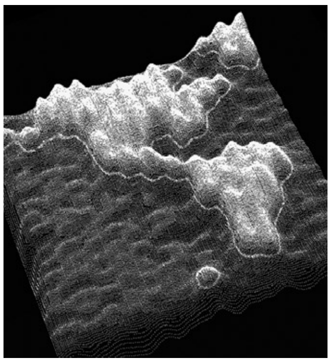
From the Lab to the Gallery



Right: Rothemund's DNA origami of North and South America rendered as a three-dimensional glass etching.

Below: Lang's *Snack Time* depicts the wedding feast of a female praying mantis on her unfortunate male partner. And yes, this was folded from a single uncut square of paper.

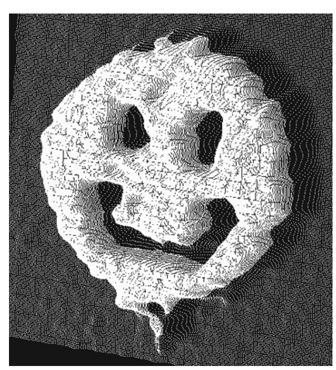
Matisse, Picasso—and now, DNA and computational origami. Science, art, technology, and design come together in a new exhibit at the Museum of Modern Art in New York. The show, entitled Design and the Elastic Mind, includes work by two Caltech alums—origamist Robert Lang (BS '82, PhD '86) and Paul Rothemund (BS '94), a senior research associate in computation and neural systems and computer science.

Rothemund, one of Caltech's two 2007 MacArthur "genius" grant winners, invented "DNA origami," in which he turns strands of DNA into any desired flat shape, from a smiley face to the outline of a contient. He took DNA from a harmless virus and developed a method to fold and pinch strands together. The result is a powerful way to build nanoscale structures out of DNA. The shapes measure about 100 nanometers, or 100 billionths of a meter, across—about one thousandth of a hair's breadth.

In addition to atomic-force micrograph (AFM) prints of Rothemund's creations, the exhibit includes representations of the AFM scans etched into glass blocks, using the same techniques used to make laser-etched glass paperweights.

Lang has combined his love of mathematics and paper-folding, becoming one of the pioneers in computational origami—the art and science of designing origami with mathematical techniques. The exhibit showcases some of his intricate creations, as well as the TreeMaker software he wrote to make his increasingly complex designs.

Both types of origami are displayed alongside a myriad of provocative exhibits, including a honeycomb vase, pig bone tissue grown into the shape of wings, and furniture modeled after human bones. The show runs through May 12. □—*MW*



Right: Have a nano day!

On March 6, the post office issued its second series of four American Scientists stamps. This set includes Caltech Nobelist Linus Pauling (PhD '25). The background art refers to his discovery that sickle-cell anemia is a molecular disease—the first to be recognized as such. Caltech is two-for-two in this series of stamps: the first set, issued in 2004, included fellow laureate Richard Feynman.

Getting Nanowired

One day, they could be everywhere, powering your computer and keeping its microprocessor cool at the same time. They're silicon nanowires, narrow devices hundreds to thousands of times thinner than this piece of paper. Two groups of Caltech researchers are discovering the remarkable properties of silicon nanowires, enabling the wires to harness solar power and to act as refrigerators by converting heat to electricity, and vice versa.

The latter group, led by James Heath, the Gilloon Professor and professor of chemistry, found that silicon could be an efficient thermoelectric material when made into wires only 10 nanometers (10 billionths of a meter) wide. "At these tiny dimensions, nature is doing things that were previously not thought possible," he says.

In a thermoelectric material, a difference in temperature sends electrons scurrying to the cooler end, creating a current. To be efficient, the material must conduct electricity well; but to maintain a temperature difference, it must conduct heat poorly. Most thermoelectric materials efficient enough to be useful are expensive and hard to make, restricting them to niche applications. Silicon, on the other hand, is one of the most abundant elements in the universe. The microprocessor industry has also made processing silicon inexpensive and easy. But because silicon is also an excellent conductor of heat, it didn't seem promising as a thermoelectric material—until now.

By growing silicon into nanowires, researchers in Heath's lab improved silicon's thermoelectric efficiency by a factor of 100. One of the reasons for the enhanced performance might be a phenomenon called phonon drag, according to the team. Phonons are heat-carrying vibrations that travel across the material. Constricted by the small size of the nanowire, the phonons don't scatter off the sidewalls in the nanowire. Instead, they travel unimpeded down the wire and drag electrons with them, which improves thermoelectric performance.

Although the silicon nanowires are still only about half as efficient as state-of-the-art thermoelectric materials, further improvements—as well as lower manufacturing costs—could make these tiny devices useful in a host of applications. They can make microprocessor chips more efficient by recovering leaked heat. Eventually, they may be able to recover heat from larger systems like car engines, and may also be used in refrigeration devices. The researchers, who include William Goddard (PhD '65), the Ferkel Professor of Chemistry, Materials Science, and Applied Physics; Jamil Tahir-Kheli (MS '86, PhD '92), a senior staff scientist with the Materials and Process Simulation Center; and graduate students Akram Boukai (PhD '08), Yuri Bunimovich (PhD '07), and Jen-Kan Yu, reported their findings in the January 10 issue of *Nature*.

