Mauna Kea (I): Halfway to Space

The volcano's summit is the finest astronomical site in the world, but building an observatory there was a gamble for everyone

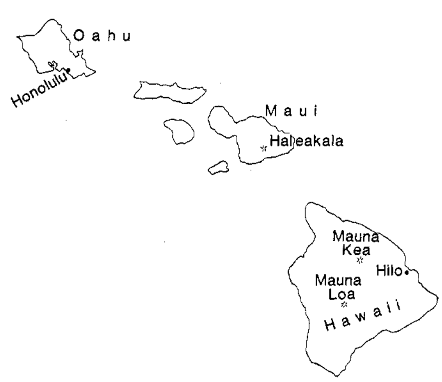
Mauna Kea, Hawaii. The observatory at Mauna Kea, on the island of Hawaii, stands 4200 meters above sea level on the summit of the highest island mountain in the Pacific. Mauna Kea itself is an extinct shield volcano, a sprawling, lumpy dome of basaltic lava rising high above cane fields, rain forests, and ranch lands. Its summit is a lifeless, red-black jumble of lava blocks and clinkers that looks nothing at all like a tropical island; it looks more like the Viking photographs of the surface of Mars. The six telescopes of the observatory stand on a cluster of volcanic cinder cones, overlooking a rugged lava plateau that falls away on every side into a sea of clouds nearly 1 kilometer below. Rising above the clouds to the south is the island's other great volcano, Mauna Loa. Rising to the northwest is the deeply eroded cone of Haleakala on the island of Maui. Otherwise, the clouds spread unbroken to the horizon.

By every measure of astronomical excellence, Mauna Kea is unsurpassed. The air above the summit is stable, dry, and clear. Clouds tend to be held far below by the tropical inversion layer. Urban development and light pollution on the island are minimal.

But Mauna Kea is also a remote, difficult place, as harsh as it is beautiful. The mountain is nearly as high as any in the Sierra or the Rockies. Its summit is subject to bitter winds and winter blizzards. The University of Hawaii spent 5 years building the first big telescope there, an 88-inch instrument dedicated in 1970. (A pair of much smaller 61-centimeter instruments were built nearby about the same time.) And it was not until the mid-1970's that work began on the three newest instruments: NASA's 3.0-meter Infrared Telescope Facility, operated by the University of Hawaii; the 3.6-meter Canada-France-Hawaii Telescope (CFHT); and the 3.8-meter United Kingdom Infrared Telescope.

Yet despite the difficulties, the near-simultaneous completion of the three new telescopes in 1979 has marked Mauna Kea's emergence as a major international center for both optical and infrared astronomy. "It's already halfway to space," says CFHT director René Racine. The skies above Mauna Kea are exceptionally dry, he adds, with little water vapor to absorb infrared radiation. "The humidity is only 5 or 10 percent, so you can get everything from 3000 angstroms to the far infrared. Mauna Kea is universally considered the best infrared site in the world."

Racine's space metaphor is apt, for the Mauna Kea observatory was born of NASA's ambitions to explore the planets. In fact, the man who discovered the mountain's astronomical virtues, the late



Gerard P. Kuiper, has more than once been called the father of modern planetary astronomy. Kuiper immigrated to the United States from the Netherlands in 1933, a 28-year-old with a fresh Ph.D. from the University of Leiden. In the 1940's and 1950's when most professional astronomers were content to leave the planets to the backyard amateurs, he pursued the subject passionately. He discovered the atmosphere on Saturn's giant moon Titan in 1944. He helped revive the long-moribund nebular hypothesis of Descartes and Kant and thus laid the foundation for the modern view of the solar system's origin. And he was one of the first to suggest that planetary systems might be very common in the galaxy—a view since popularized by one of his students, Carl Sagan.

In 1960, after twice serving as director of Yerkes Observatory at the University of Chicago, he founded the Lunar and Planetary Laboratory at the University of Arizona in Tucson. From there he began to scour the mountains of the Southwest for new observatory sites.

