STUDYING THE DESERT PLANT BY EXPERIMENTAL METHODS.

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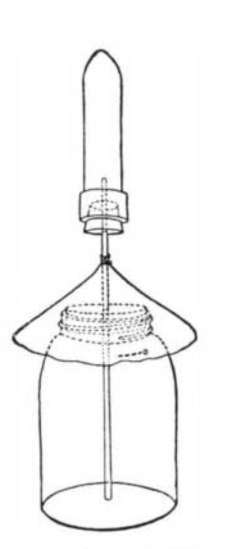
An institution destined to aid in the general upward movement in the West, the only institution of its kind in the world, moreover, is the Desert Laboratory. Established in 1903 at Tucson, Ariz., by the Carnegie Institution of Washington, the laboratory is devoted to the intimate study of the plants of the deserts and semi-arid regions.

It is situated in the midst of nearly 1,000 acres of land, which includes mountain, alluvial plain, and mesa, and is constructed of stones of volcanic origin, gathered in its vicinity. In the main structure are separate laboratories for the half-dozen investigators conducting investigations there, and a glass experimental house.

To describe the work of the staff of the Desert Laboratory adequately in a short paper is impracticable, since it includes so many fields of botanical interest. Broadly speaking, the men at the laboratory are busied with the problems that involve the movements, physiological activities, structure, and characteristics which differentiate desert plants from those of more humid regions.

Between the plants of our arid tracts and those with which they are most familiar, lies a wide gulf. No desert tree, in the conditions which usually prevail, attains a height or extent half so great as the trees in the eastern forests. None forms shade. As a rule they are not closely associated, but grow more or less widely separated from one another. Many of the shrubs are small. Like the trees, none has large leaves. Indeed, certain of them have no leaves at all, and many are provided with organs in which to store against times of need necessary supplies of water. Such characteristics argue reaction through great time to a peculiar environment, of which a leading characteristic is little rainfall.

Time was when the study of botany meant a study of plants as representing different species. At present stress is placed on the structure and various activities of plants, and the relation of these to the environment. Apparatus is devised with which to measure and record as many of these activities and environmental factors as is possible or desirable. Experimental work of this kind is largely in evidence at the Desert Laboratory.



The atometer, an instrument to measure the rate of evaporation. The apparatus consists of a porous clay thimble and a reservoir of water. As the amount of water in the reservoir is measured, any loss, by reason of evaporation from the surface of the thimble, can be accurately known.

The most vital as well as the most interesting relationship of desert plants to desert environment is the water relation. Many cactus seedlings, for example, form storage organs, which later are lost, while other species have, either above the ground or below, reservoirs, which they retain throughout their lifetime. Many cacti, which are desert plants *par excellence*, respond to a better water supply by absorbing rain water with such eagerness that the effect is shown in the distended body within a few hours after the commencement of the downpour. The giant cactus adjusts itself very nicely to varying amounts of absorbed water. The plant has a columnar body, which may reach a height of ten feet before branching, in which body water is stored. In periods of long drought the flutings of the trunk become drawn together by the drying out of the body. When the rains return, the body fills with water, and the flutings are forced farther and farther apart. This device prevents the tearing of the delicate tissues which store up the water, and which lie just under the heavy cuticular covering. The rapid absorption of water, and the advantage from slight rains, is made possible by the superficial character of the root system, which constitutes one of the most pronounced adaptations to desert conditions.

In times of plenty desert plants are profligate of their treasure—water—and give it off, with lavish disregard of consequences, to the thirsty air. The rate of evaporation falls as the rainy period recedes until the water loss in certain plants is practically *nil*. But delicate apparatus, sensitive to a few milligrammes, has been devised by which evaporation can be detected, even if very slight, and its amount estimated. Such an apparatus, which can be used on a plant repeatedly without injury, is shown in the accompanying figure.

The phases of the environment, which are being accurately recorded at the Desert Laboratory, are the rainfall, the relative humidity of the air, the rate of evaporation, the temperature of the air, and the temperature of the soil taken at various depths.

The relative humidity is continuously recorded by a hydrograph. At times the humidity of the air is extremely low, but is increased surprisingly by a very slight fall of rain. This higher humidity may at times be the deciding factor in the life of a plant, even though the precipitation is too little for direct benefit.

The rate of evaporation is determined by the atometer, which, when graduated, gives the amount of evaporation directly. By the use of this instrument the rate of evaporation at various localities in most of the States in this country has recently been studied in co-

Root system of a cactus (cholla), of which the shoot has been removed. The figure shows two superficial roots, which are useful to the plant in permitting the absorption of water, even if the rain is but a slight one, and a group of anchoring roots. Most cacti are well provided with superficial absorbing roots.

operation with the Desert Laboratory. These results have been used for comparison with the rate of evaporation at Tucson. As an illustration of the differences in rate which obtain at different habitats of plants, the following may be cited: For the week ending June 3rd, 1907: Tucson, 289 cubic centimeters; Raleigh, N. C., 126 cubic centimeters; Orono, Me., 123 cubic centimeters; Burlington, Vt., 112 cubic centimeters. The differences in evaporation rate between sunlight and shade, and on different sides of a hill, or different exposures in a gulch, are surprisingly great, which fact is an important, if not the deciding factor in determining what plants will occupy such a variety of habitats and exposures.

