SCIENCE ON WHEELS

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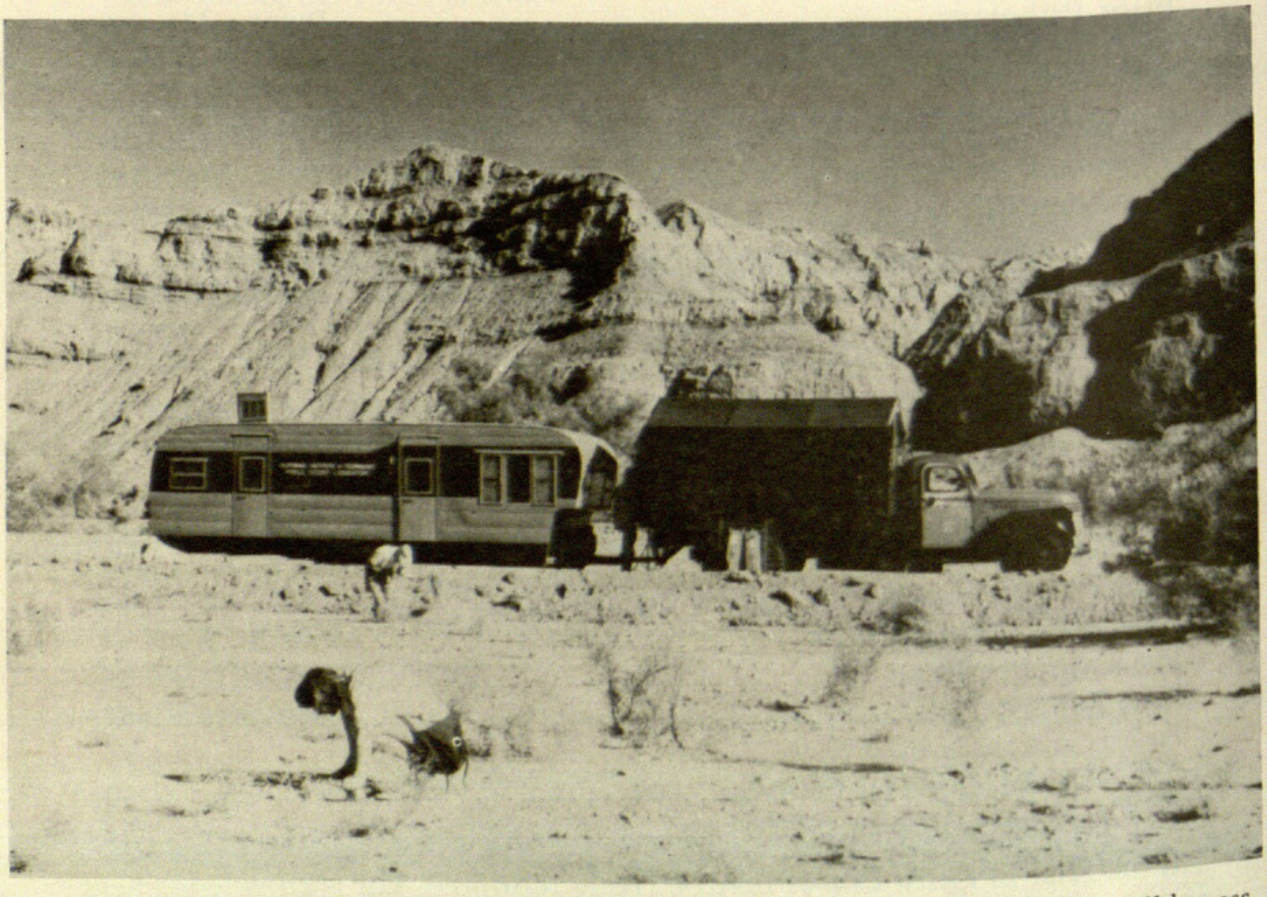
IN AN AGE in which growing specialization often tends to create a strange breed of "armchair scientists", each complacently burried in his own specialty and who literally "cannot see the forest for the trees", it is both reassuring and refreshing to see a happy union of the theoretical and practical. In Caltech's newest addition, the Mobile Desert Laboratory, there is incorporated such a spirit of scientific research in its broadest aspect.

