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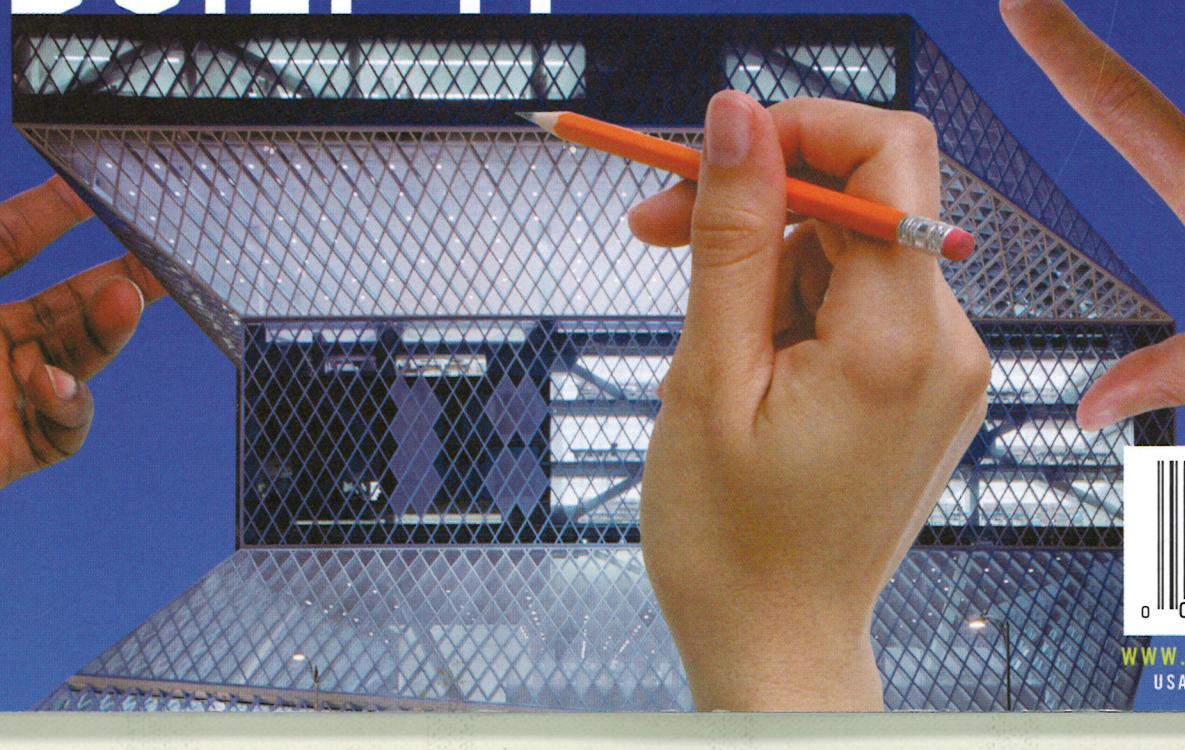

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THE SOLAR RACE

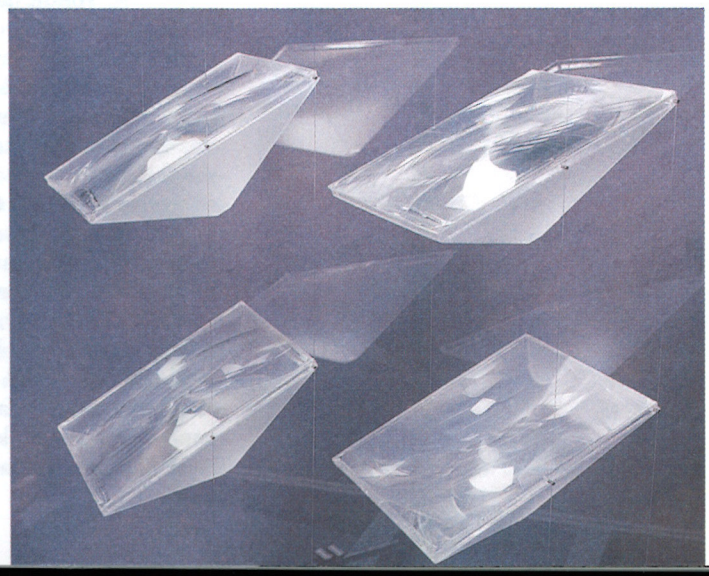
A multi-disciplinary team works fervently to make solar building technology more powerful than ever.

