Comments on the Aloe Leaf

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The Structure Of the Aloe Leaf

The two *Aloe barbadensis* Miller plants sitting on my office window sill are three feet tall and about two and one half feet wide. The plants exhibit radial symmetry, containing about four rows of leaves alternately arranged. The outer two rows of leaves are fully developed whereas the inner two rows are not fully grown and only several inches long. These inner "pup leaves" receive nourishment from the outer leaves.

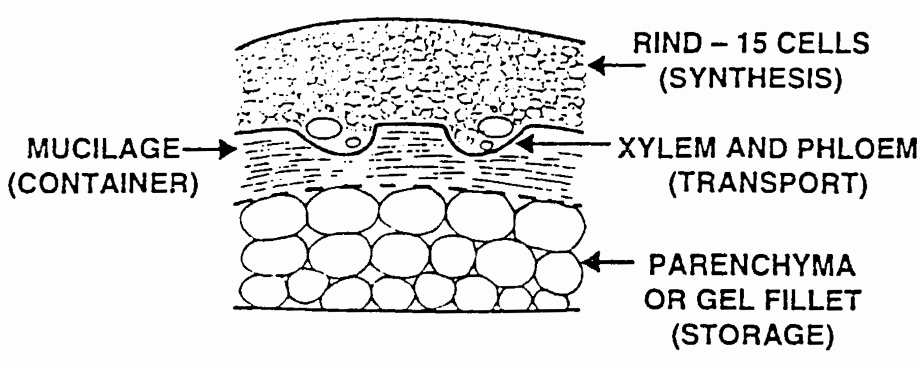
We x-rayed the leaves with a sensitive low amp faxitron instrument and observed long tubes running from the lateral tip to the leaf base. This observation was verified when we removed the inner gel completely by vacuum then by delicate dissection observed the same tubes running lengthwise toward the base of the leaf. We feel that the movement of the leaves by the wind moves the aloe from the lateral tip to the leaf base, then on to nourish the young "pup leaves." Wind increases the movement and production of the aloe vera leaf.

