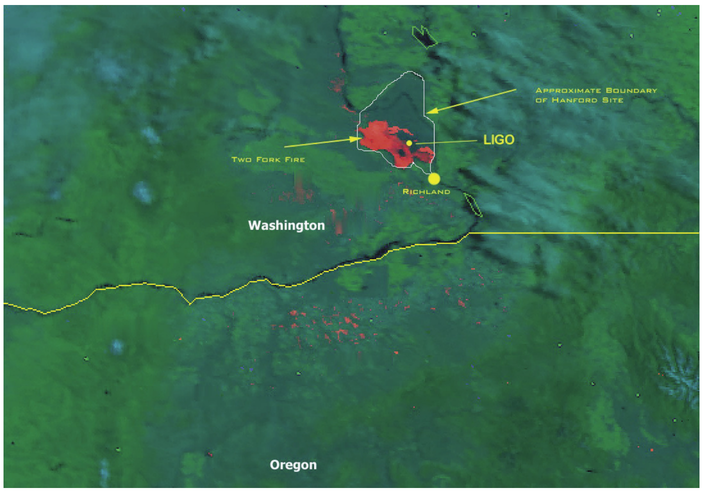
I SURVIVED THE HANFORD FIRE



Above: The heat signature (red) generated by the fire dominates this image taken by the National Oceanic and Atmospheric Administration on June 29. The tiny red spots near the Washington–Oregon border are caused by sunlight.

Below: In this 90-degree, postfire panorama, shot from an overpass on the Y arm near the corner station, the burn area and the red-orange fire-retardant residue are clearly seen. Sharp-eyed readers will also spot an elk in front of the clump of sagebrush near the intersection of the dirt roads.

Well, they haven't printed up commemorative T-shirts yet, but the LIGO Hanford Observatory has passed an unscheduled facilities test. On Tuesday, June 27, a brush fire was sparked by a fatal head-on collision on rural State Route 24 in the western reaches of the Department of Energy's Hanford site in eastern Washington. High winds and low humidity gave firefighters a run for their money, and before the fast-moving fire was finally controlled five days and 163,884 acres later, it had burned 11 houses and a number of other buildings. It also swept over the concrete and steel structures of the Laser Interferometer Gravitational-Wave Observatory (LIGO).

LIGO, a joint project of Caltech and MIT funded by the National Science Foundation, seeks to verify the last of Einstein's predictions that remains unproven—the existence of ripples in the fabric of space-time caused by colliding black holes, exploding supernovas, and other massive, violent cataclysms. (See *E&S*, 1998, No. 2.) The observatory, and its twin in Louisiana, consists of two two-and-a-half-mile-long arms joined in an L. Running the length of each arm (called the X and Y arms, since they aren't oriented north–south, east–west) is a four-foot-diameter stainless-steel pipe containing a laser beam. The pipes are the world's largest vacuum system, and protect the lasers and mirrors from being jostled by stray air molecules. The pipe, in turn, is shielded by a six-inch-thick concrete shell—in essence a long, long culvert. Buildings housing

vacuum chambers two stories tall straddle the midpoints and far ends of the pipes; a larger building where the pipes join houses the rest of the interferometery equipment as well as offices and workshops. The observatories are slated to become operational in 2002.

Fred Raab, the head of the LIGO Hanford Observatory, gave a play-by-play account of the fire in an e-mail back to campus:

"At 6 p.m. [Wednesday], with the fire still about 10 miles west of LIGO and heading northerly I went home [to the nearby city of Richland] for dinner. Sometime after 7 p.m. I noticed the sky grow ominously dark.... Richard McCarthy and I learned through Hanford emergency personnel that the fire was racing toward LIGO. Richard called the lab to tell the people working inside, and a touring Boy Scout group, to evacuate the site. I drove in to ensure that all personnel were out and Richard followed shortly to actuate our groundwater pumps and valves to recharge our fire-water tanks.

