

would destroy the larger number of the root hairs, still formed crystals as usual. Then root pressure must be entirely wanting, as well as osmotic activity in plants at this stage. Neither can the elevation of the water be due to "negative pressure," since the portion of the stem above the crystal-forming part may be split, or broken, or cut entirely away, without affecting the formation of the crystals.

Capillary force is the only means by which the water may be carried from the ground up through the plant to where it forms crystals. The constant absorption and evaporation by the dessicating tissues limit the region of saturation and confine the formation of crystals to the basal portion of the stems. The size and arrangement of the medullary cells favor the lateral conduction of the water by reason of their greater capillary power. The portion of water at the peripheral ends of the rays is frozen and in expanding is forced outward. The portions which replace it are in turn frozen, and the successive increments thus formed give the length and account for the perpendicular striations of the ice riband. This is suggested by Professor Leconte, though he compares the whole ray with the capillary pores of the soil in its action. A temperature of several degrees below freezing point is necessary to overcome the capillary force, and freeze the water in the rays, which results in the splitting of the stem.

So far as can be learned from an examination of the stems of the "frost plants," the only structural conditions necessary are large and numerous vessels, thin-walled medullary cells in a well marked ray, and a bark easily split longitudinally. The category of plants furnishing these conditions is by no means small. And it seems highly probable that frost phenomena may be exhibited by any of these plants which may pass through the death stage at the season affording the necessary conditions of temperature and moisture.

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QUANTITATIVE COMPARISONS: A COMMON ERROR OF LANGUAGE.

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In expressing the degrees in which any object—using the word in its broadest or metaphysical sense—possesses a certain attribute or characteristic there must be understood a unit of comparison or measurement. To be comprehensible, this unit must be subject to the associative law of mathematics; that is to say, if subtracted from itself the remainder must be nothing, or the zero of the scale of comparison, if added to itself the sum must be twice itself, and if from the unit—supposed positive—there be subtracted a quantity greater than itself, the remainder must be negative. These facts, which seem so axiomatic as to make their statement superfluous, are frequently overlooked even by some eminent speakers and writers.

If we say that A is twice as long as B, we make B the unit of comparison and affirm that the length of B is contained twice in that of A, or, no length being the zero of linear measurement, the length of B is one unit and that of A is two units. Similarly, if we say that A is three-halves longer than B we have:

Length A = length B + $\frac{3}{2}$ length B = $\frac{5}{2}$ length B ;
and if A is three-halves shorter than B we have:

Length A = length B - $\frac{3}{2}$ length B = $-\frac{1}{2}$ length B.

Now such a negative can occur only as indicative of reversed direction or position relative to the zero, and when no direction or position is assumed as positive the

negative, as well as its imaginary roots, expresses the impossible. For example, when we say it is twice as far from A to B as from A to C, we have no reference to the positions or directions of the lines A B and A C, but only to their relative lengths, and a negative expression under these conditions is impossible in any system of mathematics.

A photographer advertised that by an improved process he could take pictures thirty times quicker than by the old process. Here, if T is the time required by the old process and T' the time required by the new process, we have:

$$T' = T - 30 T = -29 T ;$$

the negative T being the algebraic expression for "less than no time." Granting the claim of the advertisement, it necessarily follows that the passage of time could be stopped or reversed at our pleasure and the rapidity of its backward flight would be determined only by the number of photographs taken by the new process in a unit of time. Amateur photographers will doubtless be pleased to know that they have the fountain of eternal youth so easily within their reach! It is true, however, that if an arbitrary assumption be made in regard to the zero of the scale of "quickness" the claim of the advertisement may be verified. For example, if we agree to take one second, s, as the zero of measurements, all increments constituting slowness and all decrements quickness, Q, then if $T = 59/60$ s we have $Q = 1/60$ s and $Q' = 30/60$ s, whence

$$T' = T - Q' = 29/60 \text{ s} ;$$

so that the time by the new process would be nearly half the time by the old process. But the "thirty times quicker" was doubtless intended to mean one-thirtieth of the time, and so was a notable example of an unsuccessful and absurd attempt to make a quantitative statement.

A more remarkable example, because it occurred in a carefully written essay by an eminent scientist describing a variable star, is as follows:

"On April 27 it had become invisible in the great telescope. It was then one hundred and sixty thousand times fainter than it was at the time of discovery."

Now it is evident what would be meant by saying that it was one hundred and sixty thousand times brighter at one time than another, because brightness is an essentially positive quality whose quantity is dependent upon if not proportional to the amount of luminous energy emanating from the body; but faintness is a negative quality expressing only the absence of brightness; hence if there was no lack of brightness in the star when discovered, faintness at any other time could not be expressed comparatively by using any positive factor however large.

Considering the quotation grammatically the star is said to be "fainter" in the comparative degree; hence it is evident that it was first faint in the positive degree, and since no unit of faintness is used in photometry we can only assume that the brightness of the star in its positive condition of faintness as observed at discovery is the unit of comparison; hence when it was one hundred and sixty thousand times fainter it must have been (160,000-1) times less bright than an invisible body—since the latter, without luminous energy, has no brightness and presumably one unit of faintness.

After the author of the statement quoted has shown that 160,000 times fainter is equivalent to $1/160,000$ as bright, which is doubtless what he meant, I will show that a liability of \$1.00 is the same thing as assets of \$159,999.00; and such a blessed discovery for insolvent debtors and their creditors would have so many degrees of brightness as to quite outshine any variable star!