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THE YEARS OF A DESERT LABORATORY

by
JUDITH C. WILDER

THREE occupations by scientists have given importance to a hill in southern Arizona on Tucson's western limits. Each occupation has added to the world's store of biological knowledge and each has been enriched by vivid personalities. The hill is Tumamoc, more lofty sister to Sentinel Peak — popularly called "A" Mountain. On the north shoulder of this hill, merging into the rocky but verdant background, is a long, sturdy building of native basalt. Since 1903 this structure has been a laboratory for successive institutions that have been concerned primarily with vegetation, the latest having broadened its scope into the earth sciences. The present researchers, though in a space age, are probing into the buried mysteries of our own planet which still is dependent on plant life.

At the turn of the present century, a site on Tumamoc was first chosen for the "Desert Botanical Laboratory" of the Carnegie Institution of Washington, bestowing upon the adobe town of Tucson a portion of the Andrew Carnegie fortune.[1]

[1] Andrew Carnegie (1835–1919), who came to the United States as a poor boy from Scotland, went from one successful business enterprise to another, until by middle age he was one of the richest men in the world. He retired in 1901 when Carnegie Steel Company merged with U.S. Steel Corporation and devoted the rest of his life to the distribution of his wealth. Burton J. Hendrick, *The Life of Andrew Carnegie* (2 vols., Garden City, New York, 1932). See also the *Dictionary of American Biography* (New York, 1936), I, 499–506. Carnegie's endowment to the board of trustees of the Carnegie Institution of Washington (only one of many Carnegie foundations) in 1902 consisted of registered bonds with a par value of ten million dollars. To this fund he added two million dollars on December 10, 1907, and ten million dollars on January 19, 1911. Other accumulated funds were added through the years. *Carnegie Institution of Washington Yearbook ... 1913* (Washington, 1913), ix. Tucson was given a Carnegie Free Library building in 1900.

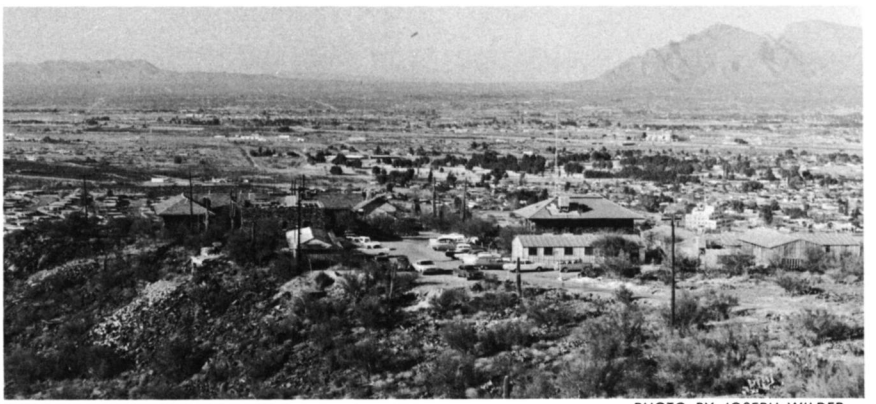


PHOTO BY JOSEPH WILDER

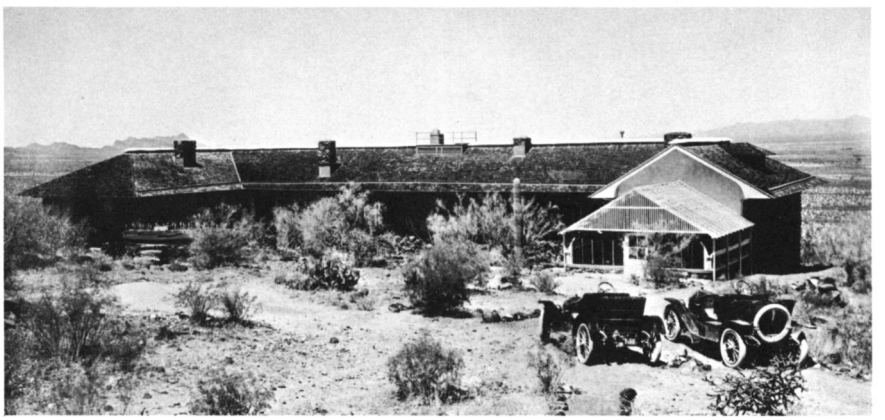
THE DESERT LABORATORY ON TUMAMOC HILL AT TUCSON

When that institution ceased to function on the hill, it was followed by the United States Forest Service. Most recently the University of Arizona has used the land and buildings for paleontological research.

The founders of the Carnegie Desert Laboratory were two adventurous botanists, Daniel T. MacDougal[2] and Frederick V. Coville.[3] MacDougal, then assistant director of the New York Botanical Garden, and Coville, chief botanist for the U.S. Department of Agriculture, while on separate exploring expeditions in the 1890s to observe the little-known plants of the Southwest and their habitats, had recognized the scientific possibilities which lay practically untouched on this last frontier. Their efforts would lead to the founding of the laboratory in

[2] Daniel Trembly MacDougal (1865–1958), a native of Indiana, received a B.S. degree from De Pauw University in 1890, an M.A. in 1894, and LL.D. in 1912. He also earned an M.S. degree from Purdue University in 1891 and a Ph.D. in 1897. He studied at Tübingen and Leipzig in 1895–1896. He was an agent of the U.S. Department of Agriculture on explorations in Arizona and Idaho, 1891–1892; assistant director of the New York Botanical Garden, 1899–1905; and director of the department of botanical research and the laboratory for plant physiology of the Carnegie Institution, 1905–1933. He died in Carmel, California. *Who Was Who in America,* Vol. 3, 1951–1960 (Chicago, 1960), 541.

