PLANT PHYSIOLOGY

Classics of Science: First Studies of Transpiration

Hales' sunflower in the sealed pot, and spearmint plant attached to the inverted syphon, as described in the experiments quoted below.

VEGETABLE STATICKS, by Stephen Hales, London, M,DCC,-XXVII.

Moisture Perspired By Plants

July 3, 1724. In order to find out the quantity imbibed and perspired by the Sun-Flower, I took a garden-pot (Fig. 1), with a large *Sun-Flower, a,* 3 feet + ½ high, which was purposely planted in it when young.

I covered the pot with a plate of thin milled lead, and cemented all the joints fast, so as no vapor could pass, but only air, thro' a small glass tube *d* nine inches long, which was fixed purposely near the stem of the plant, to make a free communication with the outward air, and that under the leaden plate.

I cemented also another short glass tube *g* into the plate, two inches long and one inch in diameter. Thro' this tube I watered the plant, and then stopped it up with a cork; I stopped up also the holes *i, l* at the bottom of the pot with corks.

I weighed this pot and plant morning and evening, for fifteen several days from *July* 3 to *August* 8, after which I cut off the plant close to the leaden plate, and then covered the stump well with cement; and upon weighing found there perspired through the unglazed porous pot two ounces every twelve hours day, which being allowed in the daily weighing of the plant and pot, I found the greatest perspiration of twelve hours in a very warm dry day, to be one pound fourteen ounces; the middle rate of perspiration one pound four ounces. The perspiration of a dry warm night, without any sensible dew, was about three ounces; but when any sensible, tho' small dew, then the perspiration was nothing; and when a large dew, or some little rain in the night, the plant and pot increased in weight two or three ounces. N. B. *The weights I made use of were* Avoirdupois *weights.*

Surface of Leaves

I cut off all the leaves of this plant, and laid them in five several parcels, according to their several sizes, and then measured the surface of a leaf of each parcel, by laying over it a large lattice made with threads in which the little squares were ¼ of an inch each; by numbering of which I had the surface of the leaves in square inches, which multiplied by the number of the leaves in the corresponding parcels, gave me the area of all the leaves; by which means I found the surface of the whole plant, above ground, to be equal to 5616 square inches, or 39 square feet.

I dug up another Sun-flower, nearly of the same size, which had eight main roots, reaching fifteen inches deep and sideways from the stem: It had besides a very thick bush of lateral roots, from the eight main roots, which extended every way in a Hemisphere, about nine inches from the stem and main roots.

In order to get an estimate of the length of all the roots, I took one of the main roots, with its laterals, and measured and weighed them, and then weighed the other seven roots, with their laterals, by which means I found the sum of the length of all the roots to be no less than 1448 feet.

And supposing the periphery of these roots at a medium, to be 10/76 of an inch, then their surface will be 2286 square inches, or 15.8 square feet; that is, equal to ⅜ of the surface of the plant above ground.

If, as above, twenty ounces of

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ARCHÆOLOGY

Aztec Calendar Found

The calendar stone of Montezuma and other interesting relics of the ancient Mexican civilization have been uncovered during repairs made on the National Palace in Mexico City, which houses the executive offices of President Calles. The objects are now in the National Museum adjoining the palace.

The calendar stone, the largest of the carvings found, is said by Prof. Ramon Mena, head of the department of archaeology of the museum, to be the votive offering of Montezuma II to the sun in return for having started auspiciously the cycle of 52 years beginning in 1507, hardly a dozen years before the coming of the Spanish conquerors and the fall of the Aztec empire. The preceding cycle beginning in 1455 is represented as having been initiated with famines and other calamities.

On the sides of the huge stone block are the carved seated figures of priests. One, extending offerings, represents the emperor Montezuma. On the top surface of the stone are

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CHEMISTRY

Vitamins For Margarine

A butter substitute that will contain as many calories and more vitamins than the old fashioned product of the cow can be made available at a low price, scientists in London declare.

In view of the general shortage of dairy products, chief source of the vitamins necessary for health and growth, Drs. O. Rosenheim and T. A. Webster of the National Institute for Medical Research, have suggested to the scientific journal, *Nature,* a cheap and effective butter substitute. Fats from livers of such readily available animals as sheep, calves and oxen, they report, contain ten times the amount of vitamin A as exists in cod liver oil.

"The well-known skill of the margarine manufacturer," Dr. Rosenheim explains, "should enable him so to incorporate the liver fats with his product as to convert a dietary article, already identical with butter in calorific value, into a cheap and palatable product of equal biological efficiency, so far as vitamin A is concerned."

The no less important rickets preventing vitamin D, another variable constituent of butter, can be supplied by mixing in small quantities

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Aztec Calendar

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symbols of sacrifice and figures of fire serpents. On the back surface of the stone are carved symbols representing the foundation of Tenochtitlan, the ancient Mexico City, and its development under the protection of the god of rain and harvest. The front surface represents the sun on the right and Montezuma on the left.

When the Spanish conquerors entered ancient Tenochtitlan, Montezuma was made a prisoner in his own palace. After his death and after the final defeat of the Aztecs under another leader early in the sixteenth century, the great temple was destroyed and the city razed to the ground. On the site of Montezuma's palace, Cortez built his own, and the present National Palace was enlarged from that. Much of the building material used came from the ruins of Aztec temples, and the relics which have been recently placed in the National Museum were dug from the ancient foundations laid down by Cortez.

