HYDROPONICS — NEW TECHNIQUES

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You will recall Brother Nicholas for his article last year in *ABT* on "Cave Biology" and in May, 1953, *The Scientific Monthly* on "Recent Paleontological Discoveries from Cumberland Bone Cave." He is a member of the Board of Governors of the National Speleological Society; and last summer was engaged in work with the Bone Cave fossils, carried on at the Carnegie Museum, Pittsburgh, and aided by a grant from the Western Maryland Railway.

One of the more outstanding student projects completed at La Salle High School this year was a scientific study of the growth of rose blossoms, using a water culture method. The student, Frank Fleckenstein, with assistance from his father, the author, and various references, worked out a technique which can be used with either small containers or large tanks. The growing solution for the experiment required four liters of distilled water, with the following chemicals:

Potassium phosphate	0.61 gm./liter
Calcium nitrate	2.124 gm./liter
Magnesium sulphate	1.1 gm./liter
Trace solution	3.75 cc./liter

The importance of minute quantities of the trace elements may be determined since, without them, the plant would die. The trace solution contains the following in one liter of water:

Manganese sulphate	1.0 gm.
Boric acid	1.5 gm.
Copper sulphate	0.5 gm.
Zinc sulphate	0.5 gm.

The record of some difficulties encountered in developing a worthwhile procedure may be an effective caution against any impulses to look for "short-cuts" from the method finally evolved. Originally, Mason quart jars were equipped with flat corks which were wedged in the mouth of the jar. A slit was cut into the cork so that the young plant could be slipped into the cork and held in place by cotton lightly packed into the slit. This slit had to be wide enough to accommodate the stem when it matured. The cork was then put in place, and the plant was adjusted so that the roots were partially submerged in the nutrient solution. Since the air was soon out of the solution, the roots grew near the top of the jar where small traces of air diffused. Changing the solution daily required considerable labor and was rather wasteful.

The method finally used was originally developed by Dr. J. W. Shive at the New Jersey Experimental Station and was modified slightly to permit a minimum amount of equipment. Dr. Shive found that, if a fine stream of air was forced into the bottom of the jar, the roots distributed themselves uniformly through the solution and made a much better growth. This required less changing of the nutrient solution and made it possible to grow fully developed plants. The fine stream of air was obtained by the *Shive constant drip method* of continuous flow of the nutrient solution. In the culture jar a thistle tube is inserted through the cork so that the stem is within a half inch of the bottom. The solution is then conducted from a reservoir, which is set above the culture jar, into a funnel by means of a capillary tube (0.6 mm. bore) so bent that it serves as a siphon. The solution

Note rose blossom and length of stem in right hand of Frank Fleckenstein. Reservoir jar on box, culture jar in middle, overflow jar to left.

then drips into the funnel, and each drop traps and forces ahead of itself a large bubble of air. An alternate method is to have the reservoir consist of another jar which is inverted in a finger bowl with the siphon so bent that one end may be placed under the edge of the inverted jar. This arrangement may be made more attractive by using colored glass jars. In addition a U-shaped, 2-mm. bore siphon may be inserted into the culture jar with the free end draining into another container.

Let us compare hydroponics with soil culture. More plants can be crowded into a given area for soil culture than in water culture. In water culture there is a smaller rooting area, although the tops have to be spread out more, whereas in soil there is a greater rooting area and the plants are grown upright. The greatest factor affecting yield in soil is the amount of nutrient material present. Even greenhouse growers have not appreciated the fact that to obtain large yields frequent fertilization is essential. Below is a table showing the parts per million in a balanced solution and those in good soil:

Ion in the nutrient solution	Parts per million	
	Balanced solution	Good soil
Calcium	360	1,000
Nitrate	1,116	500
Ammonium	252.2	100
Magnesium	108	100
Sulphur	144	50
Potassium	175	200
Phosphorus	140	60
Boron	1	1
Manganese	1	5
Iron	1	5

Although the proportion of the calcium to the other ions is somewhat different in the soil than in the nutrient solution, it is all dissolved in the solution whereas in the soil the amount of replaceable calcium is measured. Just how much of this is in solution at any one time is a question which cannot be answered by generalization. Probably calcium, as well as other minerals in the soil, is only partly available to the plants. It would be possible to make a nutrient solution that would be comparable to the soil in all elements except possibly calcium. This might not be necessary since good plants can be expected with rather wide variations in the proportion of elements.

Chemical culture growers must also check the sweetness or sourness of the growing medium; soil in one case, sand, cinders, or water in the other. This is so important that a very precise language and method of measurement has been devised. The terms "sweet" and "sour" have been replaced by the terms "acidity" and "alkalinity" or, more correctly, " relative acidity"; thus it is more exact to measure the degree of relative acidity by use of pH. Most greenhouse plants are adapted to a pH of 4–6.[1] The bottles shown in the lower right hand corner of the illustration are those used to measure pH by the colorimetric method, which depends upon the use of a dye which is capable of showing a range of shades, or even changes in color, in harmony with differences in the relative acidity of the material to be tested. This measurement of pH by the use of indicators, as these dyes are termed, can be simplified by using a universal indicator, which is a mixture of indicators covering a wider pH range than each individual one. One of the most common universal indicators is the following solution:

Methyl orange	.1	gm.
Methyl red	.4	gm.
Bromthymol blue	.4	gm.
α-Naptholphthalein	.32	gm.
Phenolphthalein	.5	gm.
Cresolphthalein	1.6	gm.
70% Ethyl alcohol	100.0	cc.