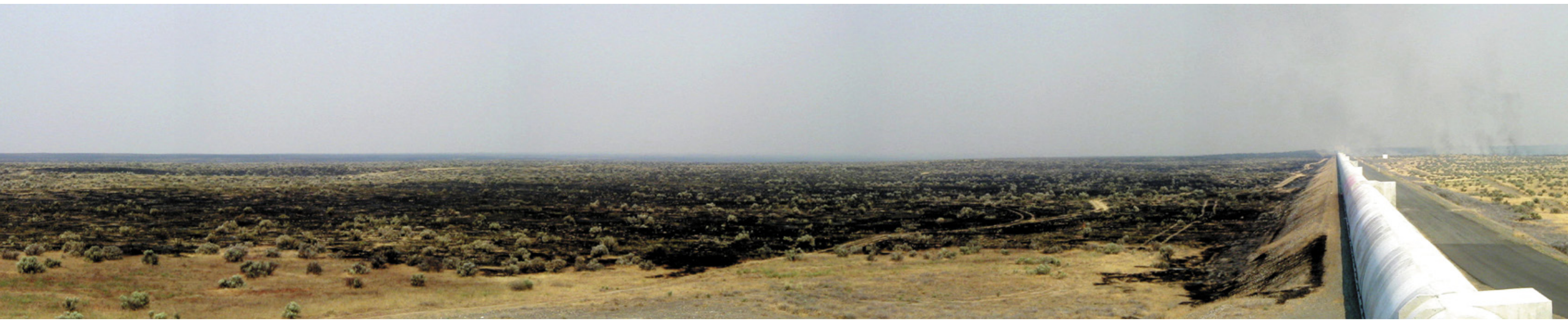
"I found the site evacuated, except for Doug Cook, our laser-safety officer, who had just completed a walk-through of all the labs and assured me that all personnel and visitors were gone. Hanford Fire had set up a command post on the site, with a large number of fire engines, earth-moving equipment attempting to trench firebreaks around the 10-mile perimeter of LIGO, and aircraft dropping fire retardant.... By this time the winds had grown extremely strong [gusts of up to 30 miles per hour were reported] with a wildfire out of control and bearing down on the observatory. For a time, the Y arm of LIGO served as a firebreak, but the winds eventually blew the fire over the arm.... The fire started racing along the Y arm past the mid and end stations.... I was able to inspect the site from the platform on the corner-station roof and could see a line of fire advancing toward the X arm, but then a wall of smoke and high winds drove me off the roof.... By this time I could see fire extending several miles to the east, about 15 miles to the west, about 10 miles south and ascending Rattlesnake Mountain. The corner station was about the safest haven around, so we remained there.

The view from the corner-station roof Wednesday night.

"As the fire [burned] away from the corner station, the firefighters rapidly left our site. I later found out that this was when the fire jumped the Yakima River and headed for populated areas of West Richland and Benton City, which were under evacuation orders. We remained, predominantly at the corner station, inspecting fire conditions with binoculars as the fire burned along the X arm toward the end station."

In between wind shifts, they were able to drive the full distance along both arms and found no obvious damage to the concrete culvert or the buildings.

"By morning the fire was mostly contained on the Hanford site, but was burning near populated areas.... According to radio reports, about 500–1,000 firefighters were on the fire, which had by now burned about 150 square miles of land. We instructed staff to remain at home while a few of us drove out to do an inspection under daylight conditions.... [We found that a] power surge around midnight had taken down our turbo pumps (without any danger to the vacuum system).... The X end station was partially covered with fire-retardant compound, whose sticky surface had a layer of ash glued onto it. I think the worst damage we may have is if the fire retardant damages the underlying paint.... The ventilation systems prevented smoke damage within the critical experimental areas



