Photographic Essay

Lichens at VACRC: Lichen Surfaces under the Electron Microscope

(A Van Andel Creation Research Center Report)

by Mark H. Armitage and George F. Howe*

Introduction

Christ told His disciples and a large crowd of other people that God maintains an exact, numerical tally of the hairs on every human head (Luke 12:7). He also asserted that God has each individual sparrow under surveillance (Luke 12:7). The Creator's cognizance, care, and control thus cover all life forms at all times. Far from forgetting His handiwork after the one, novel week of origins, God has perpetuated a continuous, ongoing involvement with all of His creation—animate and inanimate (e.g. Colossians 1:17).

The Creator's concern encompasses plants as well as animals; Christ noted that God governs the glorious colors of wild flowers in the field (Matthew 6:28–32). It would then be no stretch of the Scripture to say that His providence and design extend down to the details of the microscopic anatomy of lichens.

We present a brief commentary on certain aspects of lichen surface structure, facts that fit with the concept that supernatural activity rather than random processes prevailed in the origin of lichens. The Creator's otherwise "*imperceptible power*" (Romans 1:20—Concordant Version) can become readily *perceptible* from the study of His created beings, including lichens.

Materials and Methods

Armitage's scanning electron microphotographs (SEMs) show the upper surface of several lichen species that grow on the Hickey Basalt rocks at the Van Andel Creation Research Center (VACRC), Chino Valley, AZ. Background information about these lichens and about lichens in general is contained in our previous papers (Howe and Armitage, 2002; 2003). In a subsequent paper we intend to discuss aspects of creation design inside the lichens, as seen in transmission electron microphotographs (TEMs) and brightfield microphotographs of lichen thin sections.

We processed the lichens for scanning electron microscopy by fixation in cold, 2%, buffered glutaraldehyde for 24 hours. Specimens were then post-fixed in osmium tetroxide because this compound helps plant materials to become more conductive and ultimately more visible. Another reason for using osmium tetroxide is that we processed these lichens for SEM work together with the lichens that will be studied in our next paper using TEM—TEM specimens do require osmium tetroxide fixation. We washed the lichens next in a buffer, and subsequently dehydrated them through a graded series of acetone solutions (i.e. 20%, 35%, etc., up to 100% acetone). Next, they were sputter coated with palladium at 30 milliamps for 2 minutes. These are standard techniques described in Hunter (1993). The lichens were then photographed with an ISI-60 or with a Hitachi S-2400 electron microscope.

Results and Discussion

The Lichen in Cross Section

At the top of their thallus (lichen body), many lichens have a layer that resembles an epidermis of flowering plants, a layer that Fink (1935, pp. 6–7) called a "dermis." The surface of this uppermost lichen layer is visible at various magnifications in our SEMs. The dermi of lichens have been photographed extensively by Hale (1976), who demonstrated that their surface characteristics are constant enough to be of value in their classification and identification—lichen "taxonomy." Figures 2-15 are surface microphotographs (SEMs) of several VACRC lichen species at various magnifications.

Figure 1 is a cross-sectional view of the lichen *Xanthoparmelia sp.* Although lichen internal structure is simple and non-vascular, it bears a striking resemblance to the com-

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plex arrangement of true tissues found in layers within flowering plant leaves. This layered condition of lichens is what leads to their being designated as "stratified"(Brodo et al., 2001, p. 13). In this report, we are discussing the exposed surface of the lichen upper cortex (Figure 1—"UC").

The cortex undergoes replacement continually from below because aging cells from the layers beneath are pushed slowly upward (Fink, 1935, p. 7). The outer cortex may thus contain a few algal cells that are being eliminated from the algal layer, but the bulk of the cortex, and of the entire lichen, is fungus tissue.

The cortex serves as a skin to the lichen, preventing excessive evaporation and providing a measure of protection (Brodo et al., 2001, p. 13).

On the outer cortex of various lichen species one can find such diverse features as tiny hairs (composed of fungal hyphae), crystals of lichen acids, and even pores that expedite gas exchange (Moore-Landecker, 1972, p. 380; Jahns, 1973, pp. 174–175.) Each of these surface phenomena has a functional counterpart on the surface (epidermal) layer of flowering plants—leaf hairs, secretory glands with their crystals, and guard-cells that regulate stomate pores. Such parallelisms of form and function between lichens, on the one hand, and tissue-forming plants on the other, support the creation origins model. Convergences like these, each arising by chance from such greatly different forms that are said to have separate evolutionary histories, would be highly unlikely, in terms of naturalistic evolution.

Small bulges visible on the surface at higher magnification (Figures 3, 4, and 7) correspond to the outer surfaces of the many interwoven, fungus filaments that together form the cortex. Concerning this pattern of minor bulges and creases, Hale (1976, p. 9) wrote that they are ". . .for the most part a faithful replica of shape and orientation of underlying hyphae."

Underneath the outer cortical surface are fungal cells, whose hyphae are cemented together or "conglutinated", providing rigidity to the thallus. We will write more about these and other internal features of lichens in another paper.

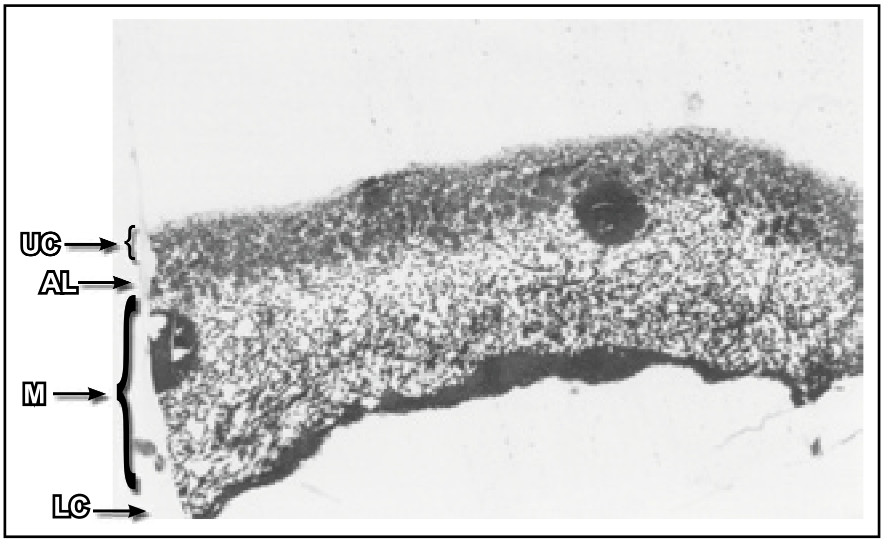


Figure 1. The various "tissues" of the lichen *Xanthoparmelia sp.* are seen here in cross section, using brightfield optics. The symbols are: AL = algal layer, LC = lower cortex, M = medulla, UC = upper cortex. As a foliose or "leaf-like" lichen, *Xanthoparmelia sp.* has a lower cortex. This is an important feature for protection underneath because foliose lichens curve up and away from the rock at many points, exposing their lower surface. The other three lichens we have photographed have the crustose morphology in which the medulla adheres directly to the underlying rock surface. Generally, such crustose lichens have no lower cortex. The absence of a lower cortex in the crustose lichens (where such a lower cortex would be of little or no "value") is one of those little scientific supports for believing that behind even the lowly lichens there is intelligent design.

