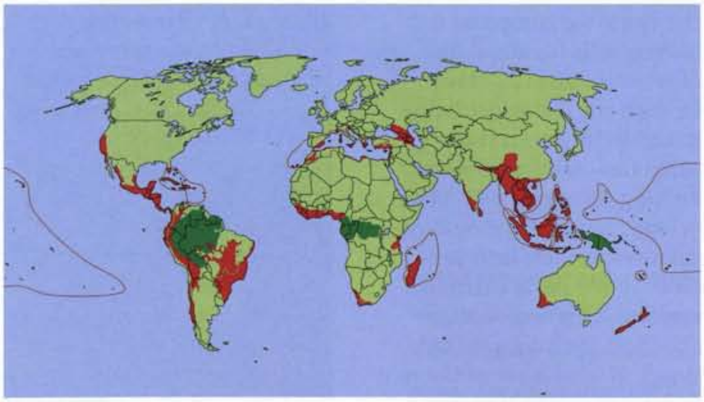
On September 12, ground was broken for the Broad Center for the Biological Sciences (below), Caltech's flagship building for biology in the Genome Era. Named for Caltech trustee Eli Broad and his wife, Edye, the Broad Center will house a dozen or so research groups working in such areas as structural, behavioral, and computational biology, as well as shared facilities for electron microscopy and magnetic resonance imaging. Above are, from left: John Rudolph of Rudolph and Sletten, the contractors; L.A. mayor Richard Riordan; Mel Simon, Biaggini Professor of Biological Sciences, who chaired the biology division during the planning process; Eli Broad; Pasadena mayor Bill Bogaard; Edye Broad; James Freed of Pei Cobb Freed & Partners, the architect; John Abelson, Beadle Professor of Biology and chair of the Broad Center Building Committee; David Baltimore, president of Caltech; and Gordon Moore (PhD '54), chair of the Board of Trustees.

Defying Nature's End

Almost everyone knows that we're hurtling toward a global extinction crisis more devastating than the one that nuked the dinosaurs, with humankind in the role of the killer asteroid. And for the past decade, there has been a steady stream of conferences on the issue. In fact, Jeff McNeely, chief scientist for the World Conservation Union (WCU), likes to show a cartoon of a ragged guy in extremis crawling through the desert toward a long, bare table behind which sit several solemn folks in suits. The man exclaims, "Thank God! A panel of experts!" On August 22 to 26, Caltech hosted "Defying Nature's End: A Practical Agenda for Saving Life on the Planet," organized by the Center for Applied Biodiversity Science (CABS) at Conservation International (CI), in collaboration with the WCU. Gordon Moore (PhD '54), co-founder of Intel, chair of the Caltech Board of Trustees, and member of the board of CI, brought the event to campus and co-chaired it. But this was "not just another biodiversity conference," said Stuart Pimm, the conference's scientific chair and professor of ecology at the Center for Environmental Research and Conservation at Columbia. The international group of world-class scientists, economists, and businessmen—"the 'A-Team' of biodiversity," in the words of co-chair E. O. Wilson, the University Research Professor at Harvard—had convened to put together a set of concrete proposals that can be done now, with existing scientific and economic resources.

This is possible because roughly 60 percent of Earth's terrestrial biodiversity is found in 25 "hotspots," which are extremely threatened places that comprise 1.4 percent of the planet's surface—an area three times the size of Texas. Protect them, and you're halfway home. Some of this land is already in parks and reserves, of course, but most of it isn't. Add in the last big wilderness areas remaining—the Amazon and Congo forests, and the island of New Guinea—and you have 80 percent of all species living on 4.8 percent of the land area, a region about the size of the lower 48 states. Offshore, most of the life (and 99 percent of the world's fisheries) lies in 10 percent of the ocean—the shallow waters of the continental shelves. "How many of you would bring back the moa and the dodo?" asked Callum Roberts, a senior



The last three big tropical forests are shown in dark green; hotspot areas are in red. Although the amount of red on the map is impressive, appearances are deceiving—the actual patches of wilderness are scattered through the red zones, and constitute about 12 percent of the acreage shown. Hotspot ecosystems, by definition, have less than 30 percent of their original extent left. And for that dwindling habitat to qualify as a hotspot, it must host at least 1,500 species of native plants—partly because plants don't wander off and are thus easier to count, and partly because the abundance of plant species correlates directly with the abundance of mammals, birds, and insects.

The ring-tailed lemur of Madagascar is vulnerable to extinction through habitat loss. Less than 5 percent of Madagascar's primary vegetation remains today.

