SCIENCE NEWS

THE WEEKLY NEW SCIENCE

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modeling medicine

a west nile–AIDS link

counting calories for parrots

pondering placebo effect

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seeking alien life

NEW TOOLS IN THE SEARCH

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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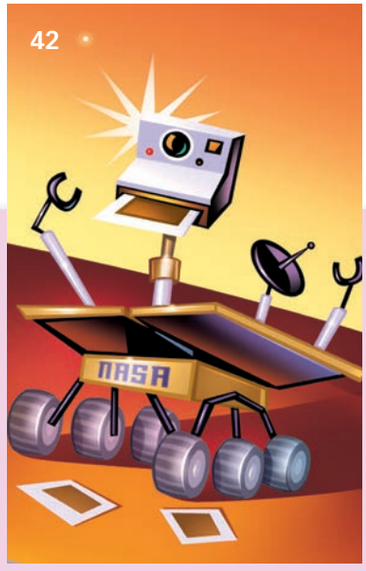

Features

This Week

Of Note

Meetings

Departments

Cover Could life of some sort be thriving on other planets? To find out, researchers are developing new life-detection devices and testing them in some of Earth's most extreme environments. (Dean MacAdam) Page 42

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Defenses Down

Mutation boosts West Nile risk

A genetic mutation has been identified that increases a person's susceptibility to West Nile virus, a new study indicates. Ironically, this mutation had previously been shown to provide a barrier against HIV, the virus that causes AIDS.

The protein eliminated by the mutation was previously thought to be useless and even a liability. The new finding suggests that it might be an essential weapon in fending off the mosquito-borne virus, says Philip M. Murphy, an immunologist at the National Institute of Allergy and Infectious Diseases in Bethesda, Md.

West Nile virus is most dangerous to elderly people and others who have compromised immune systems. Although 80 percent of infections go unnoticed, the virus caused illness in 2,819 people in the United States in 2005, leading to encephalitis or meningitis in 1,189 of them and killing 105, according to the Centers for Disease Control and Prevention in Atlanta.

The mutation that has been implicated in West Nile disease susceptibility shuts down the production of a protein called chemokine receptor-5 (CCR5). This protein is the primary cell-surface receptor that is commandeered by HIV, which uses it to enter white blood cells. The mutation that prevents CCR5 production renders 1 percent of whites highly resistant to infection by HIV but hasn't been found in other races. Scientists had reasoned that people were better off without CCR5.

In the new study, Murphy and his colleagues worked with researchers in Arizona and Colorado to analyze blood and spinal-fluid samples from 395 people in those states who had been infected with West Nile virus.

The CCR5 mutation showed up in more than 4 percent of the West Nile patients but in only 1 percent of 1,318 healthy blood donors used as a comparison group, the researchers report in the Jan. 17 *Journal of Experimental Medicine*.

"This appears to be a reasonably careful analysis" of this mutation in people with and without West Nile infections, says Richard A. Kaslow, an infectious-disease physician at the University of Alabama at Birmingham.

In people with the mutation, lacking the CCR5 protein may lead to "a brain infection from West Nile that is not well controlled," Murphy says.

In a study of mice reported in the Oct. 17, 2005 *Journal of Experimental Medicine*, Murphy's team found that all animals genetically engineered to lack CCR5 died when exposed to West Nile virus. However, normal mice fended off the virus by producing extra CCR5 proteins on the surface of white blood cells, which were ushered into the brain, where they protected against the infecting virus.

Several companies have designed drugs aimed at blocking CCR5, in an attempt to stop HIV from invading white blood cells. The approach mimics the protection against HIV conferred by the CCR5 mutation. The drugs are being tested in people.

The new findings suggest that people taking the CCR5-blocking drugs to prevent or quell HIV infection may need to take precautions to avoid West Nile disease, Kaslow says. —N. SEPPA

STATS

2,819

U.S. cases in which West Nile virus caused illness in 2005

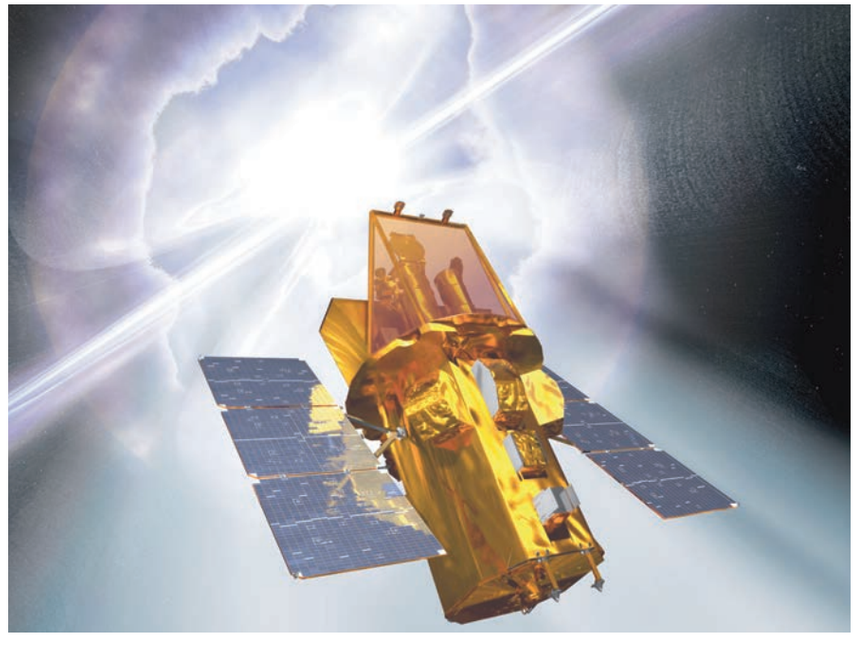
Cosmic Push

Finding pieces of a dark puzzle

Scientists call it the most elemental riddle in all of physics and astronomy: What's tearing apart the universe by turning gravity's familiar tug into a cosmic push?

Astronomers discovered the handiwork of this mysterious push, dubbed dark energy, 8 years ago, when studies revealed that cosmic expansion isn't slowing down, as had been predicted, but is speeding up (*SN: 5/22/04, p. 330*). One of the leading theories is that dark energy is distributed uniformly in space and time—akin to the case for what Albert Einstein called the cosmological constant (*SN: 12/17/05, p. 390*). Understanding dark energy would unify the force of gravity with the subatomic realm, providing deep insights into the origin and evolution of the universe, says cosmologist Sean Carroll of the University of Chicago.

So, when a report last week indicated that dark energy behaves even more strangely than researchers had suspected, it garnered extraordinary publicity—as well as vehement reactions among researchers. The study, described by astronomer Bradley Schaefer of Louisiana State University in Baton Rouge, indicates that dark energy varies over time. The work suggests that dark energy put the brakes on cosmic expansion in the past but is now accelerating it, Schaefer reported at the January meeting of the American Astronomical Society in Washington, D.C.



NASA

LIGHT ON DARK ENERGY NASA's Swift Satellite records gamma-ray bursts, rendered here by an artist, which a new study suggests provide a novel way to determine the nature of a mysterious cosmic force.

Such a universe would have some mind-bending properties, including a previously unsuspected force in nature generated by an unknown elementary particle. Furthermore, Einstein's well-supported theory of gravitation would require major modifications, adds Carroll.

The implications of Schaefer's study are so provocative, says Carroll, that for now, "no one believes it." He and others also question the data.

In fact, the most important aspect of the new study, Schaefer and Carroll agree, is not the result but the method used to get it. This is the first time that gamma-ray bursts, the most powerful explosions in the universe, have been used to analyze dark energy.

Schaefer acknowledges that his findings aren't as precise as those from more-established methods for studying dark energy.

Astronomers originally found evidence for dark energy by using another, dimmer type of explosion known as a supernova type 1a. Because gamma-ray bursts can be seen at much greater distances than supernovas can, they could, in theory, be used to probe cosmic expansion at earlier times. Gamma-ray bursts vary in brightness much more widely than supernovas do, making it more of a challenge to use them. To compensate, Schaefer took into account five properties of 52 gamma-ray bursts to gauge their intrinsic brightness.

Gamma-ray bursts "hold great promise" for studying dark energy, says cosmologist Don Lamb of the University of Chicago, but he adds that he disagrees with Schaefer's analysis of dark energy at large distances. Lamb's team is doing its own study of gamma-ray bursts and to date has found that dark energy does indeed resemble the cosmological constant, Lamb told *Science News*.

With satellites expected to find a wealth of gamma-ray bursts over the next few years, scientists will have an opportunity to determine what these explosions can reveal about dark energy, says Schaefer. —R. COWEN

CREATURE OF THE NIGHT The kakapo parrot, which can weigh more than 1.5 kilograms, forages during darkness. The birds can live about 60 years.

