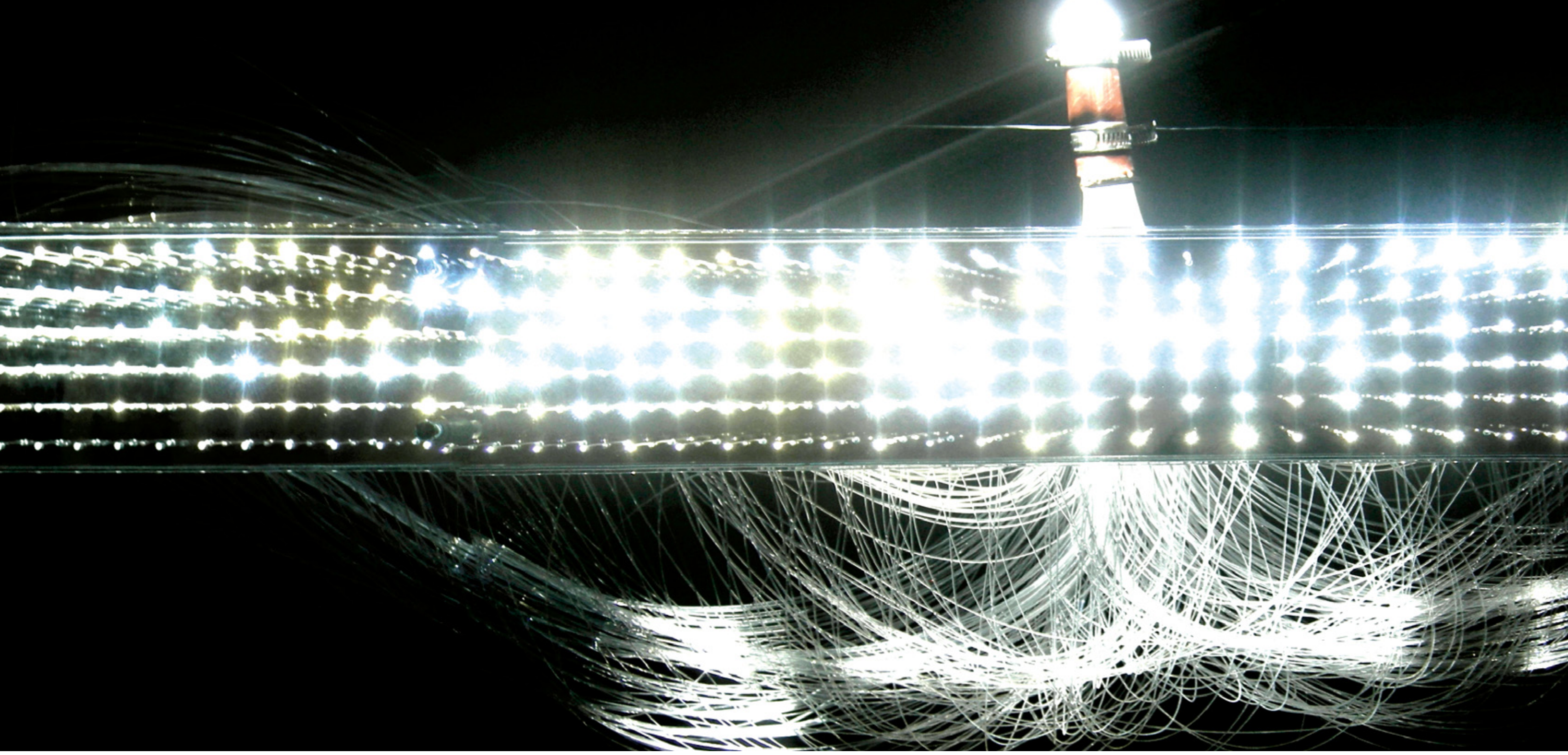


The Prodigal Sun

By Lori Oliwenstein

A Caltech building where scientists used to think about the origin of the universe is morphing into a place where they will ponder the fate of our planet. This summer, members of the newly created Ronald and Maxine Linde Center for Global Environmental Science will move into the former Robinson Laboratory of Astrophysics, reborn as the Linde + Robinson Laboratory for Global Environmental Science.