Areoles

Deep cracks called "fissures" subdivide various crustose lichen species into several-sided patches known as "areoles" (Brodo et al., 2001, p. 17.) Such cracks between areoles are visible in our photographs of *Pleopsidium chlorophana* (a species that was previously known as *Acarospora chlorophana*)—see Figures 2, 3, 5, and 7. Lichens that possess areoles, like this one, are said to be "areolate."

The fissures that divide the thallus into areoles also allow gases to circulate into the lichen layers beneath. This fits with the origins hypothesis of a planned creation because photosynthesis, which requires carbon dioxide gas, occurs in the algal cells, deep inside the thallus. By means of photosynthesis, the algae supply the nutrition for the entire lichen.

Lichen fissures may also become important as lines of separation, along which the areole may break away. Loose areoles can then be transported and they may grow independently, forming a new thallus by vegetative reproduction. Hale (1979, p. 9) reported that areoles and all other thallus fragments containing both fungus and alga, can ". . . act as vegetative propagules and when dislodged apparently

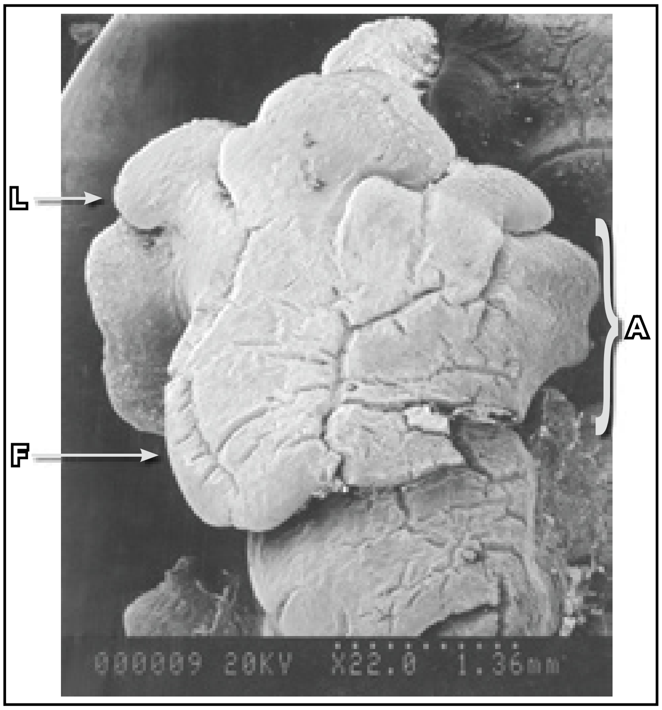


Figure 2. SEM micrograph of fissures, lobules, and areoles on the upper cortex surface of the lichen *Pleopsidium chlorophana*. The surface of this crustose lichen consists of multi-sided, irregularly shaped patches called areoles (A). Each areole is bounded by deep fissures (F) that extend down into the body of the lichen, allowing for interior aeration. A fissure can be seen beyond the arrow tip. The rounded structures at the edge of the thallus are lobules (L). The magnification on Figure 3 is 130 power ("X130") and the distance between the first and the last of the ten dots is 231 micrometers ("231 µm"). Similar magnification and micrometer markings are present on most of the figures that follow.

resume growth to form a new thallus." [A "vegetative propagule" is some portion of the plant that can grow to form a complete new plant without any sexual involvement.] Hale also noted on p. 9, that ". . .lichens are eminently successful colonizers in nature." We conclude that this highly successful vegetative reproduction in lichens supports their origin by design. To imagine that chance mutations and natural selection produced such results is "wishful thinking."

Pores: Possibly Two Kinds

On the surface of one *P. chlorophana* lichen, we found and photographed some pores with raised edges (Figures 4 and 5). We also observed larger, sunken cavities—pit-like chambers that extend downward into the thallus (Figure 6). In these large pits it is possible to look directly into the lichen

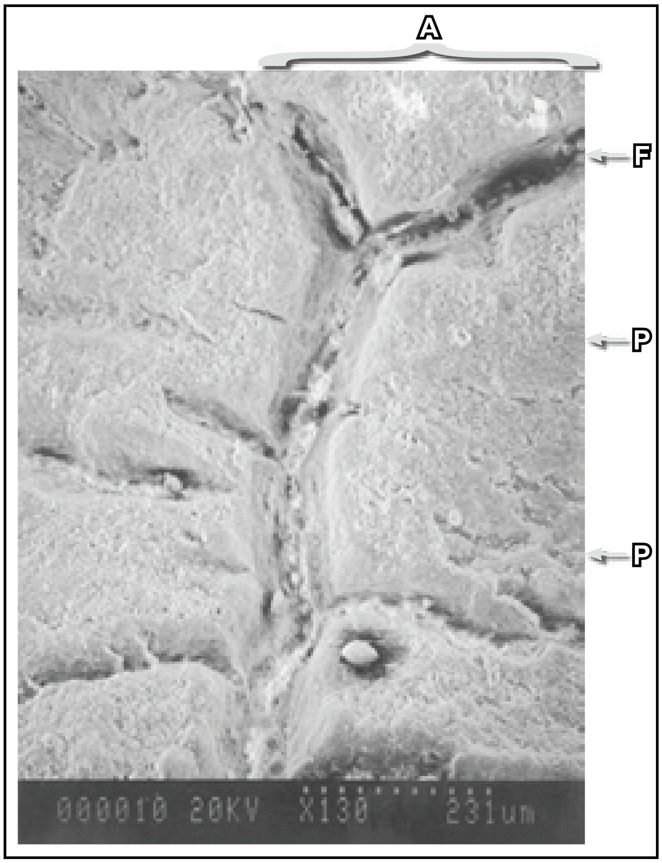


Figure 3. SEM micrograph of lichen fissures, areoles, and pores. This is an enlarged view of the center area of the same *P. chlorophana* specimen photographed in Figure 2. Fissures (F) and areoles (A) can be seen. Also visible are crater-like pores (P) to the left of each arrow. The width of these small pores is about 20 µm. (Magnification 130x)

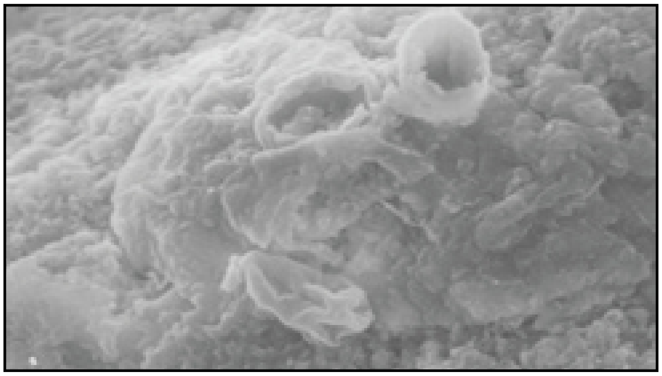


Figure 4. SEM micrograph of small bordered pores. Lip-like edges surround very small pores on the surface of the *P. chlorophana* lichen. At the time Figures 4, 5, and 6 were taken, our camera was not recording size or magnification. We are certain, however, that Figures 4 and 5 are at very high magnification. The pores here probably correspond to the small pores seen in Figure 3.