Dieting to Save a Species

Mother parrots that eat less avoid excess of sons

Now that conservationists are counting calories for the endangered, flightless parrots of New Zealand, the birds are recovering from a shortage of female chicks, biologists report.

The world population of the kakapo (*Strigops habroptilus*), a hefty, nocturnal parrot, numbers only about 86 birds, says Bruce Robertson of the University of Canterbury in Christchurch, New Zealand. About 5 years ago, conservationists realized that among the birds that they were tending, only 30 percent of the offspring were female. That's hardly the way to make a lot of new kakapos.

Using a bit of evolutionary theory called sex allocation, researchers proposed that feeding the females less could shift the male-female ratio of chicks. Now, a genetic analysis of chicks from the 2002 season shows that the scheme works, Robertson and his colleagues report in an upcoming *Biology Letters*.

Kakapos once waddled all over New Zealand, but European settlers and their predatory animals found the ground-dwelling, strong-scented birds easy to catch. In the 1980s, conservationists whisked the last 51 known kakapos to island sanctuaries.

The birds rummage along the ground for fern rhizomes and plants from which they suck juices. Every few years, rimu trees burst out with a bumper crop of their tiny orange fruits, and the kakapos feast and lay eggs.

To boost reproduction, conservationists had provided frequent feasts of apples and other treats. Females did plump up, and more chicks tended to survive.

However, the improvement in female condition might have backfired, biologists including Robertson and José Tella of Doñana Biological Station in Seville, Spain, suggested at the beginning of the decade. A clue came from the mating system, in which kakapo males set up displays and females review them.

Kakapo males spend summer nights meticulously clearing dirt patches where they then spend hours calling in females. Success in attracting a mate varies greatly from one male to the next.

Sex-allocation theory predicts that in such species, females will produce an abundance of sons when moms are fit and their sons are likely to grow up capable of attracting mates. During hard times, puny sons generally get shut out of fatherhood, so extra daughters are a better bet.

In 2001, wildlife managers put the heaviest females on a restricted diet but continued to feed the thin ones liberally. Robertson and his colleagues now report that the diet indeed ended the excess of sons. The females on short rations laid 9 male and 10 female eggs, and the already lean females produced 7 male eggs and 9 female ones.

"It's a nice application of evolutionary theory to conservation biology," says Timothy Wright of New Mexico State University in Las Cruces, who has also studied parrot conservation. —S. MILIUS

Diabetes from a Plastic?

Estrogen mimic provokes insulin resistance

Exposure to small amounts of an ingredi-ent in polycarbonate plastic may increase a person's risk of diabetes, according to a new study in mice.

The synthetic chemical called bisphenol-A is used to make dental sealants, sturdy microwavable plastics, linings for metal food-and-beverage containers, baby bottles, and numerous other products. When consumed, the chemical can mimic the effects of estro-

D. MERTON/VIREO

gen. Previous tests had found that bisphenol-A can leach into food and water and that it's widely prevalent in human blood.

The newfound contribution of the chemical to insulin resistance, a precursor to diabetes, might partially explain the global epidemic of that disease, says Angel Nadal of Miguel Hernández University of Elche in Spain, who led the new study.

The finding is a "wake-up call" for public health researchers who are concerned by the prevalence of diabetes, comments developmental biologist Frederick vom Saal of the University of Missouri–Columbia.

Earlier test-tube studies had suggested that bisphenol-A makes pancreatic cells secrete the glucose-regulating hormone insulin. To investigate this effect in live animals, Nadal and his colleagues injected adult male mice with pure corn oil or with oil containing either bisphenol-A or an equal amount of the natural female sex hormone estradiol. Animals received as many as eight shots over 4 days.

Within 30 minutes of an injection, animals receiving either the sex hormone or bisphenol-A had abnormally low concentrations of glucose in their blood, Nadal's team reports in the January *Environmental Health Perspectives*. The chemicals acted on recently discovered estrogen receptors on pancreatic cells' surfaces to boost the cells' secretion of insulin, the researchers determined.

Repeated exposure to either bisphenol-A or the natural estrogen over several days produced insulin resistance, a pre-diabetic state in which tissues lose their sensitivity to normal concentrations of insulin, Nadal's group says. Estrogen receptors in the pancreatic-cell nucleus appear to contribute to this gradual effect.

So, receptors both in the cell nucleus and on the surface could contribute to insulin resistance and diabetes, Nadal says.

This risk could add to or elucidate already documented health effects of bisphenol-A. Animal studies have suggested that exposure to the chemical early in life causes obesity, says Ana M. Soto of Tufts University School of Medicine in Boston.

Furthermore, bisphenol-A exposure might contribute to gestational diabetes in women, in whom insulin resistance often increases during pregnancy, says Jerry Heindel of the National Institute of Environmental Health Sciences in Research Triangle Park, N.C.

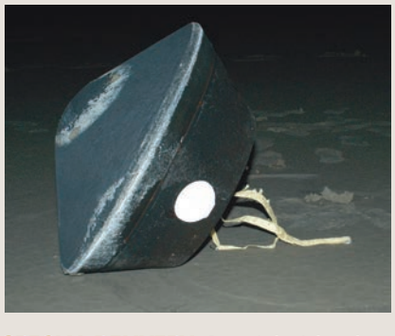
Inside cells' nuclei, bisphenol-A is less potent than the natural sex hormone, says vom Saal. But the new work shows that at the surface of pancreatic cells, the compounds have the same potency, he notes. Doses of bisphenol-A considered by the Environmental Protection Agency to have no adverse effect led to insulin resistance in the mouse study. —B. HARDER

Pay Dirt

Cometary dust collector comes home

Streaking through Earth's atmosphere after a 7-year, 5.6-billion-kilometer journey, a space capsule carrying comet and interstellar dust landed in the Utah desert on Jan. 15. NASA's Stardust spacecraft collected its most precious cargo 2 years ago, when the craft passed within 24 km of the dust-venting nucleus of Comet Wild-2 (*SN: 7/3/04, p. 13*). Scientists expect the dust to provide new clues to the solar system's origin because comets are nearly pristine relics of that time.

The tiny dust grains are the first samples of solid extraterrestrial material to be collected and brought back to Earth since the last moon rocks arrived in 1972. A craft bearing gaseous samples of the solar wind crashed when it returned to Earth in 2004. —R. COWEN



NASA

SPECIAL DELIVERY **Comet dust–bearing capsule after it landed in the Utah desert.**

Intrinsic Remedies for Pain

Placebo effect may take various paths in brain

The brain draws on a range of pain-fight-ing options when people receive sham treatments for pain, a new brain-imaging study suggests.

People who experienced pain relief after receiving fake acupuncture treatments displayed pronounced activity in certain brain areas, says a team led by neuroscientist Jian Kong of Massachusetts General Hospital in Charlestown. This pattern of brain activity differed from that reported in 2004 by another team, directed by neuroscientist Tor D. Wager of Columbia University.

In that work, a placebo cream applied to the skin diminished pain. In both experiments, the researchers induced volunteers' pain by applying heat to the forearm.

"There may be multiple brain mechanisms underlying placebo [pain relief]," Kong says. He and his colleagues describe their findings in the Jan. 11 *Journal of Neuroscience*.

Kong's group established the pain tolerance of 16 volunteers, ages 22 to 35. Using a device that delivered heat to the right forearm, the scientists noted how much heat was needed to yield ratings of low or high pain.

Volunteers then read information about acupuncture before receiving on their right arms a sham acupuncture treatment that they had been told was real. The placebo acupuncture needle retracted into its casing when pressed against the skin. To encourage expectations of the sham acupuncture's effectiveness, without telling the volunteers, the researchers slightly decreased the temperature of ensuing heat pulses delivered to participants' right arms.

Next, a functional magnetic resonance imaging scanner measured blood flow throughout volunteers' brains as low- and high-pain heat pulses were delivered to their right or left arms.

A placebo effect emerged. Individuals reported feeling substantially less pain in their right arms than in their left arms during delivery of equally intense heat. Placebo responses were accompanied by pronounced blood flow, a sign of intense neural activity, in six brain regions, the scientists say. These areas regulate pain perception, monitoring of external events, and negative emotions such as anxiety.

In contrast, Wager's team linked placebo responses to diminished activity in pain-sensitive regions overlapping those identified in Kong's study.

Wager points out that Kong's team measured elevated activity in pain-related brain regions shortly after volunteers started to feel pain, whereas his team looked at a later phase of pain. Neural activity in affected regions diminishes as pain continues, his study indicated.

However the brain orchestrates such effects, positive expectations can even reduce pain controlled by spinal cord signals, say neuroscientist Dagfinn Matre of the National Institute of Occupational Health in Oslo and his colleagues.

Earlier research had shown that nerve projections from the spinal cord create temporary, extreme pain sensitivity in heated-skin areas. To produce that effect, the scientists delivered heat pulses to the right forearms of 29 volunteers for 5 minutes.