One drop in 10 cc. of test solution gives the following colors for the respective pH values:

Color	pH
Red	3.0
Orange-red	4.0
Yellow-orange	5.0
Yellow	6.5
Green	8.0
Bluish-green	9.0
Blue	10.0
Violet	11.0
Reddish-violet	12.0

One precaution that must be observed is to place a cover over the roots when they are exposed to direct sunlight; otherwise they will be destroyed. An overflow jar should be connected to the culture jar by a piece of glass tubing to drain off the excess solution. The solution in the culture jar gradually increases as a result of the continuous flow method.

[1] The pH values for individual plants are given in Turner, Wayne, and Henry, *Growing Plants in Nutrient Solution*, John Wiley and Sons, N. Y.

The above experiment can be readily set up with a minimum amount of material. It can serve as a dynamic example of hydroponics, the importance of trace elements, and even the role of various chemicals in plant metabolism.

A *YOUR* MAN TEACHES BIOLOGY

The word *the* occurs with considerable frequency in the language of most English-speaking persons. Mr. B. has lost the word from his vocabulary. Mr. B. is my cadet teacher this year, but next year he will have a position of his own. Perhaps the case is similar to that of Van Dyke's character. The result is Mr. B.'s case is not so pathetic; that is, not to Mr. B. But to the students the effect is at times amusing, at times confusing, at times embarrassing. After several yards and rods of omissions, the matter becomes exasperating.

It isn't, I suppose, that we care so greatly for a *the*. Like air, we do not miss it until it is cut off. At first when there is still oxygen, but less oxygen, we get along very well. It is only when someone presses his hand hand against *your* throat that you struggle for air. (I intentionally use *your* here.)

This *your* man makes me writhe. As I have said, he has no *the* in his vocabulary. Perhaps to him the word *your* seems warm, and bold, and intimate. So it often turns out, for Mr. B. teaches biology. He explains, "*Your* pine tree has *your* excurrent shape, for *your* trunk is straight and *your* limbs branch at right angles." Later, he picks up a pine cone and explains, "*Your* ovaries are placed here on *your* scales." He discusses Conservations as follows: "*Your* trees help to conserve *your* water. They aid in lowering *your* temperature by increasing *your* evaporation." And more and more of this . . . .

I wish Mr. B. taught Finance!

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Elementary science teachers could do well to try some or all of the following: have an abundance of house plants in the class room; encourage pupils to bring in specimens of insects, flowers, and leaves; have pupils examine seeds, for food storage areas and embryos; make collections of common local fauna and flora; make leaf scatter-prints for special displays; grow seedlings in glass jars against moist blotting paper; plant a small spring garden. Many of the specimens can be used to start a class museum, on a shelf in the room, a window sill, or in a cabinet. **Elementary science teachers** could do well to make a seed collection of plants grown in the area. They should be air-dried first. After seeds are dry, they may be stored in any type container. An attractive label for each type is essential. Seeds should not be subjected to extremes of temperature, if they are to germinate later.

Books For Busy Biologists

KINSEY, ALFRED C., POMEROY, W. B., MARTIN, C. E., GEBHARD, P. H., and ASSOCIATES. *Sexual Behavior in the Human Female.* W. B. Saunders Co., Philadelphia, Pa. 842 pp. 151 charts. 179 tables. illus. 1953. $8.00.

This much-publicized report on female sex life by a capable, courageous, authoritative, persistent, and thorough research and teaching biologist and his associates is disappointing scientifically in many ways. Dr. Kinsey, senior author, seems surprised over some of the data obtained, and not at all certain that the 5940 highly selected and often atypical females, whose interviews were used, represent a valid cross-section of American women. His conclusions occasionally seem drawn from personal opinions rather than strictly from the data obtained, and the book clearly does not attain the scientific stature of his previous report on American men. It is, however, an excellent treatise on the biological aspects of human sex life and its mammalian origins. The book should prove a valuable aid to teachers, parents, and counselors in developing a better understanding of the biological backgrounds and significance of many sex or sex-associated problems among young people today, and in dealing with young people's problems in general; also in dispelling many misconceptions about the sex life of humans with at least the nearest to the truth obtained by anyone thus far.

THE EDITOR-IN-CHIEF

KASTON, B. J. *How To Know The Spiders.* 1st ed. Wm. C. Brown Company, Dubuque, Iowa. vi + 220 pp. illus. 1953. $2.25.

Including sections on collecting, preserving and studying spiders, and a selected bibliography, this beautifully illustrated book considers 40 families, 190 genera, and 271 species of spiders. The large family Micryphantidae is mentioned only briefly because these spiders are seen infrequently by the casual observer. An excellent pictured glossary and helpful geographical ranges are included. The keys and descriptions are conveniently short and standardized; in some instances almost excessively so. The keys permit identification of most families and genera with little difficulty. This book will serve as a particularly valuable and long-needed introduction to the spiders.

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