For many years now Dr. Frits Went, professor of plant physiology at Caltech has found a strong fascination in the vegetation of the desert. As he pursued his investigations, despite lack of adequate equipment, a mobile desert laboratory which would enable more precise and extensive studies, was his fond dream. Today, thanks to his keen imagination and vision, and to the kind gift of Mrs. Pearl McManus of Palm Springs, the laboratory is at last a wonderful reality.

But why should the desert, a place of extremes of climate, where relatively sparse vegetation stands in sharp contrast to the luscious green usually associated with botanical science, evoke such interest? The answer lies in the question itself . . . It is the very uniqueness of desert plants which permits them to grow under adverse conditions which turns the desert into a most intriguing place of study. For in seeking the answers to such questions as how plants can grow with practically no water, what are their mechanisms of germination and survival, and what relationships exist between the animals and plants, a fascinating story of Nature's ways and means of evolution is revealed. Thus, whereas to the uninitiated the desert might evoke visions of barren ugliness, to the



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curious it is ever a challenge and place of unique beauty. With a scientifically equipped mobile laboratory the answers to the above and many other fundamental questions will be sought.

But why the necessity of a *mobile* laboratory? There are several reasons for its desirability. Perhaps the most obvious one is that it enables study of more remote and interesting places than would otherwise be feasible. However, of greater importance, it permits the scientist to follow the rain, upon which all life in the desert depends. Since very often, such as at the present time, there are prolonged periods of drought, the usefulness of a stationary laboratory might suddenly be drastically reduced by finding itself completely out of range of living plants. Furthermore, a mobile laboratory permits such basic measurements of photosynthesis, transpiration, water content, etc. to be made on plants in their natural environment. From such fundamental studies, which cannot readily be carried out in the artificial environment of a laboratory, not only is a better understanding of the growth and survival of desert plants gained, but it is hoped that this theoretical knowledge may ultimately be applied to make the desert a more productive place for the betterment of mankind.

The value of the mobile laboratory is even further enhanced by what might be termed a symbiotic relationship between it and the Earhart Plant Research Laboratory at Caltech. The latter, because of its unique controlled conditions, makes it possible to duplicate the climate in nature, while eliminating or reducing the number of variables. For instance, the effect of such single factors as temperature, rainfall, etc. may be tested while daylength and nutrition are constant and disease is eliminated. Thus, the observations made in the field may be tested and analyzed, and in turn, the predictions made on the basis of laboratory tests may be studied in the natural environment. In this way both field and laboratory work gain a much greater significance than each would have separately.