Figure 5. SEM micrograph of a small crater-like pore with objects visible inside it—*P. chlorophana* lichen, surface view. Note the slightly raised margin. Possible identity of these small bordered pores is discussed in the text. Magnification data not available.

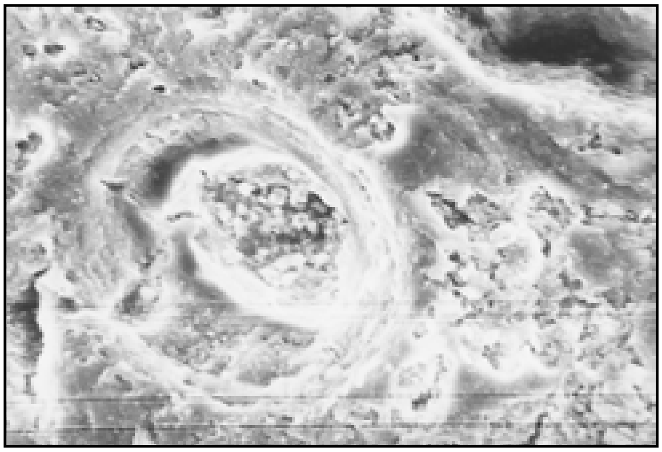


Figure 6. SEM micrograph of a view down into one of the larger pores on upper surface of *P. chlorophana* lichen (magnification data not available). Objects inside have cell-like shapes, perhaps algal cells—see Figure 10.

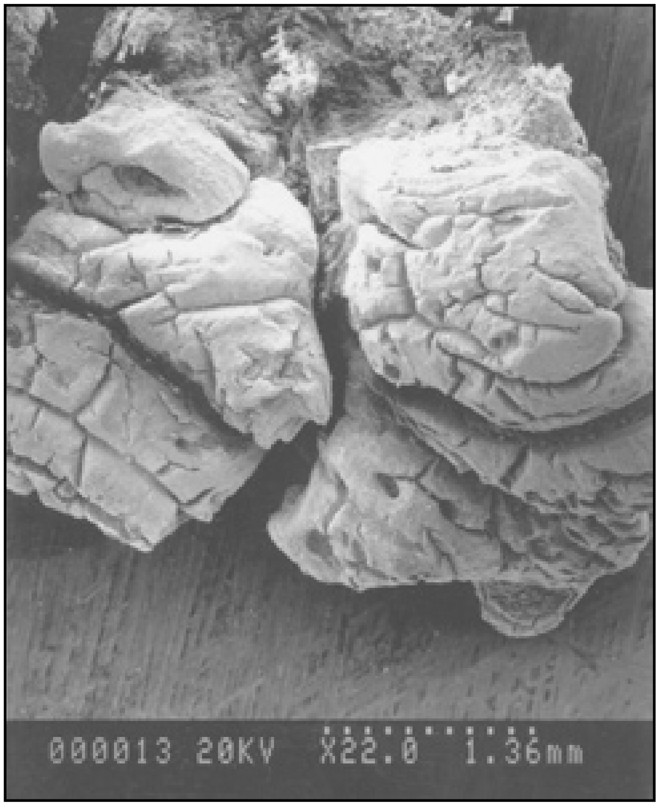


Figure 7. SEM micrograph of pits located among the areoles of another *P. chlorophana* specimen—low magnification. The pits appear as dark, oval-shaped dots. (Magnification 22x)

thallus at many loosely-arranged cells that are about the size and shape of algal cells; they have an average diameter of 20 micrometers (µm). Compare the cell-like objects of Figures 6, 8, and 9 with lichen algae from a torn portion of the algal layer of this same lichen—Figure 10. The relationship of the larger cavities to the areoles of *P. chlorophana* is obvious in Figure 7. The opening of the large chamber has a wide diameter and a narrower one (Figure 8) which are respectively 225 µm and 110µm, making them considerably larger than the pits with borders (Figures 4 and 5).

Lichen Surface Pores and Gas Exchange

Whatever these two types of pores are, they each provide contact between the outside air and the algal layer beneath the cortex. Purvis (2000, p. 18) observed that lichen surfaces regularly have pores as well as cracks, ". . .to allow gases to enter and leave the thallus." Whether it was intended or not, Purvis' remark implies teleology. If that was his intent, we would agree. Hale (1976, p. 6 and 1973, p. 4) also

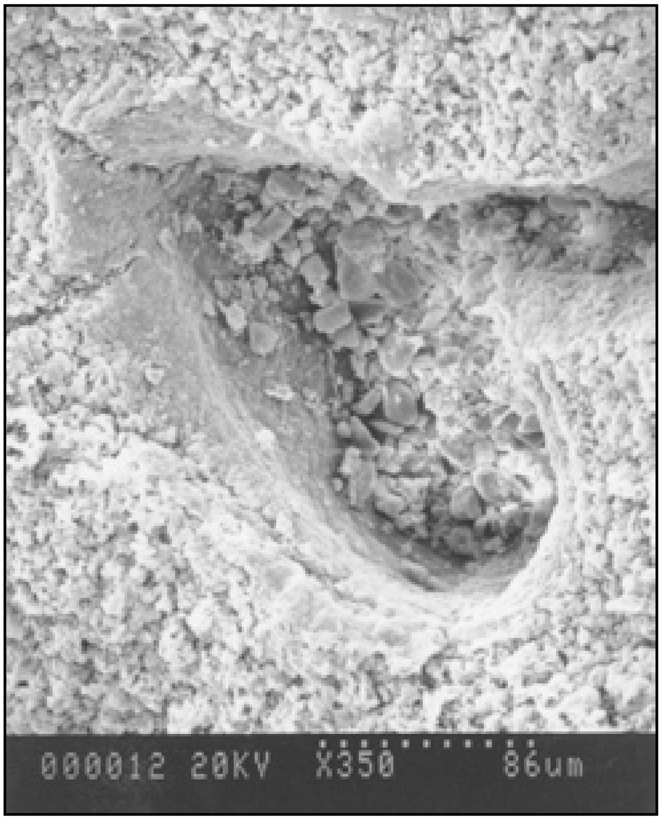


Figure 8. SEM micrograph of one of the crater-like cavities from Figure 7. The contents look like algal cells, as seen in Figure 10. The cells inside have about the same size range as lichen algae cells—from about 25 µm and smaller.