Science News-Letter, November 5, 1927

Vitamins in Margarine

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of irradiated ergosterol. This is a recently discovered product of great potency believed to be the parent substance of the anti-rachitic vitamin. After exposure for regulated periods of time to ultra-violet light, it is capable of curing human rickets in as small doses as from two to four milligrams daily.

"The margarine manufacturers," continues Dr. Rosenheim, "have therefore at their disposal, if they care to make use of them, means which should make a perfect biological substitute for butter accessible, without unduly raising the price of margarine. Moreover, by carefully controlled methods of manufacture, it should be possible to supply a product of constant vitamin content, superior in this respect to natural butter, the vitamin content of which depends on too many uncontrollable factors in the food supply of the cow."

Science News-Letter, November 5, 1927

Flax is grown in this country almost entirely for its seed.

Prehistoric people of Central America and Mexico used oil centuries before American oil wells were "discovered" and developed.

Studies of Transpiration

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water, at a medium, perspired in twelve hours day (*i. e.*) thirty-four cubick inches of water (a cubick inch of water weighing 254 grains) then the thirty-four cubick inches divided by the surface of all the roots, is = 2286 square inches; (*i e.*) 34/2286 is = 1/67, this gives the depth of water imbibed by the whole surface of the roots *viz.* 1/67 part of an inch.

And the surface of the plant above ground, being 5618 square inches, by which dividing the 34 cubick inches, *viz.* 34/5616 = 1/165, this gives the depth perspired by the whole surface of the plant above ground, *viz.* 1/165 part of an inch.

Hence, the velocity with which water enters the surface of the roots to supply the expense of perspiration, is to the velocity, with which the sap perspires, as 165 : 67, or as 1/67 : 1/165, or nearly as 5 : 2.

The area of the transverse cut of the middle of the stem is a square inch; therefore the areas, on the surface of the leaves, the roots, and stem, are 5616, 2286, 1.

The velocities, in the surface of the leaves, roots, and transverse cut of the stem, are gained by a reciprocal proportion of the surfaces.

$$\text{Area of}\begin{cases}\text{leaves} = 5616 \\ \text{roots} = 2286 \\ \text{stem} = 1\end{cases}\ \text{Velocity}\left|\begin{array}{l} = \dfrac{1}{5616} \\ = \dfrac{1}{2286} \\ = 1\end{array}\right\}\ \text{or as}\begin{cases}\dfrac{1}{165}\ \text{inch} \\ \dfrac{1}{67}\ \text{inch} \\ 34\ \text{inch}\end{cases}$$

Now, their perspiring 34 cubick inches in twelve hours day, there must so much pass thro' the stem in that time; and the velocity would be at the rate of 34 inches in twelve hours, if the stem were quite hollow.

In order therefore to find out the quantity of solid matter in the stem, *July 27th at 7 a. m.* I cut up even with the ground a Sun-flower; it weighed 3 pounds; in thirty days it was very dry, and had wasted in all 2 pounds 4 ounces; that is ¾ of its whole weight: So here is a fourth part left for solid parts in the stem, (by throwing a piece of green Sunflower stem into water, I found it very near the same specifick gravity with water) which filling up so much of the stem, the velocity of the sap must be increased proportionably, *viz.* 1/3 part more, (by reason of the reciprocal proportion) that 34 cubick inches may pass the stem in twelve hours; whence its velocity in the stem will be 45 1/3 inches in twelve hours, supposing there be no circulation nor return to the sap downwards.

Inverted Syphon

Spear-mint being a plant that thrives most kindly in water, (in order the more accurately to observe what water it would imbibe, and perspire by night and day, in wet or dry weather) I cemented at *r* a plant of it *m,* into the inverted syphon *r y x b* (Fig. 2), the syphon was ¼ inch diameter at *b*, but larger at *r.*

I filled it full of water, the plant imbibed the water so as to make it fall in the day, (in *March*) near an inch and one-half from *b* to *t,* and in the night ¼ in. from *t* to *i*: but one night, when it was so cold, as to make the Thermometer sink to the freezing point, then the mint imbibed nothing, but hung down its head; as did also the young beans in the garden, their sap being greatly condensed by cold. In a rainy day the mint imbibed very little.

I pursued this Experiment no farther, Dr. *Woodward* having long since, from several curious experiments and observations, given an account in the Philosophical Transactions of the plentiful perspiration of this plant.

These two experiments, only slightly modified, are still a part of the required work in all beginning courses in plant physiology, and the same methods are still being used also for much work in more advanced research.

Stephen Hales was born in Kent, September 7 (or 17), 1677, and died at Teddington January 4, 1761. His scientific work included experiments on the pressure of sap in plants and of blood in animals, rate of growth of plants, and their nourishment from the air, which began the science of plant physiology. He also made some attempts to study "air" derived from heating vegetable substances, from metals, and from shells. In these experiments he actually worked with oxygen, carbon dioxide, hydrogen, and perhaps other gases, but without distinguishing them from the air which he knew. But these experiments warned him of the dangers of "vitiated air" and led him to devise ventilating systems which materially helped conditions in prisons and on shipboard. Hales' most important book, *Vegetable Staticks,* from which the above experiments are reprinted, was published in 1727, when the author was 50 years old. The printing was ordered for the Royal Society by Isaac Newton, the president, only a month before Newton's death. Hales had been elected a Fellow of the Society ten years before.

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X-rays can be used to detect hidden cracks in wooden parts of airplanes.

Massachusetts automobile license tags for 1928 are to carry a small picture of a codfish, as a kind of state trade-mark.