Silicon nanowires may also help solve the energy crisis. Researchers in the labs of Nate Lewis (BS, MS '77), the Argyros Professor and professor of chemistry, and Harry Atwater, the Hughes Professor and professor of applied physics and materials science, are using the wires to build a new kind of photovoltaic cell.

Most conventional cells are made from silicon wafers. Incoming photons from the sun are absorbed by the silicon and dislodge electrons from their atoms. The electrons are then free to move, producing enough current to power calculators, light bulbs, and even entire homes. The drawback is that these solar cells must use pure, top-quality silicon, which is expensive to process.

Growing silicon nanowires is not only cheaper, but can also be done with lower-quality silicon. The trick to turning nanowires into solar cells is a unique geometry, an idea first developed by graduate student Brendan Kayes (MS '04) in 2005. Regular solar cells are flat, and absorb photons face-on. The newly freed electrons then move along the same direction, parallel to the incoming photons. They're collected at the surface of the silicon slab, where they then join the electrical current. Additionally, the cells have to be thick enough to capture all of the photons.

In the new photovoltaic cells, silicon nanowires sit alongside one another like blades of grass. Light is absorbed along the length of the wires, which, at tens of microns, are still long enough to snatch all the photons. The advantage of this configuration, however, is that the electrons move widthwise—perpendicular to the photons' paths. The nanowires are only several microns in width, so the electrons don't have to travel as far, allowing them to produce electricity more easily. Once the electrons are collected in the outer shell of the wire, they quickly travel to the top of the wire and enter the current.

The team has made nanowire arrays one square centimeter in area—orders of magnitude larger than any made before. The researchers have also been able to embed the nanowires in a flexible membrane for added versatility. The membrane is excellent at absorbing light, as is evident from its near-black color.

The best conventional silicon solar cells are about 25 percent efficient at converting sunlight to energy, says postdoc Michael Filler. The researchers' nanowire cells are just over one percent electrically efficient. But Filler says they are making rapid progress, and are aiming for 20 percent efficiency. "Our group has been pushing the forefront of the field right now," he says. Other members include postdocs Stephen Maldonado and Kate Plass, and graduate students Michael Kelzenberg (MS '06), James Maiolo, Leslie O'Leary, Morgan Putnam, and Josh Spurgeon (MS '06). Once the researchers achieve higher efficiencies, Filler hopes industry will jump in and push the design toward commercial use within the next decade. □—*KS/MW*

Dances with DNA

Nature is a software engineer par excellence. By rearranging protein and RNA building blocks, nature programs myriad molecules to synthesize, haul, detect, and regulate one another. Now scientists are trying their hands at it, and in the January 17 issue of *Nature*, a group of Caltech researchers published examples of their own molecular programs. Associate Professor of Applied and Computational Mathematics and Bioengineering Niles Pierce, senior postdoctoral scholar Peng Yin, grad student Harry Choi, and research technician Colby Calvert showed how molecules of DNA only ten nanometers in length could be directed to perform specific tasks unaided—without external energy sources, temperature changes, or enzymes.

Biomolecular engineers have assembled DNA molecules into stable patterns, like planar crystals, wireframe cages, tubes, smiley faces, and maps of North America. Pierce and his colleagues concentrate on the motion of the interacting DNA molecules. To see the distinction between these approaches, consider the difference between a choreographer (Pierce) and a cheerleading coach. The coach primarily cares where the cheerleaders end up in a human pyramid: stronger, heavier people go on the bottom, while more agile, lighter people are at the top. He doesn't care how they get there: all's well that ends well. By contrast, when directing dancers, the choreographer cares most about how the dancers move across the floor and who they partner with. Where they end up is of less importance. "The trajectory the molecules take is actually the goal of our programs, and the destination is just the by-product: it's what you get when the function is complete," says Pierce.

The dancers are short "hairpins" of DNA that fold back onto themselves. Each hairpin has three domains—one input and two output—that can interact with domains in other hairpins by matching the "letters" in one strand with the letters in another. In the alphabet of DNA, A pairs with T and G matches C; the hairpins contain between 50 and 100 letters. The hairpin's input domain is initially available to pair up with other DNA molecules, while its output domains are inaccessible. Once a matching piece of DNA binds to the input domain, the hairpin pops open and the output domains are exposed. Output domains of open hairpins can then seek out the input domains of closed hairpins and open those molecules. The ensuing cycle becomes a molecular square dance with hairpins exchanging partners according to the design of the bioengineers.

