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# SCIENCE MOUNTAIN

## *North America's highest permanent research center*

by Ray Colvig

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## *California develops North America's highest permanent research center*

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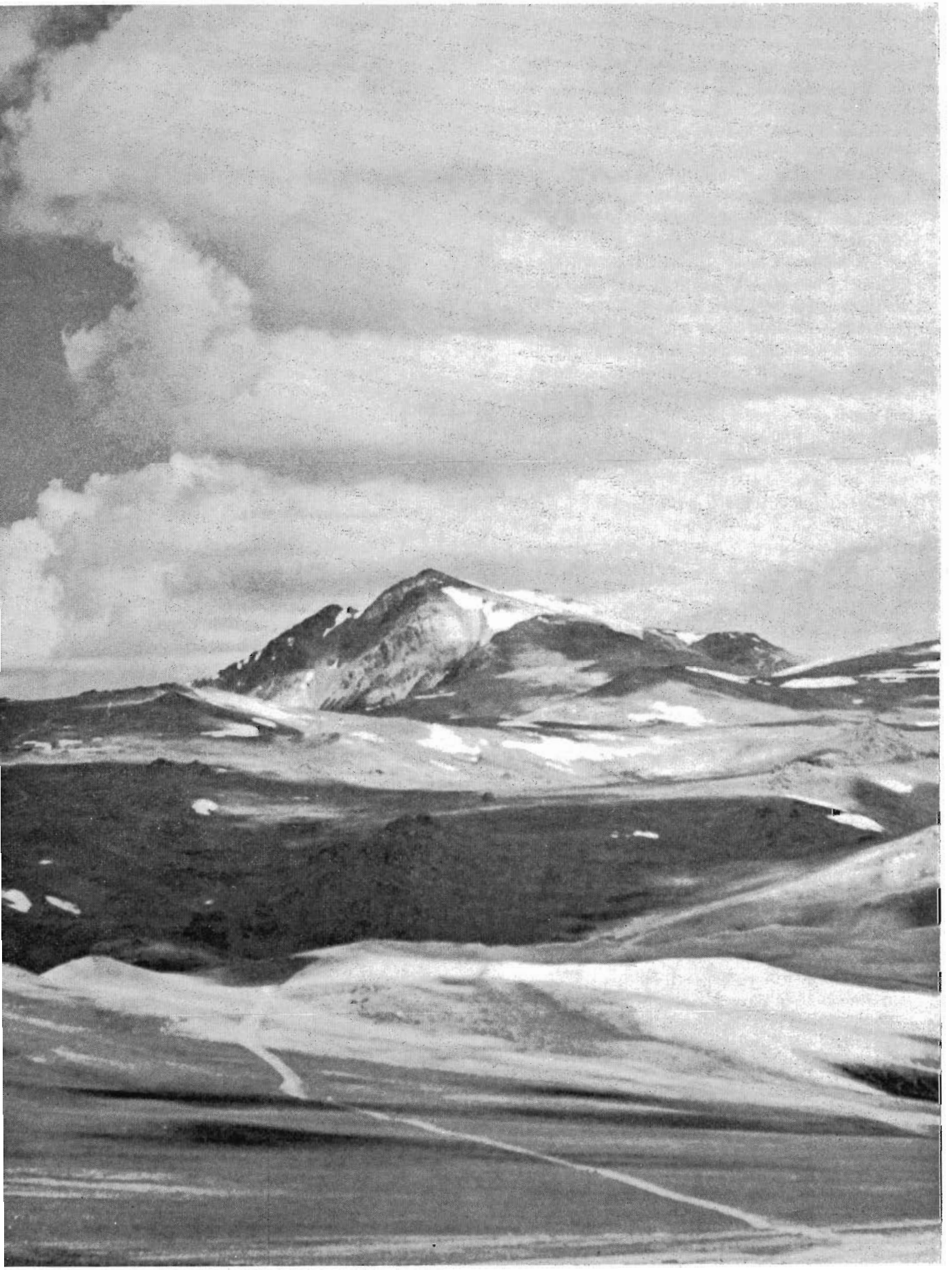
■ GO 250 MILES due east of Berkeley, 250 miles due north of Los Angeles, and 2½ miles straight up!

