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SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

dad's health legacy
questioning doping tests
enceladus' geysers, up close
lazarus african fly

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the dish on delish

YOUR FOOD, DOWN TO THE MOLECULE

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Features

This Week

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Of Note

Departments

Cover Using formulas to represent how ingredients are transformed into food has inspired new dishes, sometimes redefining traditional fare such as the chocolate mousse pictured here (see story to find out how to make one without egg or cream). (iStockphoto) Page 202

THIS WEEK ONLINE
http://blog.sciencenews.org/

Food for Thought The animal protein in our diets can have a high environmental cost.

MathTrek Statistical tools help guide responses to human rights crises.

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Foul Play

Genetics may affect athlete doping tests

A genetic quirk could help cheating athletes beat drug tests and could unfairly taint fair players.

The genetic variation affects an enzyme that processes testosterone. Testosterone is naturally made in the body by both men and women, although it is primarily known as a male sex hormone. In order to distinguish between naturally present hormone and synthetic testosterone from steroid use, drug tests measure a ratio of two chemicals found in urine.

One chemical, epitestosterone glucuronide (EG), is made at a constant level in the body, regardless of testosterone levels. The other chemical, testosterone glucuronide (TG), is a testosterone by-product.

Testers measure the ratio of TG to EG. Any amount of TG greater than four times the level of EG is considered a red flag for doping.

An enzyme called UGT2B17 adds a chemical to testosterone to prepare it for secretion in the urine. A group of scientists in Sweden found that some people completely lack the gene that produces UGT2B17, and this difference could affect results of doping tests.

About 15 percent of 145 healthy male volunteers lacked the enzyme entirely. Just over half the volunteers (52 percent) had one copy of the gene, and one-third of the men had two copies.

Some of the men were selected to get a single shot of testosterone. The researchers monitored production of TG in the men's urine for 15 days after the injection.

About 40 percent of the people who lacked the enzyme never secreted enough TG to raise warning flags in the standard test, even after getting a hormone shot, the team reports online in the *Journal of Clinical Endocrinology & Metabolism*.

"There is a risk that many such individuals have escaped detection," says Anders Rane of the Karolinska Institute in Stockholm, Sweden, and one of the authors of the study.

On the other hand, 14 percent of people with two copies of the gene made so much TG that the current test would flag them as cheaters even before they got testosterone shots.

"Have there been any false positives or false negatives among the winners of various games? We don't know, but in all probability it could have happened," Rane says.

About two-thirds of the East Asians in the study lacked the enzyme compared with fewer than 10 percent of the Swedish people tested. Different ethnic groups may use different enzymes to process testosterone, says Glenn Cunningham, a clinical endocrinologist at Baylor College of Medicine in Houston.

There is no apparent athletic advantage or disadvantage associated with lacking the enzyme, Rane says. He suggests combining genetic testing with periodic urine testing that tracks individual athletes over time.

"I think that they've made a strong case for doing the genetic testing in addition to" current testing methods, Cunningham says.

Because of the expense of genetic testing, "this is not something that is feasible to do for large numbers of people," he says. Such tests will likely be used in elite amateur and professional sports, but "I just don't know if it will be available for college and high school athletes." —TINA HESMAN SAEY

Gassy Geysers

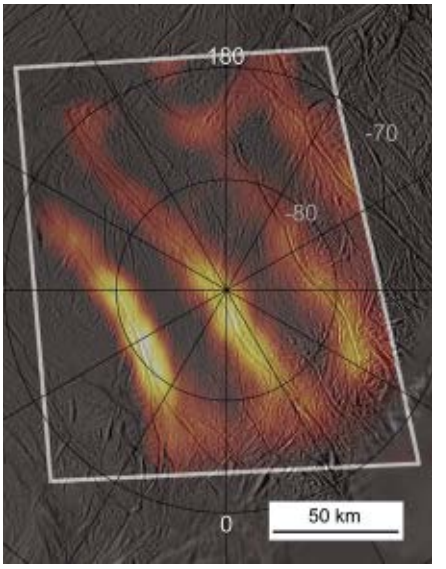
Cassini surveys Saturn's moon

Data from NASA's Cassini spacecraft raise new questions about the origin of Saturn's tiny moon Enceladus and the heat driving its plume of ice and water vapor.