[3] Frederick Vernon Coville (1867–1937) was curator of the U.S. National Herbarium from 1893 to the end of his life and was acting director of the National Arboretum from 1929. He received an A.B. degree from Cornell University in 1887 and the degree D.Sc. from George Washington University in 1921. *Ibid.,* Vol. I, 1897–1942, p. 266. *Who's Who in America,* Vol. 18, 1934–1935, cites Coville as "Best general athlete, N.Y. State Intercollegiate" for the year he graduated from Cornell.



MacDOUGAL COLLECTION, APHS

THE DESERT LABORATORY IN 1911
The automobile on the left is a Hupmobile belonging to Godfrey Sykes, and the other car is an E.M.F.

September of 1903, only a year and a half after formal establishment of the Carnegie Institution itself.[4]

MacDougal was accustomed to covering ground on foot; and, with backpack and plant press, he had collected specimens from Colorado to Sonora. On one trip in the 1890s, after coming from the East by railroad, he had secured an Indian guide to take him into the Navajo country on horseback. The guide had deserted him, taken the horses, and left MacDougal to make his way back to civilization. The story goes that MacDougal later appeared out of the darkness within the firelight of a cow camp. The camp happened to be that of the genial Sykes brothers, Godfrey and Stanley, at Turkey Tanks near Flagstaff.[5] This chance event was the beginning of a long friendship and scientific association. Coville, at the age of twenty-four, was a member of a government expedition in 1891

[4] William Austin Cannon, "The Desert Botanical Laboratory of the Carnegie Institution of Washington," *Out West*, January 1906, 6.

[5] Glenton Sykes, Notes on the Desert Laboratory, in possession of the author, November 1962. Cited hereafter as *Sykes Notes*. The recollections of both Glenton and Gilbert Sykes were invaluable to this writing. The author also is indebted to them and to Mrs. Gilbert Sykes for the photograph on p. 187, innumerable newspaper clippings, magazine articles and reprints, and constant friendly cooperation.

to Death Valley.[6] In 1900 he had made a trip across the stock-ranges of Arizona and investigated the effects of sheep grazing on the watershed of the Salt River Valley.[7] The botanical names of many desert plants include the Latinized *macdougalii* or *covillea,* in honor of these two men.

COURTESY USDA

Frederick V. Coville
1867–1937

In 1901 the board of trustees of the Carnegie Institution sent letters to men active in research in all the branches of natural science, requesting opinions as to the subjects which needed investigation, and as to the most practical methods of conducting the work. Out of these reports, varied projects were developed in all parts of the country. One proposal was embodied in "Report of the Advisory Committee on Botany." Coville, as chairman, suggested a desert botanical laboratory, a cherished project ever since his work on the Death Valley Expedition. The purpose would be to ascertain "the methods by which plants perform their functions under the extraordinary conditions existing in deserts." "The economic ground for the establishment of such a laboratory," he added,

[6] Coville's book, *Botany of the Death Valley Expedition,* Contributions from the U.S. National Herbarium, Vol. 4 (Washington, 1893), was one of the earliest critical studies of desert vegetation.

[7] Gifford Pinchot, at that time chief of the Division of Forestry (forerunner of the Forest Service) who was one of the party of four, wrote in his autobiography that the trip "made history for the grazing industry of the West." His graphic descriptions of the rigors of the horseback and chuck wagon expedition from Winslow through the White Mountains (including climbing Mt. Thomas), down to Clifton, and on to Phoenix embellish the book. The investigations resulted in far-reaching policies to resolve issues between irrigation farmers and wool growers. Gifford Pinchot, *Breaking New Ground* (New York, 1947), 177–180. Coville had gone "straight to the root of a very bitter [similar] controversy in Oregon" in 1898 concerning forest growth and sheep grazing. Pinchot (quoted in Obituary of Coville by William R. Maxon), *Science,* March 19, 1937, 280–281.

"is the enormous development of population and industries that is bound to take place in our arid region during the next hundred years."[8]

The proposal for the laboratory was accepted by the Carnegie Institution. The scope of the practical research was to be the desert plant life of the whole world. Work was soon extended far beyond the United States, to observations in Australia, Mexico, South Africa, the Sudan, and the Libyan Desert.[9]

MacDougal and Coville were appointed by the Carnegie Institution as a board to find a site for the laboratory, and to recommend research to be done, as well as personnel and a budget. Although both knew the Southwest region, "it was deemed profitable to make, together, a systematic tour of these deserts . . . and to select a locality offering the greatest advantages and facilities for the proposed work." Their itinerary, beginning at El Paso, covered a large area, though it lasted only five weeks during January and February of 1903. They skirted the edge of the Chihuahua Desert in Mexico, visited the White Sands of New Mexico — which they inspected by wagon — and went on to Tucson by rail. After two days there, they took the train again, traveling to Nogales and thence far down into Sonora to Torres, from which point they made a saddle trip over the desert west of Torres toward the Gulf of California. After going by rail to Guaymas, they returned to Tucson and spent two more days before going on to Salton Basin, Indio, Thousand Palm Canyon, and Los Angeles. The return trip east was made by train, crossing the Mojave Desert and taking the railroad spur to the Grand Canyon. Here they spent two days descending to the Colorado River by the Bright Angel trail before continuing to Washington.[10]