For more information, visit <www.cabs.conservation.org>.

lecturer in the Department of Environmental Economics and Environmental Management at the University of York. "In the ocean, we can. Their marine equivalents are still out there. Tackling biodiversity loss in the seas is like turning the conservation clock on land back to before World War II. It's a fantastic opportunity." Take the island of St. Lucia in the Caribbean, he said, where fully protected marine sanctuaries alternate with fishing grounds. In the three years since the scheme was enacted, fish stocks have tripled in the reserves and doubled in the fisheries, even though the latter have had to absorb all the fishermen displaced from the sanctuaries.

The conferees drew up an "ecological business plan," as it were, predicated on the assumption that, like any other business plan, nobody was going to invest in it if it didn't set out measurable goals. The attendees broke up into working groups organized around such topics as hotspots, marine ecosystems, freshwater ecosystems, tropical forest wilderness areas, the links between biodiversity and human health, economic incentives and disincentives for conserving biodiversity, and the societal forces driving environmental change. Armed with extensive background reports nearly a year in preparation, each group was told to come up with short- and long-term scientific goals, decide how those goals could be quantized and verified—calculating soil erosion rates from satellite images, for example, or doing spectral analysis of satellite data to map the percentages of various kinds of trees in a parcel of forest—and to draw up a budget for achieving them. Gustavo Fonseca, CABS executive director, compared it to the Apollo moon missions in scope and urgency, and said, "Practical solutions will get the job done, and our estimates of the costs are front-loaded to produce tangible results quickly."

A 50-page blueprint emerged. One portion of it deals with how best to protect the land. It is generally impractical, for example, to buy threatened habitat outright. Many developing nations are understandably sensitive about foreigners—even well-intentioned ones—owning large tracts of territory, and outright ownership feeds the perception that conservation is a luxury the First World can afford while at the same time preventing the Third World the fair use of their own resources. But one can pay the local landowners—generally, the government at some level—so much per year not to, say, mine tin or cut trees. (Or to cut only one or two high-value species of tree and then turn the area into a protected zone, in the arboreal equivalent of dehorning a rhino to save it from aphrodisiac hunters.) CI already has such "conservation concessions" programs in various stages of development in Suriname, Guyana, Bolivia, Peru, Brazil, and Cambodia. Protecting the necessary land in the hotspots and jungles will cost about $28 billion.

Jungle land is cheap, but hotspot land isn't—that's where humans are encroaching the fastest, so there are many bidders for it. Southern California is in one, for example, and we all know what the real estate market is like out here. So another portion of the blueprint laid out a strategy for integrating recent developments in computer technology, data storage, and remote sensing—a field broadly called GIS, or Geographic Information Systems (see *E&S*, 1996, No. 2)—with new and existing databases on the holdings of museums around the world to figure out exactly what lives where, who eats whom, and how their lives affect ours (and vice versa). This will allow the most threatened areas to be identified and priorities to be set, and can be done for a measly $10 million.

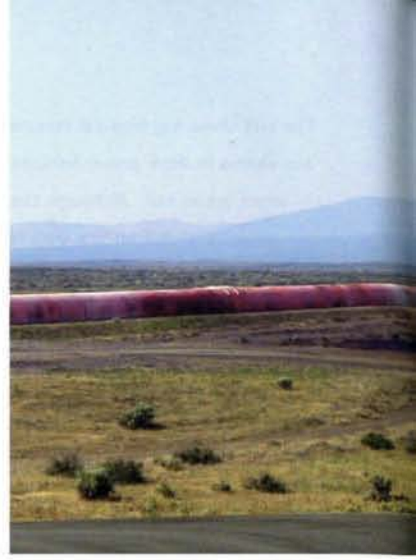
But the linchpin of the whole scheme is the establishment of a network of Local Biodiversity Facilitation Centers—at least one per hotspot. In the words of the summary report, these are to be "the war rooms and nerve centers" for the actual day-to-day conservation efforts. Each hotspot presents its own problems—jurisdictional and cultural as well as ecological—so a one-size-fits-all centralized approach just won't work. "Protecting the land means something very different in California than in the Congo," notes Pimm, adding, "Once the land is protected, we can't just declare victory and come home—we have to help the local people become better stewards." This takes a combination of research and education—for example, figuring out economic alternatives to slash-and-burn farming, so that the displaced farmers become forest guards rather than poachers. The centers are to be staffed by local people as much as possible, although growing the requisite crop of experts won't happen overnight—the entire nation of Gabon, for example, has four PhD biologists. Running each center will take about five million bucks a year. With 12 centers initially proposed, this comes to $60 million per year, or $600 million for the next 10 years.