All of these exchanges occur without Pierce having to add energy to the system. So what makes them go? "The basic feature of the hairpin is that it's initially trapped in a high-energy state," says Pierce. This state is similar to a mousetrap that has been set and baited. Until a mouse trips the trigger, the trap is stable and doesn't move. But within the spring of the trap, there is energy waiting to be released when the unsuspecting mouse goes for the cheese. A piece of DNA binding to the input domain triggers the hairpin to release the stored energy locked up in the inaccessible output domains—when the output domain pairs up with still other pieces of DNA, the entire system goes to a lower-energy state.

By designing how each hairpin domain pairs with its fellows, the Caltech team can harness this energy to make the molecules perform the specific task they want. This part of the design process is the most difficult, and requires the team to model the physics of the hairpins. Using algorithms developed by Pierce's group, the researchers ensure that when the hairpins are mixed together, they interact appropriately so that no hairpin runs off with another hairpin's dance partner.

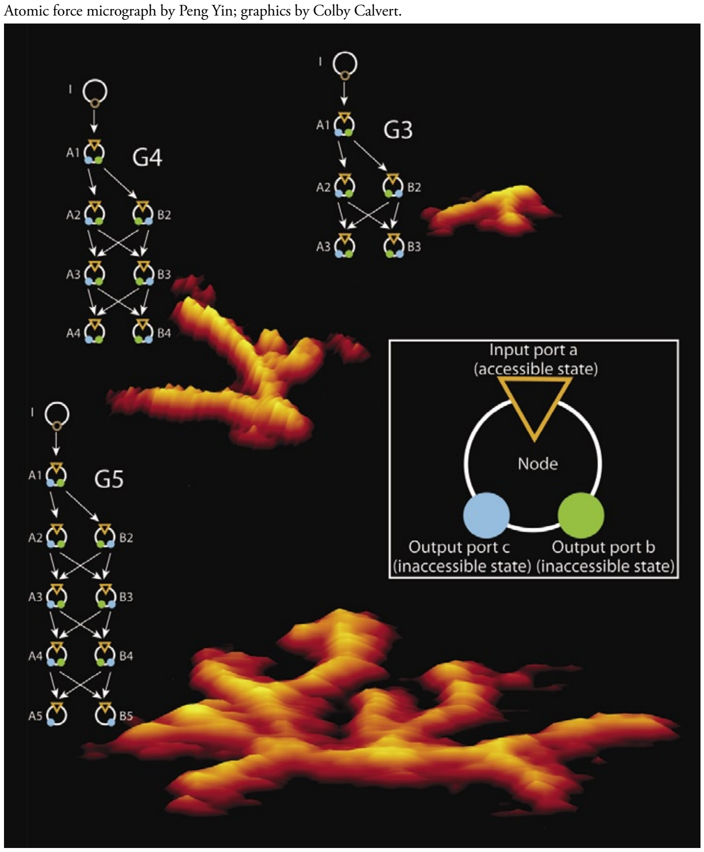
To showcase the hairpins' capabilities, Pierce and his colleagues "wrote" four different programs. In each case, the hairpins were designed not to interact until an initiator molecule was introduced to the system. For the first program, the initiator triggered the hairpins to self-assemble via a specified sequence of "handshakes" into branched structures with multiple arms shooting out from a central point, like three- and four-armed starfish. Upon completing this assembly process, the initiator then disassembled from the structure to catalyze the formation of more starfish. In the second program, the hairpins assembled into a tree-like pattern called a dendrimer, growing from the root of the tree to the leaves. Another program demonstrated a phenomenon called autocatalysis, in which a chemical reaction—in this case, the production of fluorescent pairs of hairpins—feeds on itself. After the initiator was added to the solution, the test tube would begin to glow, getting brighter and brighter exponentially. The most dramatic example was a DNA "walker" that used its DNA "legs" to lurch along a DNA track one step at a time. The walker was inspired by the protein kinesin, which glides along protein microtubules in cells to move molecular freight. "Years ago, I was amazed when introduced to the programmable chemistry of kinesin. I decided then and there that I wanted to be able to engineer that kind of molecular complexity. We still have a long way to go," says Pierce.

Pierce foresees these hairpins being put to use as molecular sensors or nanomechanical drugs. Molecular instrumentation could detect small changes within cells, like the switching on of a gene within a developing embryo, producing a fluorescent signal for scientists to read and analyze. He hopes that programs like the exponentially glowing one could develop into cheap technologies that would amplify the presence of a miniscule amount of an interesting molecule into a detectable signal. "Instead of thinking of instrumentation as something expensive that your experiment resides within, we want to design exquisite instruments that you embed within your system of study," says Pierce. Programmable molecules may also eventually lead to dynamic drugs that use one input domain to pinpoint cancer cells, triggering an output domain to kill them.