Kuiper was most urgently interested in finding good sites for infrared observatories. Planets and satellites, being relatively cold objects, emit most of their thermal energy in the infrared. The molecules in their atmospheres and on their surfaces have many characteristic absorption bands in the infrared. Unfortunately, doing infrared astronomy from sea level is like looking for the stars at noon on a smoggy day. Not only is the radiation absorbed by water vapor in the atmosphere, but the atmosphere itself is warm and glows with its own infrared radiance. In the struggle to meet the incoming photons halfway, Kuiper had pioneered in making infrared observations from balloons and aircraft. He founded a new observatory atop Mount Lemmon, in the dry Catalina mountains north of Tucson. And in 1963, in search of more new sites, he came to Hawaii.

Unlike mountain chains such as the Sierra or the Andes, Kuiper reasoned, the shield volcanoes of Hawaii do little to disrupt the prevailing weather patterns. They are broad, solitary structures, like isolated probes of the dry upper air. Kuiper's first stop was Haleakala, the "House of the Sun," on Maui. Though not the highest mountain in the islands, its logistics made sense; the crest of the volcano is a national park centered on an immense crater just below the summit, and there was already a paved road and a power line. In fact, the University of Hawaii had just established its Mees Solar Observatory at the 3000-meter summit.

Kuiper was impressed with Haleakala, but he also found that cold air and fog collected in the crater and occasionally billowed up over the summit. At best, the turbulent mixing of warm and cold air ruined the otherwise excellent seeing; at worst, the site was shrouded in fog. Haleakala would not do. But as Kuiper later told the story, the last thing he saw as the fog closed in was Mauna Kea, standing clear in the sunlight.

Kuiper studied maps. He chartered an airplane to fly him around Mauna Kea's summit, where he saw cinder cones, a broad lava plateau—and no crater. He consulted with scientists at the universi-

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Like the surface of Mars . . .

The summit of Mauna Kea. From left to right: the Canada-France-Hawaii Telescope, the University of Hawaii 88-inch, the United Kingdom Infrared Telescope, and NASA's Infrared Telescope Facility.

ty and with officials of the Hilo Chamber of Commerce. Mauna Kea began to look very promising indeed—except that there was no road to the summit, no way to get a telescope and other apparatus to the top for tests. The summit of Mauna Kea was state land, so Kuiper went straight to the governor, John Burns, to ask for a road. Burns, quick to see astronomy's economic potential for the chronically depressed Big Island, was ready to take a chance on the idea. He gave Kuiper $50,000 for his road and, this being in the days before environmental impact statements, a bulldozer soon set out over the lava fields from the existing roadhead at Hale Pohaku, an old ranger station at the 2800-meter level on the south flank of the mountain. Kuiper, seated beside the driver, gave directions, and they planned the road as they went.

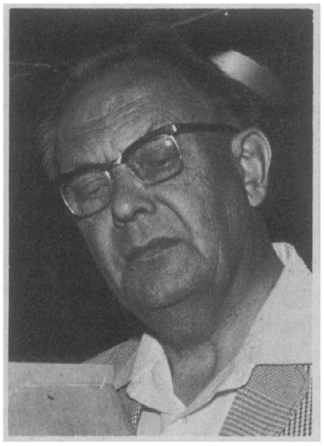
The site testing went on for more than a year, and in the end Kuiper was fully satisfied. "The mountaintop is probably the best site in the world—I repeat—in the world, from which to study the moon, the planets, and the stars," he pronounced. He asked NASA to fund a field station on Mauna Kea with a 61-inch telescope dedicated to solar system studies and operated, of course, by his Lunar and Planetary Laboratory.