The right forearms of 19 of the volunteers were then heated by an instrument containing a sham magnet that they had been told was a pain-relieving device. Those participants reported a smaller area of pain and less pain overall than those who didn't

expect pain relief, the researchers report in the same issue of the *Journal of Neuroscience*. —B. BOWER

Thermonuclear Squeeze

Altered method extends bubble-fusion claim

A technique that some scientists claim generates thermonuclear fusion in a benchtop apparatus works even without its controversial neutron trigger. So say the researchers who, since 2002, have reported that nuclear-fusion reactions can occur in a vat of chilled solvent agitated by ultrasound (*SN: 3/6/04, p. 149*). If this method of sparking fusion proves to be valid—a big if, critics insist—it could lead to a remarkably simple, cheap, inexhaustible power source.

Fusion reactions take place in the vat because clusters of bubbles form and then violently collapse, explains nuclear engineer and team leader Rusi P. Taleyarkhan of Purdue University in West Lafayette, Ind. A neutron or another energetic particle triggers a bubble to form in a low-pressure trough of the ultrasound waves, he says. Then, high pressure from the wave crushes the orb to an enormous density and temperature that fuse some atomic nuclei of the bubble's gas.

Taleyarkhan and his colleagues have measured neutron emissions as a sign of fusion reactions. Because the group had used neutron pulses to trigger the process, other researchers have been skeptical of its neutron readings.

In an upcoming *Physical Review Letters*, Taleyarkhan's team presents evidence of fusion in bubbles initiated by a uranium-based trigger that emits alpha particles instead of neutrons. "We got away from the idea of using neutrons to produce neutrons," Taleyarkhan notes.

Nonetheless, the findings still face intense skepticism. Criticisms range from doubts about experimental procedures to quarrels with interpretations of the data. "I simply do not find the results significant and/or believable," comments physicist Dan Shapira of Oak Ridge (Tenn.) National Laboratory.

Critics note that Taleyarkhan's team admits in its report that its experimental outcomes vary greatly, many of them producing no evidence of fusion. Yet to D. Felipe Gaitan of Impulse Devices in Grass Valley, Calif., the uneven outcomes are encouraging. They "could explain our inability, and that of other researchers so far, to replicate [Taleyarkhan's] results consistently," says Gaitan. Impulse Devices plans to commercialize bubble fusion.

Lawrence A. Crum of the University of Washington in Seattle says that the new work "increases the credibility" of bubble fusion. But "unless it's reproduced in someone else's lab, I'm not going to believe it," he adds.

Taleyarkhan claims that his team's findings were independently verified last year by other Purdue researchers, whom he guided. Other physicists are unconvinced.

A welcome consequence of the latest results, Crum adds, is that other researchers should find the uranium-based triggering method easier to reproduce than the neutron one. So, he says, the new work "is an important step toward determining if the results of Rusi's experiments are true." —P. WEISS

Sinking Mercury

Light-based reactions destroy toxic chemical in Arctic lakes

Sunlight triggers the entry of poisonous mercury into polar lakes, but it also removes most of the toxic compound before fish can consume it, a new study suggests. The researchers warn that increased warming in the Arctic might upset this delicate balance.

With spring, light returns to the Arctic after a long, dark winter. That polar sunrise, however, has a dark side. It triggers a burst of photochemical reactions that mobilizes atmospheric mercury, speeding its fall into arctic lakes, where fish can consume it.

Recent studies suggest that when atmospheric mercury encounters light, gases such as ozone and sea spray–borne halogens oxidize it to a more reactive and water-soluble form. Attached to rain, snow, or dust, the reactive mercury falls into oceans or lakes, where sulfur-reducing bacteria transform it to methylmercury, the highly toxic form of the metal that accumulates in fish and other organisms (*SN: 2/1/03, p. 72*).

To better understand what happens to mercury, a team of researchers led by biogeochemists Chad Hammerschmidt of Woods Hole (Mass.) Oceanographic Institution and William Fitzgerald of the University of Connecticut at Groton studied mercury in four Alaskan lakes roughly 250 kilometers south of the Arctic Ocean.

The team measured mercury entering the lakes from rainfall and as runoff from the surrounding tundra and then estimated how much methylmercury the bacteria in the lake sediments subsequently produced. The researchers also assessed whether the methylmercury was consumed by fish and other creatures or converted to less-toxic forms by light-based reactions in the lakes.

Hammerschmidt and his colleagues report that the more atmospheric mercury rains down, the more methylmercury the bacteria produce. Two-thirds of mercury in the atmosphere comes from human sources, such as fossil fuel burning, so more pollution would boost poisonous mercury concentrations in lakes, Hammerschmidt says.

More unexpectedly, the team discovered that light-triggered breakdown of methylmercury in the clear Arctic lakes is the main factor keeping the poison in check. Those reactions destroy as much as 80 percent of the poison before aquatic species can get to it, the team reports in an upcoming *Environmental Science & Technology*.

The mechanisms of that photodecomposition are still poorly understood, Hammerschmidt says. Research on arctic mercury has focused on how it gets to Earth, rather than its terrestrial fate, he says.

This research is the first to demonstrate the importance of photodecomposition in mercury cycling, agrees Robert Stevens of the Environmental Protection Agency in Research Triangle Park, N.C. "It's good science," he says.

One spur to further study is the possibility that global warming could upset the Arctic's delicate balance. In warmer and wetter weather, more mercury would fall and bacterial production of methylmercury would rise. At the same time, the rains might wash more organic material into lakes and oceans, reducing light penetration.

Hammerschmidt cautions that the same processes may also be occurring in temperate lakes, such as those in Wisconsin or Minnesota. —C. GRAMLING

LIGHT CLEANING **Photochemical reactions in clear Arctic lakes prevent toxic methylmercury from poisoning fish and other aquatic life.**

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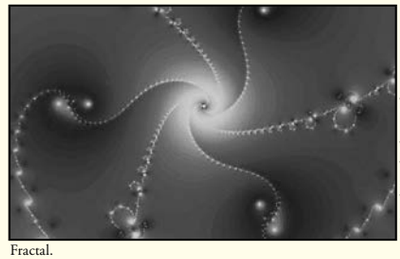

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IN PIXELS AND IN HEALTH

Computer modeling pushes the threshold of medical research

BY NAILA MOREIRA

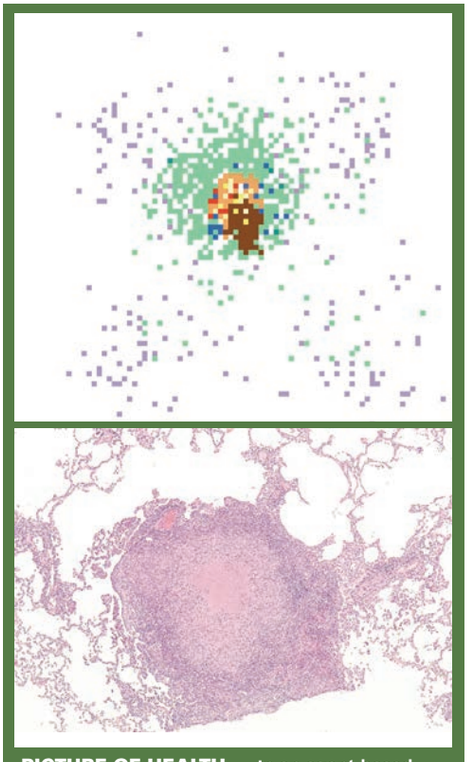
Moment by moment, a movie captures the action as a group of immune cells scrambles to counter an invasion of tuberculosis bacteria. Rushing to the site of infected lung tissue, the cells build a complex sphere of active immune cells, dead immune cells, lung tissue, and trapped bacteria. Remarkably, no lung tissue or bacterium was harmed in the making of this film.

Instead, each immune cell is a computer simulation, programmed to fight virtual tuberculosis bacteria on a square of simulated lung tissue. In their computer-generated environment, these warrior cells spontaneously build a structure similar to the granulomas that medical researchers have noted in human lungs fighting tuberculosis.

The simulation, created by Denise Kirschner of the University of Michigan in Ann Arbor, is an example of an emerging technique called agent-based modeling. This new tool in the world of medical research relies on computing power instead of tissues and test tubes. A growing cadre of researchers, including Kirschner, predicts that agent-based modeling will usher in a broadened understanding of complex interactions within the human body.

The agents in the models are individual players—immune cells in the tuberculosis example. Each player is programmed with rules that govern its behavior. Computer-savvy researchers then set the agents free to cooperate with, compete with, or kill each other. Meanwhile, the agents must navigate the surrounding environment, whose properties can vary over space and time.

Scientists can manipulate disease progression within the models by changing the agents or their environment and then watching what happens. As opposed to traditional, biologically based in vivo or in vitro experiments, these computer trials are dubbed "in silico." The results can suggest biological experiments to test the models' findings and may eventually lead to new medical treatments.