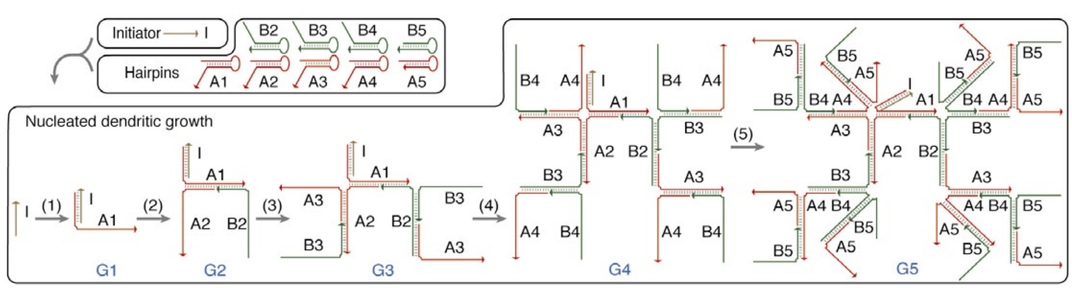
For Pierce, the work represents a step toward the long-term goal of developing a compiler for biomolecular functions that would allow bioengineers to write molecular programs the way that computer scientists write electronic ones. A compiler is the software that translates high-level programs written in a language like C++ into the binary instructions the machine actually executes. As a first step, the team has developed graphical representations of their hairpins that are used in schematics, called reaction graphs, to describe each step in a program—for example, an output domain on strand C binding to an input domain on strand D in step four, only to unbind again later in preparation for the next cycle. These reaction graphs are not unlike the flow charts beloved of computer programmers. As a software package, the molecular compiler would translate an engineer's design ideas into reaction graphs and then translate those graphs into a specific set of DNA hairpin sequences to be synthesized. "We want to liberate the molecular engineer from having to think about the detailed structural features of the molecules and instead focus on the functional behavior of the system," says Pierce.

"In designing a compiler, there's work for many different fields: computer science, applied mathematics, control and dynamical systems, chem-

Atomic force micrograph by Peng Yin; graphics by Colby Calvert.



Left: How to grow a ninja-star dendrimer. The *Matrix*-esque glyph to the left of each stage is the reaction graph, or programming instructions, for making it. Left, inset: The key to the reaction graphs. Each circular "node" represents a DNA hairpin. Input domains are triangles; output domains are circles. Inaccessible domains are filled with solid colors. Binding to an accessible domain will open the inaccessible ones. Arrows between the nodes indicate what binds to what. Below: The dendrimer is built from five kinds of A hairpins and four kinds of B hairpins that assemble themselves in sequence according to the reaction graphs.



Inset and bottom figure reprinted by permission from Macmillan Publishers Ltd. from Yin, et al., *Nature*, vol. 451, January 17, 2008, pp. 318–323. Copyright 2008.

istry, and physics," says Pierce, who is teaming up with other researchers at Caltech and elsewhere on the project. "Building a molecular compiler is a very daunting challenge, but progress in the field has been pretty dramatic in the last five years, so a primitive first-generation compiler is probably now within reach," says Pierce. Even so, the day when dancing molecules detect and kill cancer cells in humans is probably still far in the future. ☐—*MT*

How Do You Get to Carnegie Hall?

Practice! And that's exactly what everyone in the Caltech-Occidental Concert Band has been doing. On Saturday, May 24, about 60 musicians, including Caltech and Occidental College students, Caltech faculty and staff, JPL employees, and members of the local community, will perform at Carnegie Hall. "We are extremely excited about this," says senior physics major and clarinetist Lauren Porter, who has been integral to organizing the trip. "It's a huge opportunity for us, and the culmination of a lot of hard work."

Band director and artist-in-residence William Bing, a professional trumpet player, has performed at such venues as Lincoln Center, the Kennedy Center, and Disney Concert Hall, but this will be his first apperance at Carnegie Hall. He handpicked the concert's pieces to fit the venue. For instance, "Chorale and Alleluia," by Howard Hanson, was chosen because it suits the renowned acoustics of the hall. "A Prairie Hymn," by Joseph Curiale, on the other hand, was chosen for its "meditative quality, and it's a contrast to the other pieces, which are much louder," according to Bing.

Paul Asimow, associate professor of geology and geochemistry at Caltech, will be conducting "Be Glad Then, America," by William Schuman, which Asimow has known since playing as a student at Harvard. Asimow says the piece treats the timpani as melody makers, not rhythm instruments. "Our timpanist, Scott Babcock, is one of the few professional members of the band, and I am happy to give him this opportunity."

Also featured is vocal soloist Kjerstin Williams (BS '00, MS '02, PhD '06), on George and Ira Gershwins' "Someone to Watch Over Me." Williams has been a trombonist with the Caltech jazz and concert bands since her freshman year, but singing brings her an indescribable thrill. "To sing with a wall of music behind you, there's nothing quite like it," she says. "Karaoke doesn't even begin to touch it."