[8] Carnegie Institution, *Carnegie Institution of Washington Year Book, No. 1, 1902* (Washington, 1903), 3, 5. Cited hereafter as *Yearbook,* with number and annual date. Coville's plan for botanical research also included research on the function and effects of forests, botanical research in the West Indies and Central America, and establishment of a station in that region, which was later done. *Ibid.*

[9] *Yearbook,* No. 11 (1912), 76; *Yearbook,* No. 20 (1921), 43.

[10] F. V. Coville and D. T. MacDougal, *Desert Botanical Laboratory of the Carnegie Institution* (Carnegie Institution, Publ. No. 6, 1903), 1–3.

While they considered all of the localities they had seen, they chose Tucson, Arizona Territory, which they had favored from the first. One reason for the choice was the size of the city — 7,500 population at that time — with the attraction of the university, then twelve years old, and its herbarium and agricultural experiment station. More important, they felt, was the nature of the desert surrounding Tucson, "the richest and most diversified vegetation of any area in the arid part of the United States," and the variety of country easily accessible in every direction.[11]

The exact location settled upon was half way up a small mountain, two miles west of Tucson and the usually dry Santa Cruz River. Just below the hill was St. Mary's Hospital, established twenty-three years before, and at that time a circular, wooden-porched structure with two other buildings, separated from Tucson by largely unoccupied desert. The place selected for the laboratory building was marked by a long spliced gathering stick forgotten by some Papago when last harvesting saguaro fruit.

The building was constructed of the rough volcanic boulders which make up the mountain. The slate shingles of the widely overjutting roof were shipped in from the East. The founders of the laboratory were especially proud of their "most effective system of ventilation." This was achieved by crowning the building "with a huge attic super-structure, the eaves of which project four and eight feet. Under the eaves are great expanses of iron grating through which the air is drawn into the attic as it is heated by sun, and flows out through dormer ventilators." The early scientists reported that by this constant circulation and "other cooling devices" the staff was able to work in comfort when the outside temperature was 120 degrees.[12] Nonetheless, four massive evaporative coolers were installed on this building in later years.

[11] Forrest Shreve, "The Desert Laboratory of the Carnegie Institution of Washington," *Progressive Arizona and the Great Southwest* (Tucson), April, 1929.

[12] *New York Times*, July 15, 1906.

Obtaining water for the laboratory, even enough to mix mortar, was always a problem and one of the largest expenses, though the town of Tucson had contributed a pipeline that led from a well and steam pump in the Menlo Park district.[13] Tucson donated the original 840 acres of land; and the city constructed a road to the building site, and telephone and electric light connections.[14]

The name Tumamoc may have been bestowed by the city fathers or by MacDougal. It is from the Papago and refers to a horned toad. The name appears in print in 1906.[15] It has never been in common use by Tucsonans but it has become more familiar since the University of Arizona acquired the laboratory. The university now uses the designation officially.

Workers at the laboratory in the early days were zealous but light-hearted; this impression is given by old pictures and reports. A sense of out-west adventure was in the air. The scientists lived at the foot of the hill and tent-houses were the expected temporary dwellings, but in time several substantial houses were built of the same volcanic rock as the laboratory buildings. Wives pursued botanical studies and published papers. Comforts of today were not missed. The researchers usually climbed afoot up the rocky hill to work; sometimes water failed to make it up the hill at all.

The only regular staff member at the laboratory in 1903 was William A. Cannon,[16] who, like MacDougal, had been with the New York Botanical Garden. A number of other people to whom small grants had been made carried on work in 1904 and

13 *Sykes Notes.*

14 *Yearbook,* No. 2 (1903), Report of the Executive Committee, xxvii.

15 *New York Times,* July 15, 1906, and *Tucson Post,* Dec. 15, 1906. The Papago pronunciation lies between the two spellings, Tumamoc and Chumamoc. Meaning and pronunciation were verified by a present-day Papago. Tumamoc Hill is also known as Flattop. At one time it was called Sugar Loaf or Warren Hill, according to a story in the *Tucson Post,* Feb. 17, 1906.

16 William Austin Cannon (1870–1958), a graduate of the University of Michigan, obtained his Ph.D. from Columbia University in 1902. He was a research associate with the Desert Botanical Laboratory from 1903 to 1925, and was Lecturer in Botany, Stanford University, 1926–1958. *American Men of Science,* 9th ed. (2 Vols.; Lancaster, Pa., 1955), II, 168. See also 10th ed., 580.

1905. The studies endeavored, so Cannon reported, to record as fully as possible the environmental factors which surround and influence the plants of the desert day-by-day, and to measure the reactions of the plants to these stimuli.[17] The form, functioning, and distribution of spiny and succulent plants was a new field.