PICTURE OF HEALTH — In an agent-based model (top), immune cells respond to tuberculosis infection by forming a granuloma. Macrophages (green squares) hurry to the site, where they become infected. Chronically infected macrophages (red) will die. However, purple T cells can instruct the macrophages to become activated (blue) and kill tuberculosis bacteria. Brown areas represent dead lung tissue, and yellow squares are concentrations of extracellular bacteria. A real granuloma (bottom) from a tuberculosis-infected macaque monkey has a similar shape and composition.

KIRSCHNER, UNIV. MICHIGAN; P. L. LIN AND E. KLEIN, UNIV. PITTSBURGH

Even simple rules assigned to agents can give rise to surprisingly complex behaviors. When many independent agents interact, they create phenomena—such as the granulomas—that can't necessarily be predicted by breaking down the system into its separate components, says complex-systems specialist John Holland of the University of Michigan.

You've got to study the interactions as well as the parts," Holland says.

In-silico modeling differs from traditional mathematical modeling, which uses differential equations to understand how molecules or cells behave in an averaged, continuous way. Instead, the agents of in-silico modeling make independent decisions in response to situations that they encounter. As a result, unusual activity of even a small number of cells can change the entire system's behavior.

Computers can now calculate thousands of interactions with ease, says Alan Perelson of Los Alamos National Laboratory in New Mexico. "Agent-based modeling has only come into its own with the arrival of really powerful computers sitting on people's desktops, within the last 10 or 15 years," he notes.

Pioneered for economics and population-dynamics studies (*SN: 11/23/96, p. 332; www.sciencenews.org/pages/sn_arc99/4_10_99/mathland.htm*), agent-based modeling has only recently plumbed the inner workings of the human body, Perelson adds. That's partly because new imaging and genetic techniques are providing crucial data on which agents' rules can be based.

"Agent-based modeling represents a new frontier with respect to how we do science," says surgeon Gary An of Cook County Hospital in Chicago. "In medicine in particular, all the diseases that we're now dealing with are complex problems: sepsis, cancer, AIDS. All these things are disorders of the system as a whole."

INFLAMMATION SIMULATION An, whom Kirschner calls an in-silico "groundbreaker," got into agent-based modeling to help people survive traumatic injuries and major infections.

A leading cause of death for patients in intensive care units, An explains, is a syndrome called systemic inflammatory response syndrome/multiple organ failure (SIRS/MOF), also termed sep-

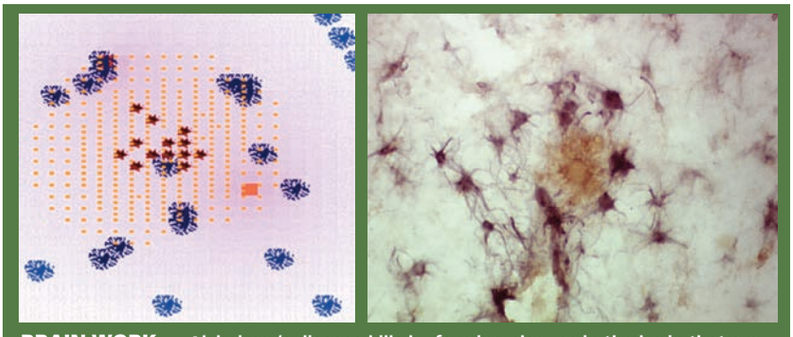
sis when it occurs in response to an infection. In this syndrome, the body's inflammatory response rages out of control after a severe injury or bacterial infection. Excessive inflammation can kill a patient by attacking and shutting down vital organs. More commonly, the runaway inflammation paralyzes the rest of the immune response, and the patient then dies of secondary infections.

During the 1990s, researchers performed clinical experiments in an attempt to develop drugs that dampen an overwhelming inflammatory response to injury, An notes. Only one drug, activated protein C, appeared to help patients with SIRS/MOF. An suggests that trials of other drugs failed because they were planned using data representing individual components of the inflammatory response rather than the interactions of the immune system as a whole.

An says, "It's kind of a Humpty Dumpty syndrome, where after you break the system apart, you can't put it back together."

An turned to agent-based experiments to understand how the body's inflammatory processes work together to generate SIRS/MOF. In a seminal paper in 2001, he described a model of the inflammatory response that included all the information that he could find about the immune system and inflammation.

By assigning inflammation-implicated cells as agents in an environment that simulated the body's circulatory system, An reproduced the four typical trajectories of SIRS/MOF. At a low concentration of bacteria, the inflammatory response killed the infection and the virtual patient recovered. High concentrations of infectious bacteria overwhelmed the simulated system, and it died.



BRAIN WORK — Alzheimer's disease kills by forming plaques in the brain that are made of fibrous beta-amyloid. In this in-silico model, immune cells, called microglia (reddish stars) and astrocytes (blue stars), congregate in a diseased neuron. Dissolved beta-amyloid is shown in shades of red and fibrous beta-amyloid is shown by yellow dots. Real Alzheimer's plaque, at right, shows astrocytes stained purple.

At moderate concentrations of bacteria, the model replicated the two trajectories of SIRS/MOF of most interest to medical researchers: organ failure and immune paralysis due to excessive inflammation. Although An says that his model is "very much in its infancy," he and his colleagues have used it to simulate the trials of some of the potential SIRS/MOF drugs that were conducted in the 1990s.

Employing only the biological data available when the trials were designed, the agent-based model could have predicted the trials' failures, the team reported in 2004. "It's not to say you necessarily would not have done the trials," An notes. "But if you had done [the modeling] before you got to the clinical trials, you might have gone back and relooked at some of your assumptions."

LAPTOP LABORATORY The new-style models contain four components: the agents, their rules, the agents' environment, and the time scale on which they operate. The environment is usually represented by a grid in which each square is programmed to contain data, such as a concentration of molecules or virus particles. The agents themselves are shown as colored dots that can migrate from square to square on the grid.

For instance, in Kirschner's simulation of tuberculosis infection, immune cells are the agents, and the grid represents a 2-millimeter-square patch of lung tissue, big enough to hold a nascent granuloma. Each of 1,000 squares on the grid contains chemical and structural information about the tissue as well as some concentration of the tuberculosis pathogen, *Mycobacterium tuberculosis*.

"You can give structure and character and rules to that lung tissue so that if a[n immune] cell is in a particular spot, it has to behave in a certain way," Kirschner explains.

Bright dots scurry over the grid, representing immune cells called macrophages and T cells. Macrophages capture and sometimes destroy foreign particles such as dust or bacteria. T cells, meanwhile, communicate with the macrophages to make them more aggressive and marshal additional immune efforts.

Worldwide, tuberculosis is the infectious disease that causes the most deaths, 2 million to 3 million per year. An estimated one-third of the world's population is infected with the pathogen. The bacteria tend to hide out inside macrophages. Unless T cells activate the macrophages to destroy their stowaways, the bacteria multiply, eventually causing the macrophages to burst and release their bacterial load to other cells.

Once infected with the pathogen, about 5 percent of infected people come down with acute tuberculosis right away. Most people, however, develop a latent form of the disease. Of these, only 10 percent eventually develop full-blown tuberculosis.

The reasons for people's different responses to tuberculosis infection remain a mystery, though all infected people form granulomas in their lungs, says Kirschner. Scientists have studied granulomas in various stages of formation, but they've never witnessed the process that creates them.

Granulomas in patients with acute tuberculosis expand and build up large proportions of dead, or necrotic, tissue in their cores. Using their agent-based model, Kirschner and her colleagues found that out of 27 parameters examined, only 7 strongly affected whether a granuloma would turn necrotic. The team described its model and results most recently in the May 2005 *Trends in Microbiology*.

For example, the timing of T cell arrival to infected lung tissue partly controlled its fate. Immediate arrival cleared the infection completely and prevented a granuloma from forming, while delayed arrival produced necrotic granulomas.

At moderate T cell–arrival times typical of normal human lungs, most of the virtual patients developed granulomas that contained the infection and had little necrotic tissue. However, the granulomas turned necrotic in about 5 percent of the trials—the same percentage of the human population that immediately develops the acute disease. The results suggest that patients would benefit from therapies that encourage rapid recruitment of T cells to sick lungs.

Experimental biologist Victor DiRita of the University of Michigan says that Kirschner's approach to tuberculosis will aid experimental efforts to understand the disease. "You can't scoff at the fact that they've now been able to grow a granuloma in a computer that has a lot of the structural characteristics, as far as we can tell, of a real granuloma," DiRita comments.

CANCER CONUNDRUM An extreme malfunction of human cells occurs during cancer. A tumor arises when a normal cell mutates into a cancer cell, which replicates uncontrollably. Tumor cells can eventually migrate to other parts of the body.