This renovation unveiled an opportunity that came in the guise of a problem. The building's centerpiece, though physically offset, is a solar telescope that was intended for Caltech cofounder and solar astronomer George Ellery Hale. The main part of the instrument is a contraption called a coelostat (SEAL-uh-stat), which sits with its associated hardware under a large white dome on the roof of the building. When in use, the coelostat's 36-inch-diameter mirror rotates to track the sun through an opening in the dome, sending the light it captures to a smaller mirror. That second mirror routes the light down an octagonal shaft, eight feet in diameter, that penetrates clear through the subbasement five stories below.

Built in the 1930s but not completed until 1968, the solar telescope had lapsed into obsolescence by the early 1980s. Now, with the Linde Center's posse of environmental chemists, oceanographers, and atmospheric scientists moving in, the question becomes: What could they possibly want with an old solar telescope?

Pretty much everything under the sun, as it turns out.

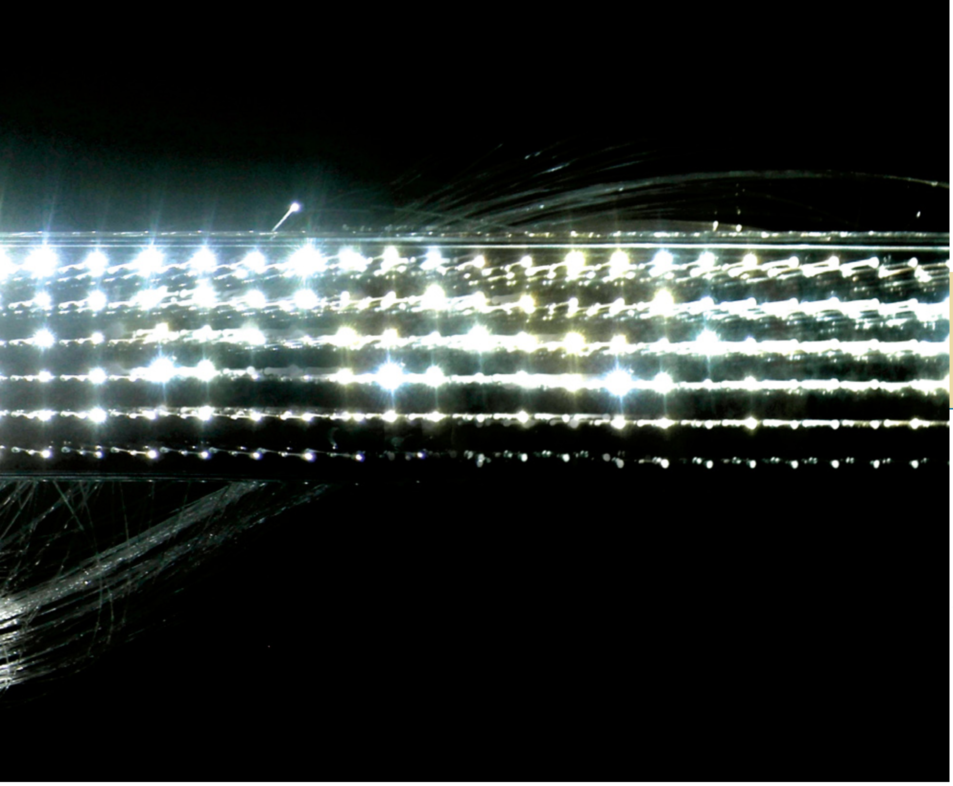
They want it to cool their building. They want it to shed light on their experiments, both literally and figuratively. And they want it to do what it's always done—keep the sun, the most bountiful renewable energy source we have, front and center in the minds of all who enter.

And so what elsewhere might have become a casualty of progress became part of it instead: an excuse to dream big, to not only embrace a very odd architectural feature but to reuse it, and the light it captures, in much the same way the building's original wooden doors and handcrafted light fixtures are being reused.