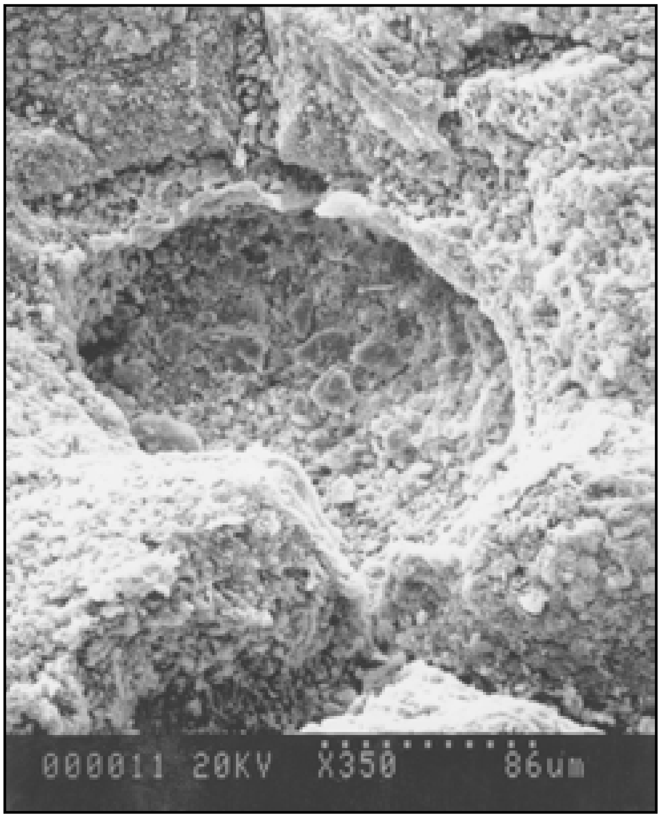


Figure 9. SEM micrograph of one of the sunken pits in the surface of a *P. chlorophana* lichen. Note resemblance between objects inside this pit and algal cells—Figure 10.

implied purpose when he wrote that lichen pores exist ". . .for gas exchange." It is difficult not to conclude that there is a high degree of functionality in each aspect of lichen anatomy—mute but perceptible testimony supporting the belief that this is the Creator's handiwork.

Hale (1976, p. 8) described this gas exchange function by stating that in some lichens the pores provide passage into the deeper layers. Unlike the stomate pores of vascular plants, however, lichen pores are permanently open, although Fink (1935, p. 12) described the pores of one lichen species that ". . .resemble stomates in that they can be closed." Hale (1973, p. 15) showed pores that are about 25µm in diameter—about the same width as our small, bordered holes, Figures 3 and 4.

Soredia and Soralia

The lichen literature offers several possible options for the small (bordered) and larger (unbordered) pits. Some of these pores looked like soralia openings, with soredia inside. Soralia (soralium, singular) are the variously shaped aperatures in which soredia are borne. Jahns (1973, pp. 46–47) lists seven types of soralia, based on shape. Certain lichens have "orbicular" soralia, looking like the larger, cup-like, non-pored cavities on our *P. chlorophana* specimens—Figures 6, 8, and 9.

A soredium is an asexual, reproductive unit that consists of one or more algal cells with some of that lichen's fungal hyphae loosely clinging to the algae (Webster, 1980, p. 368). They are produced in the medulla and algal layers (Budel and Scheidegger, 1996, p. 62). Growing outward and upward, the mass of soredial mycelium and algal cell(s) roll into a ball-like shape (Bessey, 1971, p. 219). Numerous soredia erupt from within the lichen, spilling forth from openings. In some lichens the soredia are so numerous that they cover the entire surface of the thallus (Hale, 1967, pp. 19–20). The soredia vary in size, most ranging between 20 and 50 µm, which is the size of the small objects in the larger *P. chlorophana* cavities—Figures 6, 8, and 9. In many species, soredia emerge from variously shaped slits or openings, while in others they are produced directly from the surface of the lichen.

Like so many lichen features, soredia cannot be produced by the fungus itself or by the alga grown alone. They

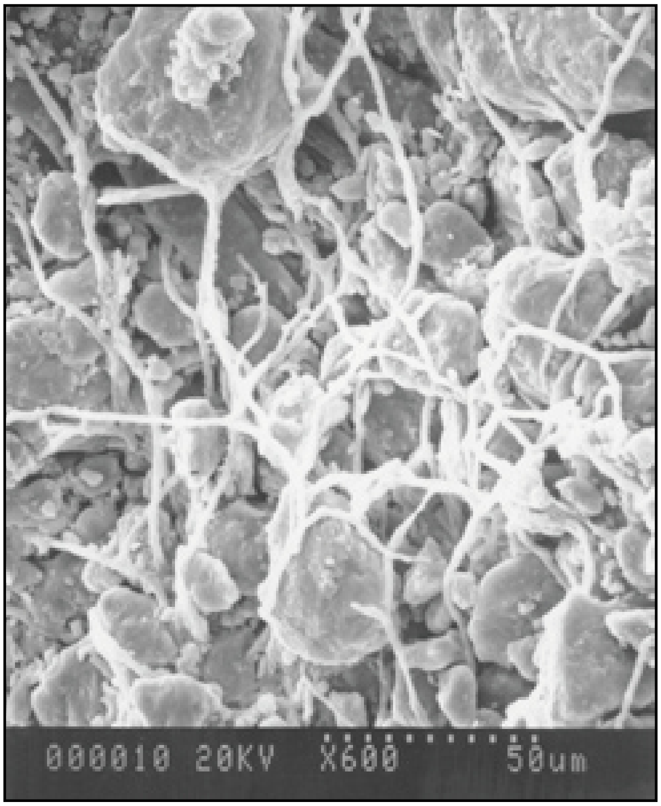


Figure 10. SEM micrograph of the algal layer of a *P. chlorophana* lichen showing fungus filaments attached. At one location in this torn specimen we were able to directly photograph its algal layer. Note the close clasping of algae by fungal filaments. Variation in algal cell diameters is from about 5 µm to over 30 µm. (Magnification 60x)