The oceans, some 50 years behind the land in terms of despoliation, are equally laggard when it comes to species mapping. A good portion of the GIS and database work will go toward figuring out where the oceanic (and freshwater, such as rivers) hotspots are. Some of them, such as the Caribbean and Philippine Seas, will clearly be contiguous to the land ones and can share centers, says Pimm, but others, including the East African Rift lakes, will need centers of their own.

The long-term goals have to do with ending "perverse subsidies"—for example, an oft-quoted statistic was that the world's commercial fish harvest sells for about half of what it costs to obtain it, with the difference being made up by government programs—and with reimbursing countries with undeveloped land for the ecological services their land provides to the industrialized nations. Forget that stuff about all the undiscovered drugs in what's left of the rain forest—how much is it worth not to slowly broil in our own juices? All that greenery is pulling carbon dioxide out of the air and retarding global warming, and that's just the tip of the (melting) iceberg of what the land does. Robert Costanza, director of the University of Maryland's Institute for Ecological Economics, presented an economic model that attempts to put explicit dollar values on such ecosystem services—a notoriously tricky business—and concluded that they are worth roughly $33 trillion a year, larger than the world's GNP. Clearly, if the rain forest countries were to get even a small slice of that, it would go a long way toward protecting the forests.

CI has set itself a deadline of one decade to raise the money, and they think it can be done. Peter Seligmann, chairman of the board and CEO of CI, recalled that a few years ago at a CI conference in Seattle, "A young guy came up to me and said, 'OK, how much would it take to get this done? Because clearly $100 million is peanuts.' I said, 'About $3 billion.' He said, 'Do you have the scientific data to back that up?' I said, 'Sure. We have tons of data.' He said, 'That would be fun!' Turns out he was one of the earliest employees of Microsoft, and had just retired at a very early age. He said Microsoft had conquered the world once already, and now he and his cohorts were looking for new challenges. It's a whole new world."

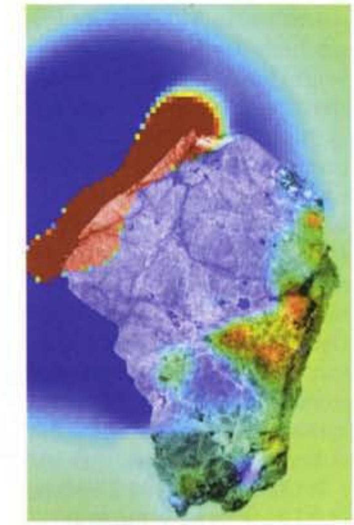
The down payment was made at the conference when James Wolfensohn, president of the World Bank, announced the creation of the Critical Ecosystem Partnership Fund to the tune of $150 million. The fund will make grants to local groups in developing countries, and is designed for rapid response with minimal red tape. It "will help us find solutions that allow poor people [in hotspots] to have a better way of life, while at the same time conserving the biodiversity on which their long-term survival depends," he said. CI, the World Bank, and the Global Environment Facility (a 166-nation organization based in Washington, D.C.) have each pledged $25 million to the fund over the next five years, with the balance to be sought from outside donors; CI will oversee its day-to-day management. □—*DS*



In other wildlife news, the arrow in this close-up points to the elk referred to in last issue's piece on the fire at LIGO's Hanford site. And the Hanford observatory met a major milestone on October 20, when, for the first time, laser beams shot simultaneously down both arms of the shorter, two-kilometer-long interferometer system. Dubbed "first lock," this is the rough equivalent of "first light" on a new telescope. Full operation is anticipated in the year 2002.

In slash-and-burn agriculture, the forest is burned off to clear land for subsistence farming. Without the trees' deep roots to hold it in place, the land quickly begins eroding, becoming useless after just a few crops. This river in Madagascar is choked with red-brown silt that used to be topsoil; the badlands behind it used to be a tree-clad hill.

LEAPIN' MICROBES!



In this composite picture of the sample, magnetic data has been superimposed on a photomicrograph. The colors show the field intensity and direction perpendicular to the plane of the page. Blue is up, red is down, and green is zero. The red region at upper left is the meteorite's "skin," which has been heated and reoriented. The interior shows a patchwork of colors, reflecting the original orientations.