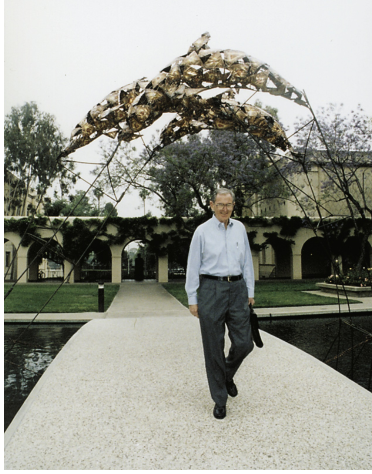
although there is a slight smoke smell and dust levels were exceeded.... None of the critical optics were exposed. Vacuum system operation has been restored to normal.

"The DOE contractors, especially Hanford Fire and Hanford Patrol, were exemplary in their efforts to keep us informed, to let key people into the affected areas while providing for public safety, and most importantly to bring tremendous resources to bear on protecting our structures."

The wide gravel foundation on which the arms are emplaced, coupled with LIGO's assiduous tumbleweed-removal program (the fool things pile up against the beam tubes with astonishing rapidity) also helped the observatory sail through what could have been a very nasty mishap indeed. The fire retardant was washed off the X end station without incident, although it doesn't seem to want to come off the concrete culvert housing the beam line. Meanwhile, the commissioning and installation work is back on schedule.

"As fires go, this one was spectacular but it was really no big deal compared to Southern California wildfires," Assistant Engineer Tom Mahood says. "The dry grass burned so rapidly it didn't have a chance to do any serious damage. This time next year, you won't even know it burned." ☐ —*DS*

Art Erupts Across Campus



Above: Welded out of copper triangles by Nate Austin, a Blacker House sophomore majoring in engineering and applied science, these dolphins leaped over the Millikan Pond bridge for a few weeks in May and early June. (Someone climbing on the scaffolding caused their demise.) Physicist David Goodstein, the Gilloon Distinguished Teaching and Service Professor and vice provost, remarked: "One morning these three beautiful dolphins appeared, as if to remind us of the endless creativity of Caltech students. What a great place to work!"

Right: Physics and geophysics major Wren Montgomery's Ditch Day stack set in stone an already worn path through a bit of garden between Avery House and the rest of campus. The mosaic is not literally "stone," but crockery shards from each of the seven undergraduate houses and Avery, plus bits of tile.

An installation called *Primordium: Leafy, Superman and Flo10* (names of plant mutations) by Los Angeles artist Marcos Lutyens opened at Caltech's outdoor art space July 22. Touching the (live) cactus triggers the recorded musings of subjects hypnotized by the artist and asked to describe their first memory of a plant. Here Institute Professor of Chemistry, Emeritus, Jack Roberts (right) and his wife, Edith, test it out, along with an unidentified visitor—who was later hypnotized as part of the show.

WormBase: Another Sequenced Genome

In a major follow-up to the sequencing of the human genome, Caltech has received a $1-million grant from the National Institutes of Health for a genome database to aid in biomedical research as well as basic biology.

Known as the Worm Genome Database, or simply "WormBase," the project will link the already-completed genome sequence of the experimental organism *C. elegans* to the functions that the genes perform, says Caltech biology professor Paul Sternberg, leader of the project. Also, the information in WormBase will contribute to advances in understanding how the genes of all animals are related so that underlying genetic interactions can perhaps be exploited for future treatments of human disease.

More commonly known as a roundworm or nematode, *C. elegans* has a genome that comprises about 19,000 genes. As a consequence of evolution, the roundworm shares a huge number of genes with human beings—as do all other organisms on Earth, including plants.

The reason this fundamental relationship will be important to 21st-century medicine is that these commonly shared genes, or homologs, often have the same functions in their respective organisms. In Sternberg's own lab, for example, researchers found that several genes that control what cells do during the

development of the worm are worm versions of human genes that mutate to cause cancer.

This finding has two implications, Sternberg says. Genes that work together in the worm are likely to work together in the human, and the normal function of "oncogenes" is to control normal cell behavior, not to cause disease.