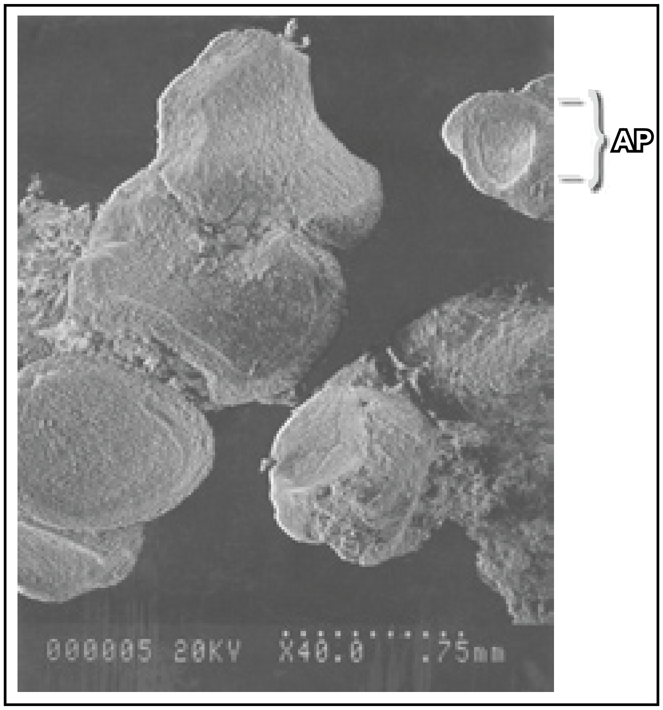


Figure 11. SEM micrograph of the surface of the reddish, crustose lichen *Calloplaca sp.* We think the bowl-shaped depressions seen at this low magnification are apothecia (AP)—one type of ascocarp). (Magnification 40x)

appear only when the fungus and alga of that lichen grow together (Hale, 1967, p. 18). The genes of the fungus and alga may have been "co-designed" to yield soredia and their surrounding soralia only when the two partners are together in close proximity—another feature that does not find ready explanation in the macroevolutionary origins model.

The soredia are loosened from the soralia and are then ". . . scattered by hygroscopical movements of the cortical tissue" (Budel and Scheidegger, 1996, p. 63). Transport of soredia occurs by wind, water, gravity, and insects (Jahns, 1973, p. 48.) Each soredium is an asexual reproductive body, capable of starting a new thallus (Bessey, 1971, p. 219).

A lichenologist brought information from Budel and Scheidegger (1996) to our attention—information maintaining that *P. chlorophana* individuals have never been observed to produce soredia. In light of this, it seems unlikely that the little algal objects are soredia.. On close analysis, the soredia-like objects in our photomicrographs do not appear to have fungal hyphae attached to them, as do the typical soredia.The possibility that this species of lichen may in fact have soralia with soredia, however, should be examined. Perhaps they have been previously overlooked.

Are The Pores Pycnidia?

The lichenologist who studied our photographs made two suggestions concerning the possible identity of the pit-like cavities on *P. chlorophana:* (1) perhaps they are the openings of pycnidia, or (2) maybe they are the walls and remnants of apothecia. Pycnidia and apothecia are features involved with the sexual reproduction of lichen fungi. Pycnidia are sunken, vase-shaped chambers in which pycniospores are produced—small cells that can grow asexually to produce a new fungus or may serve as male gametes by uniting with a female structure (Ahmadjian, 1967, p. 56. In our 2002 and 2003 papers we regrettably misspelled Ahmadjian's name). Pycnidia are well illustrated in the lichen literature—see Hale,1975, p. 9, for example. Perhaps the small, bordered holes seen in Figures 4 and 5 are the openings of pycnidia.

Ascocarps, Apothecia, and Asci?

After the pycniospore and the female cell unite, the resulting bi-nucleate cell divides many times—yielding a spore-producing mass called an ascocarp. An apothecium is a type of ascocarp having a vase- or cup-like shape. The apothecium has an opening at its top, through which the ascospores emerge. Produced in sacs called asci (ascus, singular), the ascospores are capable of germinating to form a fungus mycelium. We think the broad, bowl-shaped areas seen on the surface of the *Calloplaca sp.* lichen in our Figures 11 and 12 are apothecia of a very open type.

Ascocarps have been discussed and those of *Xanthoparmelia sp.* have been illustrated (Howe and Armitage, 2002, pp. 83 and 86). Ahmadjian's drawings (1967, p. 66) show that ascocarps are generally larger than soralia and they have a different appearance inside. In fact apothecia of the *Xanthoparmelia* lichen are easily visible to the unaided eye. Hale (1979, p. 32) has affirmed that the apothecia of the *P. chlorophana* lichen, seen in our photographs here, are visible as *pores in the areolae*.

If the larger openings in our photographs are apothecia, then one would expect to see asci inside them. As mentioned earlier, the contents appear instead to be algal cells, not asci. But perhaps after ascospore production, the apothecia of *P. chlorophana* become cavities whereby the algae are in direct contact with the atmosphere.

It will require more research to determine if the various orifices on the surface of *P. chlorophana* are the openings of apothecia, pycnidia, or both. We intend to explore these and other options further.

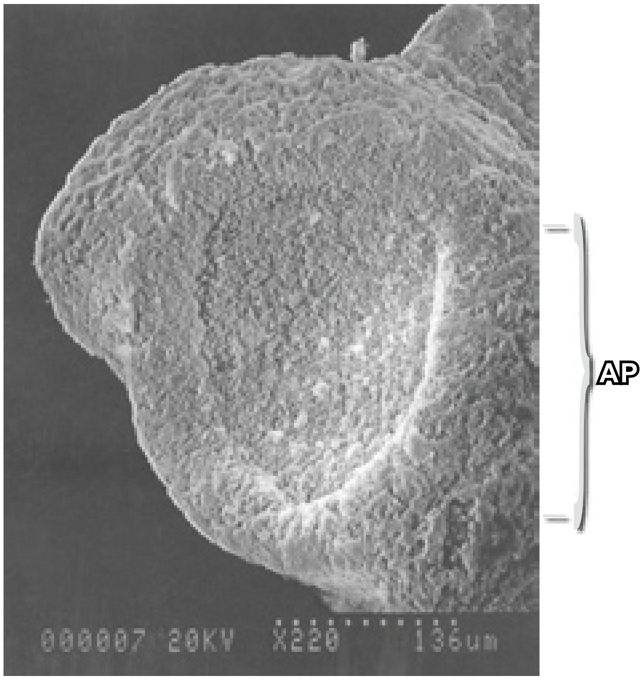


Figure 12. SEM micrograph of the object at the upper right, Figure 11, at higher magnification—possibly an apothecium (AP) in which asci and ascospores are formed. (Magnification 220x)

Lobules

A lobe is a rounded or strap-shaped division of a lichen thallus (Hale 1979, pp. 243–244) and a lobule is a subdivision of a lobe. Lichens that produce numerous marginal lobules are said to be "lobulate." Lobules have been shown to be regenerative. Hale (1967, p. 22) called them "effective vegetative propagules," the growth of which is actually stimulated by tearing or wounding. A lobule separated from the parent lichen serves to produce a new plant asexually. The internal structure of a lobule is comparable to that of the main lichen in that lobules possess a cortex, a medulla, etc. The rounded, lobe-like objects at the edge of our *P. chlorophana* specimen (Figure 2) and likewise the lobular projections all over the *Candelilaria* lichen (Figure 13) are lobules.

Isidia

Surface photographs of *Xanthoparmelia sp.* showed outgrowths called isidia (isidium, singular)—see Figures 14 and 15. Hale (1979, p. 39) noted that isidia are common on *Xanthoparmelia sp.*: "There are a number of isidiate Xanthoparmelias in the southwestern United States. . ."

