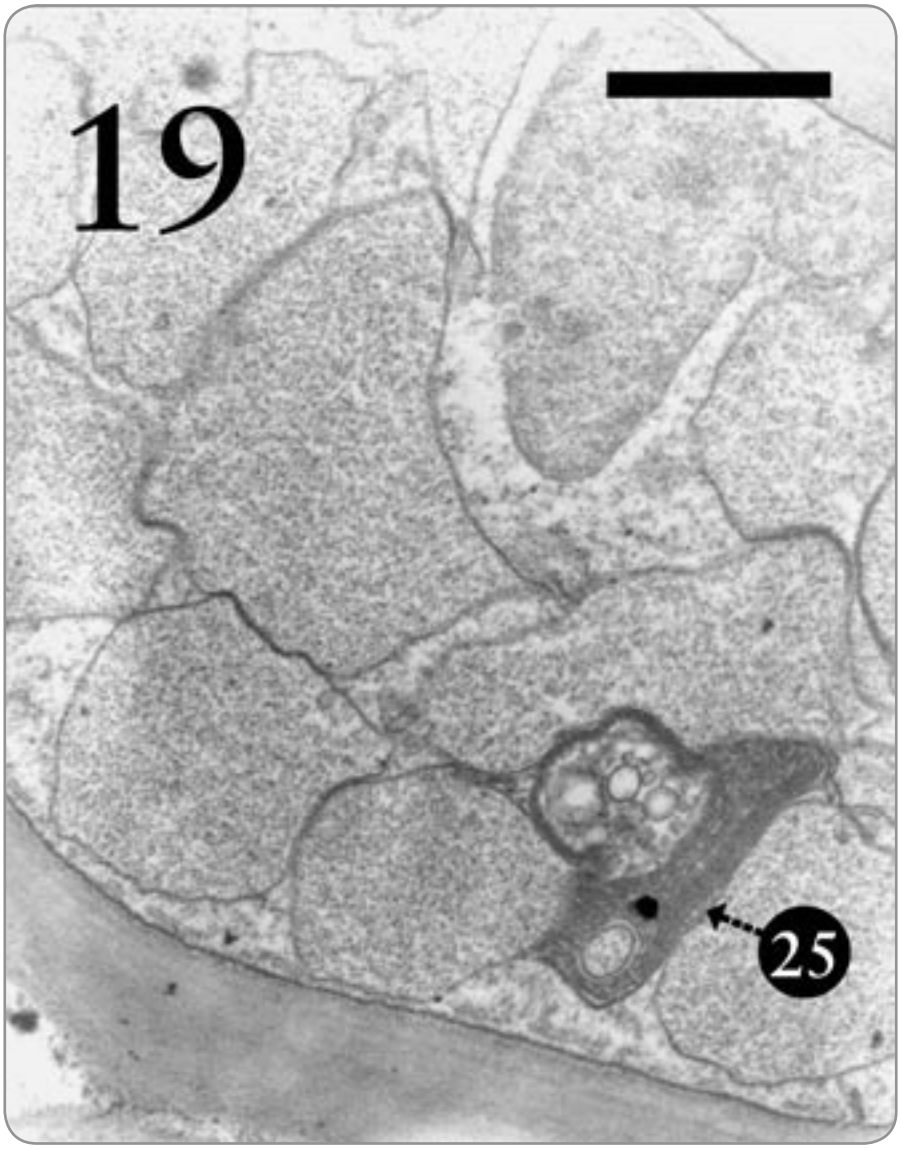


Figure 19. Part of a fungus cell from the lichen *Caloplaca sp.* at a magnification of 14,000X with a scale bar of 9 micrometers. The cytoplasm is divided into many fragments, possibly indicating that spores are being formed. The dark object at the lower right (25) has alternating dark and light layers like the myelin-like bodies, shown and discussed in Figures 11 and 16.

Septal Pores and Woronin Bodies Exist in the Fungi of Lichens

Two neighboring mycobiont cells (number 28, Figure 17) have a septal pore in the cell wall between them (see Figures 17, 18a, 18b, number 30 for septal pore and consult Peveling, 1976, p. 24). Septal pores range in diameter from 0.05 to 0.5 micrometers (Moore-Landecker, 1990, p. 17). They show that the protoplasts on each side of the septum "are connected by living strands that pass through the pore or pores and connect adjacent cells" (Alexopolous and Mims, 1979, p. 9).