Cassini lived to tell the tale of its March 12 brush with the enormous plume of ice, water vapor, and gas spewing from several fissures near the south pole of the moon. Swooping as close as 50 kilometers, Cassini went in like a dog with its tongue flapping out the window, sniffing and tasting the gassy brew for clues to the plume's origins and composition.

Astronomers had been astonished in 2005 to learn of the giant plumes of ice and water vapor blasting from the "tiger stripe" cracks in Enceladus' southern hemisphere, and the detection of organic compounds in the gassy mix suggested the moon could support life.

The March 12 fly-through, described at a NASA media briefing this week, got a closer look at the plumes and the moon's surface. Heat maps generated from the new data suggest that at least three of the tiger-stripe fissures are warm along their entire lengths and are ejecting water molecules at speeds faster than 600 meters per second.



JPL, GSFC/NASA, SWRI, SSI

HOT STRIPES **Cassini's instruments caught heat (orange and yellow) radiating from along the entire lengths of the 150-km fractures in Enceladus' south polar region.**

The brightest fracture, dubbed Damascus Sulcus, registered temperatures as high as 180 kelvins. That's more than 100 kelvins hotter than elsewhere in the polar region. Calculations published in *Nature* last year suggested that the little moon's heat comes from friction generated when the fissures' walls rub against each other as Saturn exerts its gravitational pull. But the new data don't support that idea, says Larry Esposito of the University of Colorado at Boulder and head of Cassini's ultraviolet imaging spectrograph team. The moon may be generating heat from somewhere closer to its core, perhaps by the flexing of the moon as it orbits Saturn, comments Princeton University's Christopher Chyba.

Another intriguing find was the details of the plume's chemistry, which is reminiscent of both natural gas and comets, says Hunter Waite of the Southwest Research Institute in San Antonio and leader of Cassini's ion and neutral mass spectrometer group.

That instrument found that the plume is mostly water vapor, with methane, carbon monoxide, carbon dioxide, and a mix of simple and complex carbon molecules. The cometlike chemistry suggests that the moon actually may have been a pristine object, captured in Saturn's orbit sometime in the past, says Waite.

But Chyba is skeptical. Saturn's many-mooned system has "well-behaved, orderly objects," he says. There's no evidence for the arrival of an outside object that would have to shed a lot of energy—perhaps by smashing into another object—to remain in the system.

Whether Cassini tasted life is still an open question, the researchers say. But the mixture of water and organics—precursors to the building blocks of life—is "sug-

gestive," Waite says. Chyba agrees. "The baby steps toward the origins of life are there," he says. —RACHEL EHRENBERG

Calorie Kick

Desire for sweets not only a matter of taste

Brains love cakes and cookies and Krispy Kremes, and not just for their taste. Calories feel good too.

Chemical fireworks in the brain's reward system explode in response to calories, independent of flavor, suggests a new study of mice reported in the March 27 *Neuron*.

Even when researchers eliminated mice's ability to taste food or liquid, the mice consistently chose sugary water over the diet version. The mice were also prevented from smelling or orally sensing texture in the study, by researchers from Duke University in Durham, N.C., and the University of Porto in Portugal.

"This is a very exciting new element in how you get addicted to food," says Tamas Horvath at Yale University School of Medicine. "It doesn't even matter how it tastes."

The brains of the mice without taste receptors responded to real calories instead of low-cal sweeteners, as well. Sugar consumption increased pleasure-inducing dopamine levels in the brain within an hour in taste-challenged mice, while sucralose, better known by its trade name, Splenda, did not. Dopamine, a chemical messenger in the brain, mediates internal rewards and is involved in an addict's drug-seeking behavior. Recently dopamine has been implicated in driving overeaters to binge. But the new work shows that the pleasure doesn't come from taste alone.

When normal mice ate either sugar or artificial sweetener, dopamine levels increased, as expected. But when mice had no ability to taste, only the sugar raised dopamine levels. "The animals' reward processing systems were sensitive to changes in metabolism, not just flavor," explains Ivan E. de Araujo, who led the study while at Duke, but is now at the John B. Pierce Laboratory in New Haven, Conn. "This is a new system."

At the moment, researchers don't know what metabolic cues tip off the brain's reward system. Calorie-rich foods increase blood glucose levels, insulin levels, and other hormones in addition to impacting the gastrointestinal tract. Those signals communicate "hungry" or "stuffed" to the hypothalamus, a part of the brain involved in regulating heat and energy. De Araujo's team observed an apparent calorie effect on activity in the nucleus accumbens, a brain structure involved with reward delivery.

