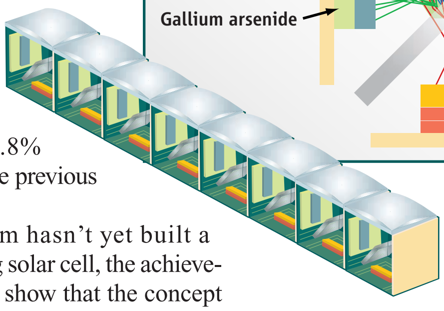
SOLAR POWER

Light-Splitting Trick Squeezes More Electricity Out of Sun's Rays

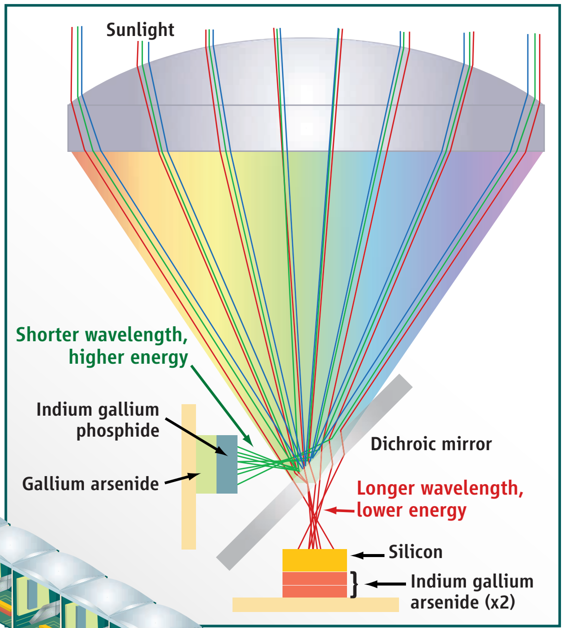
To create highly efficient solar cells, researchers have employed a novel engineering strategy worthy of Sun Tzu: Divide and conquer.

The scientists are part of a U.S. Department of Defense effort aimed at producing small photovoltaic modules for battlefield electronics. Commercially available solar panels convert to electricity only about a fifth of the energy across the solar spectrum that hits them; the goal of the program is to capture more than half. The team, led by researchers at the University of Delaware, Newark, has used a novel light-splitting technique to combine in a single device materials whose properties would otherwise make it difficult to work together. After only a year and a half of work, the $12 million project has yielded an unofficial record of 42.8% efficiency—beating the previous mark by about 2%.



Although the team hasn't yet built a prototype of a working solar cell, the achievement "is important to show that the concept works," says Henry Brandhorst, an engineer at Auburn University in Alabama, who focuses on high-efficiency cells and is not involved in the work. More importantly, he says, the "very interesting approach" could give solar-cell researchers a new set of options if it can be shown to be affordable. "We've completely made the choices for solar cells more flexible," says Delaware electrical engineer Christiana Honsberg.

Different varieties of semiconductors layered in solar cells respond to photons of varying energies to produce electricity. Until now, however, the requirement that the atomic structures of such layers line up to allow proper crystal growth has limited the combinations that researchers could use to gain better efficiencies. When the Defense Advanced Research Projects Agency (DARPA) tackled the problem in 2005, hoping that mobile cells could reduce the number of batteries soldiers carry for devices such as flashlights, they looked to advanced approaches such as nanotechnology or organics to solve the problem. Delaware researchers had a different idea: Use recent advances in optics to split the light and reroute it to smaller stacks of photovoltaic materials that otherwise wouldn't work together (see diagram). It's not a new concept; NASA scientists used a prism in the 1970s to create a "rainbow cell" with the same goal. "But a lot of the light gets lost using a prism," says Delaware electrical engineer and team leader Allen Barnett.



Twice as nice. New solar-power device splits light into high- and low-energy beams and routes them to different electricity-producing materials.