According to one version of the "panspermia" theory, life on Earth could originally have arrived here by way of meteorites from Mars, where conditions in the youth of the solar system are thought to have been more favorable for the creation of life from nonliving ingredients. The only problem has been how a meteorite could get blasted off Mars without frying any microbial life hitching a ride. But a study of the celebrated Martian meteorite ALH 84001 shows that the rock never got hotter than 105° F during its journey from the Red Planet to Earth—even during the impact that ejected it from Mars, or while plunging through Earth's atmosphere before landing on Antarctic ice thousands of years ago. In the October 27 issue of *Science*, grad student Benjamin Weiss, undergrad Francis Macdonald, Professor of Geobiology Joseph Kirschvink (BS, MS '75), and their collaborators at Vanderbilt and McGill Universities describe results obtained when testing several thin slices of the meteorite with a device known as an Ultra-High Resolution Scanning Superconducting Quantum Interference Device Microscope. The machine, developed by Franz Baudenbacher and other researchers at Vanderbilt, is designed to detect microscopic differences in the orientation of magnetic fields in rock samples, with a sensitivity up to 10,000 times greater than existing machines.

"This shows the meteorite made it from the surface of Mars to the surface of Earth without ever getting hot enough to destroy bacteria, or even plant seeds or fungi," says Weiss, the paper's lead author. "Other studies have suggested that rocks can make it from Mars to Earth in a year, and that some organisms can live in space for several years. So the transfer of life is quite feasible." ALH84001 has been the focus of numerous studies in the last few years because some scientists think there is evidence of fossilized life within it. The issue has never been resolved, but Weiss says that doesn't matter. "In fact, we don't think that this particular meteorite brought life here," he says. "But computer simulations of ejected Martian meteorites demonstrate that about one billion tons of rocks have been brought to Earth from Mars since the two planets formed." Many of these rocks make the transit in less than a year, although ALH84001 took about 15 million years. "The fact that at least one out of the 16 known Martian rocks made it here without heating tells us that this must be a fairly common process," says Kirschvink.

The sample the Kirschvink team worked with is about one millimeter thick and two centimeters in length and somewhat resembles the African continent, with one side containing a portion of the original surface of the meteorite. The team found an intense, highly aligned magnetic field near that surface, which is to be expected because it got very hot upon entering Earth's atmosphere. Any weakly magnetized rock will align its magnetization with the local field direction when heated to its "blocking temperature." But the sample's interior had randomly oriented magnetization, meaning it had not reached its blocking temperature since before leaving Mars. And when the researchers gently heated another slice taken from the interior of the meteorite, they discovered that the rock started to demagnetize at temperatures as low as 40° C (105° F), demonstrating that it had never been heated even to that level.

Thus, a radiation-resistant organism that can do without energy and water for a year could have made the journey from Mars to Earth, and such hardy critters, including the bacteria *bacillus subtilis* and *deinococcus radiodurans*, do exist. "Realistically, we don't think any life forms more complicated than single-celled bacterial spores, very tough fungal spores, or well-protected seeds could have made it," Kirschvink says. "They would also have had to go into some kind of dormant stage."

Though the study does not directly address the issue of life in meteorites, the authors say the results eliminate a major objection to the panspermia theory—that any life reaching Earth by meteorite would have been heat-sterilized during the violent ejection of the rock from its parent planet. Other studies have already shown that a meteorite can enter Earth's atmosphere without its inner material becoming hot. The results also demonstrate that critical information could be lost if rocks brought back from Mars by a sample-return mission were heat-sterilized, as has been proposed.

If life ever evolved on Mars, it is likely to have jumped repeatedly to Earth over geologic time. Because the reverse process—the transfer of Earth life to Mars—is dynamically much more difficult, it may be more important to instead protect any Martian biosphere from Earthly microbes. Says Kirschvink, "The Martian biosphere, if it ever evolved, would most likely have been brought to Earth billions of years ago, and could have participated in the evolution and diversification of bacterial life here. So there is at least a chance that we are in part descended from Martian microbes."

The research was partially funded by NASA's Astrobiology Institute, an international consortium headquartered at NASA's Ames Research Center. The JPL group that sponsored the Caltech work is one of the Institute's 11 lead teams. □—*RT*

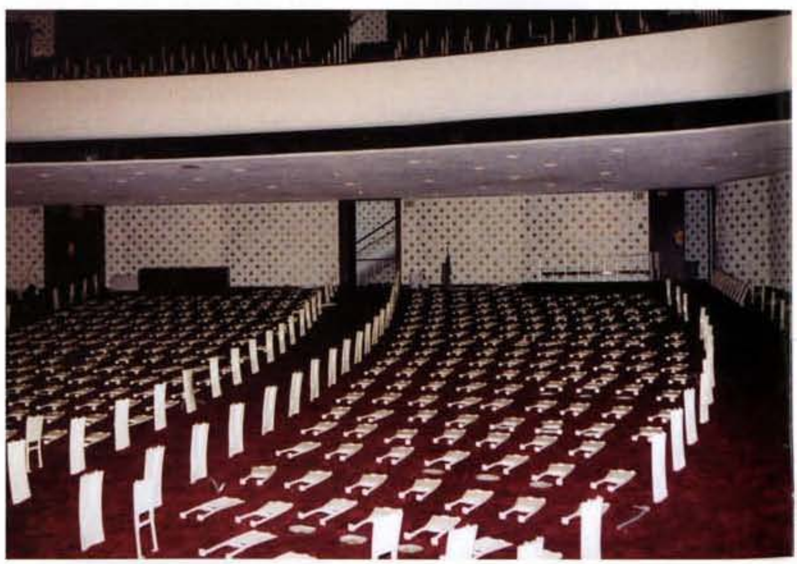
CIT, USC Can Help You See (Not UC)