Pluglike entities called Woronin bodies (Peveling, 1973, p. 161) are visible in our Figures 17 and 18 where they are numbered "29." They have been found to be present in over 50 species of filamentous fungi (Jedd and Chua, 2000). Hawksworth et al. (1995, p. 489) defined Woronin bodies as "rounded or elongated oval highly refractive bodies in the cells of certain discomycetes [an alternate name for ascomycetes], particularly in association with septa," a definition similar to the one published by Beckett et al. (1974, p. 87). Peveling described them as "bodies of an unknown nature associated with pores and plugs" (1976, p. 24). They are granular objects, surrounded by a double "unit membrane" (Moore-Landecker, 1990, p., 17). Woronin bodies are spherical, hexagonal, or rectangular in shape, membrane bound structures with a crystalline protein matrix (Paleos, web site 2006). They originate from what are called "microbodies" (Alexopoulos and Mims, 1979, p. 237).

Neither their exact composition, nor their precise functions have yet been determined (Jedd and Chua, 2000). The gene called HEX l triggers a mechanism that assembles Woronin bodies. The loss of the HEX l gene in the fungus *Neurospora* leads to a cytoplasmic bleeding condition (Jedd and Chua, 2000). Jedd and Chua (2000) see them as peroxisomes, which reseal the plasmalemma. We suggest that such organic engineering strongly validates design in the origin of fungi and lichens.

Woronin bodies are thought to block the septal pore, thereby preventing loss of cytoplasm when the hyphal strand is

damaged (Deacon, 1990). This would make them a first line of defense against mechanical injury, as another worker indicated:

> While the hypha is healthy, the Woronin bodies remain in their usual position in the cytoplasm adjacent to the pore…but when a hyphal cell ages or becomes damaged, the woronin bodies move into the pore and become a plug. This plug effectively separates the cytoplasm of the aged or damaged cell from the cytoplasm of the cells that are still healthy…Experiments have shown that if hyphae are cut, plugging of the septum would occur in four seconds. (Moore-Landecker, 1990, pp. 17–18.)

The Palaeos web site (2006) discussed Woronin bodies and described their plugging function as follows:

> A unique character of the Ascomycota (but not present in all ascomycetes) is the presence of Woronin bodies on each side of the septa separating hyphal segments, which control these septal pores. If an adjoining hypha is ruptured, the Woronin bodies block the pore to prevent the loss of cytoplasm into the ruptured compartment" (Palaeos, 2006).

"When a cell is injured," wrote Beckett et al. (1974, p. 87), "the Woronin bodies appear to coalesce and plug the pore." Peveling (1976, p. 24) listed the storage of metabolic substances and their transference from cell to cell through this pore as other possible functions of Woronin bodies.

There is a high level of functionality present in very small subcellular organelles such as mitochondria, pyrenoglobuli, and Woronin bodies. This shows that the Creator employs microscopic mechanisms to perform great objectives, as repeatedly seen in nature (Armitage, 2007). The Bible record also shows that God accomplished unusual results by utilizing insignificant means. Christ fed thousands of people, for example, by starting with nothing more than a small boy's lunch.

Mycobiont Haustoria Secure Foods from the Phycobiont Cells

Within the algal zone, the mycobiont produces penetration tubes called haustoria that press directly into the phycobiont cells (see Figure 20). These provide effective surfaces for the transport of photosynthate to the mycobiont, which is dependent on the alga for its food supply. In our earlier photographs, using very thin micro-sections, we found no haustoria. In later micrographs involving thicker sections, however, haustoria were visible (Figure 20; see also Figure 7 in Armitage and Howe, 2006).

Do New Lichens Arise in Nature Now from the Union of Free-living *Trebouxia* Cells and Germinating Fungus Sporelings?

There is a difference of opinion concerning whether or not the fungi and the *Trebouxia* phycobionts can combine successfully in nature to resynthesize a particular lichen. As early as 1976, it was realized that lichens containing blue green bacteria as their photobionts could go completely back to a free living state and then be resynthesized as *bona fide* lichens, even containing concentric bodies (Marton and Galun, 1976).

