Voyager at 25—Still Boldly Going

The Voyager mission marked its 25th anniversary this year—Voyager 2 launched on August 20, 1977, and Voyager 1 followed on September 5—and the twin spacecraft that opened up the outer worlds of our solar system to us are still going strong. Voyager 1, now the most distant human-made object from Earth, and Voyager 2, a close second on a different path, are on their way to becoming our first interstellar probes. They are now searching for the heliopause—the edge of the solar system, where the stream of charged particles from the sun meets the free-drifting ions of interstellar space. A commemorative exhibit of Voyager images is on line at http://beacon.jpl.nasa.gov/exhibits/voyager/default.html.

Broad Center Dedicated

The Broad Center's facade is clad in travertine marble and stainless steel. As Baltimore said, one is "redolent of the Beckman Institute and the historic buildings on campus; [the other,] clearly new and challenging, a harbinger of the future . . . reminds us that a new, scientific research building is an ambitious thrust into the unknown."

The Broad Center for the Biological Sciences was dedicated on September 10. Named for Caltech trustee and SunAmerica chairman Eli Broad and his wife, Edythe, the building will house 13 research groups. Representing a mix of disciplines, they will mount a joint attack on what Elliot Meyerowitz, chair of the biology division, called two of the great problems of biology: "How cells work—the ultimate in nanotechnology. And how the brain works—the most complicated problem in biology, and maybe the most complicated problem we'll ever face." Those problems may well be solved within Broad's walls in the next 20 years, he said.

Renowned architect James Freed of Pei Cobb Freed & Partners designed the building to foster communication. The labs are built on an open plan, and researchers with similar interests share the same floor. And immediately adjoining is a café where, in the words of Caltech president David Baltimore, generations of students, postdocs, staff, faculty, and the occasional administrator can discuss "science, the affairs of the world, or the latest tennis match."

The third and first floors will be the domain of the cell. Upstairs, biologists Pamela Bjorkman, David Chan, and Grant Jensen and chemist Douglas Rees will be studying the structure and function of assorted molecules, while downstairs biologist/chemist Stephen Mayo (PhD'87), mathematician Niles Pierce, and two future faculty members will be using computers to design proteins and other molecular machines.

The cell- and brain-research floors are interleaved for maximum idea exchange in the stairwells. On the second floor, biologists Erin Schuman and Kai Zinn will examine various aspects of how neurons connect and communicate; two labs are still to be occupied on this floor too. And biologist Scott Fraser will oversee the basement MRI facility, one of whose magnets is big enough to do brain-function studies on humans.

Eli Broad, whom Baltimore described as a "venture philanthropist," said, "We are often asked, 'Why did we make this cornerstone gift?'

Above: Eli Broad. Below: As the only eatery on the west side of campus, the Café at Broad will bring together people from many disciplines, leading to who-knows-what collaborations.

It's because biotechnology, more than any other scientific discipline, has the potential to make the greatest possible contribution to human well-being this century.... [We] will place L.A. squarely in the forefront of the greatest growth sector of the 21st century." □—*DS*

A Freeway Runs Through It

The Arroyo Seco runs some 20 miles from the San Gabriel Mountains to the Los Angeles River. Spanish for "dry gulch," it's actually a good-sized canyon whose intermittent stream, permanent ponds, and fertile floodplain have been a sanctuary for wildlife and humans for at least 8,000 years. In the last 100, it has also become the chief conduit between downtown Los Angeles and Pasadena, containing, at various times, a wood-planked elevated bikeway, the Santa Fe railroad, the Arroyo Seco Parkway, the Pasadena Freeway, the Metro Rail Gold Line, and soon perhaps again a bicycle expressway. At the same time, its streambed from just south of JPL has been dammed and encased in concrete in response to the catastrophic floods of the 1910s, '20s, and '30s. And, of course, the Arroyo is home to the Rose Bowl, a golf course, swimming pools, tennis courts, hiking trails … It's in this context of balancing refuge and recreation, torrents of water and streams of cars, that Caltech, Occidental College, and UCLA last year jointly offered a course entitled, "Re-Envisioning the Arroyo Seco Corridor: Watershed, Transportation, Ecological, and Community Building Issues."