Because cancer cells interact in complex ways with their environment, with other cancer cells, and with normal cells, they make a perfect target for agent-based modeling, says Thomas Deisboeck of the Massachusetts Institute of Technology.

Deisboeck and his colleagues apply agent-based modeling to

(continued on page 44)

EDELSTEIN-KESHET, C. SCHWAB/ UNIV. BRITISH COLUMBIA

IS ANYBODY OUT THERE?

Detection devices are in the works for rooting out extraterrestrial life

BY CHRISTEN BROWNLEE

In the mid-1960s, the United States Army Corps of Engineers carved a giant cave deep into permafrost in an Alaskan hillside so that scientists could do experiments inside ground that had been frozen for millennia. Entering the 110- meter Cold Region Research and Engineering Laboratory Permafrost Tunnel, as the facility is now known, is like "stepping right back into the Pleistocene," says astrobiologist Richard Hoover. Frozen, long-dead tree roots and grasses dangle from the ceiling, and the bones of an extinct species of buffalo poke out of the walls.

But Hoover doesn't visit the tunnel to scope out the remains of such flora and fauna. He's there to search for living aliens—not extraterrestrials per se, but creatures so unusual that they can survive the tunnel's harsh cold and dry environment. Similar conditions could exist on other planets, so finding living things soldiering on deep inside the permafrost could be a sign that life exists beyond Earth, says Hoover, who's based at NASA's National Space Science and Technology Center in Huntsville, Ala.

Until someone detects the first genuine extraterrestrial, it's impossible to say whether any organisms reside beyond our friendly planet. But mounting evidence suggests that Earth might not be the only oasis in the cosmos, or even in our solar system.

To speed the search for extraterrestrial life, researchers are using extreme conditions on Earth to develop a flotilla of detection devices to tease out signs of life in unlikely places. By sending these machines on scouting missions to frozen ice caps, deep oceans, and subterranean environments on our planet and someday others, researchers may eventually find that we're not alone in the universe after all.

CORE IDEA — This ice sample (inset), collected by a researcher in the frigid arctic archipelago of Svalbard, Norway, contains hardy bacteria. A new assembly of four scientific instruments detected them.

K. STORVEK/AMASE

ALIENS AHOY Extraterrestrials have long been a mainstay of science fiction, ranging from the terrifying Martians in *War of the Worlds* to the ugly but adorable ET. For many scientists, however, the real possibility of life on other planets is more exciting than anything fiction can offer.

Some researchers have considered more-exotic possibilities, but a carbon-based biochemistry similar to that of life on Earth is most likely, says Douglas Hudgins, an astronomer at NASA Ames Research Center in Moffett Field, Calif. "The variety of chemical compounds you can make based on carbon is vastly bigger than [you can make from] any other element in the periodic table," he notes.

In any case, understanding familiar forms could now set the stage for recognizing stranger life in the future, he adds.

Researchers have long known that tiny fragments of one planet, such as meteors, can crash onto another planet's surface. This gives life the potential to jump from place to place in our solar system. And recent research suggests that the ingredients necessary for life as we know it to evolve from scratch are present in many places besides Earth. The ingredients include liquid solvents, such as water; a variety of elements, such as nitrogen and phosphorus, for constructing organic molecules; and compounds that store energy.

According to Bruce M. Jakosky, director of the Center for Astrobiology at the University of Colorado in Boulder, the planet Mars and Jupiter's moon Europa offer tantalizing combinations of these ingredients right in our celestial neighborhood.

As for the possibilities farther away, a study that Hudgins and his colleagues published in the Oct. 10 2005 *Astrophysical Journal* suggests that life's building blocks are probably scattered heavily throughout the universe.

By comparing the patterns of infrared radiation emitted by gas clouds, stars, and other celestial objects with the characteristic infrared signals of molecules in the lab, astronomers can identify the celestial compounds. Almost everywhere that astronomers have applied this technique during the past 20 years or so, they've found polycyclic aromatic hydrocarbons (PAHs), rings of carbon and hydrogen that have linked to form a variety of complex organic molecules. "If you're interested in life, then you're interested in organic carbon," says Hudgins.

However, he notes, scientists searching for extraterrestrial life haven't been interested in most PAHs because the molecules aren't known to play important roles in organisms on Earth.

But while investigating the infrared signals put out by interstellar PAHs, Hudgins and other researchers recognized an anomaly. The signal didn't entirely match the one given off by PAHs in the lab. When Hudgins and his team swapped one of the lab-made molecules' carbons for a nitrogen atom, the new infrared signal matched the cosmic one.

The scientists were excited by this finding because the resulting

molecules, known as polycyclic aromatic nitrogen heterocycles (PANHs), function as the heart of many larger molecules important to life. For example, PANHs serve at the core of chlorophyll, the green molecule on which photosynthesis depends, and of hemoglobin, the molecule that holds oxygen in red blood cells.

"The vast majority of what we've always called PAHs [in space] are in fact PANHs," Hudgins asserts. PANHs arise primarily in the cool, dense interstellar clouds out of which stars and planets eventually form. Although organic molecules could not survive on the hot surface of a young planet, some could get trapped in small rocky fragments that could crash onto planets much later, when their surfaces had cooled to friendlier temperatures.

"What this means is that if you sprinkle these molecules on a nice, hospitable planet, they can be used as a raw material for developing life," Hudgins says.

RIGHT AT HOME On the crucial question of what constitutes hospitable conditions, scientists have recently had to revise their views. Previously, many researchers thought that the conditions necessary for life were so narrow that they existed only in places with certain favorable conditions on Earth. However, the study of this planet's extremophiles—organisms that can withstand conditions beyond those that people can survive—is extending life's known limits. And if organisms can inhabit a wider range of environments on Earth than had been suspected, the prospects for living organisms to develop on other planets look brighter.

For example, Hoover found colonies of bacteria when he sampled a layer of golden-brown sludge from the bottom of a frozen Pleistocene pond that was cut open to make the permafrost tunnel near Fox, Alaska. To his astonishment, as the ice containing the microbes thawed under a microscope, Hoover saw the rod-shaped cells start swimming around—picking up where they'd left off 32,000 years ago. "I knew immediately that we had living Pleistocene bacteria," says Hoover.

The previously unknown species, which he and his colleagues named *Carnobacterium pleistocenum*, is a good model for life-forms that he and other researchers suspect could exist in a similar suspended state in Mars' polar ice caps or in the ice crust on Europa, he adds.

In a very different part of the environmental spectrum, Raina Maier and her colleagues at the University of Arizona in Tucson recently found living bacteria in the most arid soils of the Atacama Desert of northern Chile. Some places there go thousands of years without receiving a drop of rain. Scientists frequently use the Atacama as an analog for the dry midsection of Mars.

Although previous research had suggested that some parts of this desert are sterile, when Maier and her team dug a little deeper in the soil, they found DNA signatures for several species of microbes. They even coaxed a few of these species to grow in the lab, the team reported in 2004.

These microorganisms "may be dormant for very long periods of time, but they're still there, waiting patiently for ... some rain, some organic matter that blows in that they could eat, or other good conditions," Maier says. Then, the bacteria spring back to life.

It's possible that microbes could be waiting in similar conditions under the dry surface of Mars or of planets outside our solar system, Maier says.

LOOK LIVELY, NOW Scientists won't be building people-staffed labs on other planets anytime soon. Instead, some researchers are developing systems to detect life remotely in many environments.

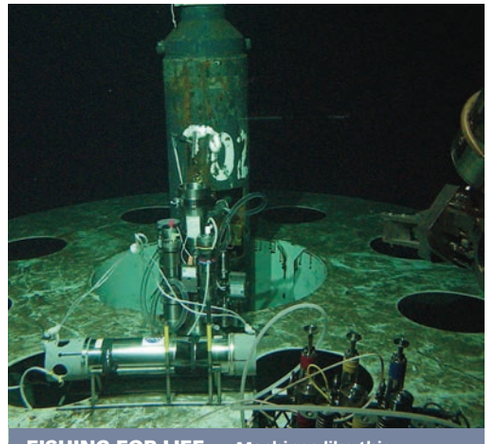
Hans E. F. Amundsen of the University of Oslo and his colleagues have grouped together four instruments that they assert can spot a single microbe in an otherwise-barren area—the biological equivalent of finding a needle in a haystack.

Their system searches for different cellular materials: bacterial genes, components of bacterial cell walls, the energy-storing molecule called adenosine triphosphate (ATP), and various proteins. A hit from all four instruments is an almost certain indication of life, says Amundsen.

"Whenever you get lucky enough to send something to Mars, you need an answer you want to be certain of," he says. "We wanted to get the same answer with several different techniques."

The researchers recently tested their system in Svalbard, Norway, an Arctic island that seems to have geological conditions similar to those of the polar ice caps on Mars. When they ran ice samples from the island's frozen volcanoes through their suite of instruments, the researchers detected rare microorganisms living in an almost dormant state.