With only minor adjustments, these geographical coordinates could guide a scientist to a research station that is unique for its wealth of scientific assets, broad scope of activity, out-of-this-world scenery, and, most of all, enormous range of altitude. Actually, there's a good chance that the scientist won't need to ask directions . . . even if he hails from Bloomington, or Cambridge, or Chapel Hill, or some other distant center of learning. The location and accomplishments of the University of California's White Mountain Research Station are already well known throughout the scientific community.

During the past year, for example, some 150 scientists and science students found that White Mountain was an ideal place to seek new knowledge. They represented six campuses of the University of California, ten other universities, and several government research agencies. Their work covered a broad spectrum of the scientific specializations, ranging through the biological sciences and into such areas as astronomy, geology, and psychology. Their ages stretched from 19 to 75; their professional standing from undergraduate student to long-time research director and department chairman. Their findings are being reported in leading scientific journals and at national and international meetings.

Already distinguished as the highest permanent research facility in North America, White Mountain is adding the solid scientific achievements that will mark it with respected status alongside Woods Hole, McMurdo Sound,

*Don Holt, Davis*



and other famed centers for "on location" experiments.

A rare combination of altitude and accessibility—along with scientific vision, determined hard work, and enlightened financial support—receive major credit for the fact that White Mountain has become California's "Science Mountain." White Mountain Peak stands at 14,250 feet elevation, only 245 feet lower than the summit of Mt. Whitney. And in the White Mountain Range (extending from northern Inyo County across the southern tip of Mono County and into western Nevada) there are some 120 square miles above 10,000 feet.

White Mountain, unlike neighboring peaks of the Sierra Nevada (and most other high mountains of North America), has a broad back and a gradual route for ascent. Walled from Pacific storms by the Sierra, it has been only moderately eroded by water and glacial ice. In effect, it provides for scientists a kind of giant "platform" in space.

Further enhancing its scientific potential, the mountain rises from 4,000 feet elevation on the floor of Owens Valley and stands only 80 miles north of below-sea-level points in Death Valley. Probably no other accessible region of the earth offers such a variety of climatic and biotic environments within such a limited geographical radius.

Other natural gifts to the mountain's scientific potential have been counted in great numbers and varieties. For example, scientists have identified some 375 species of plants in zonal patterns ranging from the desert to the alpine; 160 families of insects; and 45 native mammals. An extensive record in rock is available for geological study. Atmospheric conditions are proving favorable for specialized astronomical work. Even a slight (and highly suppositional) similarity to the environment on Mars has been utilized for a study in exobiology.

FEW of these assets were recognized in 1948 when the U.S. Navy initiated scientific work on White Mountain (with a project supporting guided missile research at nearby Inyokern Missile Range). Among those who visited the Navy installation was Dr. Nello Pace, a young dynamo of a physiologist from the Berkeley campus with a distinguished record of wartime research contributions for the Navy and a hankering to pursue the adventure of science in unusual and challenging environments. After sampling some of the scientific resources, Dr. Pace and a few mountain-wise colleagues decided that White Mountain was the right place for such a pursuit.

By agreement in 1950 between the Navy and the University (and concurrent agreement with the U.S. Forest Service), responsibility for research on White Mountain was transferred to the University. Administrative headquarters were established in the Life Sciences Building on the Berkeley campus, distinguished scientists were appointed to an advisory committee (under Chairman S. F. Cook, professor of physiology at Berkeley), and a new dimension in research was opened for scientists throughout the University and the nation.

Support for the White Mountain station in its early years was provided through contract and grant funds from the Office of Naval Research and the Rockefeller Foundation. Navy support in both money and material continues to the present day and is joined by support from the National Institutes of Health, the National Science Foundation, and most recently, the National Aeronautics and Space Administration.