Thus, improved knowledge of the roundworm at the molecular level could lead to new and improved approaches for dealing with human disease, or even result in a cure.

And as a side benefit, Sternberg says, knowing the differences between ourselves and a roundworm could lead to new approaches to eradicating the creature, which is an agricultural nuisance.

"I think one of the important things about WormBase is that it will lead to new ways to study basic mechanisms," says Sternberg, adding that the sequencing of several other experimental organisms will be important for the same reason. Among the other organisms are the laboratory mouse, the mustardlike flowering plant *Arabidopsis*, the fruit fly, and the yeast cell.

"We could see patterns emerge from information in different organisms," Sternberg says. "Now that we have the human genome, we can start asking what a certain gene does in humans, what the homolog does in yeast, or fruit flies, or worms, and what's the common denominator."

WormBase's more immediate goals will be to make the genetic information more computer-accessible to anyone interested, Sternberg says. "The standard of success would be that the bench researcher could get within a minute or two the relevant data for his or her own research, rather than go to the library and pore for hours or days through reading material."

WormBase will continue an existing database developed by Richard Durbin of the Sanger Centre in the United Kingdom, one of two centers that sequenced the worm genome; Jean Theirry-Mieg, now at the National Center for Biological Information; and Lincoln Stein of the Cold Spring Harbor Laboratory. These researchers will remain involved, Sternberg says, as will John Spieth of the Genome Sequencing Center at Washington University in St. Louis, the other sequencing center.

The new phase of the work will involve biologists in curating new data, including cell function in development, behavior, and physiology; gene expression at a cellular level; and gene interactions—in much the same manner that the Human Genome Project will continue now that the genome itself has been completely sequenced. The National Human Genome Research Institute, which is funding this project, also supports databases of other intensively studied laboratory organisms. □
—*RT*

KIP, AHOY!

Kip Thorne turned 60 on June 1. Thorne, BS '62, the Feynman Professor of Theoretical Physics, has been a fixture on campus for most of his adult life. (He did tear himself away long enough to get a PhD from Princeton, but even then he didn't linger; he hustled it out in a very brisk three years.) So, of course, Caltech threw him a party—a three-day KipFest, in fact, featuring two days of technical sessions by a parade of heavy hitters from physics, math, and astronomy. Of the 14 speakers, 9 were alumni, several of them Kip's former students. Among the speakers were Rainer Weiss of MIT, Carlton Caves (PhD '79) of the University of New Mexico, and James Hartle (PhD '64) of UC Santa Barbara's Institute for Theoretical Physics.

The talks were part serious science and part roast. For example, Clifford Will (PhD '71), now at Washington University in St. Louis, said he had "backed into Thorne's group when, registered for Astronomy 105, I discovered to my horror that the class involved experiments at night." He quickly dropped that course and signed up for Thorne's relativity class. Those were exciting times, he reminisced, as new experimental tests of Einstein's theory of general relativity were just being designed. He quoted Thorne's tag line from that period: "On Mondays, Wednesdays, and Fridays, we believe in general relativity; on Tuesdays, Thursdays, and Saturdays, we believe the Brans-Dicke theory of gravity; on Sundays we go to the beach." Will concluded with a transparency of a passage of "bad poetry Kip wrote me for my 30th birthday; and in this audience, I can't show you the last stanza."

The serious science drew from several fields on which Thorne has left his mark. Among these are black holes, neutron stars, wormholes, quantum cosmology, gravitational physics, and experimental relativity—the latter focusing primarily on gravitational waves. A lot was said about LIGO, of which Thorne is one of the fathers. Panelists praised

"On Mondays, Wednesdays, and Fridays, we believe in general relativity; on Tuesdays, Thursdays, and Saturdays, we believe the Brans-Dicke theory of gravity; on Sundays we go to the beach."

Above: Thorne (left) and fellow faculty member and physicist David Goodstein relish a zinger.