At a meeting in 2005, DARPA program manager Douglas Kirkpatrick, a physicist with experience in the lighting industry, suggested that the research team's talented optics unit use recent advances in so-called dichroic materials, which separate light into specific wavelengths. ("Where have you been all my life?" says Kirkpatrick of the eureka moment.) The research team, which included industrial as well as academic partners, took that approach and achieved with optics a 93% efficiency in processing and splitting the light in as-yet-unpublished tests. Independent officials with the National Renewable Energy Laboratory ▶

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SCIENCESCOPE

A War Over Indirect Costs

U.S. research universities could end up losing millions of dollars under a proposal to cut by more than half the overhead rate on $1.5 billion a year in basic research grants from the Department of Defense (DOD). Universities currently receive anywhere from 45% to 55% of the total amount of a grant for the legitimate costs associated with supporting research, including everything from electricity to cleaning animal cages. A report accompanying the 2008 defense spending bill marked up last week says a 20% cap is needed because overhead costs have "grown to unwarranted levels."

That's just not true, says Robert Berdahl, president of the Association of American Universities in Washington, D.C. The average indirect cost recovery rate has remained at about 51% for a decade, he says, despite the rising cost of supporting research. The proposed cap, if retained in the final defense spending bill now moving through Congress, could even force schools to forgo DOD grants, he adds.

–YUDHIJIT BHATTACHARJEE

Don't Be Put Off by Offsets

The head of a new congressional panel on climate change wants the U.S. government to more closely monitor the $100 million global market for voluntary carbon offsets, credits for green projects that companies and individuals purchase from specialty brokerage firms to compensate for carbon-intensive activities. Some climate scientists say offsets, which include forest projects and energy work in the developing world, are a distraction from the real need: cutting greenhouse gas emissions.

Representative Edward Markey (D–MA), chair of the House Select Committee on Energy Independence and Global Warming, feels offsets could play a positive role. But he thinks consumers need more information. He wrote the Environmental Protection Agency last week that "a lack of generally accepted standards has raised questions about the credibility of some offset products." He wants the agency to develop such standards, and he's also asked the Federal Trade Commission to devise guidelines for those who market such offsets.

–ELI KINTISCH

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in Golden, Colorado, measured the overall solar-cell efficiency under simulated conditions; a separate NREL team built several of the cells used in the device. The device is based on well-known semiconductors tuned to respond to specific wavelengths using doping and other physical tweaks the researchers won't reveal. New electronics allowing parallel power generation gave them additional freedom, as cells within modules connected in series produce as much electricity as their weakest link.

Each of those advances, however, although promising in the lab, could be pricey to build. Most recent commercial solar efforts have focused on making cells cheaper to manufacture, not on increasing efficiency. Kirkpatrick says the manufactured cost goal for the program is $2 per peak watt, 45% under the current industry standard. "That's the key to success," says solar energy manager Craig Cornelius of the Department of Energy, who says it can take up to 15 years for new solar-cell architectures to make it into the marketplace.

But DARPA is hoping for faster results. With the early proof of concept in the bag, research partner DuPont has announced a 3-year commercialization effort with the Delaware team to spend up to $100 million to build prototype devices. Meanwhile, the researchers are continuing work with advanced kinds of cells, including nanotech and bio-inspired varieties, hoping later to use better performing materials in what Kirkpatrick calls a "plug and play" approach. "The building blocks are all in place," says Delaware physicist Robert Birkmire.

–ELI KINTISCH

IMMUNOLOGY

A Slimy Start for Immunity?

Even slime molds get sick. Although these gooey soil dwellers, which straddle the boundary between single-celled and multi-celled creatures, gobble up bacteria as food, they can also be laid low by microbial attacks. On page 678, however, researchers report that slime molds deploy cells that combat pathogens, a discovery implying that specialized immune cells preceded the advent of multicellular organisms.

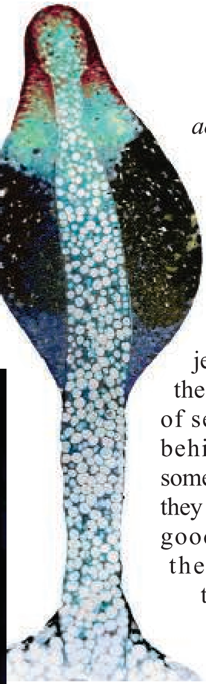
Developmental biologist Adam Kuspa of Baylor College of Medicine in Houston, Texas, and colleagues also found that the germ fighters depend on a protein used by the more sophisticated defensive systems of plants and animals. The work "shows how molecules that play a role in innate immunity are already present in amoebas," says cell biologist Michel Desjardins of the University of Montreal in Canada.