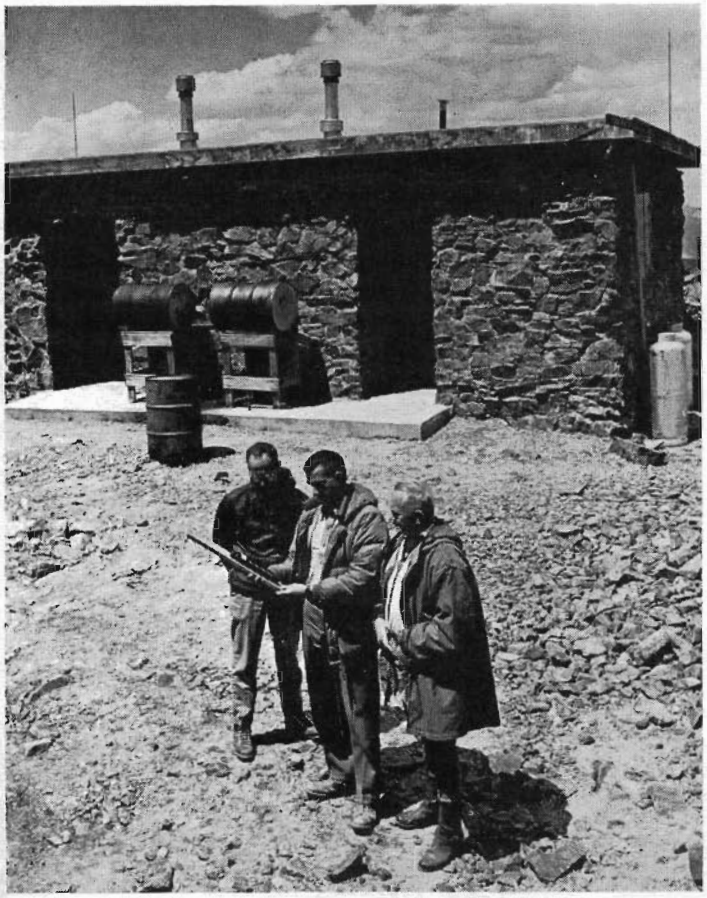
Willing workers for the task of building a research station on a mountaintop were recruited among graduate students on University campuses. A confident, get-it-done attitude was inherited from the Navy. "Scrounging" for useful pieces of war surplus equipment was developed to a high art. Battles were fought and won against the strength-sapping effects of the rarified atmosphere, high winds, balky equipment, and the relentless deadline of the winter snows.

A lot of the credit for White Mountain's success, according to Director Pace, goes to a loyal maintenance staff. Head fix-it man is Paul J. Manis, superintendent of grounds and buildings and 13-year veteran on the mountain. Other key men in operations and research are 9-year veteran William Roche and 4-year veteran David Mathias, both senior maintenance men.

DETERMINED efforts over the past 13 years are paying off today at three well-equipped scientific laboratories:

The *Crooked Creek Laboratory* (elev. 10,000 feet) near the site of the Navy's original research facility is located in a protected bowl-shaped valley 33 miles by winding road from base headquarters (and a small laboratory) at Big Pine in the Owens Valley. The main building here provides sleeping quarters, offices, laboratory space, and a homey kitchen. Smaller buildings house a complete poultry hatchery, laboratory-workshops, and storage. Crooked Creek is also the base for a major portion of the station's Navy-surplus rolling stock—including bulldozers, graders, personnel carriers, vans, jeeps, and little snow-going "weasels."

The *Mount Barcroft Laboratory* (elev. 12,500 feet) 10 miles north of Crooked Creek occupies a magnificent site at the upper end of a rocky plain. This is the principal base for scientific work on the mountain, and has been in continuous year-round operation since 1951. Activities are centered in a two-story, 40-by-100-foot quonset building complete with five fully-equipped laboratory rooms, restaurant-type kitchen and dining facilities, sleeping quarters for 24 persons, a library-seminar room, recreation room, weather station (highest in the U.S.), offices, and workshop. Nearby, smaller buildings provide accommodations for four women scientists and facilities for the station's experimental rat colony, poultry flock, and animal research. There are also pens and cages for a variety of livestock that help make this the nation's highest "farm." A 23,000-volt line completed in 1957 under a grant from the National Science Foundation brings electric power from the Owens Valley. The climate is relatively mild in summer months, but winter temperatures may plummet



Don Holt, Davis

*AT THE SUMMIT, Director Nello Pace, center, checks a barometric reading with visiting scientists Robert Elsner, left, of Scripps Institution of Oceanography and Albert R. Behnke, of the School of Medicine in San Francisco.*

Don Holt, Davis

*THE TEMPERATURE of the moon has been recorded at White Mountain with new accuracy, using an infrared telescope inside this small observatory at the 13,000-foot level above the Mount Barcroft Laboratory. Experimenters are Cal Tech scientists Jim Westfall, left, and Bruce Murray.*

*HIGH ALTITUDE HEN has her pulse taken by Arthur H. Smith, professor of poultry husbandry at Davis.*

Don Holt, Davis

as low as –32° F., special protective measures for valuable animal colonies must be taken, and snow may block access to all vehicles except the versatile "weasel."