The lower Arroyo Seco was channelized in 1938 because of rainfalls like this. Norm Brooks (PhD '54), Irvine Professor of Environmental and Civil Engineering, Emeritus, took this shot looking downstream at the two-lane bridge that connects JPL with its east parking lot on March 4, 1978, at the end of what National Weather Service meteorologists rated a series of "moderate-intensity" storms during which the rain gauge on Mount Wilson recorded 24.16 inches of rain in six days. What looks like a dead tree wedged against the pier is really water being thrown two meters into the air, from which Brooks says a flow of about six meters per second can be calculated.

William Deverell, Caltech associate professor of history; Robert Gottlieb and Marcus Renner of Oxy's Urban and Environmental Policy Institute; and Richard Weinstein of the department of architecture and urban design and Anastasia Loukaitou-Sideris of the urban planning department, both at UCLA, taught the course in concurrent sessions on their home campuses. The class shared a reading list (which included *Eden by Design*, cowritten by Deverell and Greg Hise, associate professor of urban history at USC) and met jointly twice, but otherwise took a different focus at each institution. Oxy took on issues important to the surrounding communities. UCLA offered a graduate-level "studio" course that did things like redesign the Pasadena Freeway's abrupt transition to a surface street, using the Arroyo to create a gateway to the city of Pasadena. And Deverell's class explored the Arroyo's historical and cultural legacy.

Of the course's 45 students, three were Caltech undergrads. John Harris (BS '02), Derek Jackson, and Meghan Smith (BS '02) did fieldwork with Deverell as well as classwork, he says. "It was great to tap into the students' knowledge of geology, biology, and so on, and apply that to local history. And it was fun to spend time with the students off campus, out of context." Their destinations included the Huntington Library, where dining-room furniture belonging to Caltech trustee Henry Robinson (as in Robinson Lab) is part of an exhibit on the works of Charles and Henry Greene. Says Harris, "We were all very surprised to learn about all the ways that Caltech was related to Arroyo culture." For example, renowned tile maker Ernest Batchelder taught art at Throop Polytechnic, Caltech's forerunner, leaving in 1909 in protest over the school's increasingly theoretical bent. But he and his wife remained active in school affairs: the Coleman Chamber Concerts bear her name.

For those of you who aren't up on local history, it starts with the Tongva, rechristened the Gabrielinos by the Spanish—hunter-gatherers whose women wove beautiful, complex reed baskets, now highly prized, as well as huts large enough to shelter an entire extended family. The Arroyo was relatively unused by the Spanish ranchers and farmers, and many dispossessed Tongva still lived there when California joined the Union in 1850. Pasadena was founded in 1886, the year after the Santa Fe railroad arrived and just in time for the land boom that followed. "The Arroyo was a nationally acclaimed recreation area that drew and retained visitors from all over the country," says Harris. For

A group of city folk enjoy the Arroyo's tranquility in this undated photograph by one E. A. Smith of Pasadena, courtesy of Bill Deverell.

tubercular, asthmatic Easterners, it was a small conceptual leap from "warm, dry air is good for the lungs" to "living outdoors is good for you," and thus was born the Arroyo Culture, which would define Pasadena's, and indeed Los Angeles's, self-image until the 1920s—an idealized vision of the desert southwest, both Tongva and Hispanic, adapted for American life.

The Arroyo Culture applied the notion of "living in nature" to all aspects of existence—the California bungalow, with its spacious patios and sleeping porches, and the plein air (literally "open air") style of painting being just two of its manifestations. The Arroyo and its banks became populated with bohemians and artisans (including Batchelder) of all sorts—the Southern California incarnation of the Arts and Crafts movement that had sprouted in England. This urban wilderness became the archetype of a new, suburban lifestyle, says Deverell; not city, not country, but something in between. (Of course, this was a lot easier to achieve at the turn of the century, when the county's population was comfortably under a million.) Even so, not everyone could afford to live in a Craftsman house by Greene and Greene (or even a modest bungalow), and support grew for officially turning the Arroyo into a park so that the working classes, too, could experience nature.

