PLANT PHYSIOLOGY

Upflowing Sap in Plants Pulls With Force of Tons

University of Chicago Scientists Calculate Tensions on Slender "Water Wires" in Plant Tubes

WATER, climbing hundreds of feet to the tops of the world's tallest trees, or a mere fraction of an inch in the lowly mosses at their roots, accomplishes this apparent paradox of flowing uphill because an ancient proverbial saying is not true. Water is not "as weak as water." Water, under proper conditions, comes close to being as strong as steel.

How strong water may be, under conditions faced every day by the living plants in which it flows, has been calculated by three University of Chicago scientists, Dr. Clyde Homan, Dr. T. F. Young and Prof. Charles A. Shull (*Plant Physiology, July,* 1934) They have found that a column of pure water under the low relative humidity which desert plants have to endure, can withstand, without breaking, a pull measureable in many tons per square inch. The same column, under the high relative humidity found in a tropical rainforest, may not need to withstand a pull greater than twenty pounds per square inch.

Model Simulates Plant

The apparatus models used in the Chicago measurements simulate roughly the conditions found in one of the fine tubes that carry water upward in a plant. One of the models consists of a cylinder, with its upper end closed by a firmly fixed membrane through which water can seep and evaporate. Into the lower end is fitted a piston, free to slide up and down, but arranged to permit no air to pass it. Hung beneath the piston is a weight, which can be increased or lightened at will.

The space between the top membrane and the piston is filled with water, out of which all dissolved air and other bases have been driven by boiling. This is a most imporant consideration, for dissolved air in water is like sulphur or other impurity in steel: it tends to collect in one place when stress is applied, forming a bubble which plays the part of a flaw and permits the column to break. The water, then, must be absolutely gas-free.

Using such an apparatus model, the air around the apparatus is assumed to be charged with larger or smaller quantities of water vapor, producing atmospheres with relative humidities ranging from nearly saturated (99.9 per cent.) down to a desert-air humidity of only 10 per cent. Water would then pass through the top membrane and evaporate, and the piston with its suspended weight would be pulled upward.

"Stromogenic Tension"

Then more weight may be applied until the pull of the weight exactly balances the upward pull due to the evaporation through the membrane. The upward motion of the piston would then stop; the weight at the bottom, plus an allowance for atmospheric pressure, is a measure of the pull due to evaporation through the membrane, under the relative humidity and temperature conditions at the time. This pull has been given the name "stromogenic tension."

According to the formula worked out by the three University of Chicago investigators, the stromogenic tension of a column of pure water, at 68 degrees Fahrenheit and 10 per cent. relative humidity, is in the neighborhood of 3,000 atmospheres. One atmosphere is 15 pounds per square inch, so that this tension equals 45,000 pounds, or 22.5 tons per square inch.

At the other extreme, the stromogenic tension at the nearly saturated condition of 99.9 per cent. relative humidity is only one and one-third atmospheres, or a mere 20 pounds per square inch. At the more usual relative humidities of 70 and 50 per cent., respectively, the tensions are of the order of 475 and 900 atmospheres, or roughly 3.5 tons and 7 tons, respectively, per square inch.

An apparatus more nearly approximating the physical set-up of a plant has also been used in the calculations. This interposes either a jell or a thick solution of chemical substances, with osmotic or "water-drawing" power, between the outer membrane and the water column, with a second, moveable membrane separating them. This jell or solution is a rough approximation of the interior of the leaf-cells, with their living jell of protoplasm and the thickened cell-sap inside.

The first discovery of the ability of a column of water to withstand a heavy tension was made over twenty years ago, by several European researchers. The recent studies at Chicago, however, have demonstrated a tension-resisting capacity in water far beyond any figure then reached or even thought possible. It not only accounts for the ability of the slender "wires of water" in the tubes of trees to pull themselves to the tops of the tallest trees now living, but leaves a margin of strength sufficient to lift water to nearly ten times their height.

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PHYSICS-BACTERIOLOGY

New Optical Method Aids Study of Bacteria

A NEW optical method of studying the early growth processes and metabolism of bacteria and other one-celled organisms has been developed by Dr. Harold Mestres, research associate in the Department of Public Health at Yale University. Dr. Mestres explained the working of a new densitometer for studying the number of bacteria by the amount of light a mixture of them in a solution will transmit.

With the instrument Dr. Mestres has been able to show not only that the growth of bacteria is quite different from older conceptions obtained by counting the growth rate at intervals, but has been able to follow the way in which bacteriophage controls growth of organisms. In addition the instrument will reveal the rapidity with which germicidal solutions stop the growth of organisms.

Taking a solution containing small organisms, growth can be traced, for as they grow larger and increase in number less light comes through the solution. Extinction of the light may even occur.

By measuring the transmitted light at intervals Dr. Mestres was able to show, what previous workers have suspected,