The *Summit Laboratory* (elev. 14,250 feet) is a two-room stone hut perched atop White Mountain Peak, where it is almost above half the earth's atmosphere. It is six miles north of the Mount Barcroft Laboratory by a "road" that offers few problems for heavy-duty 4-wheel-drive vehicles with expert drivers. A San Francisco writer once described the hour-long ascent from Mount Barcroft as "perfectly comfortable, providing you have no kidneys or spinal column." Completed in 1955, the laboratory has no permanent staff but is open in the summer months for special research projects. Cooking and sleeping facilities will accommodate four persons; water must be hauled from Mount Barcroft; and power is supplied by generators inside a large truck van body. How that van ever negotiated the hairpin turns and boulders along the road to the top of California's second highest mountain must remain one of White Mountain's unsolved mysteries!

RESEARCH installations and supporting facilities on White Mountain today have an estimated value of nearly $2 million. Yet to duplicate White Mountain environments at sea level would cost far more. With relative ease, scientists can repeat an experiment at sea level (on University campuses), 4,000 feet (Owens Valley), 10,000 feet (Crooked Creek), 12,500 feet (Mount Barcroft), and 14,250 feet (Summit)—neatly spaced steps along the scale toward lower barometric pressure and reduced atmospheric oxygen.

The most extensive application of this concept of "bringing the laboratory to the environment" has occurred in the field of physiology. Much of the work stems from Dr. Pace's early interests in high altitude stress and acclimatization. The long-range goal is to understand the body's fantastically intricate mechanisms and interlocking control systems for dealing with stress and to determine their capabilities and limitations. Findings are directly applicable in the treatment of "mountain sickness" that afflicts high-altitude climbers, in the health problems of the world's 10 million people who live at high altitude, and in some of the problems that may occur in future space travel. Equally important are applications in regular medical practice, where heart and lung diseases create physiological symptoms closely akin to high altitude "anoxia."

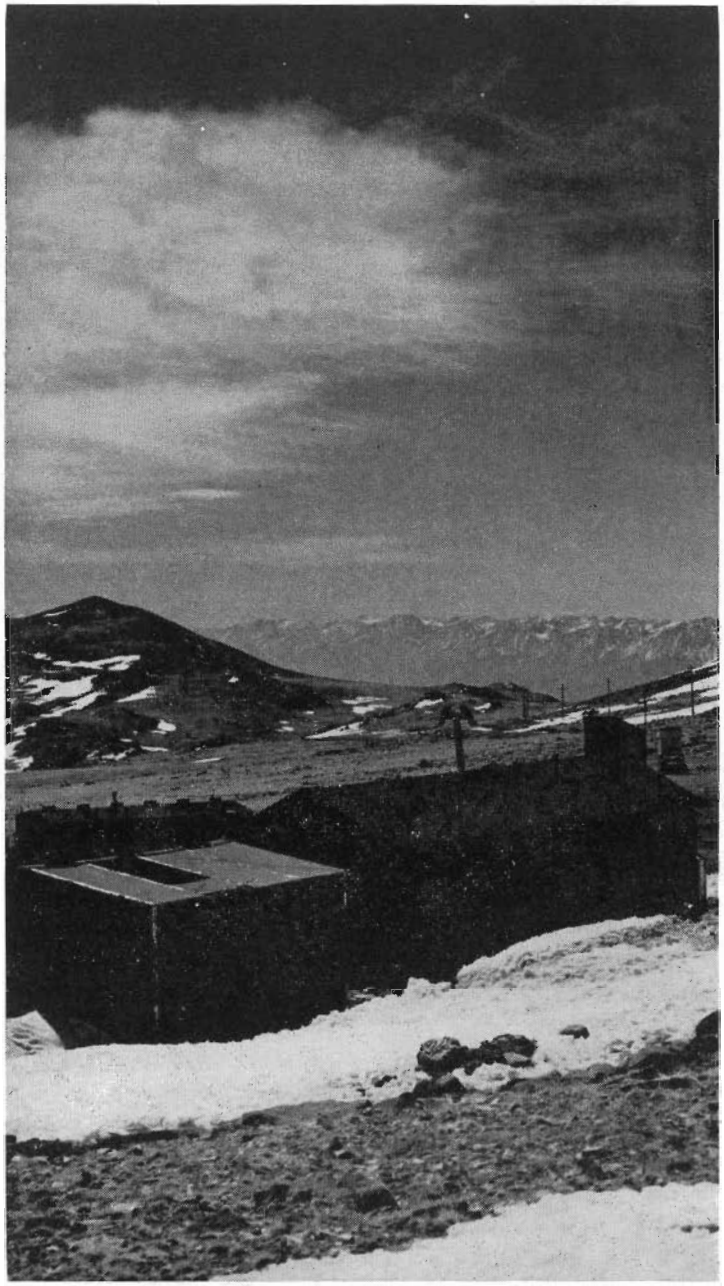
Human volunteers and many types of animals have aided physiological studies on White Mountain. For example, Dr. Pace has enlisted the help of some highly-pampered mongrel dogs to learn how tiny organs called chemoreceptors help trigger the body's responses to a shortage of oxygen. In related work on breathing and sleep patterns at high altitudes, Professor Ralph H. Kellogg of the U.C. Medical Center in San Francisco used himself and colleagues as human guinea pigs. Dr. Paola Timiras, associate professor of physiology at Berkeley, has traced endocrine responses in rats bred at sea level and high