In 1928, in a spirit of noblesse oblige, the Los Angeles Chamber of Commerce—the men who moved and shook the Southland in the days before plate tectonics—commissioned a report called *Parks, Playgrounds and Beaches for the Los Angeles Region*. Two years in the making by the Olmsted brothers and Harland Bartholomew, the leading landscape architects and city planners of the day, this comprehensive blueprint also included large wilderness reservations suitable for camping, hiking, and horseback riding. These were to be connected by parkways or "pleasureway parks," laid out so "that no home will be more than a few miles from some part of it; and … so designed that, having reached any part of it, one may drive within the system for pleasure, and *with* pleasure, for many miles.… [They] necessarily should be greatly elongated real *parks*." Landscaped to be screened from their surroundings, and "having few cross-traffic intersections," they would "produce, along with the topographic conditions, some sense of spaciousness and seclusion, and a variety of scenic effects." Yes, recreational driving was already an acknowledged pastime—by 1930, there were two automobiles for every three people in L.A., the highest per-capita ratio in the world, says *Eden by Design*.

The proposed Arroyo Seco Parkway ran from downtown Los Angeles to the San Gabriel Mountains, feeding into what is now the Angeles Crest Highway. But as studies by blue-ribbon commissions are wont to do, this one sank without a ripple. In the words of the Techers' project report, "Shamefully, the reasons this plan for a countywide parkway system failed were primarily political ones. The proposal would have required a new countywide agency with extensive powers to appropriate spending, but the Chamber of Commerce … did not want to share their power.… Business leaders were also opposed to the plan because they believed that it would take up too much valuable real estate.… Even during the Depression, hundreds and thousands of people were migrating to southern California from other parts of the country, making the real estate business extremely lucrative … 'city beautiful' ideas were pushed into the background."

Although much of the Arroyo's floor was eventually converted into a chain of parks, the result was neither the originally envisioned "pleasureway" nor a proper freeway, but something in between. Dedicated December 30, 1940, to coincide with the Tournament of Roses (the Rose Bowl had been built in 1926), the Arroyo Seco Parkway is the oldest limited-access highway west of the Mississippi. It's been designated an American Civil Engineering Landmark and is eligible for the National Register of Historic Places. It was laid out so that you could see magnificent vistas from behind the wheel, it followed the contours of the landscape, and it featured decorative walls and bridges, but it also had a large median and wide lanes for its day, and banked curves to keep the traffic humming at the state speed limit of 45 miles per hour. It was designed to

The Arroyo Seco today, with its flood-control channel and six-laned freeway. Designed in more leisurely days, this tiny off-ramp (note the 5 mph speed limit) dumps you unceremoniously into the surrounding neighborhood.

carry 27,000 cars per day, and now handles about six times that. Furthermore, says the Techers' report, "Most of the adjoining parkland goes unused, except by the local residents. Many acres of parkland have poor street access or have dilapidated facilities, and most of these parks are not even known to be open to the public."

So, what can be done at this late date to reconnect the freeway to the Arroyo Culture? If we can no longer "live in nature," can we at least drive in it? In March, the combined class presented their work to invited guests at the Los Angeles River Center and Gardens, at the confluence of the Arroyo and the Los Angeles River. Among the Techers' proposals was one to restore the original sight lines. Says Harris, "If a few 'shielding' trees were removed in a couple of places, views of the mountains could be much more dramatic." And, says the report, "all chain-link fences should be removed or obscured with something artistic and natural. These barriers and other roadside structures could be built with Arroyo stone or use aesthetic designs that are culturally significant to the Arroyo." Better signs and more historical markers would raise awareness of the surrounding parks, which need renovation, and a low-power radio transmitter like those that broadcast freeway closures could beam a program on Arroyo culture and history into your car.

It could happen, says Tim Brick, director of the Arroyo Seco Foundation, who was in the audience that day. The foundation released its own *Arroyo Seco Watershed Restoration Feasibility Study* in Caltech's Ramo Auditorium five months later, on August 21. "I was impressed by their recommendations, and we went back and beefed up parts of the watershed report from it," said Brick. "They really caught the spirit of the Arroyo." He continued, "Caltrans has recently obtained Federal Scenic Byway status for the Parkway, which means that a lot more attention will be paid to upgrading its 'look' and historical character." Meanwhile, according to UCLA's Loukaitou-Sideris, the Metropolitan Transit Authority and Caltrans are studying UCLA's proposed Arroyo-Walk, which "connects and highlights a number of cultural sites" accessible to pedestrians, while at the same time "proposes visual elements to enhance the motorists' views and perception of the area as a cohesive landscape." And Renner reports that Oxy's students have produced a brochure and Web site (http://students.oxy.edu/wheatley/bikeproject.htm) on expanding bicycle use in the Arroyo area, and another brochure listing its cultural resources. He's including them in an Arroyo educators' guide that will go out to 50 to 100 teachers of grades K–12 in October.