"It looks like caloric load itself can evolve hedonic behavior," Horvath says. The system originated before grocery stores did. When food was harder to find, he says, the brain evolved a mechanism to compel the body to gobble up energy-dense fare.

A reward system that can't be fooled by fake calories may be what trips up dieters. "If someone tries to drink diet soda or eat diet ice cream, they might still have a need to compensate later with calories from other sources," says de Araujo. —AMY MAXMEN

European Roots

Human ancestors go back in time in Spanish cave

Fossil finds in Spain have yielded the earliest known skeletal evidence of human ancestors in Europe, according to a new report. A fossil jaw and tooth from the same individual, found during excavations of a cave called Sima del Elefante in northern Spain's Atapuerca Mountains, date to between 1.2 million and 1.1 million years old, say anthropologist Eudald Carbonell of Universitat Rovira i Virgili in Tarragona, Spain, and his colleagues.

The investigators assign the new discoveries to the species *Homo antecessor*. A decade ago, they identified 800,000-year-old fossils from another Atapuerca site as *H. antecessor*. In the Spanish scientists' view, *H. antecessor* was an evolutionary precursor of European Neandertals and modern humans.

Many scientists remain skeptical of that proposal and classify the Spanish fossils as the oldest examples of *Homo heidelbergensis*, a roughly 600,000-year-old species first found in Germany a century ago.

However this debate plays out, the Sima del Elefante fossils "provide the oldest direct evidence, to our knowledge, for a human presence in Europe," Carbonell says.

Anthropologist Bernard Wood of George Washington University in Washington, D.C., agrees that the find provides the first solid evidence that human ancestors reached Europe more than 1 million years ago. "Before this report, the evidence for an early occupation of Europe had substantial and important caveats," he says.

The newly unearthed specimens were found in sediment that also contained stone tools, stone flakes produced during toolmaking, and numerous animal bones bearing butchery marks.

Carbonell's team describes its work at Sima del Elefante in the March 27 *Nature*.

Several lines of evidence provided an age estimate for the Spanish fossils. Reversals in Earth's magnetic field recorded in fossil-bearing sediments bracketed the fossils' age at between 1.78 million and 780,000 years old. The decay rate of certain radioactive isotopes in rock buried near the fossils—along with analyses of the types of now-extinct animals strewn among the finds—narrowed the age estimate down to 1.2 million to 1.1 million years old.

The new finds strengthen earlier, contested evidence from other European sites—mainly consisting of stone implements, not fossils—that suggests human ancestors occupied the region at least 1 million years ago, Carbonell says. A broad anthropological consensus holds that large

EIA/JORDI MESTRE

CAVE SAVE Researchers who retrieved this fossil jaw from a Spanish cave conclude that human ancestors reached Western Europe more than 1 million years ago.

groups of human ancestors lived in Western Europe by 500,000 years ago.

The Atapuerca investigators suggest that Western Europe was settled between 2 million and 1 million years ago by a *Homo* species that trekked out of Africa, perhaps into central Asia, and then moved westward. That species then evolved into *H. antecessor*, in their view.

One possible ancestor of the ancient Atapuerca population has been found at the Dmanisi site in the central Asian nation of Georgia. Excavations there have yielded 1.77-million-year-old remains that may come from an early, highly mobile form of *Homo erectus* (*SN: 9/22/07, p. 179*).

The Sima del Elefante fossils show no obvious anatomical links to the Dmanisi remains, Wood says. Still, an evolutionary connection between Dmanisi and Atapuerca is plausible, he says.

It's unknown whether enough human ancestors entered Western Europe before 1 million years ago to establish a permanent presence in the region so that they could evolve into later European *Homo* species, Wood notes. —BRUCE BOWER

Live Another Day

African insect survives drought in glassy state

The larvae of an African fly survive severe droughts by essentially turning into candy drops, biologists have shown. The research might lead to new ways of preserving blood for transfusions or even entire organs for transplants.

Some invertebrates, when severely dehydrated, go into a state of suspended animation in which their metabolisms completely cease. When conditions are right, the critters come back to life. The larvae of the African fly *Polypedilum vanderplanki* scrounge a living by eating detritus at the bottom of rain puddles but can survive up to 17 years of drought waiting for the next abundant rains.