altitude (including some with adrenals or pituitary gland surgically removed) and is currently seeking evidence on the way altitude affects sex hormone secretion and brain excitability. Chickens, turkeys, quail, mice, rabbits, guinea pigs, and sheep are counted among other animals that have played a research role on White Mountain.

In recent years, scientific interest has extended rapidly into White Mountain's rich and unusual resources of native flora and fauna. In fact, the mountain's best-known discovery can be counted in this category. In 1957, after a long period of painstaking investigation, the late Dr. Edmund Schulman of the University of Arizona's Tree-Ring Laboratory announced that certain specimens among White Mountain's bristlecone pines had survived more than 4,000 years and were undoubtedly the world's oldest living things. These trees that took root in the days of Abraham are now included in federally protected Schulman Memorial Grove, ten miles south of the Crooked Creek Laboratory. (For the full story of this fascinating discovery, see "Bristlecone Pine, Oldest Known Living Thing," NATIONAL GEOGRAPHIC MAGAZINE, March, 1958.)

Physical scientists began research on White Mountain even before University operations were formally established. Professors William Fretter from Berkeley and Harold Ticho from UCLA made the trek to high altitude to measure the invisible bombardment of cosmic rays; they were followed by other cosmic ray physicists from such distant centers as Duke University and the University of North Carolina. Dr. Vern O. Knudsen, former chancellor at UCLA, led a group of investigators studying the velocity of sound at high altitude. Dr. Robert E. Holzer, professor of geophysics at UCLA, linked ionization in the air to the genesis of thunderstorms.

Even social scientists find the mountain environment useful for their work. In a psycho-physiological study of the effect of altitude on behavior, Research Psychologist Laura Phillips from Berkeley (working with Dr. Pace and Dr. Robert Griswold of Stockton State Hospital) has observed group and individual behavior patterns of student volunteers during identical group-living experiences at sea level and at the Mount Barcroft Laboratory.



*LATE SPRING SUNSHINE thaws the snowbanks around Mount Barcroft Laboratory, (at 12,500 feet). This laboratory is the major*

THE range of objects and living organisms and natural phenomena that have come under scientific scrutiny at White Mountain reaches amazing proportions: to name only a few . . . grasses (Geneticist Ledyard G. Stebbins, U.C. Davis), food storage at high altitude (Chancellor and Food Technologist Emil Mrak, U.C. Davis), the robberfly (Entomologists J. A. Powell and G. I. Stage, U.C. Berkeley), yeasts (Food Technologist Martin Miller, U.C. Davis), erosion processes (Geographer C. B. Beaty, U.C. Berkeley), granites (Geologist D. O. Emerson, Univ. of Pennsylvania), the golden-mantled ground squirrel (Zoologist Robert Bullard, Univ. of Indiana), and aphid (Entomologist Albert Grigarick, U.C. Davis).

Publications based upon work at White Mountain now number more than eighty. Among them are several doctoral theses, important (but not exclusive) indications of the value of the research station in graduate education.