The joint syllabus for the course calls the degree of collaboration "unprecedented," and Renner concurs. "It was an experiment, and we learned how to do it better next time, which we'd like to do." Says Deverell, "It was a joint idea by all three campuses that just sort of grew out of discussions. I'd like to do it regularly—the mountains one year, the beaches the next, and so on. It's this kind of flexibility, and the resources of the Huntington Library, that makes teaching humanities here so rewarding." □—*DS*

Talk Among Yourselves

Jehoshua Bruck, the Moore Professor of Computation and Neural Systems and Electrical Engineering, has been named one of the collaborators in the Alpha Project, a $15.5 million, five-year program to explore how living cells respond to information and communicate with one another. Administered by the Molecular Sciences Institute and funded by the National Institutes of Health's National Human Genome Research Institute, the project will also involve research groups from MIT, UC Berkeley, and the Pacific Northwest National Laboratory. Bruck's specialty is distributed information systems—essentially groups of devices such as cell phones or laptops that interact over some kind of communication network. Here, he will help analyze cellular signal transduction, abstract its key features, and model them.

Signal transduction is a set of chemical interactions between genes, proteins, and signaling molecules that control how a cell communicates with other cells or senses things in its environment. The Alpha Project will focus exclusively on the pheromone signal pathway in baker's yeast, whose cells' signal-transduction system is quite similar to ours. The pheromone pathway involves a relatively small number of about 25 genes, so it is hoped that thoroughly understanding the system will provide new insights on human cells.

Bruck has already collaborated informally with the Molecular Sciences Institute to create computer algorithms for simulating more general biological regulatory systems. "We are not planning to conduct experiments with yeast in my lab," he says. "Our part will be to model the whole process, and create simulations to try to predict the behavior of the biological system. Also, we plan to learn from biology about new principles in circuits for computation and communications, because at present we simply don't know how to build artificial systems that compute, communicate, and evolve like biological cells."

Success for the overall project could lead to new ways of dealing with diseases such as cancer and diabetes. "At the least, we'll definitely understand this communication pathway in cells," Bruck says of the biological goals. "And if we are able to understand the mechanisms in a way that leads to advances in curing diseases, and this information can also be

applied to engineering systems, it would be even better."

The Alpha Project will be the Molecular Sciences Institute's new Center for Genomic Experimentation and Computation's flagship project. The Molecular Sciences Institute, headquartered in Berkeley, is an independent, nonprofit research laboratory that combines genomic experimentation with computer modeling. The institute's mission is to predict the behavior of cells and organisms in response to defined genetic and environmental changes, which would significantly increase our understanding of biological systems and help catalyze radical changes in the practice of medicine. The institute can be found on the Web at www.molsci.org. □—*RT*

Radar Survey Unmasks Active Volcanoes

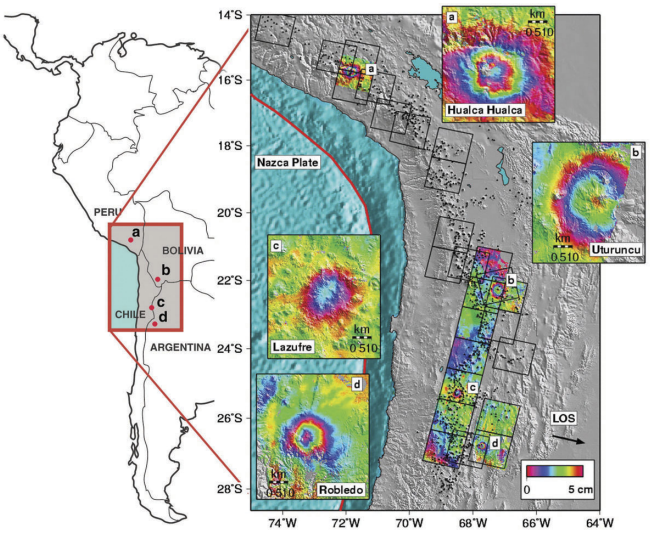
Four Andean volcanoes thought to be dormant have been revealed to be active by an innovative radar survey that tracks ground motions from space. Caltech grad student Matt Pritchard (MS '00) and Assistant Professor of Geophysics Mark Simons have analyzed interferometry data on 900 Andean volcanoes—data gathered from 1992 to 2000 by the European Space Agency's two remote-sensing satellites, ERS 1 and ERS 2—using software developed at Caltech and JPL.