In 1987, Ott reported that some rare, free-living populations *Pseudotrebouxia*, an alga similar to *Trebouxia*, do exist, as indicated earlier. Populations of *Trebouxia* itself have been isolated from bark, soil, and plant material in nature (Tschermak-Woess, 1988, p. 81). Mukhtar et al. (1994) used morphological and immunological methods to show that "free-living *Trebouxia* cells [were] among the first settlers in an area that has been completely sterilized by a forest fire" (p. 247). Galun (1988b) reviewed experimental evidence supporting the idea that *Trebouxia* is able to unite with fungi outdoors, producing lichens.

Nonetheless, Ahmadjian (2002) maintained that *Trebouxia* lives only in lichens and that "free living *Trebouxia* do not exist" (Ahmadjian, 2001, p. 383). He considered the idea of lichens arising in nature from *Trebouxia* populations and fungus sporelings to be "a myth" (Ahmadjian, 2002, p. 1). He seriously pondered this supposed lack of free-living *Trebouxia* and expressed the puzzling fact that, "vast numbers of [mycobiont] spores are discharged from countless ascocarps produced by lichens" (Ahmadjian, 2002, p. 2). Thus, there is an unresolved difference of opinion between lichenologists over whether or not *Trebouxia* lives free and unites in nature with fungus sporelings to produce lichens. If some natural resynthesis of lichens containing *Trebouxia* does occur, possibly it is not prevalent or widespread. More research is needed on the question of whether or not free-living *Trebouxia* populations occur and whether or not those algae are regularly engaged by fungi to resynthesize lichens. There is another question, which we are not analyzing here, of whether or not phycobionts other than *Trebouxia* can maintain free-living populations and whether or not they resynthesize lichens with their fungi in nature.

Did the Origin of Lichens Occur by Macroevolution or by Rapid, Special Creation?

Macroevolutionists Have Assumed What Needs to Be Proved

Some macroevolutionists speculate that free-living *Trebouxia* or other algal cells somehow grew together with fungi to form the original lichens. They assert