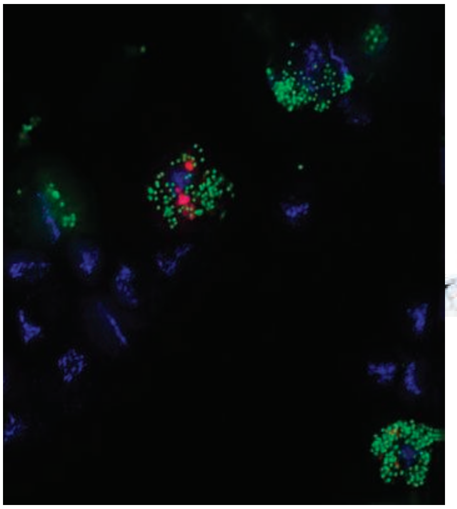
Immunity's origins are murky. Because single-celled amoebas swallow their bacterial meals in much the same way that macrophages and other immune cells envelop their targets, researchers have long suspected that food consumption gave rise to this style of self-defense.

The widely studied social amoeba *Dictyostelium discoideum* has now provided strong endorsement of that idea. The amoebas, also known as cellular slime molds, lead a double life. Much of the time, they are squishy individualists. But if food runs short, as many as 100,000 cells congregate into a slinking blob known as a slug.

The Baylor team was investigating how certain transporter proteins help the amoebas slurp up fluorescent dyes, which were proxies for environmental toxins. They noticed that the dyes mainly ended up in a subset of cells, whose job appeared to be eliminating poisons.

The researchers then discovered that these cells, which they dubbed sentinel cells, also battle bacteria that menace the slug. In lab dishes, the cells snared the amoeba's main pathogen, the soil germ *Legionella pneumophila*, banishing it from the slug. Although researchers knew that some parts of the slug specialize, for example, forming a spore-holding stalk, nobody had discerned these protective cells, Kuspa says.





To the rescue. A crawling slime mold slug (*right*, false color) protects itself with sentinel cells. These defensive cells (*above*) capture fluorescent beads (green) much the way they do bacteria.

Once they differentiate in a slug, sentinel cells crank up production of proteins involved in immunity in other organisms, including a pathogen-detecting cell surface receptor and a so-called TIR domain protein that relays signals from such receptors. Disabling the gene for one TIR domain protein in the sentinel cell armory disrupted how cells handled bacteria. The mutant amoebas fell victim to a strain of *L. pneumophila* that they typically fight off. And although typical *D. discoideum* grow vigorously on plates coated with tasty *Klebsiella aerogenes*, their normal food, the mutants languished. If those bacteria were dead, however, the altered amoebas thrived.

Sentinel cells circulate within the slug as if they are on patrol, and they appear to jettison globs of pathogens as the blob chugs along. Clumps of sentinel cells also get left behind, suggesting that, like some mammalian immune cells, they sacrifice themselves for the good of the body—although the castoffs could also be the seeds of new colonies, Kuspa says. This rudimentary immune system is not a peculiarity of *D. discoideum*: Five other slime molds also sport the cells.

Sentinel cells seem to function like human neutrophils and macrophages, Kuspa and colleagues conclude. To benefit the rest of the slug, he says, "1% of the cells essentially put themselves in harm's way." Social amoebas and their kin diverged shortly after the animal-plant split, and the results suggest an early beginning for the specialized immune system now seen in multicellular organisms.

The discovery of dedicated defenses in the amoebas isn't surprising, says comparative immunologist Edwin Cooper of the University of California, Los Angeles. "If you're multicellular, you need to be sure that some of those cells are protecting against bacteria." Immunologist Ruslan Medzhitov of Yale University suggests that researchers check for rudimentary immunity in other simple eukaryotes, such as solitary amoebas and *Volvox*, a colonial organism with some cell specialization.

–MITCH LESLIE

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