NASA was receptive, at least in principle. The agency was already funding a good deal of ground-based observation of the moon and planets in support of its flight program. Unfortunately, its planetary researchers were having a hard time wrangling much observing time on the big telescopes; in 1963 many astronomers still did not take solar system studies very seriously. "Astronomical instrumentation had developed very rapidly in the 1940's and 1950's," recalls William E. Brunk, who was then and is now the head of NASA's planetary astronomy office. "We realized that we could find out a tremendous amount about the planets if we could just get the telescope time to do it." By 1964 the space agency had concluded that it would have to build telescopes dedicated to planetary science. A 107-inch instrument had been commissioned at the University of Texas' McDonald Observatory. Kuiper himself had just completed a 61-inch telescope in Arizona. And now came his proposal for Mauna Kea.

Kuiper was a politically astute man. With the flowering of the space program in the early 1960's he had become a powerful voice in NASA's planning for lunar and planetary missions. Yet, for reasons that have never been fully explained, the space agency did not immediately take him up on his Mauna Kea idea. Some observers have suggested that Kuiper was getting too influential, that some NASA officials were beginning to see him as an empire builder. Brunk himself will say only that NASA did not want to go with a single proposal. Whatever the reason, NASA asked Harvard to submit a competing plan. And, after some delay, the agency also agreed to accept a proposal from the University of Hawaii.

"We went out on a limb with Hawaii," says Brunk. That is putting it mildly. Up against Harvard on the one hand and one of the most powerful astronomers in the country on the other, here was a little, out-of-the-way university that did not even have an astronomy department.

What it did have was a group of four solar astronomers who had just arrived that year to set up a solar program within the university's Institute for Geophysics. Although they expected to be heavily involved with the Mees Solar Observatory on Haleakala, none of them had any



Gerard P. Kuiper

professional experience on a nighttime telescope. And the leader of the group, John T. Jefferies, a 39-year-old theorist specializing in the interpretation of solar spectra, was on a leave of absence from the Joint Institute for Laboratory Astrophysics in Boulder. He was not even sure he wanted to stay in Hawaii.

But John Jefferies was not one to let opportunity pass him by. Born in Western Australia, educated there and in England, he is a proud, ambitious, and doggedly persistent man. No sooner had he learned that NASA planned to put a telescope on Mauna Kea than people started showing up in Hawaii to tell the university what its role would be. "I felt we were being disposed of," he says. "We weren't being given a role in the project consistent with what I thought we should have." When he and other university officials complained to the space agency, they essentially were told that they could choose between the two heavyweights. Jefferies decided to submit his own proposal.

"It was an exciting prospect," Jefferies recalls. "It made up my mind. The act of proposing for the telescope constituted a decision on my part to stay in Hawaii if the proposal was successful."

It was a gamble. He knew virtually nothing about building a telescope. But drawing heavily on the expertise of friends at the Kitt Peak and Sacramento Peak observatories, Jefferies and his colleagues came up with a plan: NASA would put up $3 million for the design, development, construction, and installation of an 84-inch telescope, larger and more sophisticated than the one Kuiper or Harvard proposed. The state of Hawaii, acting through the university, would put up $2.5 million for the building, the telescope piers and dome, the site preparation, and the power line. (Such outside funding was a ground rule for all of NASA's telescopes.) The university also promised to build up its astronomy program.

It was, says Brunk, the best proposal, especially considering the University of Hawaii's proximity to the mountain. The contract was signed on 1 July 1965.

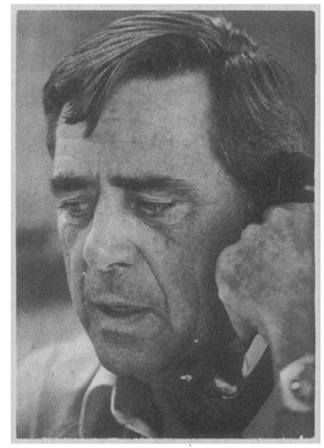
Kuiper was furious. To NASA and to his colleagues, he maintained that Jefferies was not competent to build a nighttime telescope. The University of Hawaii was in way over its head. For years thereafter he told people—strangers—how John Jefferies had stolen Mauna Kea from him.