Most other animals known to freeze-dry are microscopic, such as sea monkeys (brine shrimp) and water bears (tardigrades). Biologists have known for years that a sugar called trehalose plays a crucial role in the survival tactics of several of these species. During desiccation, trehalose replaces water in the cellular fluids and is presumed to turn into a glassy state, much like melted sugar will solidify into candy drops. The glassy sugar would keep cellular structures from falling apart.

That's indeed what happens in *P. vanderplanki*, researchers have now shown. "This is the first direct evidence" for a glassy state in any animal, says Takashi Okuda of Japan's National Institute of Agrobiological Sciences in Tsukuba.

Okuda and his collaborators collected *P. vanderplanki*—which looks more like a mosquito than a fly—in Malawi, Burkina Faso, and Nigeria. After years of attempts, the team was able to get the insects to reproduce in the lab, providing an ongoing supply of larvae.

Infrared imaging of desiccated larvae showed that trehalose is uniformly distributed throughout their bodies. And when the researchers turned the temperature up, they noticed a peak in the larvae's heat absorption at around 70 degrees Celsius. The peak was characteristic of a phase transition at which solid sugars begin to melt, demonstrating that the sugar had been in a glassy state, Okuda says.

D. TANAKA/NATIONAL INSTITUTE OF AGROBIOLOGICAL SCIENCES IN JAPAN

READY FOR SPACE Curled up into a 4 millimeter–long mummy, this fly larva can suspend its life for years, withstanding severe drought and extreme temperatures.

In another experiment, the researchers detected telltale signs of trehalose molecules bonding with the double-layer lipid membranes that envelop cells. Trehalose had thus replaced water in its role of stabilizing the membranes. The results appear in the April 1 *Proceedings of the National Academy of Sciences.*

"This adds significantly to the evidence" that the insect turns to glass, says biologist Jim Clegg of the University of California, Davis.

Okuda says he and others would like to steal *P. vanderplanki*'s secret to learn, for example, how to keep transfusion blood in a dried form. The main challenge, he says, is to get trehalose to penetrate the membranes of red and white blood cells. Eventually, the technique could be used to preserve entire organs.

And could humans some day freeze-dry themselves alive with a shot of trehalose—perhaps to survive long trips to other stars? That's a long shot, Okuda says, but "theoretically, I think it's possible."

For now, it's *P. vanderplanki* that's traveling in space: Okuda and his collaborators have sent dried larvae to be hung outside the International Space Station, to see how they fare. —DAVIDE CASTELVECCHI

Still Waters

Skin disease microbe tracked to ponds, swamps

Knowing the natural hiding place of a disease-causing pathogen is the first step to defeating it. It has taken 60 years of trying, but scientists have finally found the home environment of the microbe that causes Buruli ulcer, a devastating skin disease.

Researchers now report isolating the culprit, *Mycobacterium ulcerans*, from insects nabbed in a stagnant pond in West Africa.

Earlier epidemiological reports showed that Buruli ulcer outbreaks often occur near such still waters in the tropics. "This study confirms what other investigations have suggested, that *M. ulcerans* is present in viable form in aquatic insects," says Mark Wansbrough-Jones, a physician not involved in the study who is at St. George's, University of London.

The researchers, led by biologist Françoise Portaels at the Institute of Tropical Medicine in Antwerp, Belgium, took water and wildlife samples from ponds and swamps in areas of Benin and Togo where Buruli ulcer is epidemic. They ground up the bugs and cultured the tissues in the lab.

But in lab dishes, other faster-growing bacteria crowded out the slow-growing mycobacterium. So the researchers took the unusual step of injecting the bug tissues directly into mice and letting the microbes grow there. After 9 months, the mice began forming skin lesions that contained a strain of *M. ulcerans* virtually identical to the kind already known to cause Buruli ulcers in people. The microbes even harbored the same DNA and manufactured the same toxin that causes the skin ulceration that defines the disease. The report appears in the March *PLoS Neglected Tropical Diseases.*

"This is a major accomplishment," says Pamela Small, a microbiologist at the University of Tennessee–Knoxville. "We know that people don't spread this disease between each other. It's an environmental pathogen that has its own life. People get it accidentally."