Right now, the instruments are far too bulky and fragile to attach to a rover, says Amundsen. But the researchers expect further revisions to eventually miniaturize the machines and make them more robust, putting them in the running for a future trip to Mars.



SCHULTZ

FISHING FOR LIFE — Machines like this prototype may eventually seek out signs of life in extraterrestrial oceans. Researchers are testing it at deep-ocean hydrothermal environments.

Another system, being developed by Adam Schultz at Oregon State University and his colleagues, could set the stage to look for evidence of life in extraterrestrial oceans, such as those that might exist on Jupiter's moon Europa.

"Europa is an icy world on the surface, but we have very strong evidence that below its surface is a very deep ocean," says Schultz. "We're almost certain that something exists there that's equivalent to a seafloor hydrothermal system on Earth."

Hydrothermal environments in Earth's oceans, such as the 50,000-kilometer-long string of underwater volcanoes that forms the midocean ridge system, can be virtual smorgasbords of life. Often, researchers can see dense colonies of bacteria rising from cracks in the seafloor like "upward-flowing snow," Schultz notes.

He and his colleagues are designing their machine to isolate water seeping from the ocean floor and to test its temperature and chemical composition. These factors could reveal whether that environment is conducive to life.

The water sample would then be shuttled to a holding chamber to be maintained at a constant pressure. That's critical, says Schultz, because many microbes that live on the seafloor perish at sea level atmospheric pressure.

While the machine itself wouldn't be flown on a future planetary mission, says Schultz, "it is a working test bed for sensors and devices that would be appropriate for just those sorts of missions."

A third system, designed by David Wettergreen and Alan Waggoner of Carnegie-Mellon University in Pittsburgh and their colleagues would add a new life-detecting component to rovers similar to the ones currently surveying Mars. The system relies on four fluorescent dyes that attach to carbohydrates, proteins, DNA, or fatty molecules called lipids. These four materials are often present in life on Earth.

The machine would spray a target area with the four dyes. Then, using a bright xenon flash to make the dyes fluoresce, a camera would take four pictures through each of four filters tuned to the wavelengths emitted by each dye.

The rover would then beam the images to a computer, which would compare all the photos. In tests in Chile's Atacama desert,

three of the dyes identified microbes and other life as expected. "We like to see all four signals to confirm life," says Waggoner. He and his team hope to have a perfected version ready to go for one of the next rover missions to Mars.

PHONE HOME How will scientists make sure that the extraterrestrials aren't just Earth life that hitched a ride on a previous mission? And if the search for life is ultimately successful, what will researchers do with the newfound aliens? Both questions fall into the realm of John Rummel, NASA's planetary protection officer.

Rummel admits that his job title sometimes prompts snickers when he meets people for the first time. "They'd much rather have me chasing down aliens in the street à la *Men in Black*, but it's really a different kind of job. You don't get a badge or a gun, so you can't retire early," he jokes.

Instead, he and a group of other scientists design and enforce protocols to protect other planets from becoming accidentally colonized with Earth's microbes. They also create guidelines to shield our planet from any dangerous microbes that may someday be brought back from other planets.

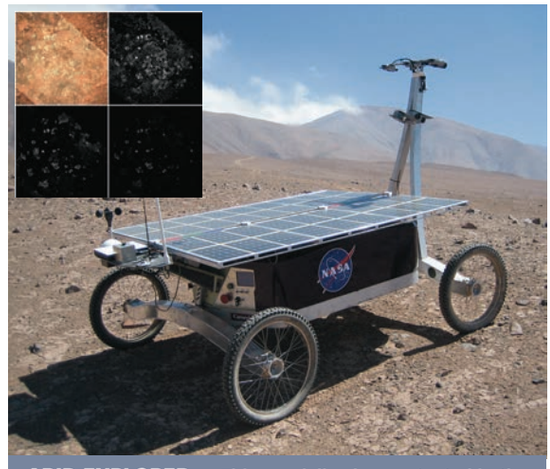
Planners for the recent Galileo mission to Jupiter, for example, had originally intended to leave the spacecraft orbiting the giant planet once its job was done. But Rummel and his team insisted that the craft be destroyed by plunging it into Jupiter's dense, hot atmosphere. Otherwise, it might accidentally crash into Europa, where terrestrial organisms could conceivably prosper.

For spacecraft intended to land on some other body, sterilization protocols depend on the destination. Most scientists consider the surface of the moon to be extremely inhospitable to life, so moon missions require little more than a basic cleaning.

For missions to Mars, the guidelines are variable. Journeys to the arid regions there require that rovers get a thorough cleaning but stop short of sterilization because Earth microbes aren't considered hardy enough to survive conditions on the planet. However, the protocols mandate full sterilization for any missions carrying life-detection equipment or going to places where there might be liquid water. Rummel and other researchers are exploring a variety of chemical and heat methods for cleaning and sterilization.

Rummel says that containment is the key to protecting Earth from possible alien germs brought back from future sampling missions. Current guidelines recommend that researchers treat extraterrestrial samples as highly dangerous until proved safe.

Nobody yet knows whether those safeguards are necessary. Until scientists come up with hard evidence of life beyond Earth, Rummel says, the existence of life elsewhere ultimately comes down to belief. "I have faith in a view of the universe that doesn't make us the only fluke," he says. ■



ARID EXPLORER — This specialized rover, tested in the dry Atacama desert in Chile, uses four dyes that cling to components generally present in life on Earth. The glows in the four photos (inset) indicate a positive result.

WETTERGREEN; (INSET) WAGGONER

(continued from page 41)

the behavior of brain-tumor cells. These and other cancer cells tend either to proliferate, causing a tumor to grow, or to migrate to a new location, but they seldom do both at once. The reasons behind a cell's behavioral choice aren't known.

Deisboeck's team examined cell responses to a molecule called epidermal-growth factor (EGF), which reaches high concentrations in tumors. EGF influences cell proliferation and migration, but no study had looked at the molecule's effect on both behaviors simultaneously. Deisboeck's group simulated cancer cells as agents, subjecting them to fluctuating concentrations of EGF and associated molecules that affect EGF's behavior.

In the model, these molecules controlled when cancer cells switch between proliferation and migration. Moreover, high densities of receptor sites for EGF on cell surfaces made simulated tumors expand faster. The team reported its results in the April 21, 2005 and the Jan. 7, 2006 *Journal of Theoretical Biology*.

Cancer researcher Ken Pienta of the University of Michigan praises Deisboeck's work. "He's able to explain cellular actions based on simple molecular rules. That gives you a perspective that's going to be critical for therapeutic development."

Pienta, in collaboration with Holland, has also created agent-based models of cancer. They cast mutations, instead of cancer cells, as agents. Depending on how mutations interact within a given cancer cell, the cell may or may not survive and propagate.

Although Pienta and Holland haven't published their agent-based efforts, the simulation has influenced Pienta's thinking as he designs biological experiments. He says, "What the modeling does is it forces you to push your preconceptions out the door."

DIGITAL PATIENTS Pienta notes that in-silico modeling by itself won't provide clinical advances. Biological experiments, both in vitro and in vivo, remain crucial for developing therapies for disease.

Agent-based modeling can suggest possible experiments, predict which hypotheses are most likely to be true, and integrate data provided by experimental biologists, says Deisboeck. Most modelers collaborate with experimentalists, who provide biological data and embark on flesh-and-bone trials to test the models' findings.

"The idea is to validate your results against experimental data," says Leah Edelstein-Keshet of the University of British Columbia in Vancouver, who uses agent-based modeling to simulate Alzheimer's disease. She's now collaborating with drug company Merck to pursue potential therapies.

> " What the modeling does is it forces you to push your preconceptions out the door."
>
> —KEN PIENTA, UNIVERSITY OF MICHIGAN

"You can imagine a future where you could interact with the agent-based models like you can in a video game," speculates Edelstein-Keshet. For instance, and use the results to decide treatment for the real patient. But Edelstein-Keshet and others caution that such a future remains a long way off.

"The real-life systems we're trying to understand are just immensely complex," says biostatistician Thomas Kepler of Duke University in Durham, N.C. "How things behave inside the body is very hard to predict based on experiments done outside the body."

However, many scientists expect in-silico modeling to play an ever-larger role in medical research. As agent-based models are combined with more-traditional mathematical descriptions of disease processes, their predictive power will grow.

"I have a strong belief that agent-based modeling is going to be a very powerful tool to analyze biology," says Kirschner. "You're really allowed to give the objects in your programming a life of their own." ■

OF NOTE

ARCHAEOLOGY

Getting a read on early Maya writing

Researchers excavating the ruins of an ancient pyramid in northeastern Guatemala have discovered examples of the earliest known Maya writing, produced between 300 B.C. and 200 B.C.