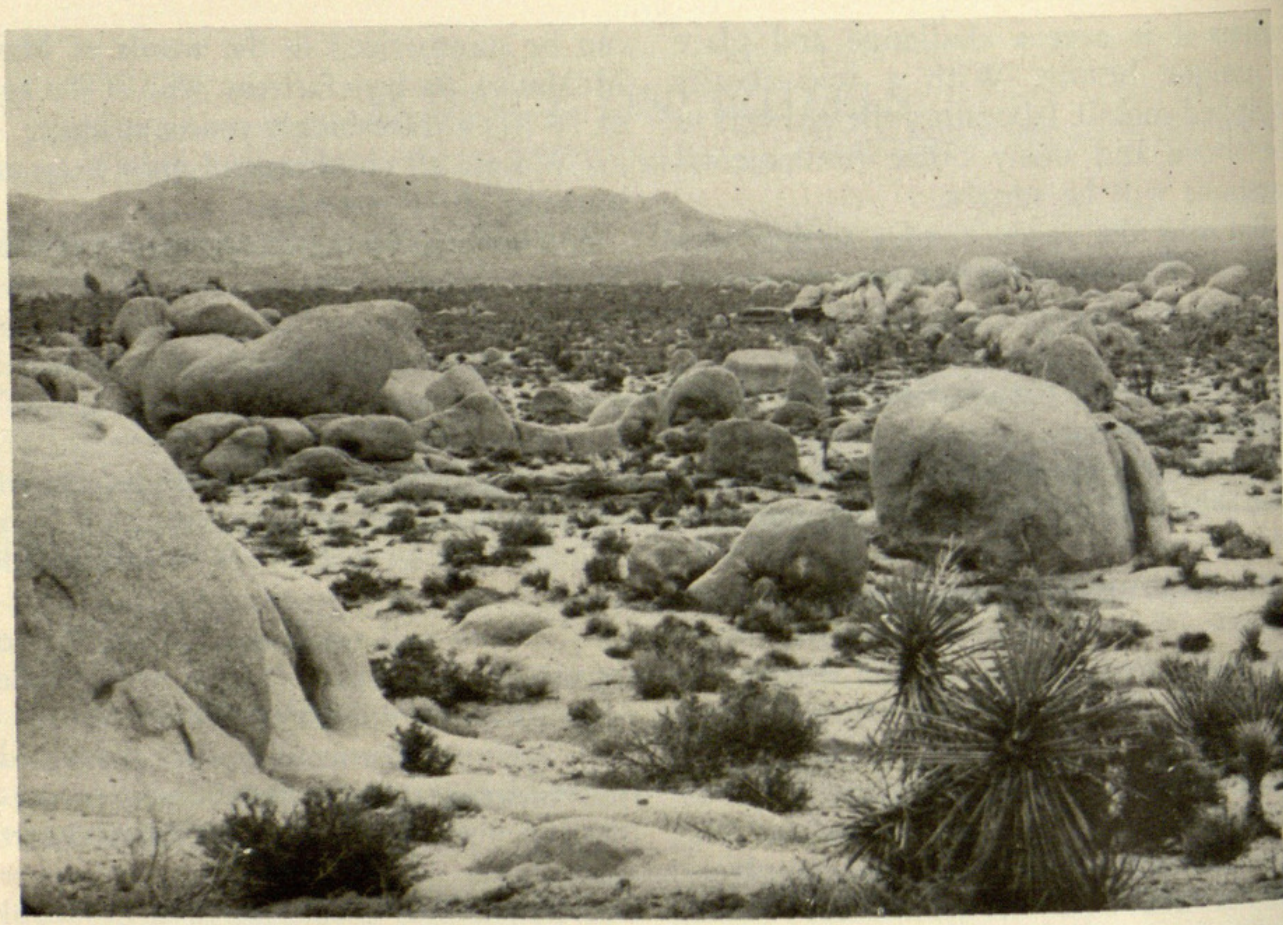
In the broadest sense the reason for, and spirit behind, the mobile laboratory can be summarized in the words of Mrs. McManus, its benefactress, who at the age of 78 has a refreshingly young attitude:

"We are all children and must keep on learning all of our lives."

Science is a cooperative seeking of the Truth, a process which, continuous from age to age ,is somewhat analogous to the formation of a beach by the deposition of individual grains of sand. These 'grains', the result of individual and combined efforts are chiefly a result of the process of learning—that which Einstein called 'holy curiosity'. As an instrument to foster such learning and to inspire more 'holy curiosity' which will result in the addition to the total body of growing knowledge, the desert laboratory is unique.

As strange a 'caravan' as ever pioneered the wilderness, the mobile desert laboratory is a sharp contrast to traditional desert associations of camels laden with water bottles. Instead, it consists of a beautiful two-toned blue house-trailer which might easily be mistaken for just another tourist group. In fact it is not uncommon to have fellow trailers honk a cheery salutation from a distance, only to gape with astonishment as they come in sight of the name proudly engraved on its side: "California Institute of Technology Mobile Desert Laboratory." The secret to its self-sufficiency lies in the large red truck which pulls it. Housed herein is a 500 gallon water tank, a generator, air compressor, and a stock of gas, oil, and miscellaneous tools, with the result that the trailer has hot and cold running water, electricity, refrigeration, gas, and is fully air-conditioned. The interior resembles an ordinary house trailer with such exceptions as drawers filled with beakers, slides, petri dishes, etc., a small library, microscopes, balances, and other special pieces of apparatus for measuring transpiration, etc. Thus, not only is it equipped for the comfort of the workers, an important factor in pursuing desert research, but also it provides the essential tools to add to the scope of the research.

Stationed at Rancho Senora de Lago near Palm Springs, the laboratory is in the capable hands of Mr. Lloyd Tevis Jr., a



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Caltech research fellow. An excellent ecologist and zoologist, Mr. Tevis conducts full time research on the animal-plant relationships of the desert. In cooperation with the Earhart Laboratory, this work is gradually elucidating some fascinating aspects of desert life survival and evolutionary methods. It will be discussed later.