By Laurie Manfra

A group of pioneering architects at Materialab, an interdisciplinary research firm based out of Rensselaer Polytechnic Institute in Troy, New York, is currently testing a radical new photovoltaic facade composed of "integrated concentrator solar modules." The system's pivoting lenses track the movement of the sun across the sky, focusing its rays onto high-tech solar cells. With record efficiency, the modules are expected to convert 30 percent of the sun's light to electricity and absorb 50 percent of its energy in the form of heat. Unlike commercially available flat-plate photovoltaic systems that sustainably oriented architects have relied on since the 1970s—which perform in the range of 12 to 15 percent operating efficiency and dissipate heat as waste energy—Materialab's system could supply as much as 50 percent of the energy for a building's continued on page 120

FACADE

Inside a double-glass envelope, thin structural guidewires suspend rows of "integrated concentrator solar modules," which reposition themselves in response to sensors on the facade that track the angle of the sun, allowing the modules to receive maximum light.

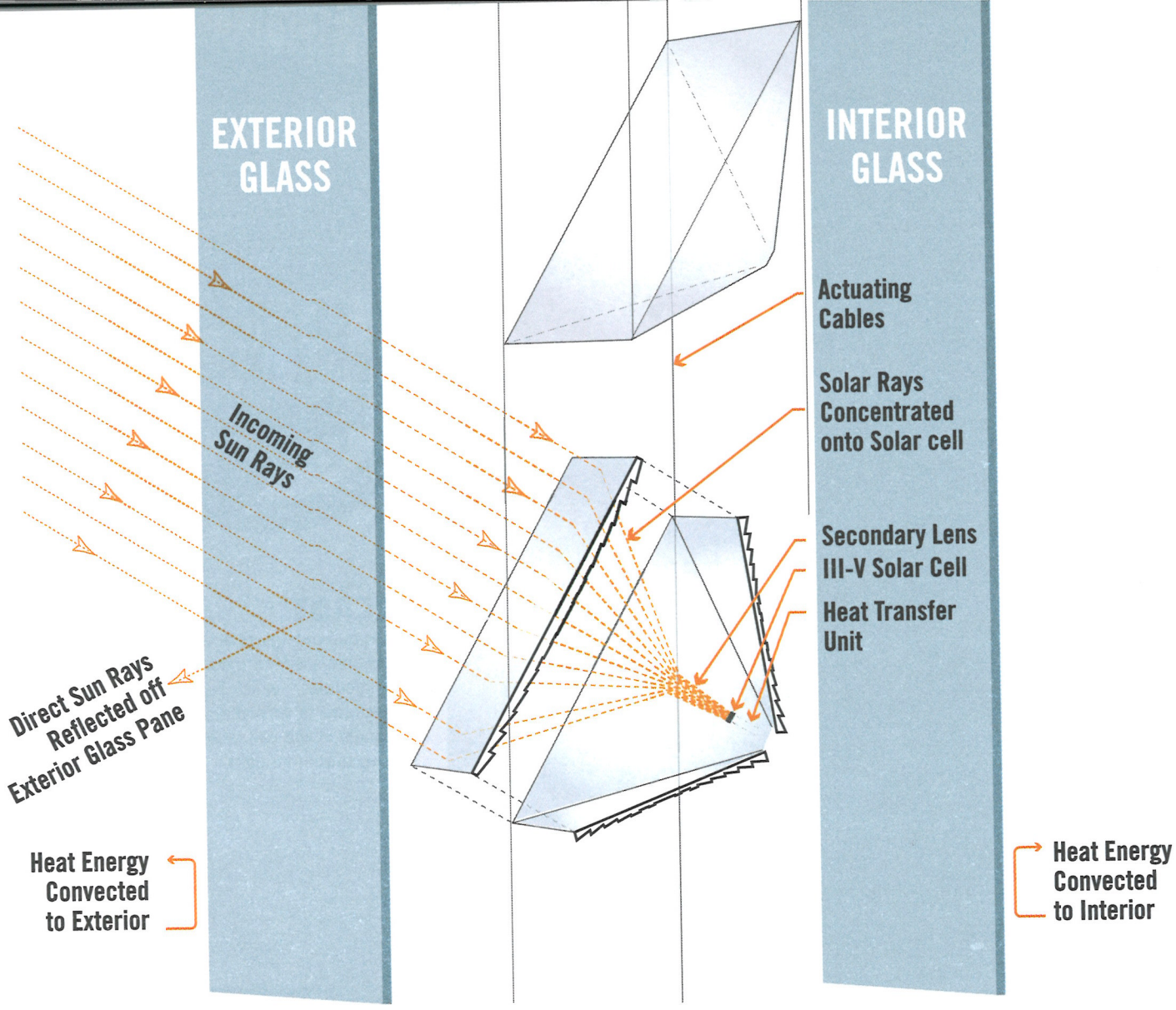


LIGHT DIFFUSION