Thorne for working tirelessly on many levels for several decades to get it built, and there was a general feeling that this entirely new way of seeing the universe will be his greatest legacy.

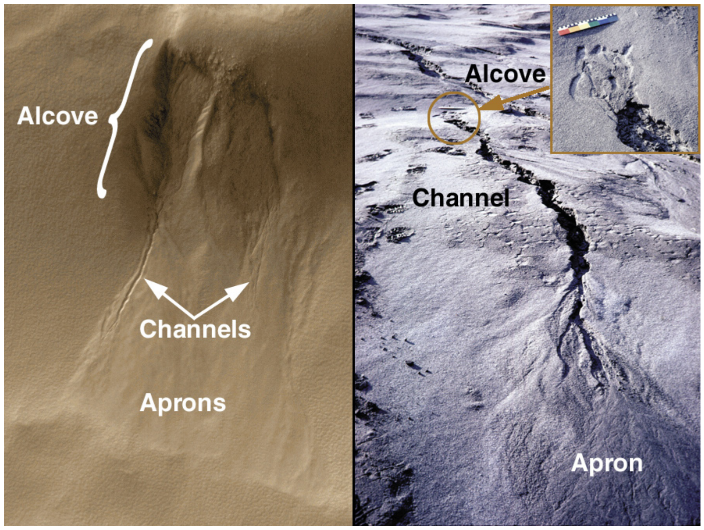
The symposium was followed on Saturday by a day's worth of lighter, Watson-lecture-type talks aimed at the general public. The all-star lineup here included bestselling authors Stephen Hawking, Thorne's sometime betting partner; Alan Lightman (MS '73, PhD '74); Timothy Ferris; and Thorne himself. A book based on these talks is slated to be published by W. W. Norton. The program ended with a family-oriented musical performance by Lynda Williams, the "Physics Chanteuse," who by day is a physics instructor at San Francisco State. □

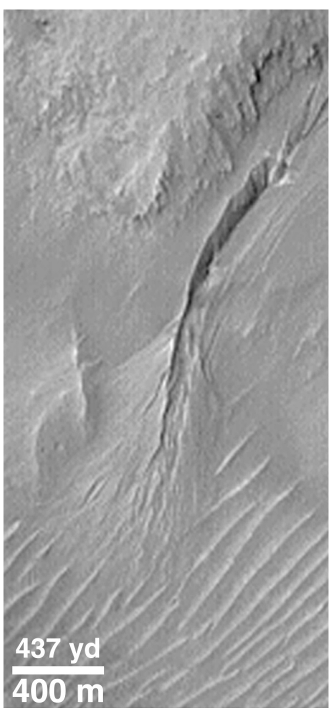
When the Levee Breaks

Mars just seems to get wetter and wetter every time you turn around. A paper by Michael Malin (PhD '76) and Kenneth Edgett in the June 30 issue of *Science*, and announced at a press conference on June 22, says that images from the Mars Orbiter Camera on JPL's Mars Global Surveyor show signs that liquid water may lie very close to the Martian surface in some places. "We see features that look like gullies formed by flowing water and the deposits of soil and rocks transported by these flows. The features appear to be so young that they might be forming today. We think we are seeing evidence of a groundwater supply, similar to an aquifer," said Malin, who is principal investigator for the Mars Orbiter Camera and president of Malin Space Science Systems in San Diego.

The gullies are seen on cliff faces, usually on the less-sunlit wall of the crater or valley in which they are found, and begin at a depth of about 100 to 400 meters from the top of the cliff—the depth at which the water is presumed to be trapped. All of them have the same general form, which resembles gullies on Earth where water emerges from beneath a layer of loosely consolidated rock or soil. A collapse zone, called an "alcove," is seen just above where the water is presumed to be seeping out of the Martian rock. (On Earth, such alcoves are formed as the emerging water erodes the aquifer that is carrying it back into the cliff face, eventually causing the material above the aquifer to collapse into the void.) The alcove leads to a channel that in turn ends in an "apron" of accumulated debris washed down the channel.