Buruli skin ulcers are oddly painless,

apparently because the bacterium's toxin dulls nerves. The toxin might also exert an anti-inflammatory effect that sidetracks an immune response and prevents wounds from healing. If ulcers get too big, doctors typically remove them surgically and apply skin grafts. An antibiotic combination of streptomycin and rifampicin can knock out smaller ulcers, but treatment takes months. Also, streptomycin must be injected and has side effects.

Buruli ulcer is becoming more common in some wet areas of West Africa than its better-known mycobacterial cousins, tuberculosis and leprosy.

Meanwhile, it remains unclear just how *M. ulcerans* infects people. The long-legged water bugs found to harbor *M. ulcerans* in this study—called water striders—probably don't transmit the disease to humans, says study coauthor Pieter Stragier, a microbiologist on the Belgian team. Since most water bugs seldom bite people, they are more likely to be temporary hosts for the microbe.

While some Australian researchers suspect mosquito bites transmit the disease, other scientists speculate that small cuts or abrasions allow *M. ulcerans* to penetrate and infect the skin through water contact. The microbe might even exist as part of a biofilm, an aggregate of adhesive microorganisms, on water-based plants with sharp leaves, Small says. The hunt for a mode of transmission continues. —NATHAN SEPPA

Mouse, Heal Thyself

Therapeutic cloning from a mouse's own cells

Scientists have treated mice that have a Parkinson's disease–like condition by making new neurons from each mouse's own skin cells.

The work demonstrates the potential of therapeutic cloning for replacing damaged neurons in people who have Parkinson's.

The individual steps of the process have each been done before in mice: cloning skin cells to make early embryos, extracting stem cells from the embryos, converting these embryonic stem cells into the right kind of nerve cells, and implanting the nerve cells into the mouse brains.

But the new study is the first to put all the pieces together by extracting skin cells from the same mouse that ultimately will receive the newly minted nerve cells, mimicking one procedure that scientists have proposed for treating Parkinson's disease in people.

"Nobody had ever done it," says Viviane Tabar of the Sloan-Kettering Institute in New York City.

In previous studies, groups of mice all received nerve cells derived from a single mouse. Preventing the bodies of the recipient mice from rejecting the foreign cells required impairing the animals' immune systems or using inbred mice.

"It's easy just to say we need to use an individual's own cells when you haven't shown that it's any better or that it's even feasible," says Tabar. "We were able to demonstrate that [self-derived] tissue worked much better functionally and immune-wise."

Tabar's team treated one group of mice with the new method. Each mouse received nerve cells made from skin cells taken from its own tail. Another group of mice all received foreign cells. As expected, the genetically matched nerve cells took up residence in each mouse's brain and were thriving 11 weeks after implantation. But in the other group, few nerve cells survived, presumably because of rejection by the immune system, the researchers report online March 23 in *Nature Medicine*.

In principle, the body should accept genetically matched cells, but the implanted nerve cells had gone through a lot of manipulation that could have caused complications. First, cloning experts at the RIKEN Center for Developmental Biology in Kobe, Japan, cloned each mouse's skin cells, which involved a jolt of chemicals. Then Tabar's team exposed the resulting embryonic stem cells to a mixture of signaling molecules to steer the stem cells toward becoming neurons.

"You take the cells out and you put them back and you don't know what's happening in between," comments Kai-Christian Sonntag of the Center for Neuroregeneration Research at Harvard Medical School in Belmont, Mass. The cloning and conversion to nerve cells "might have changed the cells' immune profiles, and they might have gotten rejected. You never know until you have proven it." —PATRICK BARRY

E. OKONSKI/SMITHSONIAN

Farm girl has the chops

The heart-shaped face of this ant soldier of the *Atta laevigata* species allows room for muscles that power her scissorlike mouthparts. While she stands ready to bite attackers, other workers use equally impressive mouthparts to slice up leaves to nourish their gardens of edible fungus. Ancient ants developed farming some 50 million years ago, long before people, says Ted Schultz of the Smithsonian Institution in Washington, D.C. (Bark beetles and termites also farm.) Schultz and Smithsonian colleague Seán Brady used DNA and ants in amber to trace the farmer-ant family tree. The leaf-cutter lineage is surprisingly new, arising 8 million to 12 million years ago, but leaf-cutters became dominant plant eaters in their tropical ecosystems, the researchers say in a paper published online March 24 in *Proceedings of the National Academy of Sciences*. —SUSAN MILIUS

You've Heard What Scientists Know. Ever Wonder How They Know It?