By 1906, two years ahead of its founders' expectations, the laboratory had justified its existence. The president of the Carnegie Institution, Robert Simpson Woodward,[18] visited Tucson in September of 1905 and recommended to MacDougal, who was still at the New York Botanical Garden but who acted as advisor to the laboratory, that plans be considered at once for its extension.

This news was "gratifying all around," as MacDougal wrote.[19] Besides his desire to increase operations, he was anxious to bring Godfrey Sykes on to the Carnegie staff for he realized that Sykes had many talents to contribute. From New York, he had been writing to the other man at Flagstaff every few days all summer. MacDougal relished their experience of the previous spring, when they had navigated six hundred miles of the lower Colorado River to the Gulf of California, and he discussed publications, official and popular, connected with this expedition. In Sykes, MacDougal found a congenial spirit. He often dwelled on small topics: "Puffed rice is the stuff," he once wrote, "and now I see it everyplace. If it weren't so bulky we might use it on our trips."

In the next paragraph of this particular letter, however, he plunged into serious business. Woodward had come to MacDougal in his New York office on a Sunday morning and offiered him a substantial increase in salary to become director of the department of botanical research and to take charge of

[17] Cannon, *Out West,* 8.

[18] Robert Simpson Woodward (1849–1924) was Dean of the School of Pure Sciences, Columbia University, 1895–1905, and President of the Carnegie Institution, 1905–1920. *Who Was Who in America,* Vol. 1, 1897–1942 (Chicago, 1943), 1380.

[19] MacDougal to Sykes, Sept. 2, 1905. The Papers of Daniel T. MacDougal, Arizona Pioneers' Historical Society.

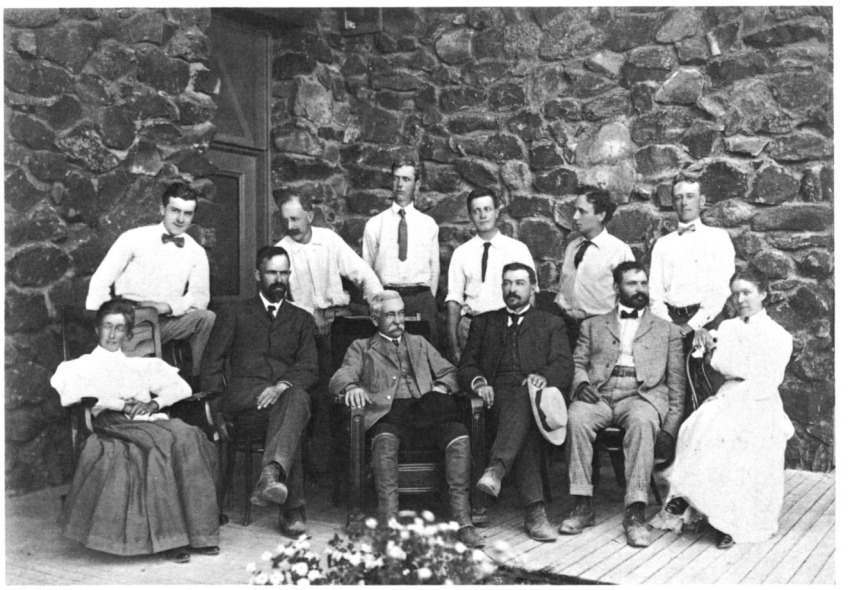


PHOTO COURTESY GLENTON SYKES

ROBERT S. WOODWARD AT THE DESERT LABORATORY, 1908
The president of the Carnegie Institution is seated, wearing leggings; MacDougal is to his left. Mrs. Sykes is the lady at left, and Godfrey is peering at her over Prof. G. B. Davenport. W. A. Cannon and B. E. Livingston stand behind Woodward and MacDougal. Livingston's wife is at right, next to G. H. Shull. Prof. F. E. Lloyd stands behind Shull.

all the botanical work of the Carnegie Institution. This work would include direction of the Coastal Laboratory at Carmel, California, as well as of the Desert Laboratory at Tucson. MacDougal had improvements in mind at the Tucson site, and he wrote Sykes, "I would wish to have you on the staff as Superintendent to supervise all construction and to have general charge of all the plant and the tract of land enclosed. All mechanical and engineering problems would devolve on you." Off in a jocular vein again, he added, "An unpleasant part of your duty would be to accompany me on exploring trips — tough, but you might be able to stand it — we'll have some of the bulliest trips ever."[20]

MacDougal took the Carnegie offer, not without the observation that his superior at the Botanical Garden, Nathaniel L. Britton, had been "so perfectly fine."[21] Later, he was able to reciprocate when Britton did research at the Desert Laboratory. The new director came to Tucson in January, 1906. He was to remain as director for twenty-two years, and as a research associate six more years until 1934, when he retired to Carmel. His scientific work is recorded in scores of professional and popular publications. He received an honorary degree from the University of Arizona in 1914.[22]

MacDougal was successful in persuading Sykes to join the staff of the Desert Laboratory soon after his own appointment to the Carnegie Institution. Sykes, born in London in 1861, had some training as a civil engineer in England before coming to the United States at the age of eighteen, on what he intended