But whatever his feelings, NASA had made its decision. Kuiper, the man who discovered Mauna Kea, had lost it. Jefferies, the little-known solar theorist, had been given his chance.

Meeting Jefferies today, one gets the initial impression of a reticent and rather shy man, not given to talking much about himself or his feelings for the observatory. But his longtime associates have a very different impression. "He sweeps you up in his enthusiasm," says Ginger Plasch, for 8 years his administrative assistant. "There's a charisma that creates a sense of family here. He gets people to share his vision."

The criticisms of Jefferies are many: that he was high-handed and dictatorial in those early years; that he did not consult often enough with his own (rapidly growing) staff; that he was too impatient with administrative detail, without being willing to delegate enough authority. But among friends and critics alike, one also hears unanimous praise for Jefferies: he, more than anyone else, is the man who made it all happen.

As soon as the contract was signed in 1965 Jefferies began expanding his staff for the task ahead. Among them was the highly respected Hans Boesgaard, whom Jefferies hired away from Lick Observatory to be his chief engineer. He also retained consultant Charles W. Jones of Los Angeles to do the detailed designs for the telescope. Meanwhile, Jefferies and his colleagues began a new round of site testing to pick a precise location for the instrument. How did the wind turbulence around the cinder cones affect the seeing from point to point? What sites had an unobstructed view of the sky? What sites were shielded from artificial lights down below? Where do ground fogs collect? They measured the seeing with portable telescopes and, like Kuiper before them, found it difficult to believe it was as good as the instruments told them. They bounced their jeeps to the summit and back over Kuiper's precarious road and they learned about wind chill, altitude sickness, and chronic



John T. Jefferies

shortness of breath. And they felt, Jefferies says, "the intense loneliness, the desolation of the site."

In the end, Jefferies decided to put the telescope very near the summit on the lip of one of the largest cones, reserving the summit itself for the "ultimate-inch" telescope that he hoped might someday be built there.

The telescope was patterned after the Kitt Peak 84-inch. The mirror blank, a disk of fused silica glass, was ordered from Corning Glass Works with the specifications "84 inches diameter, plus 4 inches, minus zero"—a wording that reflected the tendency of large mirror blanks to come out of the mold with flaws around the outer edge. In effect, Jefferies was ordering an 88-inch mirror in the hope of getting at least 84 usable inches. He was in luck. He got the full 88. And the 88-inch telescope it became.

The groundbreaking for the observatory building itself was in 1967. "When we first went up we were given a number of studies from the Air Force that suggested we'd run into severe problems at such altitudes," says Sidney Wolff, Jefferies' deputy director at the Institute for Astronomy. "Astronomers themselves have found, working on very high mountains, that everybody gets sick at 5200 meters, a few people get sick at 4200 meters, and somewhere in between, people simply stop functioning. It's an individual thing. A hundred meters can make the difference. And because of these stories, many astronomers were hostile to our building a telescope up there in the first place."

More insidious were the mental effects, she says. People get irritable at 4200 meters, their judgment becomes erratic, and they tend to make mistakes. "So we had rules," says Wolff. "For example, you were supposed to breathe oxygen for 1 minute every 30 minutes." Some $120,000 was spent on a system to provide oxygen-enriched air to the control room and other places where the observers would be spending their time. "But we found out we didn't need it," she says. Instead, dormitories and a mess shack were built for the construction crew at the Hale Pohaku ranger station (the same "temporary" buildings that serve visiting astronomers today); it turned out that by spending their off hours at 2800 meters instead of sea level, the workers stayed acclimated to Mauna Kea's 4200-meter summit.

Far worse than the altitude, it turned out, was the weather. Winds of 100 kilometers per hour are not uncommon on the summit, and in the winter there are fierce blizzards. (The observatory currently operates the only snowplow in the state of Hawaii.) "I don't think the contractors quite believed it," says Wolff. "They had built highways in Alaska, but they were really not prepared for the nature of the winters on Mauna Kea. They had all the forms ready to pour the concrete for the foundations—and it snowed. It took them weeks to get the ice melted out. And then when it warmed up the wind would blow and the concrete buckets would swing around.