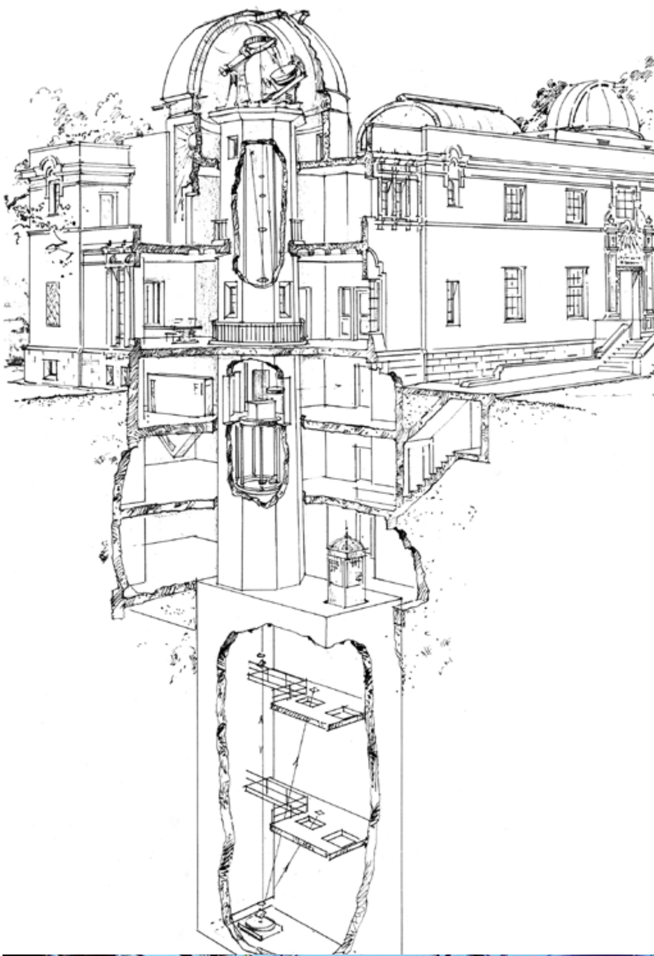
This waste-not-want-not reimagining of the coelostat and its solar shaft is part of the new occupants' gestalt, says Tapio Schneider, director of the Linde Center. These scientists want to actually practice what they're researching; after all, it's hard to solve global environmental issues in an energy-munching building.

"A central activity in the Linde Center is studying how the climate has varied in the past, as a key to understanding how it may change in the future," Schneider says. "Similarly, we wanted to use the scientific and architectural past of the building as we were reconfiguring it for the future."

Transforming these scope-in-the-sky musings into reality, however, would require the best of the best in several fields. Loisos + Ubbelohde, a firm specializing in energy efficiency and lighting design, teamed up with consultant



Left: Fiber-optic light fixtures will send sunshine into basement laboratories.



Returns

Richard Treffers—an expert in restoring old or abandoned telescopes—to really think through the telescope's reuse, and to automate its instrumentation.

"The controls hadn't been updated since it was built," notes Bart Hale (no relation), the Linde + Robinson construction manager with Caltech's facilities office. "They were completely nonfunctioning. Now they've been stripped out, and Richard has come up with a whole new set for us. It's remarkable."

That newfangled control system will check with a weather station on the roof, only kicking into gear and opening the telescope's impressive white dome when the sun is visible. When the dome's doors part, the coelostat will track the sun's movements—and the moon's as well, on nights when it's sufficiently visible—without human intervention and while taking into account such things as seasonal changes in the sun's path across the sky.

And, thanks to the good folks at the University of California's Lick Observatory, the images that are sent down the solar shaft will be as sharp and clean as possible, now that the mirrors have gotten their first-ever face-lift. "The technicians cleaned the mirrors' surfaces, and put a new reflective layer of aluminum on top, with a special overcoating," says Treffers. "Aluminum degrades, so you need that protective coating if you want the mirrors to survive another 80 years or more."

Once the sunlight is in the shaft, pretty much anything goes. Small mirrors will grab bits of the solar beam and redirect them onto a translucent glass window separating the shaft and the first-floor library, creating a real-time, safe-to-stare-at image of the sun that will be at least a foot in diameter;

The south facade of the Robinson Laboratory of Astrophysics featured a bas-relief sunburst just beneath the solar telescope's dome; like the scope itself, the sun was spared during the renovation and will remain as a symbol of the work done within.