Not only does this imply that significant volumes of liquid water may exist much closer to the surface than anyone had believed, the kicker is that the features appear to be so young that the water may still be there. The most persuasive evidence offered was an image that showed a gully's debris apron partially covering a field of sand dunes. There are no





Right: Although the scale is different (note the footprints in the right-hand photo), the essential features are the same. The left-hand image is of the south-facing wall of an impact crater on Mars at approximately 54.8° S, 342.5° W and covers an area 1.3 kilometers wide by 2 kilometers long; the one on the right was taken by Malin on an ash field on the flanks of Mount St. Helens. The colored bar in the inset is 30 centimeters long. Below: This Martian dune field lies at the foot of a south-facing wall in the Nirgal Vallis near 29.4° S, 39.1° W.

craters on the dunes, so they are quite young, and the apron is on top of the dunes, so it must be even younger. It's not known for sure that these dunes are still active, but if they are, the apron would have to have been formed within the last few centuries. Said Malin, "They could be a few million years old, but we cannot rule out that some of them are so recent as to have formed yesterday."

Because the atmospheric pressure and surface temperature on Mars is so low, any water emerging from underground would immediately boil away or freeze before having a chance to flow downhill, so the thinking is that these channel-carving outbursts must have been flash floods. "When water evaporates, it cools the ground," said Edgett. "That would cause the water behind the initial seepage site to freeze. This would result in pressure building up behind an 'ice dam.' Ultimately, the dam would break and send a flood down the gully." The average water release per event is estimated to be about 2,500 cubic meters—enough to fill seven community-sized swimming pools.

The gullies are still quite rare, having been seen so far at only a few hundred sites among the many tens of thousands the orbiter has looked at. Most lie between 30 and 70 degrees south latitude, which on Earth roughly corresponds to the region between Sydney, Australia, and the Antarctic coast. □—*DS*

In other Mars news, on July 28 Edward Weiler, associate administrator for NASA's Office of Space Science, announced that JPL's Mars Rover concept was his choice from two mission options under study for the 2003 launch window. (The other option, proposed by Lockheed Martin Astronautics, of Denver, Colorado, was an orbiter featuring a camera capable of spotting objects 60 centimeters across—about the size of a footstool—as well as an imaging spectrometer designed to explore the role of ancient water in Martian history.) As *E&S* was going to press, NASA had decided to send *two* identical rovers to vastly different sites—perhaps one safer and one riskier—to be selected in the next couple of years.

These offspring of the Sojourner rover (see *E&S* 1997, No. 3) will land in January 2004 using the Mars Pathfinder's "drop, bounce, and roll" technology, but will be able to travel up to 100 meters per Martian day—nearly as far as Sojourner did over its entire lifetime. And this time around, the rovers will carry *all* of the science instruments, rather than having some on the lander and some on the rover. Consequently, the rovers will weigh about 150 kilograms (some 300 pounds) compared to Sojourner's 11.5 kilograms, and while Sojourner was about the size of a microwave oven, these babies will be more along the lines of a coffee table.

The robot geologist's tool kit will include a panoramic camera, three times sharper-eyed than Pathfinder's, and a miniature thermal-emission spectrometer, both to be mounted on a mast near the front of the rover. The rover will also carry magnetic targets that will collect magnetic dust for the various instruments to study. And a robotic arm that would make Inspector Gadget jealous will feature three more instruments plus an abrasion tool. The latter will grind away weathered rock surfaces to expose fresh material for scrutiny by a Mössbauer spectrometer, an improved version of Sojourner's alpha-proton X-ray spectrometer, and a microscopic imager. Cornell University will be the lead institution for the science payload, which—surprise!—is designed to search for evidence of liquid water in Mars's past. □—*DS*