You don't need glasses if you have 20/20 vision, but that one set of numbers doesn't say much else about how well you can see. Until now, measuring the rest of the central visual field has been a laborious process. The fastest (and most expensive) machine takes as much as 40 minutes per eye, and the data collected is sparse. But a new test, developed by Wolfgang Fink, a postdoc in the lab of Steve Koonin (BS '72), provost and professor of theoretical physics; and Alfredo Sadun, professor in the Department of Ophthalmology and Neurological Surgery at the Doheny Eye Institute of the Keck School of Medicine at USC, takes five minutes, gives detailed sensitivity information over the entire central visual field, and requires only a PC with a touch-sensitive screen. The software, which will be distributed worldwide on the Internet, could automate diagnoses of many eye diseases, and even some classes of brain tumors.

"If you think of the visual field as an island in a sea of darkness," says Sadun, "old-fashioned perimetry essentially sent boats toward the island from various directions until they hit the shoreline." But the interior remained uncharted, and, if contrast sensitivity equals elevation, that interior resembles a volcanic island: the summit is the fovea, the patch of retina about half a millimeter square

Watson Lectures Set

The lineup of Watson lectures has been annouced for this winter and spring. Leading off on January 17 is "The Physics of Snow Crystals," by Professor of Physics and executive officer for physics Ken Libbrecht (BS '80). Then on February 21, JPL's Michael Kobrick will speak on "Planetary Phrenology: The Lumps and Bumps of the Earth." Earth's atmosphere takes its lumps on March 14, when Associate Professor of Atmospheric Chemistry and Environmental Engineering Science Paul Wennberg tackles "Chlorofluorocarbons, Climate Change, and the Future of Stratospheric Ozone." The molecular motif continues on April 11 with "Understanding the World, One Molecule at a Time," by Associate Professor of Applied Physics Stephen Quake, and on May 9 with "In Praise of Permissiveness: Coaxing Cells to Make Novel Macromolecules," by David Tirrell, McCollum–Corcoran Professor and professor of chemistry and chemical engineering and chair of the Division of Chemistry and Chemical Engineering. The season concludes on May 23 with "The Coming Revolution in Photography," by Carver Mead (BS '56, MS '57, PhD '60), Moore Professor of Engineering and Applied Science, Emeritus. As usual, all lectures are at 8:00 p.m. in Beckman Auditorium, and are free and open to the public. □

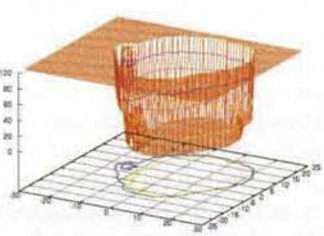


Watson audiences are sitting pretty. Beckman Auditorium, which was built in 1963, got a thorough rehab over the summer that included new seats, shown here being installed over the new carpet.

where we see most sharply. Nearby is a bottomless crater—the blind spot, where the optic nerve leaves the eye. And all around, the land slopes down to the sea. In a healthy eye, the descent is gradual and smooth. But disease can erode the terrain into razorback ridges, gullies, and even cliffs of blindness.