Unlike conventional blinds, the modules actually capture direct light and heat (above left), providing a new solution to the problem of interior glare (above). The daylighting technology is integrated into the design of the transparent module, which has a lens on its underside that diffuses glare and scatters excess light.

FRESNEL LENS

Harvard physicist Peter Stark is designing the geometry of Materialab's Fresnel lens, which has concentric surface grooves that control and magnify the passage of light. The 10-by-10 inch modules (shown here) are designed to fit within standard deep mullion curtain walls but can also be customized according to site conditions.



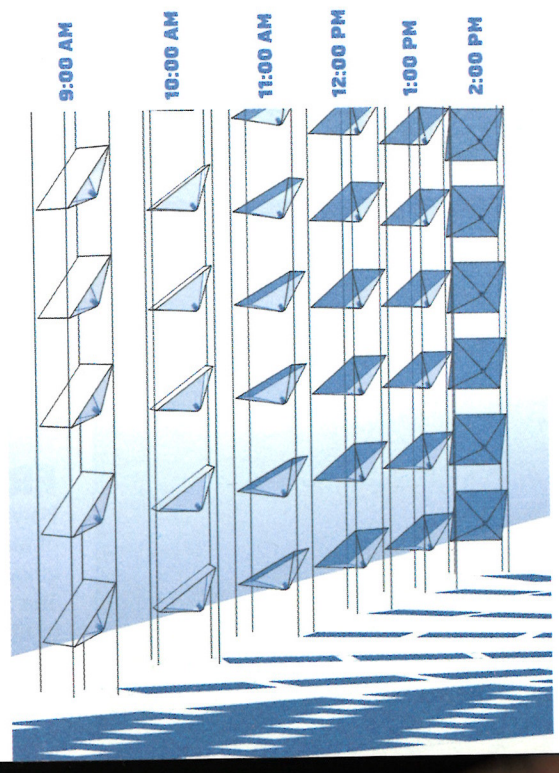
"I realized that photovoltaic systems had to move well beyond what was available in the marketplace," says Materialab founder Anna Dyson.

TIME LAPSE

Each vertical stack of lenses rolls and tilts like a track blind, keeping the surface of the lenses perpendicular to incoming sunlight. At sunrise the modules angle east toward the horizon. Gradually they roll west, tilting upward until noon, and back down until dusk.

THE MODULE

The lens converges incoming sunlight onto a powerful III-V gallium arsenide solar cell (developed by Spectrolab for NASA) that captures light more effectively than the silicon-based cells architects typically specify. Microchannels at the base of the module transfer energy in the form of heat and light to wires contained in the actuating assembly.