Inside the dome, the coelostat awaits the return of its mirrors. The pedestal in the middle of the photo is for the 30-inch mirror that will send the sunbeam down the shaft. The 36-inch main mirror goes in the rotating mount at the bottom left.

through tubes into labs for use in various research projects; and via optical fibers into light fixtures.

LET THE SUN SHINE IN

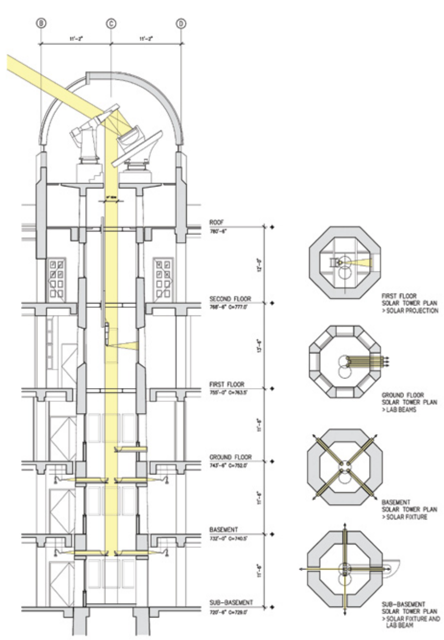
Exploiting natural light to illuminate an office or laboratory might not be stop-the-presses stuff in general; windows have been around for quite a while, after all. But in Linde + Robinson, the sunlight will be snaking into places it rarely gets to in other buildings.

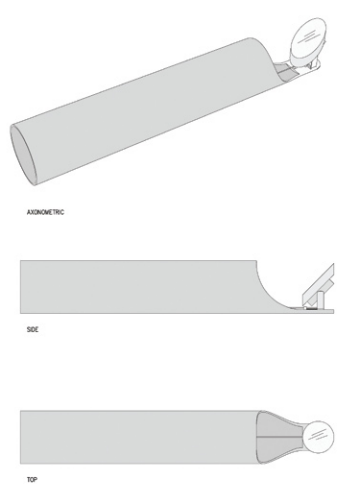
Loisos + Ubbelohde designed an "optical train" that will wend its way down to the subterranean spaces of the building. Arrays of small mirrors in the shaft at the basement and subbasement levels will divert daylight into fiber-optic bundles feeding ceiling lights in the adjoining laboratories. (During sunny days only, of course. On cloudy days, or after the sun goes down, it's back to those good old fluorescent lights.)

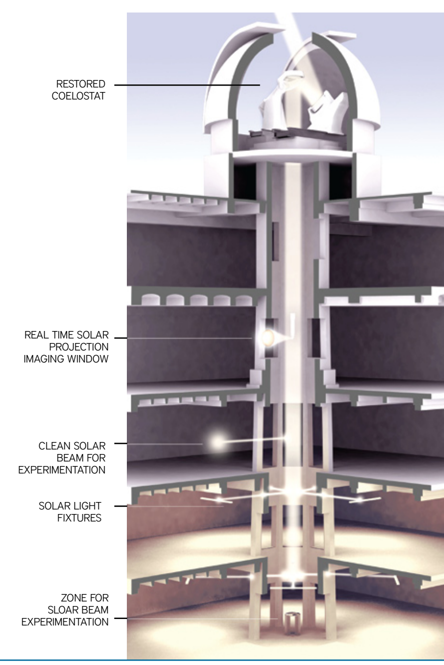
But the most exciting aspect of this solarpalooza is the prospect of using the light not just as *light*, per se, but as a test subject, as information, as an object for exploration. After all, this is the real thing: light from the sun itself. And it's right there, right at hand. Why squander the opportunity to put those photons to the test—whatever that test may be?

"During some of the early planning meetings, I remember asking about using the solar telescope to run photolysis reactions—using sunlight to break down chemicals—as opposed to taking the experiments up to the roof," says environmental chemist Michael Hoffmann. "The main idea was to work with actual solar photons in the lab rather than using artificial, lab-generated light."