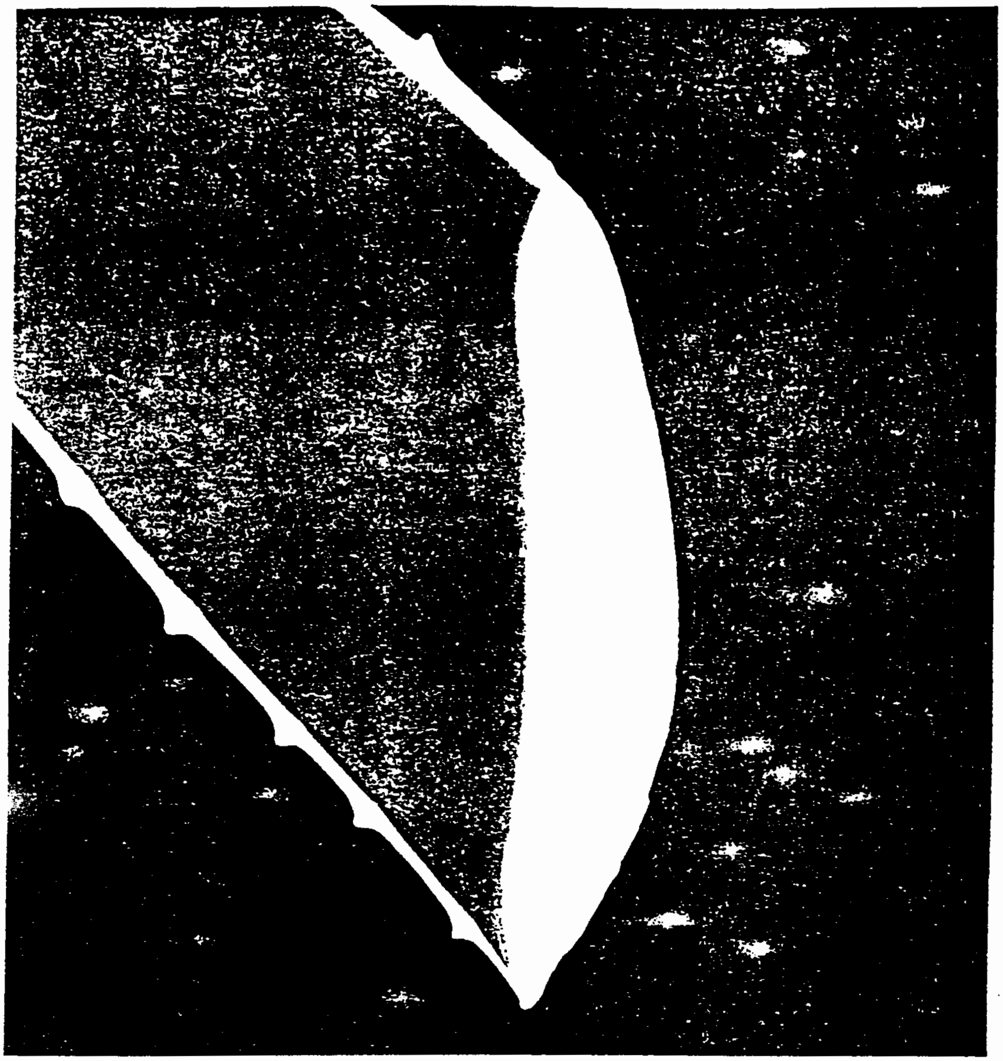
A cross section of the leaf shows the outer rind consisting of 15 cell layers in thickness (Figure 1). The rind is the "manufacturing plant" where carbohydrate, fat and protein are made. The green color comes from the chloroplasts (round bodies) which are important in the manufacturing of aloe vera. The vascular bundles consist of the xylem which carry water, minerals and nitrogen from the roots to the green rind. Calcium and magnesium contribute to the hardness of the rind. The phloem transports synthesized materials to the roots and to other parts of the leaf. The pericyclic tubules connect the xylem and phloem to the large tubules running lengthwise toward the leaf base that nourish the "pup leaves." We once thought that the mucilage functioned to transport green rind materials to the parenchyma for gel fillet storage. However, this movement is caused by the wind and not mucilage. Mucilage consists of long chain polysaccharides whose function is to act as a container to hold and keep the enclosed aloe gel sterile. The gel fillet consists of large parenchyma cells that store water and large amounts of carbohydrate.

How Aloe Vera is Made

The rind containing the chloroplasts takes the CO_2 coming in from the stomata and the water coming from the roots in the presence of sunlight, and by a process of photosynthesis makes an "active carbon" (Figure 2). The "active carbon" forms glyceraldehyde or malic acid which yields mannose and glucose. These are the two main simple sugars in aloe. In the process of aloe synthesis, the leaf can make long chain polysaccharides in an approximate ratio of one glucose molecule to six mannose molec-

Figure 1. Cross Section of Aloe Leaf





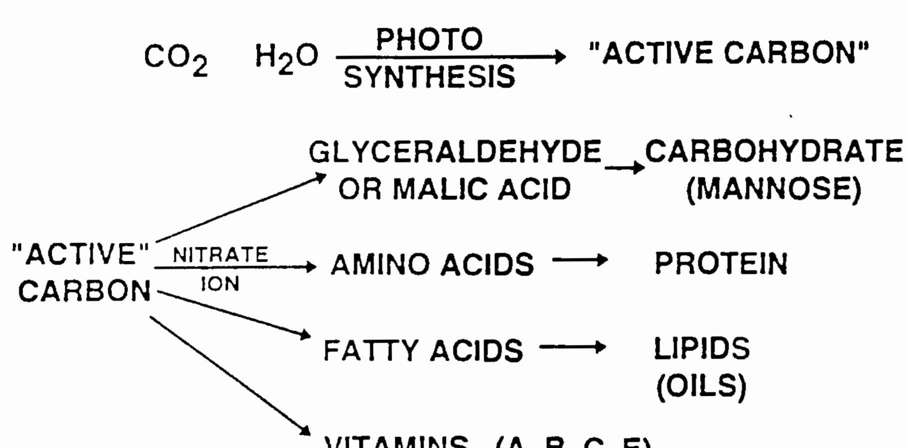
ules. This polysaccharide has a relationship at one end to protein and at the other end the mannose (not glucose) fits into a fibroblast receptor to cause cell growth and repair. Our laboratory found that mannose but not glucose has biological activity. Amino acids and fatty acids are also formed from the "active carbon" to produce protein and lipids. Carbohydrate, fat, protein as well as vitamins are united together in a unique way to give us the miracle of aloe. No other cell handles these constituents in the same way as recorded in aloe leaf synthesis.