From this convenient location in the desert, many interesting and varying types of desert are easily accessible. Included are such areas as the Salton Sea, numerous desert canyon washes such as Box Canyon, sand dunes and Joshua Tree National Monument.

In the brief time since the inauguration of the mobile laboratory last summer, investigation of a number of intriguing problems has already begun. Although actually still in the organizational stage, with each trip there is a chain-like reaction fostering new prospects to explore and opening wider and wider horizons.

In order to gain some idea of the scope of desert research and the usefulness of a mobile laboratory, let us look briefly at a few of the problems.

One of the first questions to arise in the mind of the observer of desert vegetation is—how can plants grow under such dire conditions of daily temperature fluctuation, prolonged drought, sudden bursts of rain, wind, sand storms, etc. and why will they not grow elsewhere where conditions are apparently more favourable?

For instance, it is found that such desert trees as Palo verde, Smoke tree, and Ironwood occur only in washes. The secret to their survival here lies in a controlling mechanism of germination which assures an adequate supply of water for survival of the seedling. Germination after merely a moderate shower would prove fatal and in the course of evolution a mechanism has developed to prevent such loss. This is found in the seeds, all of which are extremely hard. All attempts to germinate them in the laboratory, regardless of amount of moisture supplied, proved futile, but when abraded, they germinated readily. This is exactly what occurs in nature. During the floods which occur in the area of their growth, sand, rocks, etc. carried by the rushing waters provide a grind-

ing action on the seeds which permits them to germinate. At the same time, part of this water sinks into the bottom of the wash, providing water for further growth. Thus, in areas where normally rainfall is very scarce we find luscious green Palo verde and beautiful Smoke trees—all because nature has provided a scheme of insurance for survival of the seedlings. Further adaptations, such as a long vertical root which the seedling is able to produce rapidly in order to reach the moisture below, indicate the uniqueness of these hardy desert plants.

By tampering with the natural environment, man often upsets Nature's ways sometimes with drastic results. A striking example of this was observed near the All American Canal recently. It was found in one area that there was a sharp division of vegetation. On the one side a healthy growth of Palo verde, Smoke tree, and Ironwood, and on the other, a noticeable lack of all these trees and a generally poor state of associate shrubs. The disappearance of the vegetation on the latter side was entirely of man's origin. The whole area which originally had been a wash had been partly blocked to flood waters in order to prevent clogging of the canal. The results were clear-cut. Where nature had been tampered with, death of the vegetation dependent on floods had disappeared.

The mobile laboratory makes it possible to study the survival of vegetation under the extremes of desert conditions and thus to gain a more comprehensive view of the factors involved. At present, the results of a prolonged drought are being investigated to see which shrubs have survived. Only those which are able to exist under most extreme conditions are found to be still alive. For instance, near Palm Springs where often Franseria and Hymenoclea grow in association, Franseria is seen to be the first to be dying off. In areas where hillsides result in an accumulation of rain water thus effectively increasing the total, sharp differences are noted from nearby flat places. Hence, in a particularly dry area near the All American Canal, it appeared, on preliminary investigation, that no germinations had occurred as the result of a recent light rainfall. A little further search, however, revealed an abundance of seedlings on the hillside, in contrast to the barren ground all around. In the White River (dry) area near Palm Springs, a similar drainage effect was noted. Whereas in the area receiving the benefit of drainage, many seedlings of Atriplex were found. A short distance away most of the old Atriplex bushes had recently died and no seedlings were found. Indication of the dropping of the water table here was found in the poor condition of the Mesquite, whose extensive roots ranging from 30-100 ft. always signify a water table about 30 feet below the surface.

In observing the differences of behavior of desert shrubs, one wonders what the reasons are. To find the answers, we must go to the basic physiological processes of the plants, such as photosynthesis, respiration, transpiration, etc. It is one of the objects of the laboratory to study these in detail in the natural environment. By learning the unique adaptations of desert plants, much basic knowledge of these fundamental processes can be gained and perhaps, eventually, application of it will make the desert more productive for man. The present equipment for these purposes is as yet incomplete but preliminary investigations have been made. In desert plants, where moisture is at a premium, loss of water through transpiration could be serious. Nature has ingeniously endowed these tough dwellers with the means for their protection as seen from measurements. Thus, Hofmanseggia showed practically no measurable transpiration at all, and both Creosote bush and Ironwood showed a marked decrease during the hotter part of the day. After watering the last two shrubs, Creosote bush showed an increase in transpiration within one day but Ironwood had not as yet changed.