To make that happen, another small mirror in the shaft will direct some of the sunlight through a "mirror tube" to an optical table in Hoffmann's ground-floor laboratory, thereby turning the sunshine into just another utility, along with nitrogen, compressed air, and vacuum lines. In other words, says Schneider, "After decades in which it went unused, the solar shaft is going to be re-lit. It will literally shed light on the future of our environment by providing a light source for investigating such questions as how smog forms, and by delivering spectra from which the composition of the atmosphere can be inferred."







PICTURE CREDITS
32–33, 33, 34 — Loisos + Ubbelohde; 33 — Caltech Archives;
34 — Lori Oliwenstein; 35 — Lance Hayashida

To that end, atmospheric chemist Paul Wennberg is adding the coelostat to the Total Carbon Column Observing Network (TCCON), a Caltech-managed program to monitor greenhouse gases. TCCON records solar spectra in the near-infrared region; the spectra are then teased apart to accurately determine the abundances of carbon dioxide, methane, nitrous oxide, hydrofluoric acid, carbon monoxide, and water in the atmosphere.

Despite the fact that Caltech runs TCCON, the campus hasn't actually housed any of its key devices until now. "It will be fantastic to have a permanent instrument here," says Wennberg, "and very nice to repurpose the coelostat. The modern instrumentation housed in the solar shaft will give us exquisite spectra of the sun rivaling those obtained from the original spectrograph that previously filled most of the basement. This new use of the coelostat is similar to its original function, except that what used to be the noise—the absorption by the atmosphere—is now the signal."

Meanwhile, over in Hoffmann's lab, researchers will be testing some of the light-to-energy conversion systems being developed by JCAP, the Joint Center for Artificial Photosynthesis (see page 22). "Using natural sunlight instead of the energy-inefficient mercury or mercury-xenon lamps that are now used in the lab has obvious advantages," Hoffmann notes. Sunlight is free, for one thing, and the results his lab gets will be a much more accurate reflection of the conversion systems' real-world performance.

GETTING TO THE BOTTOM OF IT

The innovations don't end with the light. Back in its heyday, the shaft opened into the "solar pit"—a vast, concrete-walled space 55 feet deep. The solar beam would hurtle down that entire length, eventually hitting one last mirror that would send it to a nearby laboratory, where the light that had begun its journey up in the dome would finally be resolved into an image of the sun up to 22 inches in diameter.

Today, the pit—now with water-proofed walls—is slated to become the centerpiece of an innovative, space-saving climate-control system. The pit will be filled with 50,000 gallons of water and, explains Hale, "at night, the water will be brought to the roof to cool to a mean chilled temperature of around 54 degrees Fahrenheit; during the day, we'll circulate that water through pipes throughout the building."

But that's not all: the pit will double as a cistern, collecting as much as an additional 10,000 gallons of water during the rainy season. "We'll use the rainwater to flush the toilets," says Eric Soladay of the Integral Group, the mechanical engineers on the project.

The chilled-water air-conditioning system will slash the amount of energy spent on cooling the structure by 80 percent; add that to the solar lighting and the host of other innovations and you wind up with a building whose overall energy use is expected to be just one-sixth that of a typical lab-laden edifice.

No other laboratory building in this country will be quite as energy efficient, says Schneider—in fact, these will be the first labs ever constructed in an existing historic building to earn a LEED platinum rating, the U.S. Green Building Council's top designation.

"This renovation does more than just nod to the building's history like an ancestor in a mantelpiece photo," says Schneider. "Instead, it makes creative use of that history to come up with solutions for the future."

Tapio Schneider is the Gilloon Professor of Environmental Science and Engineering and director of the Ronald and Maxine Linde Center for Global Environmental Science.

Michael Hoffmann is the Irvine Professor of Environmental Science.

Paul Wennberg is the Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering.

Architectural Resources Group, the project's lead architectural firm, specializes in historic renovations. Del Amo Construction is the general contractor.

The renovation of the Linde + Robinson coelostat was made possible by a gift from Foster and Coco Stanback. For information about how to help support the renovation of this building and the implementation of its unique environmental solutions, visit http://www.lindecenter.caltech.edu/.

Far left: A cross section of the solar shaft, and a set of plan views detailing the diversions the light will take on each floor.

Left center: Three views of one of the mirror tubes that will carry sunlight to the labs.

Left: A 3-D rendering of the shaft.

Right: The solar shaft, from below, in mid-renovation.