If you live near the Big Apple and would like to catch the show, visit http://www.carnegiehall.org or call 212-247-7800 for tickets. ☐—*JS*

Caltech Connects with Local Classrooms

As a Caltech grad student, I *never* get to work at a quarter after 7 a.m., but when I join science teacher Tobias Jacoby in his classroom at Blair High School in Pasadena, this is when my day begins. Mr. Jacoby and I have been paired up through the Caltech Classroom Connection (CCC), an outreach program that brings together Caltech graduate students, postdocs, faculty, and staff with Pasadena teachers. The hope is that putting people who practice and love science into the classroom might inspire students to take it more seriously—in their course work, and maybe also in their career plans.

The guidelines for interaction within teacher-Techer pairings are pretty loose; each pair decides how to spend their time together. For some teachers, science is a little outside their comfort zone, and they enjoy the confidence boost of having an expert volunteer on hand to field difficult questions. "It's so great to have someone with me who I don't have to explain everything to, because he just knows," gushed one teacher, describing her volunteer at a recent CCC dinner. Other teachers—like Jacoby, who is perfectly at ease explaining torque, momentum, and kinetic energy—can really use an extra set of hands, as well as someone to bounce

Thalia Reyes (left) and Maria Murillo, physics students at Pasadena's John Muir High School, try to turn on a light-emitting diode (LED) with a battery made from a potato, a zinc nail, and a penny during a CCC-assisted lab session. Photo by their physics teacher, Dave Herman.

ideas off of for new labs and activities.

During my classroom visits, I have mostly been helping out with labs and problem-solving sessions. Today I am helping out with a physics lab on collisions, and before the students arrive we set up five-foot-long, low-friction tracks on tables around the classroom. We place two brick-like carts with magnetic front bumpers on each track. The students will roll one cart into the other, stationary cart to observe how momentum is conserved in elastic and inelastic collisions. In an elastic collision, the magnets repel each other, and the carts rebound. In an inelastic collision, the bumperless ends collide with a satisfying "thunk," and the moving cart comes to rest, sending the stationary cart rolling down the track. A motion detector positioned at one end of each track records the positions and velocities of the carts over time.

There are 45 students in this class, one of two large classes Jacoby teaches in addition to a smaller IB (international baccalaureate) group. At first glance they seem to be masterfully combining high social energy with academic lethargy: friends giggle and chat and seem to pay no mind to the assignment at hand. They make the people I interact with in an average day at Caltech seem awfully sedate.

I circulate among the groups. There are some questions about the instructions. I demonstrate the use of the motion tracker for one group, sliding the cart slowly along the track as the position and velocity are plotted on a laptop screen. "Wow," said one girl. "I actually understood that because someone actually explained it to me." She just made my day.

It's a challenge to come up with activities aligned with the state's science standards, using inexpensive and readily available materials. CCC volunteers are succeeding admirably and having fun in the process. One volunteer used Kool-Aid to demonstrate the concept of molarity to a chemistry class. The students made several batches of Kool-Aid with different proportions of powder and water, and then calculated the concentration—or molarity—of sugar in each, by assuming that Kool-Aid is 100 percent glucose. They then related how the drinks tasted to their sugar concentrations. Another volunteer demonstrated that energy could take on different forms by powering an LED with a battery made by sticking a zinc nail and a copper penny into a potato. Volunteers are endowed with a small budget for supplies; after purchasing a graphing calculator for his class, a volunteer demonstrated for his group how optimization can be used to figure out the most efficient combination of ingredients to make Cheez Whiz.

As I relive the high-school physics curriculum, it strikes me, as it has many, that science as taught in schools doesn't really tell kids anything about how scientists do their jobs. In my class, I hope to use some of the time devoted to magnetism to tell students about one of the tools I use in my own neuroscience research: magnetic resonance imaging. Maybe with the help of some cool pictures, showing detailed brain structures and specific regions that light up when people learn reward associations, I can impress upon them that physics is important for many fields of study: biology, psychology, medicine, and engineering.

The CCC works with the Pasadena Unified School District, which has seen its ups and downs through the years. As a district where a high proportion of parents send their kids to private schools, the public system is left to fend for itself. In my classroom, the diverse group of students is friendly and open with each other, and Blair strikes me as a safe and genial place to learn. That said, class sizes are large, resources are scarce, and state test scores are often below standard.

Founded in 2002 by Eddie Branchaud (MS, PhD '06), then a mechanical-engineering graduate student, the CCC has grown from just a few teacher-Techer pairings to 20 this year. This growth has been possible thanks to funding from the Howard Hughes Medical Institute, Caltech's Moore-Hufstedler Fund, the Mattel Children's Foundation, and the National Science Foundation, secured with the help of faculty director Christina Smolke, assistant professor of chemical engineering. This generous support has enabled the hiring of James Maloney (MS '06) as full-time codirector. He acts as an ambassador for the project, visiting local schools and sitting on education committees. His presence has helped secure an ample supply of teachers who are interested in participating in the program—what they need now is Caltech volunteers to match. (If you think you might be interested in participating, please visit http://www.classroomconnection.caltech.edu/ or email ccc@caltech.edu.)