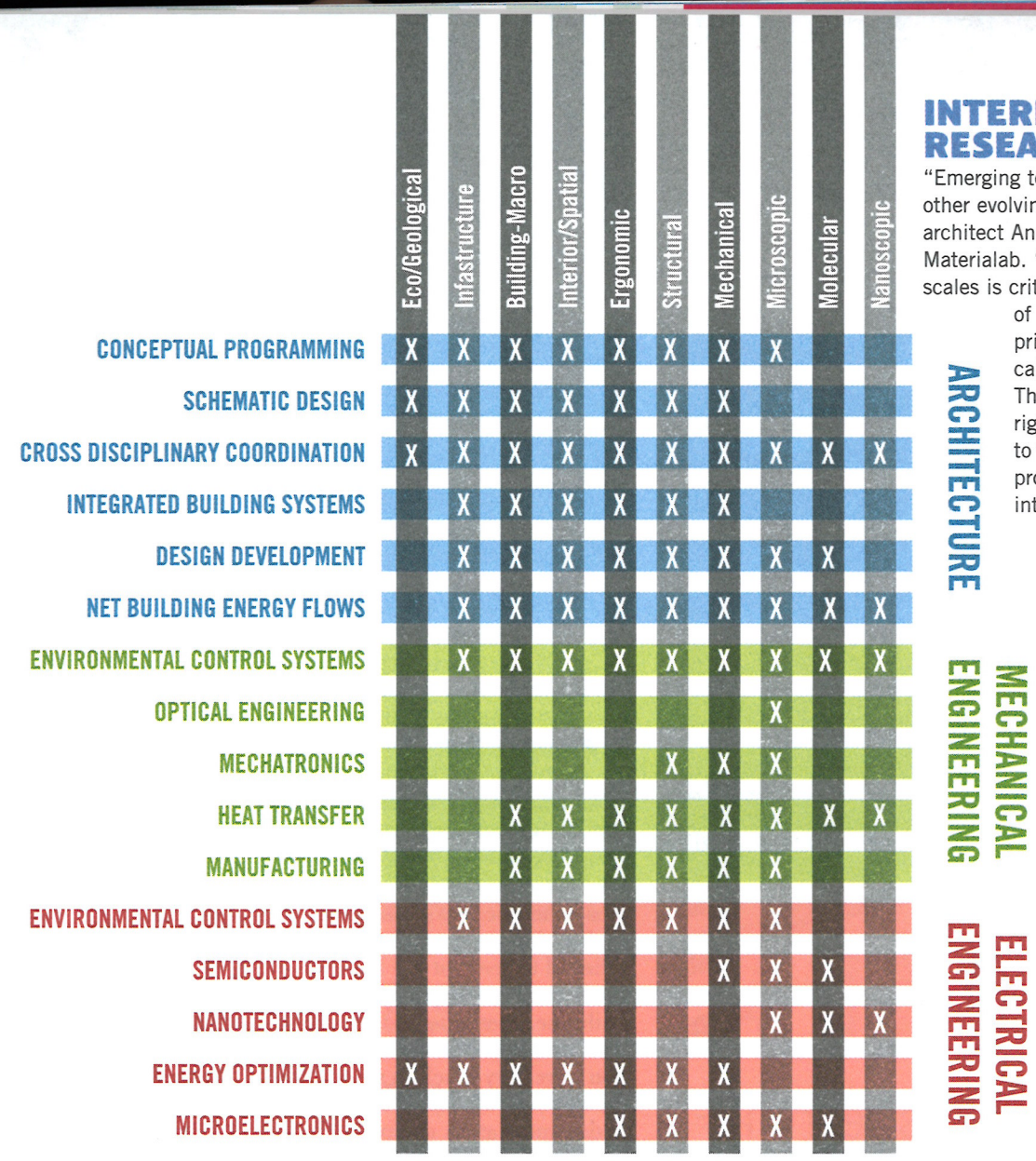
continued from page 118 operational needs, bringing us that much closer to a true solar revolution.

"I realized that in order to produce enough energy to actually change the energy-consumption profile of a building, photovoltaic systems had to move well beyond what was available in the marketplace," explains Anna Dyson, founder of the Materialab consortium and director of the project, who felt that the architect's role had been reduced to that of a recipient product specifier with a limited ability to influence advancements in building technology. So the 38-year-old Yale graduate assembled a cross-disciplinary team of expert scientists and engineers to design a photovoltaic system that better harnesses the sun's energy. By integrating emerging technologies in the fields of nanotechnology, optical and electrical engineering, solid-state lighting, and mechatronics (computer controls and mechanisms working in conjunction) into one dynamic system, her team has devised a solution that optimizes the absorption of energy and seamlessly transfers it to standard building HVAC and electrical systems. "If you're going to do interdisciplinary research, which is essential when developing an ecological system, you have to look at multiple scales simultaneously," Dyson says.

While a majority of Materialab's scientists and engineers are located at Rensselaer, Dyson also sought researchers elsewhere with the specific expertise to refine the system's more innovative components. Rensselaer professor and mechanical engineer Michael Jensen is working to optimize the transfer of thermal energy from solar cells to building systems responsible for domestic hot water, space heating, and air-conditioning. Resident electrical engineer Partha Dutta, who has patented a manufacturing process for the nano-size solar cells, is determining the optimal combination of semiconductors to reduce manu-