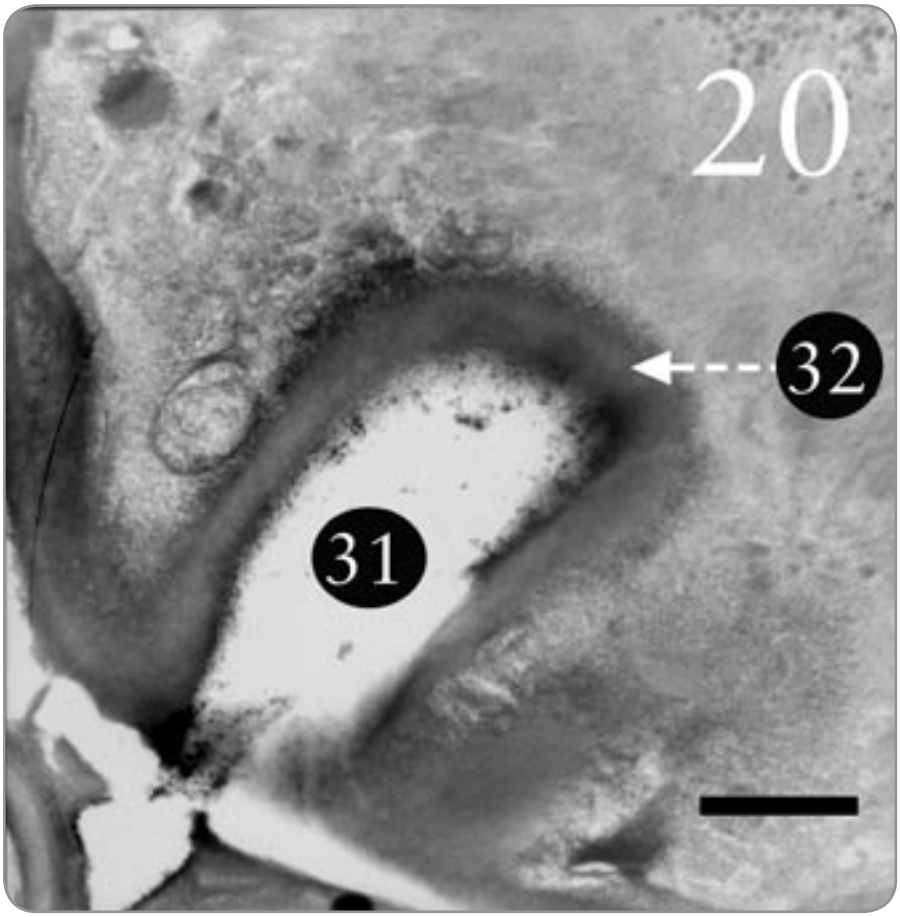


Figure 20. *Trebouxia* cell of the lichen *Acarospora sp.* with a bulgelike indentation (31). We think this indentation is a haustorium entering the mycobiont cell from a nearby phycobiont. Note the pyrenoglobuli above the large number "2" in the "20," proving that the cell above is an algal cell. The size bar is 3 micrometers. The cell wall (32) includes the wall of the fungus haustorium and the cell wall of the alga, closely pressed together. Haustoria afford a great increase in the area of contact between the fungus and the alga, allowing for a more rapid transfer of photosynthate.

that it all started long ago as a result of potential mycobiont fungi searching for food among nearby photobiont cells. Concerning the actual origin of lichens, however, the creationist Cairney (1975) wrote that "no naturalistic means has been found for supposed evolutionary development of such an association" (p. 211). He also asserted that "there is scanty evidence of any evolutionary progression leading up to lichen associations" (Cairney, 1975, p. 212). Evidently, neo-Darwinian macroevolutionists have little or no evidence to show that lichens arose when ancient fungi searched for food among free-living algae.

Did Fungi Originate by Evolution?

Lichens are supposed to have been both "ancient" and "early," preparing the way for other forms of life on land. Such speculation is not borne out by genetics: "Interestingly, recent molecular studies provide no support for the idea that lichens living today are 'ancient' compared with other fungi" (Purvis, 2000, p. 47). He added that the very taxonomic order to which most of the lichen fungi belong, the Lecanorales, is a relatively "advanced group of ascomycetes," (Purvis, 2000, p. 47). After acknowledging this, Purvis (2000) then tried to deflect the obvious inference (that lichens are really quite "advanced" phylogenetically) with the following gratuitous remark: "This evidence does not mean that lichen-like associations were not among the first to conquer land" (p. 47). But if lichens were actually among the first plantlike creatures on land, as implied, those putative, primitive first lichens evidently were not the direct ancestors of today's lichens, because contemporary lichens are quite modern [advanced] in structure.

There is a striking resemblance between spores of living fungi and fossil fungi, the latter of which are thought by macroevolutionists to be millions of years old.

> Fossilized fungal spores in deposits up to 60 or so million years old can be found fairly readily. Many are highly distinctive and extremely similar to present day species…Such fossils give a strong impression that even the most distinctive fungal morphologies are maintained for long periods of time … The close similarity between the fossil specimen and existing genera again emphasizes the trend in fungal evolution to conserve form and morphology over very long periods of time (Moore, 1998, p. 16, 18).

Thus, little or no evolution of fungal spores has transpired over vast theoretical ages. Concerning the use of fossils in the study of fungus evolution, Moore (1998) further reflected that:

> Most aspects relating to the origin and subsequent evolution of fungi are impossible to establish from any fossil record, so ideas and concepts must be gleaned from other sources. (p. 9)

One of these "other sources" is evidently the comparative study of DNA sequences. What is being ignored in those phylogenetically based DNA comparisons, however, is that "similarity" does not necessarily indicate "kinship" or "common ancestry," but might instead demonstrate "design" and a "common Designer." Subsequently Moore (1998) mentioned a "general lack of convincing fossil records of fungal origin…" and added that, although there are similarities between red algae and fungi, "no evidence could be detected to support the idea that higher fungi and red algae might have shared a common origin" (p. 9).

Similarities between one particular lichenized fungus and a non-lichenized fungus may or may not indicate kinship between them (see Jacobs and Ahmadjian, 1969, p. 222). Similarities of this type could exist if the Creator had made two fungi quite similar: one to interact with an alga to make a lichen and the other to live without algae. Or, God may have created one form of fungus, directly modifying it thereafter to yield a lichenized and a non-lichenized version.