Graduate students Tara Gomez and Jennifer Franck (MS '04) codirect with Maloney. The trio is extremely proactive about providing support to volunteers. "We want to make sure that grad students are getting some good teaching experience from the program, and we hope that this will help them decide if they want teaching to be a part of their future," says Franck.

It's really striking how much fun volunteers are having with students at all levels. As a scientist walking into a third-grade class, "you get treated like a rock star," says Maloney. Kids that age are so naturally curious that a simple, hands-on demonstration can be the basis for a great lesson.

My high-school group is a little more aloof, and at first I worried that they would just dismiss me as a hopeless nerd. They very well may, but I'm not in high school anymore—so who cares? My students always make me laugh, and if I can say or do some small thing to help them squeeze a passing grade out of the torture session that is high-school physics, then we will both be happy. □—*SB*

Signe Bray is a graduate student in computational and neural systems who does brain imaging in the labs of Professor of Biology Shinsuke Shimojo and Assistant Professor of Psychology John O'Doherty.

Martian Avalanches

JPL's Mars Reconnaissance Orbiter has captured the first-ever picture of Martian avalanches in action. The dramatic image below, taken on February 19, shows billowing clouds marking the course of dust and ice spilling down a 700-meter-high cliff that slopes at more than 60 degrees.

The High Resolution Imaging Science Experiment (HiRISE) camera shot a swath of terrain some six kilometers wide by more than 60 long near the Martian north pole. The frame captured at least four avalanches—in this close-up of one of them, the dust cloud is 180 meters across. The white to the left in this false-color rendering is carbon-dioxide frost at the top of the cliff.

This action snapshot provides a rare glimpse of the Red Planet's geology in motion. Scientists will compare it with previous shots of the area, and more observations through the Martian summer might reveal details about how the ice erodes. □—*MW*

Marketing Gets into Your Head

Do you often lust after the most expensive item on the shelf?

You're not alone. After all, expensive stuff is coveted—by definition. Otherwise, why would people pay exorbitant prices for things they really don't need?

Take wine, for example. On surveying a wine menu in a fancy bistro, you might be tempted to judge the quality of the wines by their price. And why not? The more expensive wines are probably better, and will likely be a tastier accompaniment to your tuna carpaccio.

Now suppose that your usually cheap date orders an expensive bottle before you sit down, but you take a sip assuming that she chose her usual house red. Would you enjoy it more had you known that she made an uncharacteristic splurge? A new study led by Caltech Associate Professor of Economics Antonio Rangel (BS '93) suggests that yes, the mere knowledge that a bottle is pricey can cause you to enjoy it more.

In a paper published in the January 2008 issue of the *Proceedings of the National Academy of Sciences*, Rangel, postdoc Hilke Plassmann, Associate Professor of Psychology John O'Doherty, and Stanford Professor of Marketing Baba Shiv describe performing a little bit of trickery on a batch of study participants recruited largely from the Caltech community. "We advertised we'd pay people money for tasting wine—everybody was willing," says Plassmann. During the study, participants were asked to sample five wines identified only by their price.

Unbeknownst to the eager tipplers, however, two of the wines were the same but labeled with two different prices, one markedly higher than the other. For example, a $90 wine was presented sometimes as a $10 wine and other times at its true retail price.

After tasting the wines, people were sometimes asked to evaluate either the intensity of the flavor or the pleasantness of the taste. It turns out that a $90 wine doesn't taste nearly as good when you think that it costs $10. Both wines that were presented at two different prices were rated as more pleasant when identified with the higher price tag. However, the flavor intensity ratings, which acted as a control question, were not affected by the labeled price. Follow-up questions showed that participants truly believed that they tasted five distinct wines.

Eight weeks after the initial study, participants were invited back to taste the wines again, this time without any price information. Not surprisingly, without the price tags, the difference between two samples taken from the same bottle disappeared. And this time, the wine people liked the most was actually the cheapest—a $5 bottle.

"In marketing, people spend a lot of money to create brand associations in people's minds, and establish a price-quality relation," says Plassman, "and we know that it works. Marketing studies demonstrate that people perceive more expensive items as higher quality. But does it taste different, or do people rationalize? We didn't know."