The discovery shows that the Maya developed a writing system at around the same time as script emerged in ancient societies of what is now Mexico, say William A. Saturno of the University of New Hampshire in Durham and his colleagues.

Saturno's team found hieroglyphic symbols on painted walls and plaster fragments buried inside the remains of a pyramid at a Maya site called San Bartolo. Dating relied on radiocarbon measurements of bits of burned wood buried with the script samples.

Much of the writing is difficult to decipher, the investigators report in an upcoming *Science*. They regard one hieroglyphic symbol at San Bartolo as an early version of a Maya sign meaning *lord*, *noble*, or *ruler*.

Until now, the first fully legible Maya writing dated to around A.D. 250. However, preliminary studies by independent teams suggest that inscriptions carved in stone monuments at two other Maya sites were made between 300 B.C. and 100 B.C. —B.B.

BIOTECHNOLOGY

Cranberry aid for assay

Cranberry juice, often used to stave off urinary-tract infections caused by *Escherichia coli*, also keeps the bacteria from reducing a biosensor's specificity, scientists report.

Past research had shown that cranberry juice fights the infections by stopping *E. coli* from adhering to human cells. Frances S. Ligler, Brandy Johnson-White, and their colleagues at the Naval Research Laboratory in Washington, D.C., tested whether the juice would also prevent the bacteria from attaching to biosensors' glass surfaces.

On its surface, the sensor has a pattern of different antibodies that capture targets—proteins or microbes, for example—from food or clinical samples. A subsequent application of antibodies that have a fluorescent tag pinpoints the location of the target, revealing its identity.

E. coli bacteria, often found in biologic samples, bind all over the glass surface, says Ligler. Since this bacterium shares surface proteins with other microbes, the fluorescent antibodies can attach to the *E. coli* in a sample along with the desired target, producing areas of brightness that obscure a target's location.

When the team mixed cranberry juice with its samples, however, the juice "prevented the sticking of these very sticky bacteria" to the slides, Ligler says. A 50 percent solution of the juice eliminated almost all the background fluorescence. The researchers found no such effect with other juices, they report in an upcoming *Analytical Chemistry*. —A.C.

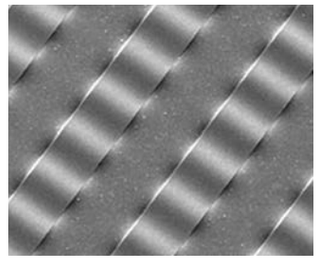
MATERIALS SCIENCE

Making waves

Flexible silicon is no longer an oxymoron. Scientists have created thin, wavy silicon ribbons that stretch along with their rubber backing. The technique could lead to comfortable, sensor-filled uniforms that monitor a soldier's vital signs or to electric devices that can wrap around complex shapes such as aircraft wings.

Fashioning a rigid material such as silicon into a thin film can make it bendable but not stretchable, says materials scientist John A. Rogers of the University of Illinois, at Urbana-Champaign. Rogers' team uncovered silicon's flexible nature by accident, he says.

A lab member inadvertently stretched the rubber stamp used to apply thin silicon strips to a plastic backing. When the rubber snapped back, the silicon ribbons buckled along their lengths into a rippled shape. These strips turned out to be 10 to 20 times as stretchy as rigid silicon is.



ROGERS

RIPPLED RIBBONS These micrometer-wide ribbons of silicon flex when their rubber backing is stretched.

The ribbons expand and compress much as an accordion bellow might, notes Rogers. His team makes them in thicknesses ranging from 20 to 200 nanometers, widths of a few micrometers, and lengths up to an inch.

To make devices such as transistors and diodes out of the flexible material, the researchers added components such as conductors to thin strips of silicon on a wafer. Then, they transferred the device onto a uniformly stretched rubber backing and released the rubber's strain to introduce waves. The device's electrical properties withstood 100 cycles of stretching and compression, the group reports in the Jan. 13 *Science*.

Rogers says that the team is now working on squares of silicon that give in two directions, and the researchers are investigating how they might increase silicon's stretchiness by an additional factor of 10. —A.C.

ASTRONOMY

Gravity at play

Astronomers are delighted to have found 19 galaxies that appear to be bent out of shape. The distorted images are cosmic mirages, arcs or rings of light created when the gravity of a massive foreground object bends and magnifies the light from a galaxy lying behind it. Albert Einstein predicted the effect, known as gravitational lensing, in 1936, but telescopes at the time weren't powerful enough to discern it.

In the study, Adam Bolton of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and his colleagues combined the power of the Hubble Space Telescope with the breadth of the Sloan Digital Sky Survey. That survey of one-fourth of the sky employs a ground-based telescope in Apache Point, N.M. Using Sloan data, the team picked out large, elliptical galaxies capable of acting as gravitational lenses. When they pointed Hubble at 28 of these lensing candidates, they found arcs and rings close to 19 of them, indicating that they were indeed distorting the images of more-distant galaxies.

Eight of the 19 lensed galaxies have had their light bent into a circle called an Einstein ring. This pattern arises when one galaxy is almost exactly aligned behind another, as seen from Earth. Astronomers had previously identified only three Einstein rings.

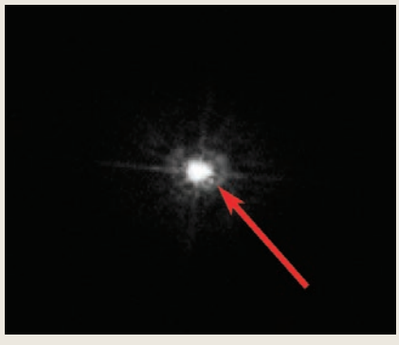
In addition to providing curious shapes, gravitational lensing is a powerful probe of dark matter, the invisible, exotic material that theorists say resides in massive halos around every elliptical galaxy. Although dark matter halos can't be directly seen, astronomers can deduce the presence of this material by the extent to which its mass bends the light of background galaxies.

Bolton and his colleagues describe their study in the February *Astrophysical Journal*. —R.C.

POLARIS PARTNER

Hubble spots North Star companion

Old drawings portray the North Star, Polaris, as a solitary beacon of light. But the star, which generations of seafarers have relied on for navigation, has two stellar companions, as indicated by Polaris' motion. One of the stars has been visible to astronomers for centuries, but the other, smaller, fainter star that tightly orbits Polaris has now been photographed for the first time by the Hubble Space Telescope.



STELLAR PARTNER Image shows Polaris and its newfound, close companion (arrow).

Small telescopes can easily view the more distant partner, which English astronomer William Herschel discovered in 1780. The newfound body, dubbed Polaris Ab, lies about 6 billion kilometers from Polaris and takes about 30 years to orbit it, report Nancy Evans of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and her collaborators. The triple-star system is 430 light-years from Earth.

Evans' team plans to track the orbits of both partner stars to more accurately measure the mass of Polaris. Pinning down that number is key to understanding the star's evolution. Polaris is the nearest known Cepheid variable, a type of star used to measure the distances to other galaxies and the rate of expansion of the universe. —R.C.

PLANET FORMATION

One star better than two?

The raw material for planets comes from disks of gas, dust, and ice particles that form around young stars. According to one leading theory, planets arise when diffuse, cold material within a disk collides and sticks together, gradually building boulder- and house-size objects into larger and larger bodies that slowly become planets.

In a competing theory, known as the gravitational-instability model, a sudden fragmentation of the disk can trigger the wholesale formation of giant planets, such as Jupiter, without any gradual buildup.

In both cases, theorists have assumed that planet formation is most likely to succeed in stars that don't have partners. The gravity of a nearby star might disrupt a disk, halting the planet-forming process. However, 30 of the 161 planets currently known beyond the solar system are found orbiting stars that have at least one partner.

Alan P. Boss of the Carnegie Institution of Washington (D.C.) now contends that when it comes to planet formation, two stars are at least as good as one and, in some cases, even better.

Boss' computer simulations of planet making indicate that if the gravity of a companion star only weakly disturbs the disk of its partner, planet formation should continue just as it does in a single star. In some cases, the disturbance could even trigger the fragmentation process required in the gravitational-instability model, hastening the formation of planets.

That's good news for planet hunters, he notes, because about two-thirds of the stars in our galaxy have companions. This result "increases the likelihood of the formation of planetary systems resembling our own, because binary stars are the rule in our galaxy, not the exception," says Boss. —R.C.

GALACTIC PARADOX

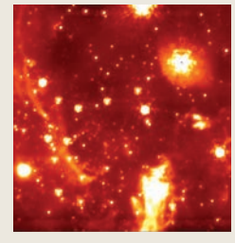
Images reveal possible origin of young stars

Newborn stars have no business being anywhere near the monster black hole that lies at the center of the Milky Way. The tidal forces that the black hole exerts on the cold, low-density clouds of gas and dust that give rise to stars are so enormous that they would rip the cloud to shreds long before stars could emerge.