Questions Surround the Evolutionary Origin of the Alga *Trebouxia* and its Mycobionts

For many years, Ahmadjian has expressed the idea that free-living *Trebouxia* algae descended from the somewhat similar, multicellular alga *Pleurastrum terrestre*. He thought that somehow *P. terrestre* became unicellular and then "evolved as a result of association with fungi" (Ahmadjain, 1967, p. 38; see also Ah-madjian, 1993, p. 38). Such an ancestry for *Trebouxia* is obviously speculative. Ahmadjian (1967) remarked that, "lichen fungi must have originated from free-living forms, but there is little evidence to support this view" (p. 33). Moore (1998) likewise acknowledged that the fossils supply little or no evidence for establishing the evolutionary origin of lichen fungi.

The Lichen Thallus—an Evolutionary Puzzle

Jahns (1988) embraced the origin of the lichen thallus by evolution, but emphasized some of the problems involved. Non-lichenized fungi do not have any thallus, whereas lichenized individuals do. "Several theories try to explain the origin of the lichen thallus. An acceptable explanation is difficult to find" (p. 97). While the lichenized fungi have a complex vegetative thallus, the vegetative body of non-lichenized fungi is merely a "loose hyphal network" (Jahns, 1988, p. 97). Since lichens are deemed by evolutionists to be polyphyletic (to have formed repeatedly from unrelated sources), it is necessary for evolutionists to also espouse the very unlikely proposition that the complex thallus of lichens evolved many times independently in unrelated fungal taxa.

More Problems for Evolution

Cairney (1975, p. 212) observed that if lichens did arise in nature by the evolutionary union of fungus and alga, the germinating fungal spores would have needed to find their critical algal partners immediately, something that would not have been likely unless free living *Trebouxia* colonies were widely distributed back then. But if independent *Trebouxia* populations once were quite successful in nature, why would they have begun to cohabit with fungi? Also, why would such free-living *Trebouxia* populations have become somewhat scarce thereafter? If it were once possible for *Trebouxia* to unite readily with fungi, why does this not happen regularly now in nature, when both partners are highly "coadapted" to live together?

Ahmadjian and other workers have found that *Trebouxia* and certain mycobionts can be cultured independently in the lab where the alga and its fungus then can be brought together to yield lichens. But all such laboratory syntheses of lichens have "required a carefully controlled program of environmental alterations" (Cairney, 1975, p. 212). Cairney also stated that, "where lichenization has actually occurred in the laboratory, conditions have been carefully and intelligently contrived to bring about the association." He concluded that, "the creationist view of the lichen association is the one which best fits lichen synthesis data" (p. 212).

One of our reviewers suggested that evolutionists probably have developed a logically consistent hypothesis of the gradual development of symbiosis in the literature and that we would do well to review it here. However, we are unable to locate such a coherent hypothesis. We invite letters to the editor if such an evolutionary attempt has been produced; we would indeed like to review and evaluate it. For the most part, lichenologists bring up evolution as if it were an accepted fact, spending little if any time attempting to sketch credible scenarios based on experimental data. In a previous paper (Armitage and Howe, 2004), we have listed quotations from evolutionary lichenologists demonstrating that they have assumed what needs to be proved and have communicated presuppositional beliefs rather than origins scenarios based on scientific data.

A Creation Origins Model for Lichens

Although lichens are currently not included in the plant kingdom, their phycobionts and even their mycobionts resemble plants in many ways. We will

thus assume that algae and fungi were created on the third day of creation, when it is reported that God made other plants, including seed plants, by commanding the earth to bring forth green vegetation, "plants … and trees bearing fruit with seed in it, according to their kinds" (Gen. 1:12 NIV).

In opposition to this creation of all plant types on one day, evolutionists believe that simple plants emerged first and evolved gradually to form the more complex plants across vast theoretical ages. The evolutionary view obviously does not fit with the biblical narrative, despite arguments from "theistic evolutionists." The Bible says nothing of "common ancestry" or evolutionary descent in the creation of plants. Nor does it imply the existence of vast ages, but assigns the origin of plants to one real creation "day."

The long ages of evolutionary progress cannot be confirmed by science either. Both the time and the need for plants to arise by macroevolution disappear if they were directly and recently created in one day. There is no conflict between this young earth creation model and experimental science.

We do not profess to understand the steps or sequences used by the Creator in His work. Like macroevolution, special creation entails processes that are, as yet, undiscovered. Perhaps God made the free-living algae and the non-lichenized fungi first, and then later coupled algae with various fungi to yield the ancestral lichen "kinds." As one of our critical readers suggested, God may have "endowed all higher fungi with the ability to form a lichen thallus if given the right trigger." More work is needed on what these triggering phenomena might involve.