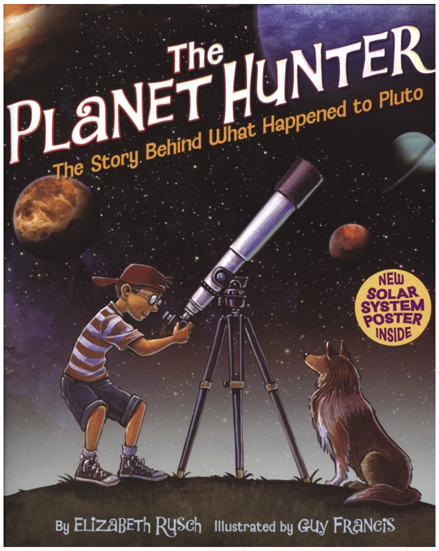
To answer this question, the researchers looked at what was going on in participants' brains while they sampled the wines. They used functional magnetic resonance imaging, a technique that takes a three-dimensional snapshot of activity throughout the brain at a rate of about once every two seconds. They compared brain responses to the wines presented as expensive to responses when the same wines were presented as less expensive, and found that the medial orbitofrontal cortex was more active when people tasted the more expensively labeled wine. This region is located above and between your eyeballs, and is involved in processing experiences we deem rewarding, like winning money and smelling food. Activity in this area was correlated with people's expressed enjoyment of the wine, which tended to be greater the more expensive the bottle.

This is not the first study to show that information culled from sources other than our noses and taste buds can influence our enjoyment of a smell or taste. An earlier study by an Oxford University research team led by Edmund Rolls tested the impact of labels on our perception of an odor. They gave participants a whiff of cheddar cheese while a computer monitor displayed either the words "body odor" or "cheddar cheese." Not surprisingly, people preferred the scent labeled as cheese. Activity in both the orbitofrontal cortex and another region involved in processing emotional information, the amygdala, mirrored this preference.

But this study is the first to show that marketing actions, in the form of hefty price tags, can have an effect on the brain. The authors propose that activity in the orbitofrontal cortex reflects a value that the brain assigns to the wine that combines information about its taste and its price. Activity levels are higher the more impressive the overall value, teaching the brain to make this excellent choice again.

The brain's propensity to integrate outside knowledge into what we think are internally generated opinions might make humans seem like dangerously manipulable creatures. But we evolved in social groups, so why not make use of the group's wisdom when making decisions? If you are unable to ascertain the value of an item for yourself, integrating other people's impressions into your judgment might not be a bad idea.

Unfortunately, the wisdom of the group is not going to help you pay for that expensive bottle, or prevent you from indulging in regrettable trends. If your brain can trick you into thinking something tastes better than it does, could this explain those terrible '50s food fads? Spam-and-fruit-cocktail gelatinized party loaf, anyone? ☐—*SB*



The Planet Hunter: The Story Behind What Happened to Pluto
by Elizabeth Rusch
Illustrated by Guy Francis
Rising Moon, 2007
32 pages, $15.95

High-achieving researchers often get their share of the spotlight. They win prestigious prizes, go on national television and radio, have books, and newspaper and magazine articles written about them and their discoveries. But rarely do you see a scientist featured in an illustrated children's book.

Professor of Planetary Astronomy Mike Brown now has that distinction. He is the hero of *The Planet Hunter: The Story Behind What Happened to Pluto* (Rising Moon, 2007), a children's book written by Elizabeth Rusch and illustrated by Guy Francis. Rusch tells the story of Brown's childhood, his discovery of Eris—briefly known as the 10th Planet—and the subsequent vote that demoted Pluto and made headlines around the world.

A perusal of children's books about scientists turns up stories about the likes of Albert Einstein, Galileo, and Leonardo da Vinci—subjects who tend to be old and dead. So if you're like Brown and don't fit either category, how do you get a children's book written about you?

In January 2005, Brown discovered an object in the Kuiper Belt, a population of at least 70,000 icy bodies beyond the orbit of Neptune. But this object, nicknamed Xena (as in the television series' Warrior Princess), was bigger and farther away than Pluto. Controversy swirled over whether the shiny sphere, now officially named Eris, was indeed the 10th planet. If it wasn't a planet, Pluto shouldn't be either, since both objects are markedly different in size, orbit, and location—among other characteristics—from the other eight planets.

Rusch had been engrossed in the debate since the beginning, she says. In August 2006, the controversy came to a head as the International Astronomical Union convened in Prague to vote on the definition of a planet. Rusch realized the implications of the vote were huge, regardless of the result. Every book, poster, and placemat adorned with the solar system loved by children everywhere would have to be changed. This dramatic revision would have to be explained to kids, says Rausch, who has written for both adults and children. "It wasn't so much that [Brown] discovered the 10th planet," she says, "but that our understanding of the solar system was going to change one way or another, and the story behind that had to be told." She wanted to show that science was about constant discovery involving real people, and not just facts to be memorized from a textbook.

She pitched the idea to her editor, got quick approval, and, just a week after Pluto got the boot, sent Brown an e-mail requesting an interview. Initially unsure about the request—admittedly an odd one for an academic—Brown agreed to talk and help with the book. Swamped with media requests and other distractions from the "crazy Pluto thing," as he calls it, Brown then forgot about the project. "The funniest part of this, at least to me, is that I have almost no memory of this," Brown says. "There were so many other things going on, this was just one of a million things that were happening." In fact, Brown neglected to tell his wife until the book came out in December 2007.