Skin Penetration by Mucilage & Aloe Vera

We felt for a long time that mucilage functioned to transport aloe from place to place in the aloe leaf. We were wrong. The transport function is done by the wind moving the leaves and causing the aloe to be moved toward the center of the plant. If an animal bites the aloe leaf, the long chain polysaccharides of mucilage contracts to seal the hole and prevents loss of aloe vera to the outside as well as to prevent contamination of the inner aloe gel. Contraction studies were done on the aloe leaf at various distances from the tip. The cross sectional contraction of the leaf was greater as one moved toward the leaf base. This may be due to the greater amount of mucilage found toward the medial aspect of the leaf. These results were also a function of time. Our electron microscopic studies on mucilage tended to verify these results.

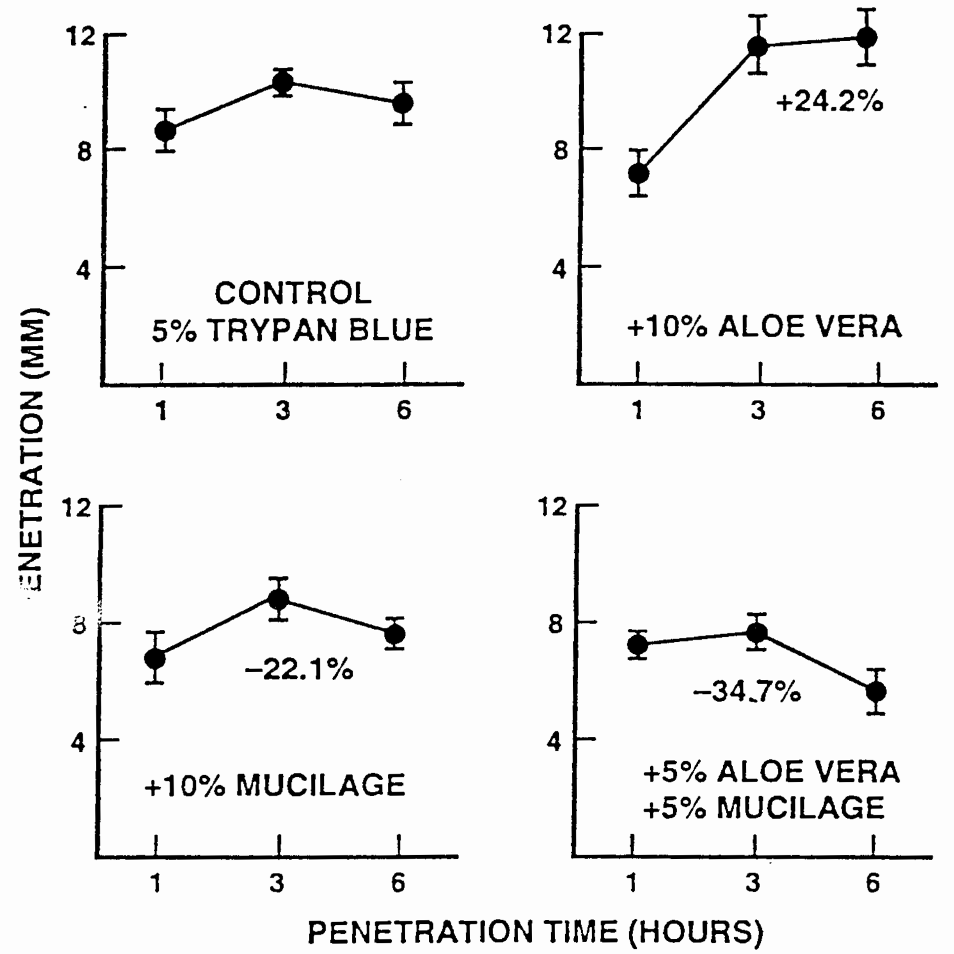
Different regions of the skin exhibit different degrees of skin penetration. For example, hydrocortisone penetrates the palms and soles very poorly because the stratum corneum is thicker in these regions. However, in the scrotum, the stratum corneum is thin and one observes the best skin penetration. It is very simple for hydrocortisone to move through the lipid part of a cell membrane but very difficult to

