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Prepared Contribution

During a visit to the Desert Research Station of the University of California at Riverside, we were cautioned about the remarkable penetration capability of some of the cactus spines. This suggested unusually high compressive strength and it occurred to me that perhaps, if I may use the metaphor of the Sufi Mystics, the "Divine Engineer" had something to teach us by contemplation of these spines.

I was interested to find out what sort of cellulose gave them their remarkable mechanical properties. A few days later while visiting GE NMR I had an opportunity to analyse some of the samples of cactus (Sp. Opuntia Ramosissima) spine. Initially, we experienced a problem in preparing the samples as they could not be cut by a knife and we had to resort to wire cutters. We then placed the prepared samples in the spectrometer and the spectrum obtained was somewhat similar to that of cotton. There was a slightly greater intensity exhibited at the centre of the C-1 region suggesting, in my view, that the cactus spine is somewhere intermediate on the evolutionary scale between some of the lower plants and the higher plants which we have studied. The most surprising finding was that, nowhere in the spectrum was there any evidence of the presence of aromatic components. Absolutely no lignin was present. There was a slight indication, at about 180 ppm, of carboxyl groups.

After some additional chemical analyses our conclusion was that the fibres, within the spine, were composed of highly crystalline cellulose covered with some pectic substance which had carboxyl groups on it. The ash content of the spine material indicated that there were about 1.5 - 2% of calcium ions present.

The cactus spines, then, seem to represent interesting composite biological plant tissue of remarkable mechanical strength, with no lignin at all, held together by the chelation of calcium ions between carboxyl groups.

I have made this contribution, at this point in our discussions, to illustrate that the additives synthesised by nature sometimes are distributed in a very effective manner.