[20] MacDougal to Sykes, Sept. 12, 1905, in *ibid.*

[21] *Ibid.*

[22] In 1950 MacDougal attended the International Botanical Congress in Stockholm as honorary president and again attended the Congress at the meetings held in Paris in 1954. He did everything with great energy to the end of his 92 years. Robert H. Forbes, remembering him at dinner parties at his home on Olive Road, recounts that he was a brilliant conversationalist. "He overshadowed his poor wife. I think he was too much for her. I remember a trip in a car with him driving. I think Mrs. MacDougal was so jolted around she didn't like to go on his trips very often." He was always trying to create a new species of plant "by various and sundry methods such as electric shock." Robert H. Forbes, interview, Oct. 19, 1965.

to be the first lap of a trip around the world. Later this ambition was realized, but in the meantime he was ready for any adventure and soon found himself driving longhorn cattle on the trail between Abilene and Cheyenne and working for a cattle company in western Kansas.[23] By the time he was twenty-five, he was in northern Arizona, his brother had joined him, and they were in the ranching business themselves near Flagstaff. The price of beef slumped during the ten years they had the Turkey Track brand,[24] but they continued to manage their cattle. Beyond that, the brothers also worked at various engineering jobs in Flagstaff, as both had great inventive and mechanical ability. They kept a sawmill going, and they built the telescope dome and installed instruments at Lowell Observatory.[25] During this time, too, Godfrey, bitten by his "wanderlust bacillus," spent nearly three years in Japan and Australia and on the high seas in between.[26]

One of Sykes' interests was the Colorado River.[27] On several expeditions in 1890, he had navigated the lower reaches of the Colorado, for pure enjoyment at first, as well as for the sake of geographical exploration. Later, it became his custom to go south for the winter, taking his loyal "little English wife" — who shared his enthusiasms and hardships — and eventually the "two precious babies," on river boat trips of many weeks.[28] For these trips he would construct a boat on the spot at Needles and float down three hundred miles to Yuma or farther, camping on shore at night. In 1904, leaving his family in Yuma, he made a voyage down the lower Colorado to the

[23] Godfrey Sykes, *A Westerly Trend* (Tucson, 1944), 100–109.

[24] Marks and Brands, Book 3, Yavapai County; registered by Stanley Sykes, Sept. 7, 1887; pp. 264–265.

[25] *Arizona Daily Star* (Tucson), Nov. 18, 1944.

[26] *Westerly Trend,* 175 ff.

[27] His most important scientific publication was probably *The Colorado Delta* (Carnegie Institution of Washington and the American Geographical Society of New York, 1937), 193 pp.

[28] *Westerly Trend, passim.*

SHOP BUILDING AT THE DESERT LABORATORY IN 1909
This structure is still in use. Godfrey Sykes' sailboat, the *Atriplex*, protrudes through the door. The automobiles are Maxwells. This photograph, and that on p. 197, are reproduced from glass plates in the MacDougal-Shreve Collection in the Department of Biological Sciences, University of Arizona, used by permission of Dr. C. H. Lowe.

delta and to Baja California in the sloop *Atriplex*. It was probably on this trip of several weeks that MacDougal and Sykes got best acquainted. The area was examined with regard to botany, hydrology, and the collection of specimens. A more ambitious expedition to the same area was made in 1905.

Godfrey moved from Flagstaff to Tucson in 1906, hoping most of all that the lower altitude would improve his wife's heart condition. First he took her and his young son Gilbert to San Diego. Then he traveled in January by wagon team with his nine-year-old son Glenton from San Diego to Tucson. He wanted the team of horses for the job he was just beginning. The trip took twenty-six days, slowed inordinately because of sand dunes and the flooding that created the Salton Sea.[29]

The work on Tumamoc proceeded rapidly. A road was completed, the rock walls of the addition to the main building were laid, and the greenhouse was built that year. The next summer Sykes was borrowed by the Carnegie enterprise in

[29] *Sykes Notes.*

Pasadena to build a road up to the Mount Wilson Observatory in the San Gabriel Mountains. He took his family with him to the Coast to spend the summer, but his wife, Emmie, died while they were there.

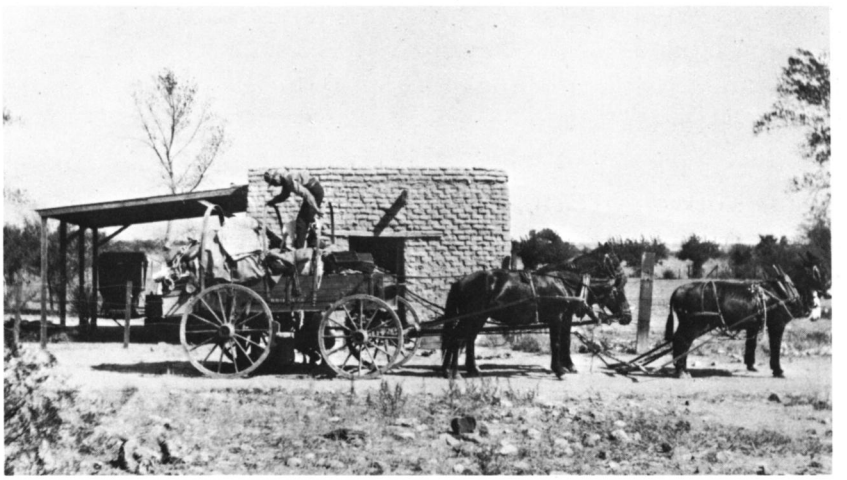
Back in Tucson, Sykes took care of his sons in a comfortable camp at the foot of Tumamoc, preferring two wall-tents to a more orthodox manner of living.[30] He made life happy for the boys and there was never any lack of interesting activities. For instance, in the very next year, they watched the Pinacate Expedition pull out in two horse-and-mule-drawn vehicles from the corral at the foot of Tumamoc Hill.[31] The two boys, aged seven and eleven, were excited by the adventure of being left alone for over a month while their father was on the expedition. The nuns at St. Mary's were to give them their suppers, while they would get other meals for themselves over an open fireplace at the tent house.