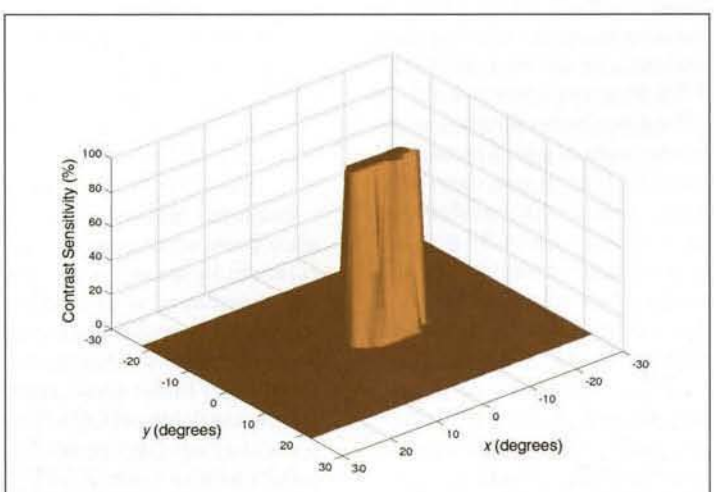
About 25 years ago, says Sadun, campimetry was invented, which, in effect, scatters a platoon of parachutists across the island and measures the altitudes where they touch down. The 40-minute method takes data at six-degree intervals—a few dozen points in all. But the new method, called the 3-D Computer-Based Threshold Amsler Grid test, is like dropping a whole battalion of paratroopers spaced as closely to one another as you like. To take the test, the patient closes one eye and stares at the touch screen, which displays a so-called Amsler grid of dark gray lines on a black background. Bright green letters flash by at random in the middle of the grid, setting the benchmark for the mapping by giving the patient something to focus on. The patient outlines the grid's visible portions with a fingertip, after which the computer ups the contrast by 5 to 20 percent and the process repeats. (One could do this up to 255 times—once for every possible shade of gray your monitor can display—but five levels is plenty for most purposes.) The computer assembles the set of tracings into a 3-D map of the visual field, and the test is repeated with the other eye. "It's a lot easier on the patient," says Fink. "In the old method, you had to stare at this red dot for the whole 40 minutes, which takes a lot of concentration. Little kids and old people can't do that very well. But a constantly changing letter naturally attracts the eye, and it takes only a minute or so to trace each contrast level. Then you can take a break before going on to the next one." Fink created the software to display the grids and compile and render the results; an earlier version developed by Sadun used graph paper printed in various shades of gray ink, and the outlines the patients drew on the paper had to be tabulated by hand.

Many eye diseases carve characteristic landscapes. Glaucoma (below), for example, is caused by high fluid pressure within the eyeball compressing the optic nerve, which dies slowly from the outside in. The patient gradually loses peripheral vision, winding up with tunnel vision before going blind altogether—the volcano erodes to a lava plug that ultimately collapses. In macular degeneration, by contrast, patients lose their central vision first. The early stages of macular degeneration look like Meteor Crater in Arizona—a steep-sided hole in the middle of the field. As the disease progresses, landslides occur around the crater's rim, broadening the crater's floor and sloping its walls outward. Macular degeneration occurs as the retinal pigment epithelium cells (the eye's garbagemen, who live behind the light-sensing cells and soak up excess light and the chemical byproducts of vision) are done in by a lifetime of wear and tear. In the early, "dry" stages, the accumulating trash kills the cells above, cleanly knocking out a portion of the field to produce the crater. Later, in the "wet" stages, one or more blood vessels grow in through gaps between the cells and then leak. The extra fluid distorts the retinal cells' positions, degrading the surrounding visual field and eroding the crater wall. "We can tell the difference between anatomical lesions and functional lesions," says Sadun. "An anatomical lesion—a scar—is an abrupt cliff. Functional impairments, like those caused by leaking fluid, are gradual slopes. And now we can pinpoint the fluid's source." If caught early, the wayward blood vessel can be destroyed with a laser and the condition contained.

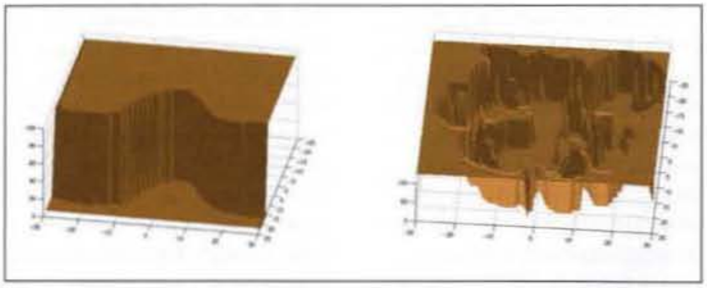


Above: The early, "dry" stages of macular degeneration, rendered as a wire grid and a contour map.

Below: Mapping a person with normal vision would produce a plateau at 100% contrast sensitivity across the entire measured field. This glaucoma patient has an extreme case of tunnel vision. The retinal coordinate system on the *x* and *y* axes is centered on the fovea.



