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.

Science News Letter, January 26, 1935

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,

that during the first hour or two of growth the bacteria grow rapidly in size and do not greatly increase in number. Then, at a clearly defined time multiplication sets in and the organism population increases. Cell metabolism is therefore highest at the beginning of cell growth and not, as is generally said, after a period of lag.

The study of the action of bacteria shows the organisms growing steadily up to the time when the phage was introduced into the solution. Then quickly the solution begins to clear up and allow more light to pass through. This indicates that the phage is "eating up" or destroying the bacteria.

First work on the development of the densitometer and its optical technique of studying bacterial growth was undertaken while he was at Stanford University, Dr. Mestres stated. The work is now being continued at Yale, where Prof. C. E. A. Winslow is chairman of the department.

Science News Letter, January 26, 1935

PLANT PATHOLOGY

Blame for Eel-Grass Disease Laid on One-Celled Animal

HUNTERS on the Atlantic coast who have been unable to find any water-fowl to shoot at can address their woes to *Labyrinthula,* a microscopic, single-celled, parasitic animal, researches at the New Jersey Agricultural Experiment Station at Rutgers University have revealed.

Labyrinthula has practically ruined the pastime of many sportsmen by causing an epidemic wasting disease that has killed eel grass along the entire Atlantic coast and has thus destroyed or greatly reduced the principal food of geese, brant, certain species of ducks, and various economically valuable fish and mollusks, particularly scallops.

Charles E. Renn, Station microbiologist, who has been cooperating with the Woods Hole Oceanographic Institution, discovered that *Labyrinthula* causes the wasting disease while working under the supervision of Dr. S. A. Waksman, head of the Station's department of soil microbiology and a member of the Oceanographic Institution. Mr. Renn encountered a hitherto unreported spindle-shaped micro-organism in the diseased leaf tissue of the eel-grass. The organism occurred with such regularity and was so oriented in the tissues that it was immediately placed under suspicion as a parasite, and a study of the habits of the living form undertaken. Its true parasitic nature was established.

Mr. Renn's research demonstrated that *Labyrinthula* could penetrate eel-grass leaves and produce the wasting disease in from four to forty-eight hours. Affected eel-grass is weakened and made susceptible to the attacks of bacteria, fungi, and other parasitic organisms.

The recent outbreak of the wasting disease was reported as early as 1929, but not until 1932, when eel-grass was almost entirely destroyed along the Atlantic coast, was the seriousness of the ailment impressed upon sportsmen. There was some recovery early in 1933, but before the summer's end destruction of the eel-grass had again increased to an alarming extent. The same situation prevailed in 1934.

Science News Letter, January 26, 1935

ICHTHYOLOGY

Fresh-Water Fish Learn To Live in Sea Water

GUPPIES, mild little family-loving fish now much in vogue with amateur aquarists, have been turned into hardy, sea-faring "old salts" by Miss Gloria Hollister, research associate of the New York Zoological Society. Miss Hollister tells how she has been able to get guppies, which are normally fresh-water fish, to adapt themselves to life in full-strength sea water. (*Bulletin, New York Zoological Society,* Nov.-Dec.) Young fish have been born in the salt water, and both parents and offspring are still living.

Miss Hollister began by putting guppies into mixtures of fresh and salt water of various strengths. All the guppies continued to live when the mixture contained no more than 50 per cent. of sea water. In a 60 per cent. mixture 71 per cent. of the little fish survived. Even when their first experience with salt water was a 70 per cent. mixture of sea water with fresh, about a fifth of the guppies lived. But an addition of 75 per cent. or more of salt water to the fresh was too much for the guppies.

Miss Hollister then "acclimated" guppies by starting at the 50 per cent. level and increasing to larger and larger concentrations of salt until finally she had them living in perfect contentment in 100 per cent. sea water.

The new environment has not been wholly without effect on the guppies' behavior. They developed a behavior peculiarity which she calls "the spirals," a tendency to swim in a spiral track, sometimes going through the performance on their backs. They go into "the spirals" whenever they are startled, as by a sudden flash of light.

Miss Hollister has put several other fresh-water fish through a course of salt-water adaptation. She has also reversed the process, inducing certain salt-water fish to become used to fresh water. In one tank she has two fish species, one normally living only in fresh water, the other only in salt, swimming about together, both apparently quite comfortable and happy.

Science News Letter, January 26, 1935

CAPTAIN OF A WHALE

It looks like a sculpture of a grotesque little old man's head, but it is really the otic capsule, or bony ear-box, of a sperm whale, which houses not only the huge mammal's organs of hearing but the apparatus which controls his sense of balance, and thus his ability to get about in the sea. Its natural dimensions are about double those shown in the illustration. This specimen belongs to Dr. H. C. Bryant of the U. S. National Park Service.