When the Desert Laboratory staff was expanded in 1906, other botanists took up residence at the foot of the hill, or in town, and stayed for greater or lesser periods. These included Burton E. Livingston, of the University of Chicago, and his wife; Professor and Mrs. Francis E. Lloyd, from Columbia University; Professor and Mrs. Volney M. Spalding, University of Michigan; and Professor John J. Thornber, at the University of Arizona. New devices for work in plant physiology were developed and many important contributions were published.[32]

30 *Westerly Trend,* 268. Godfrey soon began building the present Sykes house of basaltic rock at the foot of the hill, but, with trips abroad intervening, he did not finish it until the 1920s.

31 William T. Hornaday, *Camp-Fires on Desert and Lava* (New York, 1908), deals with this exploring trip which revealed the remote area to white men for the first time.

32 For example: Spalding, *Distribution and Movement of Desert Plants* (Carnegie Institution, 1909); Livingston (with Forrest Shreve), *The Distribution of Vegetation in the United States, as Related to Climatic Conditions* (Carnegie Institution, 1913); Cannon, *Botanical Features of the Algerian Sahara* (Carnegie Institution, 1913); Lloyd, *Physiology of Stomata* (Carnegie Institution, 1908) and *Guayule (Parthenium Argentatum Gray), a Rubber-Plant of the Chihuahua Desert* (Carnegie Institution, 1911); MacDougal, *Botanical Features of North American Deserts* (Carnegie Institution, 1908), *Across Papagueria* (Bulletin of the American Geographical Society, 1908), and *The Salton Sea; a Study of the Geography, the Geology, the Floristics, and the Ecology of a Desert Basin* (Carnegie Institution, 1914).



Loading the wagon to start the trip at the Desert Laboratory, November 2, 1907. This is the vehicle Hornaday facetiously called their White Water touring car. The mules leading the horses are Bill and Maude, "one size larger than jack rabbits."

The members of the expedition at Papago Tanks. MacDougal is on the far left and Hornaday at right. The man with his hat off is John M. Phillips, the official photographer, but this picture was made by Godfrey Sykes. The man seated by Phillips is Jeff Milton. Compare with the photo in Hornaday, *Camp-Fires on Desert and Lava*, facing p. 203.

There were well-known visitors, too, through the years — Hugo de Vries, Dutch botanist; Herbert Eugene Bolton, historian; Frederick E. Clements, ecologist; and Britton and Joseph N. Rose, authorities on cactus.[33]

Andrew E. Douglass, financed by the Carnegie Institution for his work on tree-rings and climatic cycles,[34] was associated later with scientists on the hill. Still another scholar was Forrest Shreve, whose career spanned the longest period of time of anyone at the laboratory.

Forrest Shreve came to the laboratory from Maryland in 1908. Three years previously he had received his doctoral degree from Johns Hopkins University. He spent a few months in the rain forest of Jamaica, and two years as a professor of botany at Goucher College, but the rest of his life — forty-two years with the Carnegie Institution at Tucson — was spent in the study of deserts. His contributions to the knowledge of this subject are perhaps more often cited than those of any other North American.[35] From 1911 to 1920 he was editor of *The Plant World,* a small monthly out of which grew the present journal *Ecology*. *Plant World* was published in Tucson while

[33] Britton and Rose, *The Cactaceae* (4 vols.; Carnegie Institution Publ. No. 248; orig. ed., 1920). This monumental work has recently been reprinted (4 vols. in 2; New York, 1963).

[34] Douglass makes acknowledgment "... to the Carnegie Institution of Washington for bearing the expenses of publishing and for the yearly appropriations through its Division of Ecological Research, to aid this study by securing suitable help and occasional field trips and instruments." Douglass, *Climatic Cycles and Tree Growth, Vol. II, A Study of the Annual Rings of Trees in Relation to Climate and Solar Activity* (Carnegie Institution, Publ. No. 289, 1928), 6.

[35] His work, the first volume ("Vegetation") of *Vegetation and Flora of the Sonoran Desert* (Carnegie Institution, Publ. No. 591), was begun in 1932 with Ira L. Wiggins. The term vegetation in the title refers to the ecological treatment of the subject, while "flora," treated by Wiggins, is taxonomic description. The second volume by Wiggins did not appear in print until the complete two-volume work was published by Stanford University in 1964.

THE PINACATE EXPEDITION

Daniel T. MacDougal and the eminent naturalist, William T. Hornaday, led the first scientific expedition into the Pinacate Mountains of northwest Sonora during November, 1907. The photographs at the left are from the MacDougal Collection, in the Arizona Pioneers' Historical Society.