The best example of the test's power so far is distinguishing anterior ischemic optic neuropathy (AION) from optic neuritis. AION is a small stroke that affects the optic nerve. It hits one in 6,000 people at about 60 years of age, but it can strike people as young as 30. It's untreatable and can destroy most or all of the visual field, and if it occurs in both eyes—which happens about one-third of the time—you can go blind. AION looks like the sea cliffs at Big Sur, with the precipice dividing what's still getting blood from what isn't. In optic neuritis, on the other hand, the nerve fibers get attacked by the body's own immune system in a process very like multiple sclerosis; in fact, optic neuritis may progress to MS. Optic neuritis strikes one in every 3,000 to 4,000 people, and peaks at age 20. "Up to now, the two diseases have normally been differentiated and diagnosed on the basis of age," says Sadun. "If you have a 20-year-old, odds are it's optic neuritis, and if it's a 50-year-old, it's probably AION. But what if the patient is 40? You can't be sure." Again, most of the visual field can be destroyed, but the damage done by optic neuritis looks quite different. Because the disease attacks bundles of nerve fibers at random, you get a badlands of



AION (left) produces a cliff of blindness, while optic neuritis (right) creates a far more complex landscape.

jagged hills and valleys of irregular depth. And the important thing is, optic neuritis may be treatable if caught early enough. The rogue immune response can be subdued, the nerve damage reversed, and the descent into MS sometimes prevented.

The eye is a window to the brain in more ways than just letting light in. In theory, says Fink, tumors in many parts of the brain can be detected there, as long as they impinge on a set of neurons used in visual processing. "There are classic patterns of visual impairment that are known to be associated with certain tumors. If we could expand and refine that library of patterns, the ophthalmologist could tell the neurosurgeon where to focus the CAT scanner to most likely find a tumor. Then the surgeon would be able to image it and deal with it appropriately." The collaboration is looking at pituitary adenoma—a common brain tumor, in which one the chief symptoms is partial vision loss caused by the tumor pressing against the optic nerve. "Most brain tumors are benign," says Sadun. "So the issue becomes, do we leave it in or not? Will we do more harm than good if we try to take it out? These are the most agonizing decisions we have to make." But a series of visual field tests done over a span of several months could show if the tumor is growing slowly enough that it's safe to leave it in.

This brings up another important point—the third dimension of contrast sensitivity provides a powerful diagnostic tool, but the fourth dimension of time may prove more important still. "We are now looking at the steepness of the slope and its change over time as measureable parameters," says Sadun. Does the patient start out with a deep hole that just gets wider, like a gravel quarry, or does it grow like a gentle valley? There's a wealth of data for tracking a disease's progress and recommending treatment options.

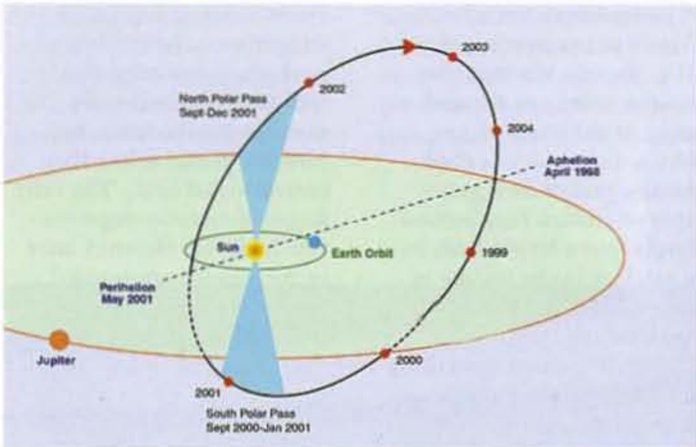
The collaboration envisions a central database, perhaps at the World Health Organization's headquarters in New York, in which the characteristic patterns of all sorts of conditions would be accumulated. Doctors all over the world could send in patients' maps via the Internet, and pattern-recognition software such as a neural network (see *E&S*, Summer 1990) would offer a statistical diagnosis. Such a system could be on line in a year or two, says Fink, who already has developed such a system for a related test. It clearly won't replace the ophthalmologist, but for those common diseases where clear-cut patterns exist, it could make a big difference to general practitioners in remote corners of the world. □—*DS*

For more information, see <www.wfbabcom5.com/wf335.htm>. And the "Eyemovie" shown on the back cover of *Caltech News*, Volume 34, No. 3 (another of Fink's projects) is now available on CD at <www.wfbabcom5.com/wf324.htm>.

Tales of Brave Ulysses

The Ulysses spacecraft, managed by JPL for the European Space Agency and NASA, marked its tenth anniversary on October 6. Ulysses' mission is to study the sun's heliosphere at high solar latitudes. The heliosphere is the vast region of interplanetary space dominated by the solar wind—an outflow of charged particles from the sun. There have been plenty of heliospheric studies near the equator, but the heliosphere around the poles is fundamentally different because of the sun's powerful magnetic field, whose poles roughly coincide with the geographic poles. The lines of force emerging from the poles act as a conduit for the solar wind, as well as for charged particles from outer space called cosmic rays.