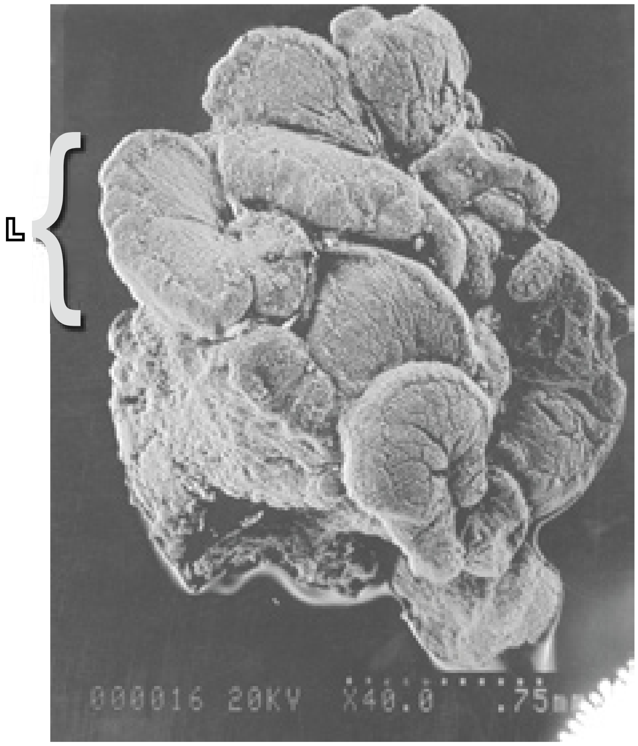


Figure 13. SEM micrograph of lichen lobules (L), clearly evident on the surface of the yellow-orange lichen, *Candelilaria sp.* Each lobule has the structure of a lichen in miniature, capable of yielding a new thallus asexually if it breaks away from the parent plant. (Magnification 40x)

Isidia arise from the surface of the upper cortex, whereas soredia develop from deeper tissues and erupt outwards. Soredia do not have the tissue organization of the parent lichen (cortex, medulla, algal layer, *etc.*) but isidia do, and isidia are therefore said to be "corticate." The degree of tissue-like organization within isidia varies with different lichen genera.

Isidia can eventually break away from the lichen, leaving a scar on the thallus. An isidium may then regenerate, forming another lichen. Thus, isidia serve primarily as vegetative propagules—and the list of different lichen asexual reproductive structures grows longer!

Isidia can be of different shapes: coralloid, spherical, or columnar. Like those in Budel and Scheidegger (1996, p. 53), the isidia in our photographs (Figures 14 and 15) lie somewhere between being spherical and columnar in shape. Ours are 80 to 120 µm wide and up to 190 µm tall (Figure 15). Published size figures for isidia are between 10 and 300 µm wide and between 50 and 3000 µm tall. The smaller figures here are probably from very immature isidia.

Asexual Reproduction in Lichens

The different asexual reproductive bodies that we have already discussed are distributed by wind, water, and even gravity: areoles, lobules, soredia, isidia, and even picniospores. Speaking of these features and others, Purvis (2000, p. 18) wrote: "There is a wide range of structures and surface features, which help the lichen grow and reproduce." There is a great potential for asexual reproduction in lichens, which Brodo et al. (2001, p. 30) addressed: "In fact any fragment of lichen containing both the fungal and algal components can, theoretically, form a new lichen. . ."

The list of asexual reproductive bodies produced by lichens includes many others that we are not discussing in this paper: spinules, blastidia, schizidia, *etc.* Brodo et al. (2001, p. 63) listed 20 different reproductive units in all, most of them asexual in character! Hale (1979, p. 9) summed it up: "Soredia, isidia, and thallus fragments can all act as vegetative propagules and when dislodged apparently resume growth to form a new thallus. . .lichens are eminently successful colonizers in nature." Is such success-

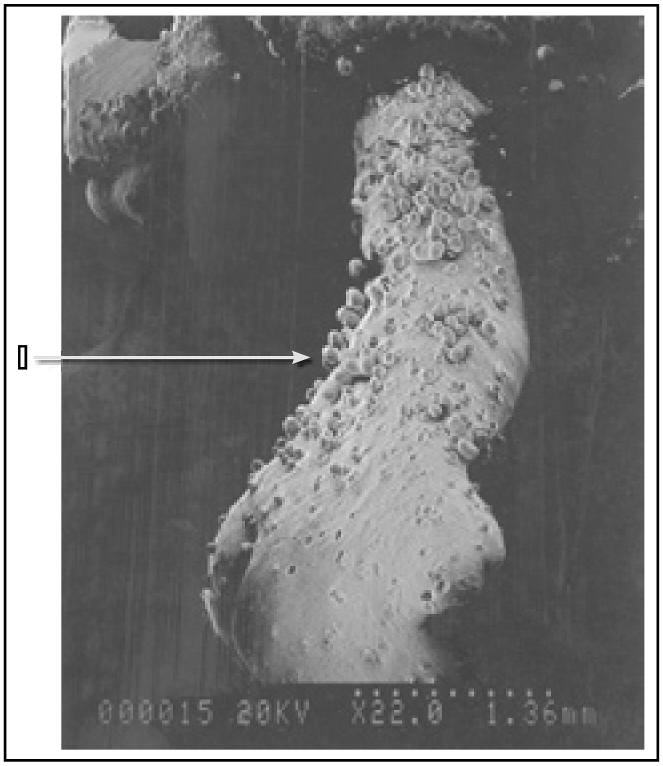


Figure 14. SEM micrograph shown dozens of isidia (I) of various sizes, borne on the surface of the grayish-green lichen, *Xanthoparmelia sp.* Isidia have an internal structure similar to that of the parent plant, so they too are miniature lichens—asexual reproductive bodies. (Magnification 22x)

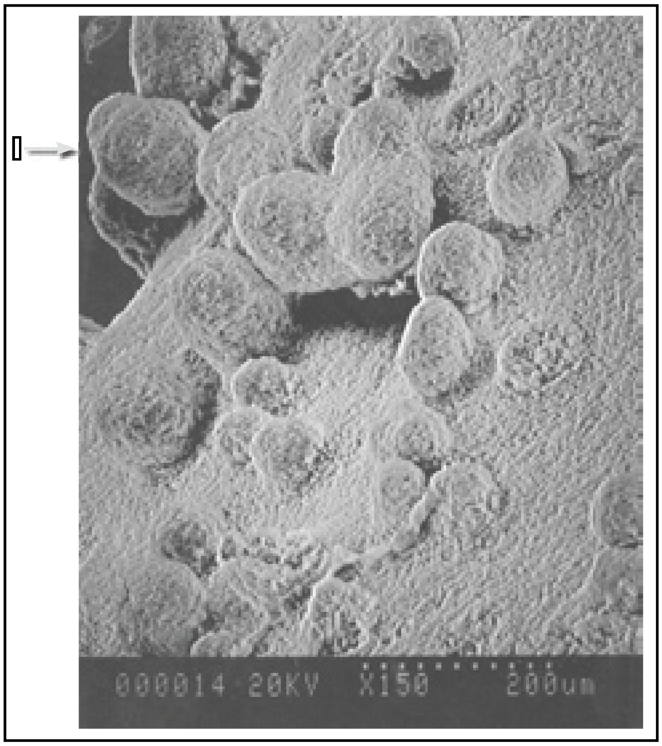


Figure 15. SEM micrograph showing several isidia (I) from the center of Figure 14 at higher magnification. In *Xanthoparmelia sp.*, and in many other lichen species, isidia vegetative propagules, which may produce new lichen plants when they become detached. (Magnification 150x)

ful versatility in reproduction indicative of design or chance in lichen origins? We see design.