In the ability of many desert plants to vary the size of their leaves or even lose them depending on the availability of moisture, is seen another of nature's methods of protection. Thus, Creosote bush *(Larrea tridentata)* one of the sturdiest of desert bushes, will after a long drought

lose its olive green leaves, retaining only brownish green ones, and if the drought continues, it may drop them altogether and still live for some time without rain. Dew is believed to be of importance in supplying moisture to plants which apparently have no other source. However, very little work has been done on these problems and this and many other questions as yet remain unanswered.

Whereas perennial shrubs in the desert depend for their survival mainly on tolerable growing conditions throughout the year, this is not true of annuals which, under unfavourable conditions, are tided over for varying lengths of time by dormant seeds. In order to study the nature of such germination, twelve stations have been marked off in Joshua Tree National Monument and rain gauges stationed in each one. After a rainfall the seedlings can then be counted and the survival pattern studied, all in relation to the amount of rainfall. Searching for desert seedlings is one of the most fascinating of occupations. Few people have ever seen these beautiful frail-looking plants because of their minute stature; in order to find them one must lie flat on the ground (because of which they have been called 'belly plants'). Perhaps the most remarkable thing in connection with these annuals is that once they have germinated, regardless of the density in a given area, survival is almost 100%. The reason here once more lies in the nature of the seeds, which germinate only after sufficient rainfall has occurred, because of inhibitors associated with them which must be leached out. This has been confirmed by laboratory experiments in which water supplied from below failed to cause germination, whereas when artificial rainfall of sufficient amount was given from above, enabling the required leaching to occur, germination followed. Furthermore, it has been found that the nature of the annuals which will germinate after a rainfall depends on the subsequent temperature, which accounts for the fact that massive flowering occurs only after a November or December rainfall.

Observation of the remarkable survival of desert annuals makes it necessary to reconsider some of the conventional ideas of the nature of evolution. It is Dr.

Searching for desert seedlings is one of the most fascinating occupations of research workers. (Dr. Frits Went at right)

Went's belief that the concept of competition and struggle for survival is highly over-emphasized in general, but rather that evolution operates mainly through a process of control of germination, or in other words, a form of 'birth control'. This is dramatically demonstrated in the desert annuals which, rather than compete, share the available water, light, nutrient, etc. although these are at a premium. Much more work remains to be done in this respect to further the understanding of the ways of evolution.

No study of desert vegetation, no matter how extensive, could be complete without a consideration of the relationship to animals. For to the various animals existing in the desert, such as ants, rodents, rabbits, snakes, etc. plants and especially seeds, are of essential importance as their food supply, and consequently the effect on the plant's survival and on evolution cannot be overlooked. For this reason, the study of animal relationships will occupy an equal place with that of plants in the program of the mobile laboratory.

Mr. Lloyd Tevis is presently undertaking a long term study of the relation of ants to desert annuals in this respect. This is done by marking colonies (of Black Harvester ants) and then following their fate over a period of time. By digging up their storage granaries, or simply by robbing the ants of the seeds which they are carrying, it is possible to study the types of seeds upon which they depend for their food. It was found that of the 15 odd kinds of seeds which they collected, over 90% of these were of Plantago and Pectocarya, which also were found to be staples of the kangaroo rat. The question, therefore, arises, what is the effect of this on the survival of the plants? If sufficient seeds are eaten by animals so that germination is drastically reduced, then it might be expected that over a long period of time this plant would disappear. In order to study the types of plants which have seeds in the vicinity of the colony under observation, equal plots were marked off and watered once at different times of the year. As previously shown, germination depends on the temperature subsequent to the watering and such was the case here. Thus, as a result of watering in the warm months of July to September, Euphorbia and Abronia, summer annuals germinated, whereas, October's and November's watering produced Plantago and Malvastrum, respectively. It is of interest to note that Pectocarya, one of the staples of the ants' diet, did not germinate at all as a result of any of these waterings. Whether or not it will do so under natural conditions or if the ants will change to another source of food should this supply be reduced remains to be seen.