Figure 2. Aloe Leaf Synthesis*



*Rind

Figure 3. Influence of Mucilage and Aloe Vera on Skin Penetration (MM) of 5% Trypan Blue Over Six Hours



go through the stratum corneum. Since aloe vera hydrates the stratum corneum, it helps the hormone get through the skin. We feel that aloe vera contains water soluble and lipid soluble components which serve as a vehicle for compounds that have difficulty going through the skin. This property of aloe could reduce the dosage and toxicity of many valuable substances by making them more biologically available.

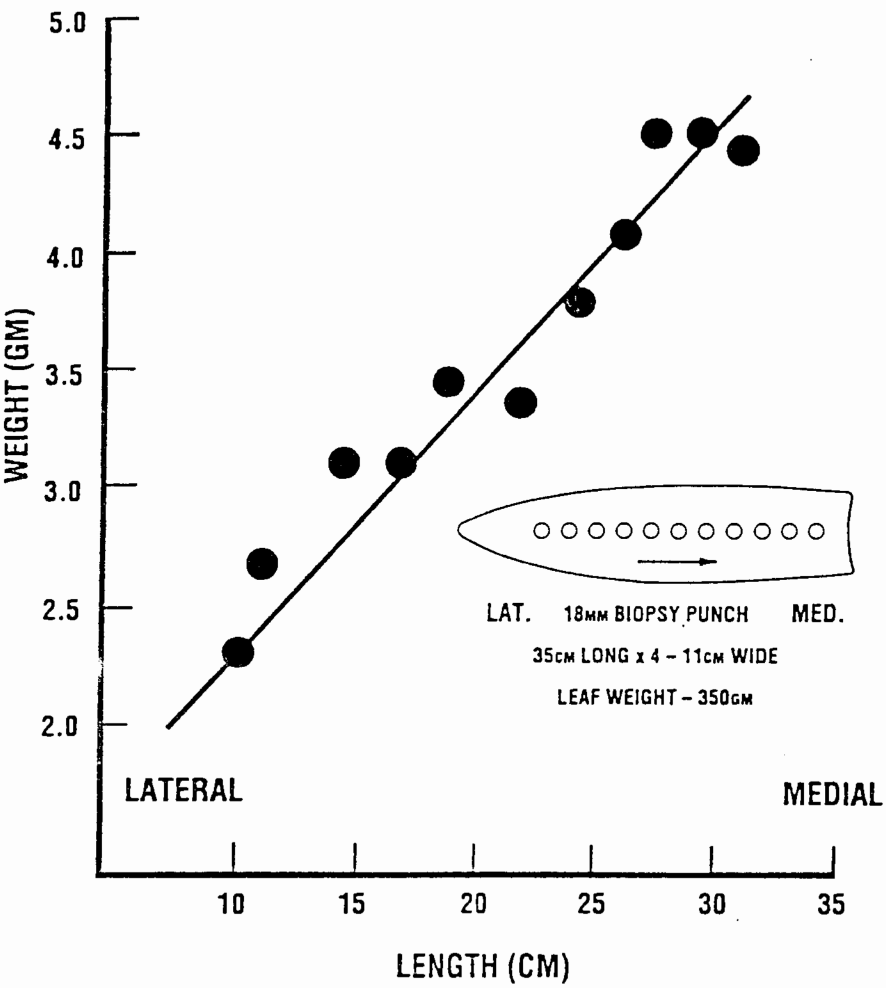
Figure 3 shows the influences of mucilage and aloe vera on skin penetration (MM) of 5% trypan blue over six hours. The penetration for trypan blue is a good way to prove and study the effect of aloe vera and mucilage on skin penetration. Ten percent of aloe vera increased the trypan blue skin penetration +24.2% over the 5% trypan blue controls. On the other hand, 10% mucilage inhibited the movement of trypan blue – 22.1%. This response tends to prove the concept that mucilage acts as a container for the aloe gel in the leaf. Furthermore, mucilage probably acts as a mechanical cover over wounds to improve wound healing by keeping the wound cavity moist. Thus, aloe vera increases skin penetration by water hydration, occlusiveness (acts as a cover) and increases compound solubility. A mixture of 5% aloe vera and 5% mucilage inhibits 5% trypan blue skin penetration – 34.7% in reference to controls. This suggests that mucilage inhibits skin penetrability of aloe vera. As a result of this work, one might consider that aloe vera hydrates and softens skin whereas mucilage prevents the loss of water to mechanically improve wound healing. The presence of growth factors in aloe such as gibberellin and mannose phosphate have a biological action on wound healing and inflammation.