For a better perspective on science above the clouds, we'll "meet" a few of the high altitude investigators at work on White Mountain on a typical day a few months ago:

Dr. Raymond J. Hock is a research physiologist and White Mountain's full-time resident scientist. He's also a great believer in exercise . . . for mice! Some of his native deer mice trapped at different altitudes have run the mouse equivalent of a four-minute mile on an ingenuous treadmill set up to test their endurance. Object of the

*Don Holt, Davis*
*center for research on White Mountain with its laboratories, kitchen and dining facilities, sleeping quarters, library, offices, workshops.*

work is to shed new light on environmental adjustment within a single animal species and to determine whether this is a "built in" genetic adaptation or merely a continuing process of acclimatization. Today Dr. Hock is at work in his laboratory at Mount Barcroft. Tomorrow he may be trapping animals at some distant location . . . or repeating his experiment at lower altitude in the Owens Valley . . . or preparing instruments for a new NASA supported study of the physiological changes that accompany winter hibernation in the yellow-bellied marmot (and may some day show man how he can "hibernate" in space) . . . or collaborating with UCLA Physiologist Robert E. Smith in a biochemical investigation of the liver cell mitochondria of low- and high-altitude animals. Dr. Hock joined the White Mountain staff in 1959 after nine years of arctic study with the U.S. Public Health Service and the U.S. Air Force.

Dr. Arthur H. Smith could qualify as one of the world's most high-minded poultrymen. Professor of poultry husbandry on the Davis campus, he introduced chickens to the high altitude environment in 1952, is now observing the growth of the seventh selected generation in flocks at Crooked Creek and Mount Barcroft. He's an all-around scientist (and a Navy man like Dr. Pace), and his interests run to the applied aspects of poultry breeding as well as to things man can learn about himself by studying a well-known bird. Chickens are admirably suited for environmental study, he has found, because the sensitive embryo can develop at a different altitude from the parent. Also, chickens are highly responsive to altitude effects: they have a high mortality, suffer from mountain sickness, and develop lower heart rates and higher respiratory frequency and circulating red cell concentrations.

The clucks of Dr. Smith's chickens have been joined by the baas of four Suffolk sheep at the Mount Barcroft Laboratory. These are aiding an experiment by Dr. Jiro Kaneko, assistant professor of clinical pathology, and Dr. Charles Cornelius, associate dean, both of the School of Veterinary Medicine at Davis. By injections of radioactive carbon-14 and iron-59, the scientists are studying the survival of red blood cells and the pattern of iron metabolism in animals at high altitudes.

Six "old timers" holding a unique reunion on White Mountain add a cosmopolitan and historical note to the mountain's summer scene. All eminent men of science, they turn back the clock and repeat the strenuous physiological experiments that brought them scientific fame as members of the International High Altitude Expedition to Chile in 1935. They are contributing to an intensive study supported by the Federal Aviation Agency to determine the physiological aspects of aging (that is, to find a more reliable yardstick for "age" than the calendar). Their leader is Dr. David B. Dill of the University of Indiana, former director of the Harvard Fatigue Laboratory. Relaxing at the Summit Laboratory after a hard day of work, the "old timers" recall their exploits in the Andes while Dr. Ancel B. Keys of the University of Minnesota (famed for his findings on diet and heart disease) prepares a suitably low-cholesterol dinner.

Dr. Wes Ferguson and his wife are hermits for the summer in their house trailer near the Schulman Memorial Grove. With great care and patience. Dr. Ferguson makes test borings into the trunks of dead and living bristlecone pines, counts and compares the growth rings, adds valuable new knowledge in the rare field of dendrochronology. He's a research associate in the University of Arizona's Tree-Ring Laboratory, and his work is extending the "master chronology" begun by the late Dr. Schulman.

Dr. Harold Mooney and Robert White, energetic young

botanists from UCLA, haul their portable laboratory to remote spots on the mountain to learn how plants adapt to vastly different environments. Their experiments are similar to the work many botanists do in their laboratories, except that here the tests are made on living plants in the field. With complex apparatus they designed and built, the investigators can analyze plant respiration and metabolism while controlling temperature and light. All types of vegetation from lichens and tiny alpine flowers to the ancient bristlecone are yielding their secrets in the experiments.