Of the four volcanoes, Hualca Hualca, in southern Peru, is especially worthy of close observation because it is in a well-populated area and just a few miles from Sabancaya, an active volcano. A second volcano, Uturuncu, in Bolivia, was found to be bulging at a rate of one to two centimeters per year, while a third, the Robledo caldera, in Argentina, is actually deflating. The fourth is a previously unknown region of surface deformation on the border between Chile and Argentina, christened "Lazufre" because it lies between the volcanoes Lastarria and Cordon del Azufre.

Besides revealing volcanic hazards, the study proves the mettle of a new means of tracking ground deformation. The fact that not one of the four volcanoes was known to be active—and thus probably wouldn't have been of interest to geophysicists conducting studies using conventional methods—shows the promise of the technique, Pritchard says. The data are superior to ground-based results in that a huge amount of subtle information can be accumulated about a large number of geological features.

Each satellite bounces a radar signal off the ground and measures the time it takes to return. On a later pass, when the satellite is again in approximately the same spot, it sends another signal to the ground. If the two signals are out of phase, then the distance from the satellite to the ground is either increasing or decreasing, and if the features are volcanic, then the motion can be assumed to have been caused by the movement of magma underground or by hydrothermal activity. "You can think of a magma chamber as a balloon inflating and deflating," says Pritchard. "So if the magma is building up underground, you expect a swelling upward, and this is what we can detect with the satellite data." With an appropriate satellite mission, all the world's subaerial volcanoes could easily be monitored on a weekly basis—an invaluable hazard-alert system for areas lacking regular geophysical monitoring.

Another unusual finding shows the method's promise for better understanding volcanism. The Lascar volcano, in Chile, has had three major eruptions since 1993, as well as several minor ones, and many volcanologists assumed there should have been some ground swelling as well, Pritchard says. "But we found no deformation, which could tell us interesting things about magma plumbing." There are several possible explanations: The first and most obvious is that the satellite passes took place at times between inflations and subse-

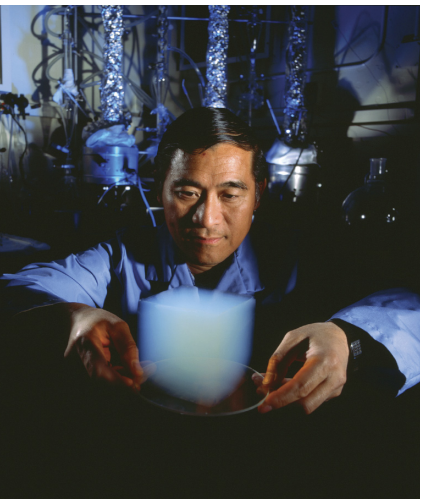


The four volcanoes, with the bands of color showing the amount of movement detected. The satellites actually measure ground deformation along their lines of sight, which are about 20 degrees away from vertical. The arrow labeled "LOS" in the lower right corner shows the direction in which the satellites were looking. (After Pritchard and Simons, *Nature*, volume 418, page 168.)