The Aloe Leaf Assay

Sample weights (18MM diameter) taken at intervals from the lateral tip to the medial base of the leaf can be used to assay: the percentage composition of the leaf, the percentage of water and solids, the percentage of aloe vera gel in the leaf and the total and relative amount of glucose over the entire leaf (Figure 4). Sample weights taken every 10 cm show a straight line relationship. The rind represents 37.9± 2.7% and the fillet 60.2± 2.6% of the leaf. The rind weight decreases to 30% of the leaf whereas the fillet increases to about 70% as the samples approach the leaf base. Both measurements move in a straight line fashion.

From this data one could theoretically calculate from the leaf how much aloe is contained in one acre of land if the number of plants were recorded. From the leaf tip the percentage of solids decrease from 6.2% to 2.0% at the leaf base. This relationship is inverse to the percentage of water. All values represent 13 measurements per aloe leaf. If one assays the relative glucose in each sample, a parabolic curve can be obtained which can be used to assess the specific glucose activity

Figure 4. Sample Weights (18 MM Diameter) of Entire Length of the Aloe Leaf



of the leaf. Plants and aloe obtained from different fields can be compared as well as the various influences on the quality and quantity of aloe vera. For example, we estimate that wind can increase the production of aloe vera 70% to 100% over plants protected from the wind. The influences of soil, water and temperature need to be evaluated using a method similar to this one.

The Aloe Vera Cell

We have looked at leaf cells from 90 to 50,000 magnification using stains that are specific for mucopolysaccharides. The cell diagramed in Figure 5 represents one seen at about 40,000 magnification. The nucleus is clearly visible surrounded by two cell membranes that contain mucopolysaccharides which are being transferred into the cell lumen for storage. Some of this long chain polysaccharide is transferred to the mucilage layer under the rind. We feel that the lumen and the mucilage polysaccharide are biologically active. Possibly, the lumen polysaccharide may be a bit more active but more work needs to be done in this area. Also, we feel that the mucopolysaccharide can move across the cell membrane but how this occurs can only be speculation at this time. It looks as if it does not need to be broken down to smaller units to go from cell cytoplasm to the lumen for storage. Is the long chain polysaccharide biologically active? We feel that it is. The cellulose cell wall surrounds the cell membranes and unites with other cell walls. How the nucleus controls the making of aloe vera in the cell cytoplasm and how the cell metabolizes the aloe for energy and growth will require further research. ■

Figure 5. The Aloe Vera Cell