Drs. Bruce Murray, James Westphall, and Robert Wildey of the California Institute of Technology have constructed the highest and most scenic astronomical observatory in America. Their pint-sized Palomar, located at 13,000 feet elevation near the Mount Barcroft Laboratory, contains an infrared telescope with gold-plated mirrors that is cooled by liquid hydrogen. It is up to 50 times more sensitive than any previous system for measuring the temperatures of comparatively "cold" celestial objects. Avoiding much of the interference from the earth's atmosphere, the Caltech scientists have already made some remarkable discoveries: the shadowed area of the moon is less than 270° F. below zero, at least 30 degrees colder than hitherto supposed; the mean temperature on Jupiter for 12 different nights was minus 229° F.; the first measurement of very faint heat radiation coming from a single object beyond the solar system was obtained in observation of the giant star Betelguese.

Another telescope on the mountain belongs to Eric Simpson, 20-year-old undergraduate astronomy major on the Berkeley campus. His project stems from a long-time hobby, but it is also serving as valuable training for his planned future career as a professional astronomer. With a ten-inch telescope he built at home, he studies astronomical observing conditions at three locations near the U.C. laboratories. His patient work with the telescope and camera through many chilly evenings will pay off in a fine set of star "tracks" and valuable data on the atmospheric turbulence above the White Mountain Range.

Dr. Louise Heim is a long way from her classrooms and laboratories at Adelphi College on Long Island, where she is assistant professor of histology, neuroanatomy, and physiology. Granted a year's leave as a National Science Foundation Faculty Fellow, she is working with Dr. Paola Timiras on the Berkeley campus on basic experiments probing hormones and behavior. How does oxygen starvation affect brain function? In the rat colony at the Mount Barcroft Laboratory, Dr. Heim seeks the answers through repeated electro-shock seizure tests (standard measures of brain excitability) on rats born at White Mountain and other rats transported from sea level.

DR. PACE looks over a plaster model of White Mountain in his office on the Berkeley campus.

"We'll soon be buzzing up there in a couple of hours," he says, "and that will give us a tremendous boost in the number and kinds of research projects we can undertake."

He's speaking of the fact that a three-place helicopter and full-time pilot will be available, thanks to a grant from the National Aeronautics and Space Administration. The helicopter will transport personnel, animals, and research materials from University campuses to the mountain and from the mountain laboratories to outlying research areas. With an operating ceiling of 20,000 feet, the helicopter will have no trouble setting down at the Summit Laboratory. And with less wear and tear on the liver and backbone, too.

"Progress may never be as rapid as we'd wish," Dr. Pace adds, "but momentum has been building from the very beginning."

Already a site has been designated near Bishop for a new, fully-equipped laboratory in the Owens Valley. Later, as funds become available, the long-range plans call for permanent-type buildings at the mountain laboratories, better roads, and an electric power connection to the Summit Laboratory.

Will the coming of greater convenience and comfort and the passing of the "explorer" era discourage the more adventurous souls among the scientists?

"The real adventure lies in the unknowns explored through science," Dr. Pace answers, "we've only begun to scratch the surface at White Mountain."

A VISIT to White Mountain is an exhilarating experience in a strange and beautiful world. Bone-white skeletons of defunct bristlecone pines assume fantastic postures, as though frozen with fright in some primordial cataclysm. Seeming to mock these stark symbols, the force of life bursts forth in other bristlecones with heavy profusion of dark green needles and brilliant red bulbs. The yellow-bellied marmot, already swelling with fat before his winter sleep, plays endless hide-and-seek on a heap of giant boulders. Lunar-like plains paved with shimmering white rock reflect a smogless sky where nature juggles thermal currents to produce the drama of a thunderstorm. Eastward on the mountain, a labyrinth of granite-walled canyons and tiny green-jeweled valleys might entice the adventurous to seek a Shangri-La. Westward slopes plunge with dizzying two-mile drop to the sage-carpeted floor of the Owens Valley. Everywhere are views of matchless and almost unbelievable grandeur . . . glimpsed here and there on the ascent and then spread full circle from the summit . . . the massive jagged escarpment of the Sierra Nevada dominating the western horizon from Mt. Whitney north almost 200 miles to Mt. Rose . . . the near-inaccessible northern reaches of the White Mountain Range where bighorn sheep make their last California stand . . . the desolate basin-and-range topography of Nevada disappearing toward the east into the desert haze.

Nature, it would seem, has provided the scientist with the setting, the tools, and the inspiration for discovery. ◄