The temperature of the soil is recorded continuously by means of the soil thermograph. At the Desert Laboratory there are two thermographs which give the temperature of the soil at the depth of 6 and of 12 inches, and one so placed that the temperature at a much greater depth also is recorded. A study of the records shows that there is a regular daily range, which during settled weather varies little in the amplitude of its fluctuations for days together, but that the advent of change, such as cloudy weather or rains, lowers the curve decidedly, and may greatly alter its character. In summer the 6-inch thermograph usually records higher temperatures than the more deeply placed one, and in winter the opposite is frequently the case. The temperature of the soil is of great moment to the plants, since their power to absorb water, provided there is water in the soil available for absorption, is directly influenced by the changes in the soil temperatures. Generally, higher temperatures favor water absorption, while lower temperatures retard it.

The Desert Laboratory studies show that, aside from plants that inhabit the river flats, all desert plants depend on surface water for their entire supply. This is exactly opposite to the prevailing opinion, and explains the imperative need of the special adaptations

Apparatus for determining the amount of water lost from a plant by evaporation from its surface. The apparatus consists of a delicate hygrometer and thermometer, and a bell glass which covers tightly both the hygrometer and the plant. A shade is employed to avoid high temperatures in the bell. Post-like projections in background are large cacti.

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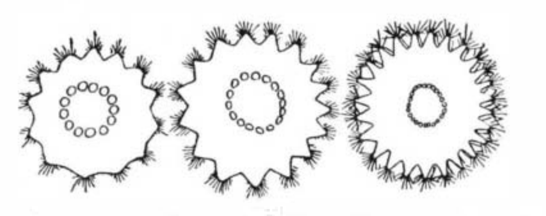
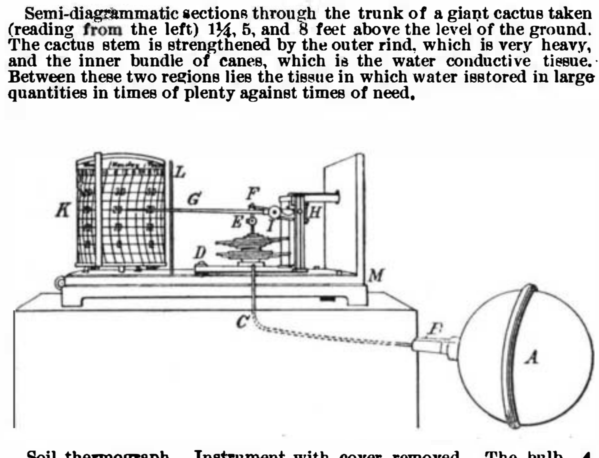
of the plants in relation to water absorption and retention.

In addition to investigating the environment of the desert plants, and their response to their environment, the Desert Laboratory has launched researches on a broader scale on the movements of plants of the arid regions and on the exact effects of acclimation. The paths of migration which the plants of southern Arizona probably followed are being studied, and the natural introduction of plants into the Salton Basin, as the sea recedes from its shores on drying, is being watched with great interest. This latter investigation into the facts which attend the movements of the plants into an area of over 400 square miles in extent, one of Nature's largest experiments, will extend over a long series of years, and will be of great importance in actually demonstrating the paths of plant migration.

The remote ancestor of each desert plant lived under humid climatic conditions in whatever portion of the world it may have grown. That ancestor had a form, a structure, and activities quite similar to plants living under such conditions at this day. In the long stretches of the past, portions of continents became arid, and accompanying this gradual drying out, the plant inhabitants were gradually changed so that they could endure the increasing aridity. How have the plants been able to do this? Were it not for modern methods of investigation, this question could never be answered. With the principle of experimentation to aid, the direction toward the solution is not difficult to find, although the road may be rough. One method of attempting the solution of the problem is that of transporting a plant from one condition of life to another condition, as from a more moist to a less moist habitat, or *vice versa*, and noting the effects. This precise study on acclimation is being undertaken at the Desert Laboratory on an extended scale. Gardens are being planned, and are located under very diverse conditions, such as desert and mountain and seaside, where plants are introduced from a great variety of



Semi-diagrammatic sections through the trunk of a giant cactus taken (reading from the left) 1¼, 5, and 8 feet above the level of the ground. The cactus stem is strengthened by the outer rind, which is very heavy, and the inner bundle of canes, which is the water conductive tissue. Between these two regions lies the tissue in which water isstored in large quantities in times of plenty against times of need.



Soil thermograph. Instrument with cover removed. The bulb, *A*, capillary tube, *C*, and expanding chamber, *D*, are filled with kerosene. On the top of the expanding chamber is the writing and adjusting device, *E* to *I*, which records by a pen on the cylinder, *K*, which is driven by internal clockwork and revolves once a week, the fluctuations in volume of the kerosene in the large bulb. This is the temperature of the place where the bulb is located.

localities and are being studied with care. Such a garden laboratory located at Carmel-by-the-Sea, Cal., where acclimation researches will be carried on, has lately been presented to the Carnegie Institution by the Carmel Development Company. It is at once the most northerly and westerly extension of the acclimation stations.

No Airship Coast Defense.

Our readers will doubtless recall the startling announcement recently made in the daily press of a contemplated coast defense airship division of the United States army. Whether or not the newspaper accounts sprang from the brain of some Washington reporter who found affairs in the Capitol so dull that he felt impelled to create news, or whether some army officer expressed the hope that some day a coast defense airship division would be formed, an expression which served as the basis of the elaborate newspaper reports, we cannot say. At all events correspondence with the War Department for the purpose of verifying the report has brought forth a complete denial. We are assured by a prominent officer of the Signal Service that there is no truth in the report that efforts are being made to form a coast-defense airship division.

An automobile truck recently saved Camptown, Pa., from threatened total destruction, its chauffeur making an emergency run to Wyalusing and bringing back a fire engine with its entire crew of twenty-three.