Since the topic was a timely one, the project had to move swiftly. The fact that it took just over a year from pitch to publication is an anomaly, Rusch says. Normally, children's books can take three years to publish. The editor found an illustrator, Guy Francis, who, as it turned out, illustrated the favorite book of Brown's two-year-old daughter, Lilah. Everything came together smoothly, as if, well, the eight planets were aligned.

For Rusch and Brown, the final product was a success. According to Brown, "The story is dead accurate," including such details as his failed childhood attempts at rocketry, illustrations of his childhood dog Roscoe and the green 1964 Volkswagen Beetle he drove in high school, and the discovery of Eris and the demotion of Pluto. He's not sure how successful it'll be in bookstores, but "it's fun to watch the Amazon rankings," he says. At the time of this writing, it's number 138,554, and at one point reached the top 25 in the category of science and technology biographies for children, joining Einstein, da Vinci, and others who are old and dead. *The Planet Hunter* has also been nominated for a 2008 Pacific Northwest Book Association Award.

The fact that Brown has a young daughter helps him understand the book's audience, he says. Lilah, who appears in the story, loves the book. "She thinks it's the book about her," he says.

The last illustration portrays Brown with Lilah a few years older, looking at the night sky with a telescope. "When I was flipping over the proofs, I saw that, and my heart just sort of melted," he says. "I have a soft spot for the book just for that." □—*MW*

Annenberg Groundbreaking

Caltech will soon have a new home for its interdisciplinary program in information science. The first institution in the nation with such a program, Caltech broke ground for the Walter and Leonore Annenberg Center for Information Science and Technology on December 7.

The field of information science is as broad as it sounds, encompassing many areas of science and engineering from the theoretical foundations of information to how nature handles it in biological systems to how it shapes social systems.

"When you're crossing so many different disciplines, when you're reinventing the very boundaries of science and the way it can improve our lives, you deserve a research home, an intellectual crossroads that is as collaborative and inclusive and revolutionary as the work itself. This center will be that home," said Wallis Annenberg, vice president of the Annenberg Foundation, which donated $25 million to build the center. Stephen D. Bechtel Jr., a life trustee of Caltech, recently awarded $1 million to the project. Caltech hopes to raise a total of $31.5 million.

The 50,000-square-foot building will contain an 80-seat lecture hall, several small classrooms, an instructional computer lab, and studio and office space for faculty and students. The center will also feature atrium and lounge spaces to promote collaboration and interaction. The building's exterior is mostly glass, with a window in nearly every room, connecting the structure with the campus, said Frederick Fisher, the principal architect.

The center will also herald a new information-based curriculum at Caltech, and possibly beyond. "The dream is very vivid in my mind," said Jehoshua "Shuki" Bruck, the Gordon and Betty Moore Professor of Computation and Neural Systems and Electrical Engineering and founding director of the Information Science and Technology initiative. One day, he hopes, information will be taught in schools and universities alongside traditional subjects like history or physics.

The Annenberg Center aims for a Silver rating from the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council. Slated for completion in the summer of 2009, it will be one of three new LEED-rated buildings on campus. □—*JP/MW*

PICTURE CREDITS: 2 — Paul Rothemund, Robert Lang; 3 — USPS; 8, 12 — NASA/JPL-Caltech/U. of Arizona; 11 — Audrey Wu, Dick Sneary Illustrations

And Schlinger, too.

Chemists and chemical engineers at Caltech will soon have a new playground. Work on the Warren and Katharine Schlinger Laboratory for Chemistry and Chemical Engineering began on February 13.

The lab will form a new focal point for the Division of Chemistry and Chemical Engineering, said David Tirrell, the McCollum-Corcoran Professor and professor of chemistry and chemical engineering. The new lab will attract new faculty and spur research, said Tirrell, who also chairs the division.

Located near the western end of the San Pasqual walkway on campus, the four-story building will occupy 60,000 square feet and should be finished in 18 months. It will also likely merit a Silver rating under the Leadership in Energy and Environmental Design (LEED) Green Building Rating System for environmentally sustainable buildings.

The Schlinger Lab was named in recognition of a $20 million campaign donation from Warren and Katharine Schlinger. Warren (BS '44, MS '46, PhD '49) spent 12 years studying, researching, and teaching at Caltech. Katharine grew up in the Pasadena area and met her husband while working as a department secretary for Chemical Engineering.

In addition to the Schlinger and Moore Foundation contributions, gifts have come from an array of supporters, including the estate of former trustee Victor K. Atkins; trustee G. Patricia Beckman (daughter of Mabel and Arnold Beckman, PhD '28); Barbara J. Dickinson (widow of Richard Dickinson '52); the Ralph M. Parsons Foundation; the John Stauffer Charitable Trust; John W. Jones ('41); Helen and Will Webster ('49); Gregory P. Stone ('74); and others. Funds raised to date total $37 million; the building is anticipated to cost $45 million. □—*EN*