Some time after Creation week, God's curse upon human disobedience affected the ground bringing forth thorns and thistles (Gen. 3:18). The text does not say that thorns and thistles were created after this curse, but that the ground would then favor their growth. Nevertheless, it is possible that the Creator made certain changes in plant kinds at the time of Genesis 3:18, initiating thorns and thistles. If there had been preexisting unexpressed genes for thorns and thistles, for example, God might have caused those genes to be expressed at that time. While not specifically stated in the Bible, perhaps lichens were generated from preexisting, non-lichenized fungi and free-living algae in the context of Genesis 3:18.

Before the curse of Genesis 3:18, perhaps all fungi were either symbiotic (such as mycobionts living inside lichens) or otherwise non-pathogenic. Perhaps pathogenic fungi, disease causing bacteria, and viruses were each formed by God from non-pathogenic ancestors, as part of the curse. Perhaps mutations resulting from the fall were involved. Accordingly, a non-symbiotic fungus that closely resembles a certain lichen mycobiont could be the descendant of that mycobiont instead of being its ancestor.

After the global flood (described in Genesis chapters 6 through 9), God may have enacted changes upon the created "kinds." At this time, plants and animals were becoming reestablished in many novel, post-Flood habitats. While the Bible says that the heavens and the earth "and all their host" were finished when the Creation week was over (Gen. 2:1), the Creator might still have made minor adjustments thereafter. He may have synthesized some lichens rapidly in that early post flood period by genetically altering certain fungi, enabling them to join with various algae.

Matters like these, and other related questions, such as how God might have preserved lichens during the Flood, deserve further attention by creation-minded scientists. We think that the creation view, with certain unknown and maybe some unknowable features, still finds far greater fit with the scientific origins data than does the neo-Darwinian macroevolution. The detail seen in lichen ultrastructure is fully accountable in a creation origins model.

Acknowledgments

We are solely responsible for the comments and photographs in this essay, but we acknowledge with gratitude assistance given to us in various ways. The following individuals have supplied valuable editorial assistance, for which we are grateful: Stephen B. Austin, Jerry Bergman, Wayne Frair, E. Norbert Smith, and two anonymous referees. We are indebted to Peg Westphalen for enabling us to secure materials through inter-library loan. We also appreciate the work of Cindy Blandon in arranging the photographs and the text. We thank the contributors to the CRS Research Fund and the Van Andel Creation Research Center Fund. Interest from these endowments has helped finance various phases of our research.

Although disagreeing with the philosophical presuppositions of many lichenologists, we are nonetheless grateful for their detailed studies of God's little lichens.

With deep and final appreciation, we respectfully acknowledge the exceedingly skillful work of the Creator, as reflected repeatedly in the ultrastructure of lichen cells.

References

CRSQ: *Creation Research SocietyQuarterly*

Ahmadjian, V. 1967. *The Lichen Symbiosis.* Blaisdell, Waltham, MA.

Ahmadjain, V. 1993. *The Lichen Symbiosis.* John Wiley and Sons, New York, NY.

Ahmadjain, V. 2001. *Trebouxia*: Reflections on a perplexing and controversial lichen photobiont. In J. Seckbach (editor), *Symbiosis*, pp. 375–383. Kluwer Academic Publishers, The Netherlands.

Ahmadjain, V. 2002. Lingering lichen myths are hard to dispel. *International Symbiosis Society Newsletter* 2(2):1–2.

Alexopoulos,C. J. and C. W. Mims. 1979. *Introductory Mycology*, 3rd Edition. John Wiley and Sons, New York, NY.

Armitage, M. H. 2007. The pillars of evolution are crushed by microscopic things. *CRSQ* 43:252–260.

Armitage, M.H., and G. F. Howe. 2004. Lichens at VACRC: Lichen surfaces under the electron microscope. *CRSQ* 4l:242–251.

Armitage, M.H., and G.F. Howe. 2006. Lichens in cross-section: Evidence for design and against macroevolution. *CRSQ* 42:252–264.

Armitage, M.H., and G.F. Howe. 2007. The ultrastructure of lichen cells supports creation, not macroevolution: A photo essay and literature review—Part I. *CRSQ* 44:40–53.