Nonetheless, the galactic center contains hundreds of massive, newborn stars, a puzzle that Andrea Ghez of the University of California, Los Angeles calls the paradox of youth (*SN: 6/21/03, p. 394*). Ghez and her colleagues say that they have now solved the puzzle.

Astronomers have had two leading theories to explain the young stars' existence. According to one model, the stars didn't form in their current locations but instead were ferried in as part of a massive star cluster with enough gravity to stick together even as it entered the black hole's arena. In this scenario, the star cluster broke apart soon after its arrival, sprinkling the region with young, massive stars in either circular or elliptical orbits around the galactic center.

In another model, the young stars formed where they now reside but arose within a flattened disk of gas and dust that managed to stay intact despite its proximity to the black hole. In this case, all the stars should have the circular orbits they would have had when born. The stars would lie too far apart for their mutual gravity to have altered their orbits from circular to elliptical.



DANGEROUS NEIGHBORHOOD High-resolution image of young stars that lie just a few light-months from the supermassive black hole at the Milky Way's center. Image from the Keck II telescope.

Ghez and her colleagues recorded a series of unusually sharp images of stars at the galactic center taken by a laser system on one of the world's largest visible-light telescope, the Keck II telescopes atop Hawaii's Mauna Kea. Beamed into space, the laser light acts as a virtual star, enabling a rapidly adjustable mirror on the telescope to continuously change shape to compensate for the blurring caused by Earth's turbulent atmosphere. The team tracked the motion of more than 30 slow-moving, young stars that lie a few light-months from the galaxy's core. That's just far enough away from the center that the black hole couldn't have distorted the shapes of the star's original orbits.

The images reveal that most of the 30 massive stars have elliptical orbits, indicating that, as migration theory suggests, these stars did indeed travel to the galactic center after forming elsewhere, says UCLA astronomer Jessica Lu, a member of Ghez' team. —R.C.

EVANS, H. BOND, NASA, ESA, GHEZ ET AL.

Books

A selection of new and notable books of scientific interest

THE BOTANIST AND THE VINTNER: How Wine Was Saved for the World

CHRISTY CAMPBELL

In the mid-1860s, tales of "a new vine disease in the south of France" began to spread. Before long, the unidentified pestilence shook the French winemaking industry. Botanists looked with puzzlement at the withered brown leaves and the roots infested with tiny orange insects. All the typical insecticides of the day, including sulfur and cayenne pepper, failed, and the infection, phylloxera, quickly spread throughout Europe. Botanists and vintners were left wondering where the insects came from and how they spread. The scientists noted that vines imported from the Americas didn't succumb to the insect, leading a few botanists and vintners to recall the recent writings of Charles Darwin on adaptation. The insect, a type of aphid, originated in the Americas. British journalist Campbell reveals the intriguing story behind the identification and eventual eradication of phylloxera and how French botanist Jules Planchon of Montpellier and U.S. entomologist Charles Riley saved the French wine industry from ruin. ***Algonquin, 2005, 360 p., hardcover, $24.95.***

THE THREE-POUND ENIGMA: The Human Brain and the Quest to Unlock its Mysteries

SHANNON MOFFETT

The human brain is a fragile, watery mass that is nevertheless more powerful and complex than any computer and that houses the very essence of a person. Neuroscientists have yet to determine what produces consciousness, why we dream, or how amnesiacs can store information without remembering it. Moffett, a medical student at Stanford University, examines the latest research into how the brain processes information. Each chapter is devoted to a different aspect of brain research, from functional magnetic resonance imaging of memory formation, to linking specific neurons and experiences, to probing the effects of meditation on the brain. Moffett describes how the brain develops and changes over a person's lifetime. She provides an educational, behind-the-scenes glimpse into the efforts of neuroscientists to uncover the brain's secrets. ***Algonquin, 2006, 304 p., b&w illus., hardcover, $24.95.***

SNOWSTRUCK: In the Grip of Avalanches

JILL FREDSTON

One morning in January 2000, an avalanche swept without warning through Cordova, Alaska, knocking houses off their foundations and burying alive one woman as she sat in her armchair. The dramatic description of the ensuing rescue effort opens this story of the deadly power of snow. Fredston has spent her life researching avalanches—probing how they are triggered and forecasting their likelihood. In this book, she draws on a wealth of personal experience—from tracking avalanche paths on mountains with her husband, also an avalanche specialist, to guiding rescue efforts—to convey the devastation brought on by these natural phenomena. She recalls the harrowing accounts of a skier buried so tightly that he could move only an index finger and of the death of a close friend who, despite his familiarity with the dangers of avalanches, succumbed to one. She also ponders the risk-taking behavior of many avalanche victims and details occasional miraculous rescues. ***Harcourt, 2005, 352 p., b&w photos, hardcover, $24.00.***

AGLOW IN THE DARK: The Revolutionary Science of Biofluorescence

VINCENT PIERIBONE AND DAVID F. GRUBER

The last German submarine sunk in World War I was betrayed when it triggered the glow of microbes in the Mediterranean Sea. This phenomenon, which gives certain jellyfish their flickering luminescence and is characteristic of more than 90 percent of deep-sea creatures, is called biofluorescence. Pieribone and Gruber reveal the painstaking efforts of scientists to identify the mechanisms behind this mysterious light, including 19th-century work by Raphael Dubois, who coined the terms *luciferase* and *luciferine* to describe the catalyst and fuel for the biofluorescent reaction. In the 1930s, Edmund Newton Harvey identified these compounds in numerous glowing organisms, including the firefly, and 30 years later, Osamu Shimomura discovered the novel way by which jellyfish produce light. Cellular-molecular biologist Pieribone and journalist Gruber detail how the groundbreaking discoveries of these and other researchers have had widespread implications in forensic science, molecular biology, and neuroscience. ***Harvard, 2006, 288 p., color photos, hardcover, $24.95.***

BLACK BODIES AND QUANTUM CATS: Tales from the Annals of Physics

JENNIFER OUELLETTE

Physics as a science explains much about the natural world. However, its technical language makes the understanding it offers inaccessible to many people. Science writer Ouellette attempts to overcome this hurdle by explaining physical principles in terms of popular culture. With references to Dan Brown's book *The Da Vinci Code*, movie director Stanley Kubrick's *Dr. Strangelove*, and other cultural touchstones, Ouellette makes physics and its history entertaining. For instance, she explains the connections between the film *Back to the Future* and Albert Einstein's theory of special relativity and between development of the laser and its role in television programs such as *Star Trek*. Each concept is clearly explained in an entertaining narrative. ***Viking Penguin, 2005, 320 p., paperback, $15.00.***

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LETTERS

Push, pull, zap, drench

I'm surprised that NASA envisions an absurdly massive, nuclear-powered "gravitational tug" to avoid "the biggest problem" of a contact-tug's need to "fir[e] its rocket engine only at specific times" to compensate for an asteroid's rotation ("Protecting Earth: Gravitational tractor could lure asteroids off course," *SN: 11/12/05, p. 310*). Cassini, in orbit around Saturn, fires its rocket engine "only at specific times" routinely. Voyager-1 and Voyager-2 have been firing theirs "only at specific times" ever since launch in 1977.

DAVE DOODY, ALTADENA, CALIF.

The menacing asteroid described in the article seems to have an unusual characteristic. It's more than 13 times as dense as water, making it heavier than lead and more than 60 percent heavier than solid iron.

STEPHEN CURRY, DALLAS, TEXAS

Another possible approach to deflecting an asteroid would be shooting projectiles to change the body's momentum in a carefully planned way. The mass being flung could be mined from the asteroid itself.

JOHN D. HOSHOR, FORT MYERS, FLA.

I would think one could easily attach thrusting craft at either of the asteroid's poles, where a continual thrust would be in only one direction. This should be no more difficult than positioning a gravitational tractor at an unvarying distance and direction from the asteroid.

DAN LIPP, FORT COLLINS, COLO.

A much more powerful and simpler-to-control asteroid tractor would use electric charge. Very small amounts of charge would generate more force than gravitation, allowing the spacecraft to be smaller. If the craft had an ion drive, the charged particles could be a by-product of the drive system.

DAVE BLAU, CUPERTINO, CALIF.

The proposed space tractor could carry along a few thousand gallons of water, which would be poured onto the asteroid in such a way as to freeze on its surface. Once the solid is in place, there would be a location for a pushing or towing device.

TOM HARVES, GREENBANK, WASH.

*NASA's Stan Love replies that his team assumed an asteroid density of 2,000 kilograms per cubic meter, "appropriate for silicate rocks with internal porosity and void spaces caused by impact fracturing." —*R. COWEN

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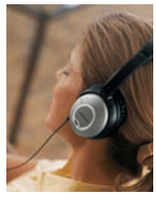

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