Which Mode of Lichen Reproduction Is Most Important: Sexual or Asexual?

Quite aside from *how* the many lichen vegetative reproductive bodies came into existence, a different and more scientific question arises: what role does fungus sexual reproduction play in lichen life histories at the present time? Three facts need to be taken into account in answering (Ahmadjian, 2002). (1) There are no known free-living strains of *Trebouxia sp.*, the alga found most commonly in lichen species. But if *Trebouxia* cells are not widely distributed outside of lichens, (2) it does not appear likely that germinating fungus ascospores would stand much of a chance of hooking up with their favorite alga! Actually, (3) the very act of a lichen fungus sporeling joining with a free-living alga to produce a new lichen has never been observed in nature.

Some workers maintain that the *principal* means of lichen dispersal are the asexual options, and others go so far as to say that asexual reproduction is the lichen's *only* reproductive option. But years ago, Ahmadjian (1967, p. 65) wrote that a very puzzling situation would exist if the *asexual* reproductive structures were the only means by which lichens multiply in nature. It would mean that all the ascospores produced by all lichen fungi are without function. Unlikely as such a deduction seemed to him in 1967, Ahmadjian appears recently to have adopted that conclusion. He calls the following idea a *pervasive myth* (2002, p. 1): ". . . that the most common photobiont of lichens, *Trebouxia*, occurs free-living (outside the lichen) and thus is available to sporelings of mycobionts who use them to reconstitute the lichen." He speaks almost wistfully about the myriads of ascospores, and we sympathize with him: ". . .the fate of the sporelings is not clear." He further noted that it is ". . . hard to imagine that there is not a function for so many spores" (Ahmadjian, 2002, p. 2).

Indeed, it would actually amaze both creationists and evolutionists if it turns out that all these fungus spores, released by lichens in such great numbers, play no function in lichen reproduction at all! Evolutionists would face explaining how it is that such "useless" features as pycnidia, ascocarps, asci, and ascospores would have persisted in full-blown form through hundreds of millions of years—time during which these structures would have been a detriment to survival, not an advantage. Creationists likewise would need to explain how it is that truly functionless features would be present in God's little lichens. It will take more work on lichen reproduction in nature to settle this question for both groups.

Origins Speculations

Lichen Literature and Evolution

Technical lichen documents have been useful in our study. In some cases they represent whole lifetimes spent diligently analyzing this little corner of creation. Evolution, on the other hand, has contributed little or nothing to lichenology. In fact, evolutionary ideas often run counter to the data, so that evolution theory becomes a "rationalization after the fact" rather than a predictive, scientific tool. For example, if macroevolution (defined as "common descent") were valid, one would expect to find numerous instances in which lichen species are in various stages of producing new taxa. Such is not the case. We see instead a stasis that fits with the special creation of "kinds," each rich in genetic potential, but possessing fixed boundaries beyond which variation does not occur. If we are asked to believe that evolution is "too slow a process for humans to observe," that would be tantamount to saying that evolution is not part of science.

If evolution were *scientific*, then technical literature would be terribly deficient in the absence of neo-Darwinian discussions. To the contrary, most lichen treatises make little reference to macroevolution, for the lack of which they are none the worse off. Comments about natural selection in these books often amount to little more than a passing nod, here or there. A highly useful monograph on lichens could be written without one reference to evolution.

This shows that the scientifically based macroevolution theory, like scientific creation, is a *philosophy* of origins. Evolution has no special claim to scientific superiority among competing origins models. Evolution ought to be treated in research and teaching as a philosophical construct, which lies outside the domain of science. If macroevolution were a pure science, it would then be able to pass "muster" by showing the usual hallmarks of experimental science—a requirement at which it fails spectacularly.

In their writings, evolution-minded scientists often fail to distinguish between their presuppositional origins beliefs and empirical science; little off-hand comments betray this failure. Here are five examples of flawed logic from the papers of various lichenologists.

(1) "Some desert and Antarctic lichens have adapted to their environments by the formation of thick, compact upper cortical layers. . ." It remains to be proved that these lichens adapted themselves to such extreme conditions. Perhaps they were equipped with those capabilities beforehand, by design. (2) Of another lichen, a worker writes that it ". . .somehow has adapted to life near large cities and towns." Whether or not this was evolutionary adaptation, as he assumes, is unknown. Maybe this survival capability was a pre-adaptation originally programmed into the genes

of that lichen by the Creator. (3) One evolutionist has said that lichens living where there is not much water ". . .have adapted to this lack of liquid water by being able to absorb water vapor very quickly." The question of how they got this amazing feature has obviously been "begged." (4) A more glaring illustration of a logical fallacy called *petitio principii* (begging the question) lurks in the following quotation: "The existence of different kinds of algae and fungi in the symbiosis implies that lichens have arisen on a number of separate occasions during evolution." The word "implies" is far too strong, because not one lichen has ever been observed to have "arisen" by evolution. To say that we are rather sure lichens have arisen by evolution on *several* occasions is to "beg" the question that needs to be proved. (5) Speaking about fungi, another scientist wrote "Evolution in this group. . . has been extremely diverse, resulting in a wide range of body types, reproductive mechanisms, and associations." His unsupported assumptions are again obvious, since it has not been shown that evolution had anything to do with producing the wide diversity among fungi.

These will be sufficient to illustrate the underlying tone of illogic found in evolutionary writings and the way these statements really add nothing to the science discussed in the manuscript. All of this would have been quite proper, however, had the writers made it known in their reports that they possess a presuppositional bias for macroevolution, which is an unprovable origins model.