Shreve edited it, and for several years before, when it was edited by Lloyd.

In 1928, Shreve was put in charge of desert investigations by the Carnegie Institution board. Even after the institution suspended operations, it continued to finance his work alone. He died in Tucson in 1950 at the age of seventy-two. A tall, dignified figure, he was accustomed to wearing high-topped buttoned shoes or pumps with raised heels and other oddities of dress. Over the years, he traveled into the roughest terrain of Arizona and northern Mexico, with the consistent object of understanding the relation of plants to their environment.[36]

DEPRESSION years and shifting research interests finally cost the life of the Carnegie Desert Laboratory. Support by the Carnegie Institution of all their botanical research was curbed in the thirties as securities lost value and income from investment fell off. The laboratory closed in 1937; three years later, only Forrest Shreve was conducting research there. His office was in a pink stucco house at the bend of the road next to St. Mary's hospital. This small building, which had been on the edge of a Chinese truck garden in earlier days, was at one time the administration building for the laboratory. It later belonged to the hospital and was razed in 1965.

The Carnegie era ended in 1937 but the hill stood fast, and activities began anew when the Forest Service of the U.S. Department of Agriculture took over the buildings in August of 1940. Under its laws of incorporation, the Desert Laboratory could be sold or transferred only to a public concern. After months of correspondence, Arthur T. Upson, director of the Southwestern Forest and Range Experiment Station, was called to the Carnegie Institution headquarters in Washington. Referring to the laboratory, the director, Vannevar Bush, said, "It's yours; have your attorneys draw up a paper of donation of

[36] Homer L. Shantz, "Forrest Shreve," *Ecology*, Vol. 32 (July, 1951), 365–367. A bibliography of one hundred of Shreve's publications is included.

property for a consideration of one dollar." The whole thing took about two minutes, Upson recalls.[37]

A building of lava rock slightly to the southeast of the laboratory, which had been built in 1911, had been gutted by fire in 1938 but was rebuilt in 1940 by the Forest Service. Divided into seven rooms for offices and classes, it is now used by the Geochronology Laboratories of the University of Arizona. Another stone building, square and flatroofed, was constructed by the Forest Service in 1940 and continues to be used by them, under an agreement with the University, as Tucson offices for the Rocky Mountain Range and Experiment Station. The greenhouse, which forms a wing of the main laboratory, is used by the station for herbicide studies.

Upson was director of the Southwestern Forest and Range Experiment Station from 1935 until 1942. He was succeeded by Raymond Price, who was on Tumamoc as director until September 1953, when the Southwestern station was merged with the Rocky Mountain Station. Price then transferred to the headquarters at Fort Collins, Colorado, where he has remained as director.

An important worker in forest research was on the hill during these years. Gustaf A. Pearson, a botanist and forester from the University of Nebraska, had been concerned with ponderosa pine production since the establishment of the Fort Valley Experiment Station at Flagstaff in 1907.[38] Fort Valley was combined with three other stations to form the Southwestern Forest and Range Experiment Station in 1929 and Pearson was made director with headquarters in Tucson; summers were spent at Flagstaff. In 1935, after serving fifteen years, he gave up the directorship, but as senior silviculturist continued his extensive research on ponderosa pine. Field work which he started at Fort Valley is still carried on by his successors. Forty

[37] Arthur T. Upson, interview, Nov. 4, 1963.

[38] "Gustav Adalph Pearson, 1880–1949," *Plateau,* Vol. 28 (1956), 86–90. (*Plateau* erred in the spelling of Pearson's first and middle name, which should be Gustaf Adolph).

thousand trees have now been measured at five-year intervals for as long as fifty to sixty years. In Pearson's words, "These records become more valuable with each measurement. They are a legacy to the next generation of foresters."[39] Pearson was struck by a heart attack on the hill on the last morning in January, 1949, just before he was to leave Tucson for an international silviculture meeting in Sweden. He died at his desk in the east stone building.[40]

The final transfer of the original deed to the Carnegie property was executed on July 6, 1960, under the provisions of an act of Congress authorizing sale of the holdings to the University of Arizona. The university in turn agreed to the indefinite continued use by the Forest Service of one building and greenhouse.[41] At the present time, Clark Martin, who was a range examiner and student on the hill in 1942, supervises the project work of the station: management of semi-desert cattle ranges, with field work done at the Santa Rita Experimental Range.

GEOCHRONOLOGY became the third "occupation" of Tumamoc Hill.[42] The development of the University of Arizona's program in geochronology — literally, "earth-time study" — began in 1952, in conjunction with the departments of geology, meteorology, botany, zoology, chemistry, and anthropology. The first master's degree in this subject was awarded in 1964 and a doctor's degree in geochronology is now attainable.

The geochronology laboratories took over the hill gradually,[43] purchase of the property by the University from the

[39] *Ibid.*, 87.