Beckett, A., I. B. Heath, and D. J. McLaughlin. 1974. *An Atlas of Fungal Ultrastructure*. Longman Group, London, UK.

Cairney, W. J. 1975. Lichens: A dilemma for the evolutionary model. *CRSQ* 11:211–213.

Deacon, J. W. 1980. *Introduction of Modern Mycology*. John Wiley and Sons, New York, NY.

Fink, B. 1935. *The Lichen Flora of the United States*. The University of Michigan Press, Ann Arbor, MI.

Fisher, K.A., and N. J. Lang. 1971. Comparative ultrastructure of cultured species of *Trebouxia*. *Journal of Phycology* 7:155–165.

Galun, M. 1988. Effects of symbiosis on the mycobiont. In *CRC Handbook of Lichenology, Volume II*, pp. 145–152. Edited by M. Galun. CRC Press, Boca Raton, Fl.

Hale, M. E., Jr. 1967. *The Biology of Lichens*. Edward Arnold, London, UK.

Hawksworth, D. L., P. M. Kirk, B. C. Sutton, and D. N. Pegler. 1995. *Ainsworth and Bisby's Dictionary of Fungi*, 8th Edition. CAB International, Wellingford, UK.

Holopainen, T., and L. Karenlampi. 1984. Injuries to lichen ultrastructure caused by sulphur dioxide fumigations. *New Phytologist* 98:285–294.

Howe, G. F. 1966. Cells, the amazing abode of life. In: *Behind the Dim Unknown*, edited by J. C. Monsma. G. P. Putnam's Sons, New York, NY.

Howe, G.F., and M. Armitage. 2002. Lichens: A partnership for life. *CRSQ* 39:81–88.

Howe, G.F., and M. Armitage. 2003. Lichens: A study in color. *CRSQ* 39:245–350.

Jacobs, J.B., and V. Ahmadjian. 1969. The ultrastructure of lichens. I. A general survey. *Journal of Phycology* 5:227–240.

Jacobs, J.B., and V. Ahmadjian. 1971. The ultrastructure of lichens. II. *Cladonia cristatella:* The lichen and its isolated symbionts. *Journal of Phycology* 7:71–81.

Jedd, G., and N. Chua. 2000. A new self-assembled peroxisomal vesicle required for efficient resealing of the plasma membrane. *Nature Cell Biology* 2:226–231.

Jahns, H. M. 1988. The lichen thallus. In *CRC Handbook of Lichenology, Volume I*, pp. 95–146. Edited by M. Galun. CRC Press, Boca Raton, Fl.

Marton, K., and M.Galun. 1976. In vitro dissociation and reassociation of the symbionts of the lichen *Heppia echinulata*. *Protoplasma* 87:135–143.

Moore, D. 1998. *Fungal Morphologies*. Cambridge University Press, Cambridge, UK.

Moore-Landecker, E. 1990. *Fundamentals of Fungi*, 3rd Edition. Prentice Hall, Englewood Cliffs, NJ.

Mukhtar, A., J. Garty, and M. Galun. 1994. Does the lichen alga *Trebouxia* occur free-living in nature: Further immunological evidence. *Symbiosis* 17:247–253.

Ott, S. 1987. Reproductive strategies in lichens. In E. Peveling. and J. Cramer (editors), *Progress and Problems in Lichenology in the Eighties*, pp. 81–94. Berlin, Germany.

Palaeos web. 2006. http://www.paleos.com/Fungi/Ascomycota/Ascomycota.html.

Peveling, E. 1973. Fine Structure. In Ahmadjian and M. E. Hale (editors), *The Lichens*, pp. 147–182. Academic Press, New York, NY.

Peveling, E. 1976. Investigations into the ultrastructure of lichens. In D. H. Brown, D. L. Hawksworth, and R. H. Bailey (editors), *Lichenology: Progress and Problems*, pp. 17–26. Academic Press, New York, NY.

Purvis, W. 2000. *Lichens*. Smithsonian Press, Washington, DC.

Smith, T. L., and C. Brown. 1985. Perspectives on the origin of mitochondria. *CRSQ* 22:78–83.

Tschermak-Woess, E. 1988. The algal partner. In M. Galun (editor), *CRC Handbook of Lichenology, Volume I*, pp. 39–94. CRC Press, Boca Raton, FL.