GUARD CELLS, STOMATA, AND DESIGN IN PLANTS

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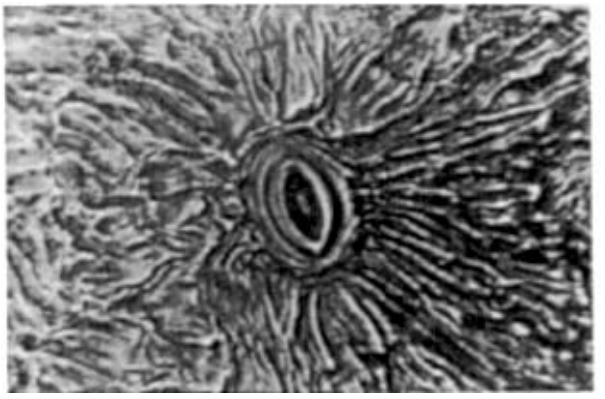

Figure 1. Guard cell pair and stoma of *Rhododendron californicum.* Approx. 800 power. Willis E. Keithley.

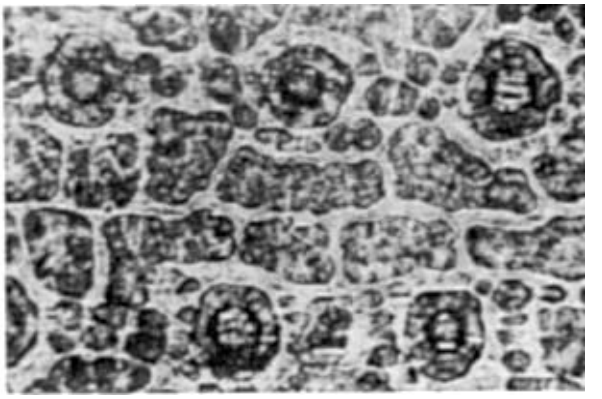

Figure 2. Guard cell apparati and view of epidermis, *Taxus brevifolia.* Approx. 800 power. Willis E Keithley.

The enigma of the photosynthetic process has long interested biologists, and though many new avenues of this chemical complexity have been discovered, the plant leaf still retains many secrets. But even if we could understand all the complications of chlorophyll, it still would not minimize the prime puzzle of how such a chemical reaction could have developed. That it could have arisen gradually by progressive expedient and refinement defies all reason.

What a multiplicity of factors would have to be involved in such an adventitious accident to spawn such a contrivance! And as we look at some of the apparatus used by the plant to achieve this photosynthetic miracle, the complex is compounded.

One of the most singular of these devices is the intricate array of stomata, or pores through which gas exchange and water loss take place. These stomate systems are the tiniest and most precise servo-mechanisms ever formed. On the foliage of most plants, countless numbers of these minute "valves" carefully regulate the exchange of carbon dioxide and oxygen by the expansion and contraction of the guard cells surrounding each pore. (See cover illustration and Figures 1 and 2.) Each of these stoma is so delicate that six million of these microscopic marvels can be found on a leaf the size of a human hand.

Several theories have been proposed for guard cell action. No one of them has been fully verified but a classical one includes the following:

a. As light stimulates the photosynthetic activity in the guard cells, it amplifies the sugar content, which increases the osmotic concentration.

b. Use of carbon dioxide during photosynthesis lowers the pH of the cell which enhances the enzymatic conversion of stored starch to glucose and this also increases the osmotic pressure. Several other chemical trigger systems may be involved also.

c. Water then enters and supplies the pressure which expands the guard cell and opens the stoma. Thus the pores are open in the daytime, allowing the leaf to take advantage of the necessary radiant energy, and at night the process reverses to close them.

One is fascinated by the artistic configuration of these miniature miracles as each kind of leaf has its own distinctive motif of epidermal cells as seen in the accompanying illustrations. But while there is an almost infinite diversity of patterns, there is a resolute consistency of design.

As one contemplates the process by which these vital valves could have developed, several questions demand consideration. How did photosynthesis in the palisade cells occur before the stomata were formed? Since a stoma apparently operates in coordination with that same photosynthetic method, which came first, palisade or guard cell? Was one the product of the other? Did this flawless organization of elements "evolve" through some ephemeral "super-ordinated system" or "psychic pressure"? If so, what evidence is there of prototypes, or discarded experimental forms so necessary to the evolutionary succession of any structural heirarchy?

It would be asking almost too much to assume that any trial and error development or "molecular selection" could have devised such an orderly operation the very first time. Yet this is precisely what would have to happen for any of the leaf's activities to become operative.

Although microscopic in size, these scrupulous stomata point up very distinctly the enormity of the well-known predicament encountered in attempting to trace the progression of evolution through the plant kingdom. But just as distinctly, the precision and functional unanimity of these astute cells affirm the veracity of fiat creation.

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