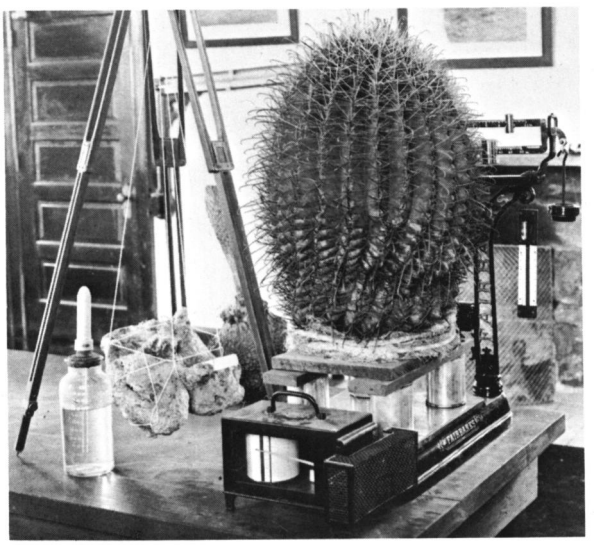
[40] Pearson obituary, *Arizona Daily Star*, Feb. 1, 1949.

[41] Clark Martin, interview, Sept. 22, 1965.

[42] The remnants of a prehistoric occupation by men who may have counted scientific minds among their number are visible in the form of rock shelter and defense ruins on the flat top of Tumamoc. Here now are towers for shortwave radio transmissions of various law enforcement agencies, and the University's Lunar and Planetary Laboratory telescopes.

[43] Facts concerning the Geochronology program were supplied or checked by Terah L. Smiley, whose help is gratefully acknowledged.

federal government not being completed until 1961. Terah L. Smiley is director of the program which is now a department of the university. Earth-time study — dating the earth and reconstructing its history — is approached by all means which modern science can apply: radiocarbon and other radioactive



An Early-Day Experiment: Measuring Cactus Weight Loss

techniques, and the use of plant and animal fossils. Research facilities and classrooms for palynology (the study of pollen and spores, especially in fossil form) and paleontology (the study of fossil bones) are located on Tumamoc, as well as the administrative offices of the geochronology laboratories. The geochemistry section under Paul E. Damon and C. Vance Haynes is located on the campus in Tucson.

Fossil pollen and spores underlie geochronology. Most of the research and teaching at present on Tumamoc Hill is concerned with these organic remains. Even though pollen grains and spores are microscopic, they are amazingly durable. They are found, for instance, in two-hundred-million-year-old sediments at Petrified Forest National Park. Every spore and pollen grain bears a characteristic stamp of the plant family from which it came, and sometimes a more refined configuration

identifying it as to genus and species. Because fossils of these organisms occur in vast numbers, they can tell a story of life in past geologic ages and are used as "guide fossils" in stratigraphic geology, particularly in oil exploration. They also may be used to map out the vegetation of ancient landscapes and to indicate past climates the world over. As an illustration, the Willcox Playa (dry lake) in the Sulphur Springs Valley of southeastern Arizona, which has been barren of all vegetation since the Ice Ages a million years ago, saw pines and sagebrush advance and recede from its shores to the surrounding mountains as the climate cooled and warmed.

On Tumamoc Hill at present, Paul S. Martin works on the paleoecology of the Pleistocene. As this involves the extinction of large animals, his studies extend to Africa and Madagascar. Gerhard O. W. Kremp is concerned particularly with research in fossil spores from the beginning of organic life and progressing through the Tertiary, when flowering plants developed. Both teach courses in pollen analysis and paleobotany. Lucy Cranwell Smith, research associate, works independently on pollen and spores, particularly those of the Antarctic. John F. Lance is engaged in studying the development of mammalian animals in the southern Arizona area through the last sixty million years, as revealed by fossil material. Several students are pursuing master's and doctoral programs in geochronology or one of the disciplines comprising it.

The luxuriance of vegetation on Tumamoc is partly due to fencing since 1907, and partly to the soil — a type of clay, rich in minerals, derived by weathering of the volcanic basalt which forms the hill and others nearby. Records show that the area receives about one inch more rain annually than does Tucson two miles away. Saguaros are plentiful but palo verdes probably outnumber other tree and shrub plants, and in good flowering years they make a brilliant mass of yellow over the mountain for several weeks in May. Ocotillos, responding quickly to rain, are green several times a year. Creosote bush,

mesquite, *Lycium,* and the *Opuntias* fill in as though landscaped. *Encelia, Penstemon, Verbena,* and mallow bloom along the roadside in spring. *Jatropha* makes patches of autumnal color across the shoulders and canyons of the hill when the heart-shaped leaves of this rather rare shrub turn from glossy green to burnt-orange. A dense covering of a number of grasses manages to grow among the rocks and adds a green or russet tinge.

The influence of the Tumamoc Hill laboratories is more extensive than ever. Correspondence and exchange of publications continues with practically every country of the world; and visiting scientists, who made life so interesting for the early Carnegie staff, continue to be welcomed. Warm friendship and mutual contribution have been enjoyed in recent years by scientists and students from Australia, Japan, India, South America, and Mexico. Two international scientific meetings have been conducted there. Open houses, seminars, and illustrated lectures are held. Beards are again in evidence.

"The Laboratory," wrote Godfrey Sykes as an old man reminiscing in *A Westerly Trend,* "with its many problems unconnected with the bickerings and animosities of mankind . . . is an excellent place in which to calm down, regain one's modicum of sanity. . . ."