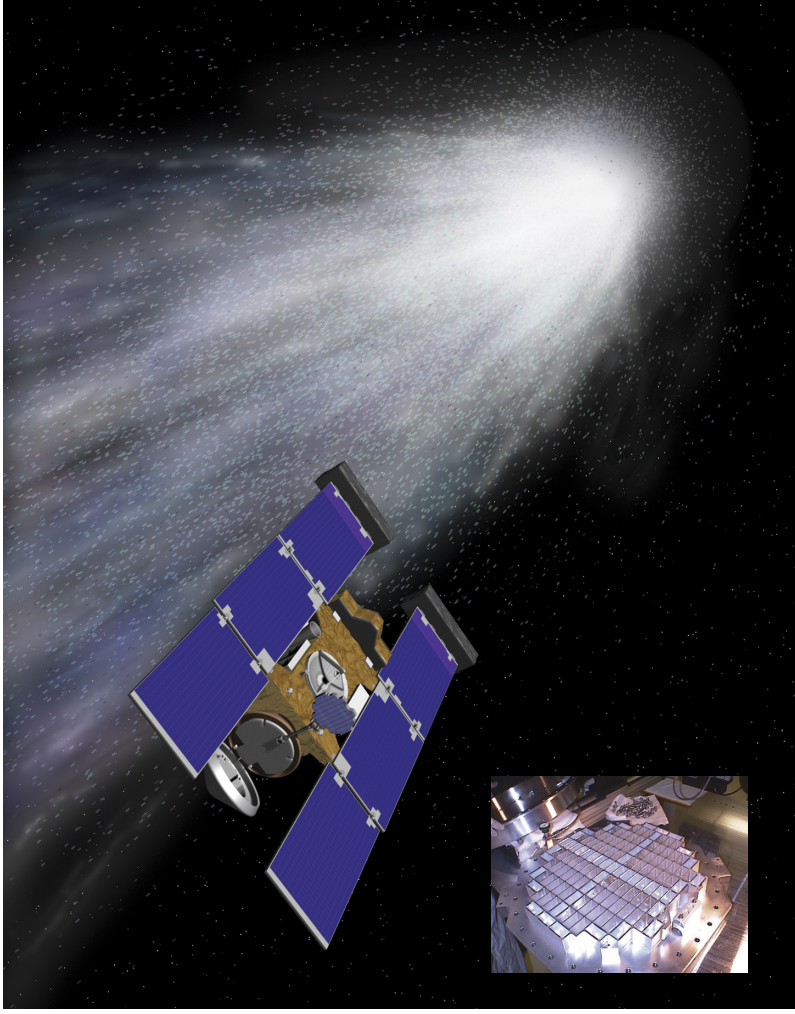
The White-Glove Test

Like a finger dragged across a neglected bookshelf, JPL's Stardust spacecraft is swiping up dust—rock particles finer than sand grains blowing through the solar system from the direction of Sagittarius. (You can actually see the stuff on a good night—it's the dark band running down the middle of the Milky Way.) On August 5, Stardust deployed its dust collector, which is shaped like an oversized tennis racket; the spacecraft took an earlier sample from February to May 2000. The racket is strung with a ghostly material called aerogel—a silica compound that is 99.8 percent empty space—a concept developed by Stardust's deputy principal investigator, Peter Tsou, to slow down and trap the fragile particles without damaging them.

Stardust is en route to a January 2004 meeting with comet Wild 2, where the racket's other side will be used in a backhand stroke to grab the first sample ever taken from a comet. Wild 2 never gets closer to the sun than the orbit of Mars, so the comet's ice and dust should be little changed from when it, and the rest of the solar system, formed more than 4.5 billion years ago. The sample-return capsule will be parachuted back to Earth in 2006. □—*DS*



Peter Tsou and an aerogel cube.



Comet Wild 2 will be safely past its active peak and on its way back into the deep-space deep freeze when Stardust catches up with it. The spacecraft will fly through the comet's coma, or dust cloud, about 150 kilometers in front of the nucleus. The inset shows the collector being filled with aerogel.

quent deflations, so that no net motion was recorded. It could also be that magma is somehow able to pass through the volcano without deforming it; or that the magma chamber is so deep that its deformations aren't visible at the surface.

The paper appeared in the July 11 issue of *Nature*. □—*RT*

Watson Lectures Set

Mark your calendar for this fall's lineup of Earnest C. Watson Lectures. The series leads off with Jack Beauchamp (BS '64), Ferkel Professor of Chemistry and former chair of the National Research Council Committee on Commercial Aircraft Security, talking about "Countering Terrorism: The Role of Science and Technology" on October 9. Henry Lester, Bren Professor of Biology, follows on October 23 with "The Response to Nicotine." Next Edward Stone, Morrisroe Professor of Physics and former director of JPL, chronicles "The Voyager Journeys to Interstellar Space" on November 6. Professor of Physics Nai-Chang Yeh looks at "Superconductivity—Resistance is Futile" on January 15, 2003. And finally, Associate Professor of Materials Science Sossina Haile explores "Fuel Cells: Powering Progress in the 21st Century" on January 29. As always, the lectures begin at 8:00 p.m. in Caltech's Beckman Auditorium, and are free and open to the public.