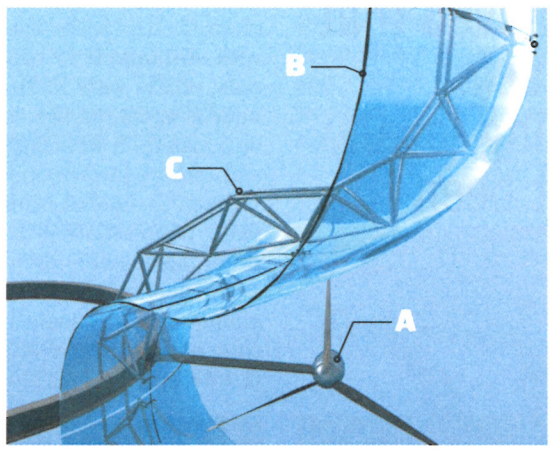
INTERDISCIPLINARY RESEARCH

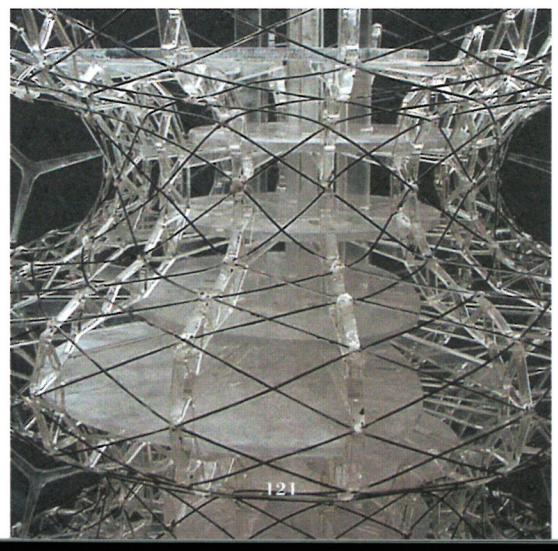
"Emerging technologies depend on advancements in other evolving technologies to move forward" says architect Anna Dyson, project director and founder of Materialab. "Looking at interdependency across the scales is critical." The diagram (left) plots the overlap of information within the project's three primary disciplines—architecture, mechanical engineering, and electrical engineering. The scale of information shifts (from left to right) from the macro, to the human scale, to the nanoscale. Each department's key projects are listed from top to bottom, and interdependency is plotted in the crossbars.



WIND GENERATION SYSTEM

Materialab is also developing the Wind Amplified Rotor Platform (WARP), which generates energy using small mechanical turbines (A) strategically positioned on aerodynamically curved panels (B) and trusses (C) that form a continuous surface (right) that attaches to a building at support points (model, bottom right).





facturing costs and improve efficiency. Harvard-based physicist Peter Stark is designing the groove patterns of a custom Fresnel lens that magnifies and controls light intensity. At Rensselaer's Lighting Research Center, lead engineer Nadarajah Narendran is researching how to run interior LED lights off the power produced by photovoltaic cells, and Yutao Zhou is developing a computer simulation that will reveal how diffuse light not captured by solar cells will affect an interior space. Additionally Materialab's team of nine architects, designers, and engineers enlist the help of Rensselaer graduate and undergraduate students to carry out tests and prepare renderings. "The number of people working on the project is always somewhere between ten and thirty, depending on the time of year," Dyson says.

Materialab has received more than $1 million in research grants, a substantial portion from the New York State Energy Research Development Association (NYSERDA), who hopes the technology will help the state and the nation reach the long-term goal of lowering the cost of solar energy to a level where it can compete with fossil fuels. "Traditionally our research-and-design department has sponsored manufacturers developing stand-alone devices. Rarely have we gotten involved with architects, even though they play an important role in specifying products," says NYSERDA's program director Peter Douglas, who as a trained architect believed that Materialab's project had engineers with the right skills to provide a credible solution but would also embody an architect's imagination and ingenuity.

Once the project is realized, architects will be able to specify the mechanical system for new construction or retrofit existing buildings by placing it in a double-skin envelope with ultra-clear glazing on the exterior (to transmit a greater portion of the solar spectrum) and low-e glass on the interior (to control heat gain). The expense is calculated into the overall system cost, which the team aims to keep lower than one dollar per watt. Currently in the process of building a full-scale prototype that will be ready for testing in two years, Materialab is working to bring this new technology to market in as little as three, a feat that would not have been possible had the scientists and engineers worked in isolation. "In a building, all of the systems are interdependent," Dyson explains. "Yet they get developed separately. In our culture of highly specialized research, visualizing the relationship between all of these technologies is critical, and that's the work of an architect." ◘ **www.metropolismag.com**