"Meanwhile, the telescope was sitting in Hilo," she laughs. "It had been sprayed with some kind of protective coating, and with all the delays the coating baked on. It took weeks to get it off again."

And so it went: foundations were poured, a dome was erected, and what was then the sixth largest telescope in the world was hauled up, piece by tedious piece, over a narrow, dusty, erosion-prone jeep road to the summit of the highest mountain in the Pacific. Construction took nearly 2 years longer than planned. But, despite all predictions to the contrary, Jefferies and the University of Hawaii did build their telescope. It was dedicated in June 1970 and began full-time operation that November.

Kuiper was invited to the dedication ceremony and he came, bearing equipment to make yet a few more water vapor measurements. Dale Cruikshank, who was an associate of Kuiper in the 1960's and who is now at the University of Hawaii, believes that by this time Kuiper had become reconciled to his defeat. His own projects in Arizona had kept him busy, and perhaps he had come to appreciate how difficult it would have been to run Mauna Kea from Tucson. And besides, it seemed that Jefferies did indeed know what he was doing. Kuiper examined the telescope and the observatory facilities with a sharp, professional eye, and said he was very impressed.

"Mauna Kea was a gamble, we tend to forget that," says Wolff. "Fifteen years ago things were a little more open, people were more willing to take a chance than they are now. Funding now is so tight, and the level of proof on environmental factors and so forth is so high for major projects that I don't think people will make the investment to search out new, undeveloped mountain sites. I think we really have the collection of observing sites that people will use now. I'm not sure that a project like Mauna Kea is something that will ever be done again."—M. MITCHELL WALDROP

This is the first of two articles on the history of Mauna Kea observatory. Next week: The Institute for Astronomy, and the Infrared Telescope Facility.

Brain Opiates in Mental Illness

A lack of brain opiates has been postulated to cause mental illness. So has an excess of the chemicals. There is evidence for both views.

About 6 years ago researchers discovered the endogenous opiates, brain chemicals that may have profound effects on mood and behavior. The discovery raised hopes that an understanding of how these chemicals work in the brain would provide solutions to such intractable medical problems as schizophrenia and depression. At a recent conference on "Opioids and Mental Illness"* investigators discussed their attempts to pin down the postulated link between the endogenous opiates, which are also called endorphins, and the development of mental illnesses.

At present there are two competing theories to explain how the agents might be involved. One theory holds that an excess of the chemicals is at fault, the other that a deficiency is to blame.

The clinical and other trials done to test these hypotheses during the past 5 years have yielded mixed results. They have sometimes, but not always, indicated that giving opiates to mentally ill patients could improve their condition, a finding which would support the idea that the patients do not have enough of the brain chemicals. But other studies have found that chemicals that block the actions of opiates have therapeutic benefits and thus support the opposing view.

Suggestions that opiate drugs might be useful for treating mental illness predate the discovery of the endorphins. Tincture of opium, for example, was sporadically used to treat depression for many decades. But the idea began to gain more credence beginning in the early 1970's, largely as a result of studies of heroin addicts. "The addictions," says Edward Khantzian of Harvard Medical School, "are a place where the biology and psychology of the mind meet."

Khantzian, Léon Wurmser of the University of Maryland Medical School, and other psychiatrists who treat addicts, often noted that the patients had turned to drugs as a self-medication to relieve their mental disturbances. Khantzian explains, "After sitting with many addicts I began to suspect that they craved less for euphoria, but that they craved more for relief from the dysphoria associated with anger, rage, and related restlessness that short-term narcotics seem to provide." In addition, psychotic patients who had been drug-free often experienced improvement of their symptoms when they began taking methadone, an opiate that is widely used for treating heroin addicts.

Attempts to wean addicts from drugs, whether heroin or methadone, gave further support to the self-medication theory. A small but consistent proportion, usually about 10 to 15 percent, devel-

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