Ulysses' solar polar orbit goes to 80 degrees north and south—like traveling from the northern tip of Greenland to Antarctica—the only



Above: Ulysses' second orbit around the sun. The orbit has a six-year period.

spacecraft ever to reach such high solar latitudes.

Ulysses is currently near the south pole, at latitudes it last visited during September 1994, at the minimum point of the solar cycle. Solar activity—which runs in an 11-year cycle and manifests itself in such things as increases in sunspots, solar flares, and the aurora borealis—is now at its maximum, and scientists are eager to see what's going on up there. □

The John W. Lucas Adaptive Wind Tunnel was dedicated on November 15. The tunnel replaces the historic 10-foot wind tunnel, a mainstay of the Graduate Aeronautical Laboratories (GALCIT) since 1930. (See *E&S*, 1997, No. 2.) Funded by the Richard M. Lucas Foundation and named for Richard's brother John, a longtime JPL staff member, the new tunnel can simulate 175-mile-per-hour winds and has "smart" walls in its test section that can be flexed by computer control to manipulate the air flow around the model being tested. The facility tour included the still-under-construction test section, where we see, from left: Hans Hornung, Johnson Professor of Aeronautics and director of GALCIT; Mark Lucas, son of Genevieve and John W. Lucas; Harry Ashkenas (MS '46, ENG '50), of JPL; Genevieve Lucas; John W. Lucas; and Paul Joas of the Lucas Foundation.

Art, the Universe, and Everything

Back in the 1920's, Edwin Hubble used the Mount Wilson Observatory overlooking Pasadena to prove that the universe has no center. But it does, and it's right here in Pasadena—through May 2001, anyhow. That's when *The Universe*, a multicultural, multimedia exploration of the cosmos as interpreted by artists and scientists throughout the centuries, is being put on by eight Pasadena institutions. A collective opening reception will be held on February 3, when most of the programs begin.

Participants include the Armory Center for the Arts, Art Center College of Design, Caltech, the Huntington Library, the Norton Simon Museum, One Colorado, the Pacific Asia Museum, and Southwest Chamber Music.

The Caltech contribution is a science-fiction film festival called "The Future of the Universe." Four films, chosen by Professor of History Robert Rosenstone, will launch an examination of the science that has inspired the science fiction, and perhaps the science fiction that has inspired the science. Each film will be followed by a panel discussion between scientists, science-fiction writers, humanists, and film-industry professionals. The series begins with *Contact* (1997) on Sunday, January 14, 2001, at 2:00 p.m. in Beckman Auditorium. The other films will be shown on Tuesdays at 7:30 p.m. in Baxter Lecture Hall, and include *Things to Come* (1936) on January 30, *The Day the Earth Stood Still* (1951) on February 13, and *Blade Runner* (1982) on February 27. Admission to all screenings is free; however, tickets will be required to see *Contact*, because of the anticipated demand. Tickets are available from the Office of Public Events at (626) 395-4652.

The Armory will be showcasing contemporary interpretations of space and the universe by American artists including Ed Ruscha, James Rosenquist, Dorothea Rockburne, Robert Rauschenberg, Rockne Krebs, Linda Connor, Carl Cheng, Vija Celmins, and Kim Abeles. Some of the works have been specially commissioned for this exhibition, including "a monumental outdoor night laser installation connecting important locations within the city of Pasadena." Art Center is presenting "The Universe from My Backyard," an installation by Russell Crotty featuring intricately rendered spheres representing the night sky. The Huntington will exhibit astronomical rare books, maps, and artifacts, from some 12th-century manuscripts that rarely go on display to a selection of Edwin Hubble's papers. The Norton Simon has chosen 60 masterpieces organized around the themes of the cosmic axis between heaven and earth; cosmic circles, including haloes; and the constellations. One Colorado will display photographs from the Hubble Space Telescope, including a 45-foot image of Harbig-Haro 47 (a jet ejected from a star, and perhaps a planetary system, aborning) stretched across Crate & Barrel. The Pacific Asia Museum is exploring how Hinduism, Jainism, Buddhism, and Daoism have expressed their conceptions of the cosmos through art, including a spectacular 10-foot-by-10-foot-by-10-foot Buddhist mandala recently built by one of the world's finest Tibetan artists. And Southwest Chamber Music will perform "Music of the Spheres," from medieval music up to John Cage's *Atlas Eclipticalis*, a contemporary score based on star charts.

For details, including all the workshops, children's activities, and other things not mentioned here, check the web at <www.pasadena-universe.org>. □