Over-design and Extreme Situations

Lichens show an outstanding tolerance to environmental extremes, a tolerance that far exceeds the demands of their various environments. Lichens are so resistant to low temperatures that some were still able to carry out respiration after being subjected to -183°C for 18 hours (Ahmadjian, 1967, p. 111). At the other extreme, one lichen species was able to respire at temperatures close to 100°C. Concerning their uncanny ability to survive in conditions of low moisture, Ahmadjian had this to say:

> Lichens also can withstand dry periods for considerable lengths of time, *far longer than what they normally encounter in their natural habitats*. Even the least resistant lichens can withstand up to sixteen weeks of constant drying either under dry air conditions or over a dehydrating agent such as phosphorus pentoxide. More resistant forms survive for over one year without detectable signs of damage. (Ahmadjian, 1967, p. 111) [Italics are ours]

Such a proclivity of living systems to go "over and beyond" the demands of nature can be called "over-design." Over-design fits with a belief in creation. Evolution by natural selection of gene mutations could not yield systems that would go beyond the basic prerequisites for mere existence and survival. It has not even been shown that evolution can yield resistance to moderate periods of drought in various *known* environments. To further ask that it generate the equipment necessary in lichens to endure drought for over a year is unfounded.

The same criticism applies to the belief that evolution was the source for resistance to low temperatures. It is unlikely that ancestors of lichens experienced temperatures as low as -183°C. It cannot be demonstrated that natural selection would be able to develop survival apparati against such extremely low temperatures, temperatures that probably never even existed in the environment of the evolving organism. Such extreme capabilities on the part of lichens, however, support the kind of fail-safe engineering posited in the creation origins model.

We would be remiss if we did not mention a fascinating event reported by Purvis (2000, p. 18) in which lichens endured a strange and unusual challenge. Their potential for survival in the face of bizarre conditions is highlighted in that certain lichens remained alive and continued to grow after having been gold-sputtered for SEM examination!

To ask that evolution develop one or two means of asexual reproduction taxes ones scientific imagination to the breaking point. To suggest further that evolution somehow yielded 20 different kinds of lichen propagules would be the height of unfounded assumption. But such fail-safe planning, such over-design, fits nicely with the belief that the divine designer carried out origins.

Conclusion

Over-design is the type of engineering that only intelligent designers (like humans or deity) can build into their products. The surface features observable in lichens growing at VACRC, the functions they fulfill, and the versatility in lichen reproductive physiology support the special creation model as the key component in lichen origins.

Acknowledgments

We extol the One who produced lichens, making them in such a way that by simply studying them, one can learn much about His intelligence and provision! We alone are responsible for the contents of this photographic essay, but we gratefully acknowledge the help of the following people in supplying input and/or technical assistance in various ways: an anonymous lichenologist, John Meyer, Peg Westphalen, Emmett Williams, Cindy Blandon, Stephen B. Austin, Jerry Bergman, Lane Lester, Eugene Chaffin, and Kevin Anderson. We also thank those who have contributed to the CRS Research Fund and the VanAndel Creation

Research Center Fund, interest from which has helped to support various phases of this research.

References

CRSQ: *Creation Research Society Quarterly*

Ahmadjian, V. 1967. *The lichen symbiosis.* Blaisdel, Waltham, MA [Regrettably, we misspelled Dr. Ahmadjian's name in our two earlier papers.]

———. 2002. Lingering lichen myths are hard to dispel. *International Symbiosis Society Newsletter* 2:1–2.

Bessey, E. A. 1971. *Morphology and taxonomy of fungi.* Hafner, New York.

Brodo, I. M., S. D. Sharnoff, and S. Sharnoff. 2001. *Lichens of North America.* Yale University Press, New Haven, CT.

Budel, B. and C. Scheidegger. 1996. Thallus morphology and anatomy. In: Nash, T. H. III (editor). *Lichen biology.* Cambridge University Press, New York.

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

Hale, M. E., Jr. 1967. *The biology of lichens.* Edward Arnold, London.

———. 1973. Fine structure of the cortex of the lichen family Parmeliaceae. *Smithsonian Contributions to Botany Number 10.* Smithsonian Institution Press, Washington, D.C.

———. 1975. Monograph of the lichen genus Relicina (Parmeliaceae). *Smithsonian Contributions to Botany Number 25.* Smithsonian Institution Press, Washington, D. C.

———. 1976. Lichen structure viewed with the scanning electron microscope. In: Brown, D. H., D. L. Hawksworth, and R. B. Bailey (editors). *Lichenology: Progress and problems.* Academic Press, New York.

———. 1979. *How to know the lichens.* William C. Brown, Dubuque, IA.

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

———. 2003. Lichens: A study in color. *CRSQ* 39: 245–251.

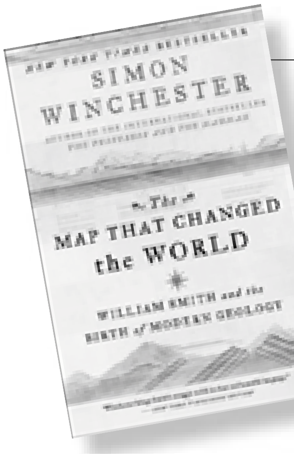
Hunter, E. 1993. *Practical electron microscopy.* Second Edition. Cambridge University Press, New York.

Jahns, H. M. 1973. Anatomy, morphology, and development. In Ahmadjian, V. and M. E. Hale, Jr. (editors). *The lichens.* Academic Press, New York.

Moore-Landecker, E. 1972. *The fungi.* Prentice-Hall, Englewood Cliffs, NJ.

Purvis, W. 2000. *Lichens.* Smithsonian Institution Press, Washington, D.C.

Webster, J. 1980. *Introduction to fungi*, second edition. Cambridge University Press, New York.



Book Review

The Map that Changed the World
by Simon Winchester
Harper Collins Publishers, New York, 2001, 330 pages, $14.00.

This book is a biography of William Smith (1769–1839), the "Father of English Geology." Smith studied rock strata while supervising canal construction. He noticed that similar fossils often were found in particular layers at far different locations, thus discovering the "principle of faunal succession." With this knowledge Smith constructed geological maps which showed various bedrock strata. One particular geological map, giving the book title, encompassed all of England and Wales. It required thousands of miles of travel while Smith made geological surveys. This map of England and Wales, 6x8 feet in size, took 15 years to complete.

Smith did not have an easy life. He was orphaned at an early age and raised by an uncle. His geology expertise was long ignored because of a lower class heritage. The wife he chose was mentally ill. Poor investments and plagiarism of his maps landed Smith for awhile in a London debtors' prison. In his final years, Smith's achievements were finally recognized and he was awarded the 1831 Wollaston Medal.

The book is a disappointment from the creation viewpoint. There is no mention of any interaction between William Smith and Charles Darwin (1809–1882). This is surely an oversight since their lives overlapped by 30 years and they lived in the same vicinity. A more serious problem, author Winchester grossly misunderstands the creation position. He writes, "any intelligent understanding of fossils [assaults] divinity's most firmly held notions, like the Creation and the Flood" (p. 111). To the contrary, fossils are excellent evidence for the global Flood. Winchester also describes creation as "thousands of years of fettered and blinkered prejudice" (p. 286). William Smith himself was an agnostic.

Smith's early maps are of historical value in recording *Flood* strata. The paperback book edition contains only a small, poor-quality illustration of his major map. A hardback edition includes a larger fold out copy of the map. Special thanks to Mart DeYoung for providing the book for review.

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