In cooperation with these field studies, soil samples are tested in the Earhart Laboratory under different temperature and moisture conditions to provide a more detailed picture of what seeds are present and under what conditions they germinate best. Also, unknown seeds collected from the ants, as well as those deposited by the ants can be grown and identified. It has been found that of seeds collected from 11 feet below the surface of the earth in the ants' granary, almost 100% germinated, whereas of those discarded by the ants, only a very small percentage proved to be viable. If the viability can be related to the nutrition within the seed, it would appear, therefore, that the ants are efficient housekeepers.

The problems indicated here are but a few of the numerous possibilities which a set up such as the mobile desert laboratory can cope with. It is hoped that its unique facilities will be used by many scientists of all fields and all countries so that a well rounded ecological picture may be painted.

In pursuing such studies as are permitted by the Laboratory, the effect on the research worker himself cannot be overlooked. For science is the result of the imagination of man and among that which feeds the imagination, man's contact with nature is perhaps the greatest. The desert, which is a place of extreme beauty of colour and form, of deep calmness and of peace, cannot fail to have a stimulating effect on him who comes to study its mysteries. In observing the plants of this area of extremes, can one fail to absorb some

of its philosophy? For the laws of nature apply equally to plants and man, and if desert plants can survive and bloom in the face of such apparent odds, surely man can live happily with his abundance of natural blessings. Wordsworth expressed this more aptly:

"One impulse from a vernal wood
May teach you more of man,
Of moral, evil, and of good
Than all the sages can."

The mobile desert laboratory, fully equipped and self sufficient, in the middle of the wilderness, stands as a symbol of man's ingenuity and as an instrument to help gain a better insight into nature's laws. In a complex civilization, often too hurried and too confused, it brings the scientist back to the natural world to study its basic laws. For to those who would learn the secrets of nature, the clues are present and the study is well rewarded. Or, as is enscribed over the entrance to the Biology Building at Columbia University:

"For the advancement of Natural Science, speak to the earth and it shall answer thee."

Earhart Laboratory
Caltech

Demonstration Home Garden of Native Plants at the Santa Barbara Botanic Garden

KATHERINE K. MULLER

THE GROWING INTEREST of visitors to the Santa Barbara Botanic Garden in the use of native California plants for home landscaping has been strongly indicated in recent years by the frequent questions asked of the Garden staff. To illustrate the use of native plants in an area of limited space and to show the means of using them to meet numerous landscape problems of home owners in the Santa Barbara area, the Botanic Garden recently completed planting of a demonstration home garden.

The site selected for this demonstration garden measures approximately 57 by 61 feet. It is located north of the Strawberry Meadow and readily accessible to Garden visitors. Grape stake fences along the two sides and a steep bank at the back, below Mission Canyon Road, enclose it as a distinct unit. Because of the sloping site, the garden was laid out with two terraces, a lower broader one which includes an outdoor living area as well as planting space, and a narrower one occupied by path and planting beds. Construction materials were selected to harmonize with the native plants. Railroad ties were used for steps, a blue-grey shale for paths and outdoor living area, and natural sandstone rock for low retaining walls. The basic plan was done for the Garden by the office of Cornell, Bridges and Troller.

Only plants known to be available in at least some nurseries and to be relatively easy of culture were used in the home garden. Thus a shady corner includes Columbine, Bleeding Heart, Wild Ginger, Barberry, Alum Root, Douglas Iris and Yerba Buena. A hot dry section is planted principally to Buckwheats, Sages and Monkeyflower hybrids. Prostrate Ceanothus and Manzinitas are used on the bank between the terraces, while the upper bank includes a variety of ornamental shrubs and perennials. A screen planting at the back is composed of Toyon, Lemonade Berry and Fremontia. The showiest of our chaparral shrubs have been placed as accents against the fences or in especially selected spots. Small beds have been left for spring wildflowers and free flowering perennials such as Penstemons.

It was felt that labels placed near the plants would destroy the effect of a home garden. In their stead, a numbered map has been used with each plant indicated by a number and a list of the corresponding names attached. This is posted on a fence