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DAD'S HIDDEN INFLUENCE

A father's legacy to a child's health may start before conception and last generations

BY TINA HESMAN SAEY

Pregnant women know the drill. Don't drink. Don't smoke. Don't eat too much fish. Take vitamins. Mothers have long shouldered the responsibility, and the blame, for their children's health. Fathers don't usually face the same scrutiny.

How a man lives, where he works, or how old he is when his children are conceived doesn't affect their long-term health, scientists used to think. But growing evidence suggests that a father's age and his exposure to chemicals can leave a medical legacy that lasts generations.

Animal studies demonstrate that drugs, alcohol, radiation, pesticides, solvents, and other chemicals can lead to effects that are handed from father to son. Human studies are less clear, but some show that fathers play a role in fetal development and the health of their children.

Teenage dads face increased risk that their babies will be born prematurely, have low birth weight, or die at birth or shortly afterward, a new study in *Human Reproduction* shows.

Babies of firefighters, painters, woodworkers, janitors, and men exposed to solvents and other chemicals in the workplace are more likely to be miscarried, stillborn, or to develop cancer later in life, according to a review in the February *Basic & Clinical Pharmacology & Toxicology*.

Fathers who smoke or are exposed at work to chemicals called polycyclic aromatic hydrocarbons put their children at risk of developing brain tumors.

And, older fathers are more likely to have children with autism, schizophrenia, and Down syndrome and to have daughters who go on to develop breast cancer.

Though some of these observations are decades old, attitudes lag even further behind, says Cynthia Daniels, a political scientist at Rutgers University-New Brunswick in New Jersey. Dads aren't held accountable if something goes wrong during fetal development.

MATTER OF MATH Since men make new sperm every 74 days, people used to reason, the genetic slate is wiped clean every couple of months. And even if a man makes defective sperm, the "all-or-nothing" view of reproduction holds that damaged sperm don't fertilize eggs. No harm. No foul.

So no one bothers to remind men to protect themselves against environmental toxins. There are no images of "crack dads" and "crack babies" in the media like those of women who harm developing fetuses with drug and alcohol use, Daniels said in February at a meeting of the American Association for the Advancement of Science held in Boston.

When someone does study fathers-to-be, the focus is usually on fertility, not on the consequences for children's health, she says.

Yet even fertility messages meet resistance from many men.

Harry Fisch, director of the Male Reproductive Center and a urologist at Columbia University Medical Center, found that out when he suggested that men, like women, have ticking biological clocks.

Men can produce sperm throughout life, but that doesn't mean their cells are forever young.

"Every cell in the body ages," says Fisch. "Every cell. The older you get, the more chance of an abnormality. The same thing goes for sperm."

Men younger than 20 and older than 30 make more abnormal sperm than men in their 20s. These damaged sperm could create an unhealthy embryo or pass on damage that could lead to birth defects or illness in offspring.

It is not a popular message.

"Men do not want to hear this," Fisch says. "When my book came out, I got e-mails. I got faxes saying, 'How dare you say this? How can you say this? We know that there are men in their 70s having healthy children.'"

Despite these anecdotal accounts of elderly dads, studies demonstrate that older men are at increased risk of passing on genetic abnormalities. It's a matter of math.

Women are born with all the eggs they will produce in their lifetime. The cells that give rise to eggs divide 24 times, all before birth. But the cells that produce sperm continue to divide throughout a man's lifetime. Each year after puberty, a man's sperm-producing cells replicate about 23 times. Every time the cells divide is another chance for error.

> "Every cell in the body ages. Every cell. The older you get, the more chance of an abnormality. The same thing goes for sperm."
>
> — HARRY FISCH, COLUMBIA UNIVERSITY MEDICAL CENTER

As a result, the sperm produced by a 40-year-old man have gone through about 610 rounds of replication. That's 610 chances of introducing a mutation in the DNA, or improperly divvying up genetic material.

Parents over age 40 are six times more likely to have children with Down syndrome than 25-year-old parents, Fisch and colleagues showed in a 2003 study in the *Journal of Urology*. An extra copy of chromosome 21 causes Down syndrome. This extra chromosome is just as likely to come from dad as mom in the older couples.

Older dads also have a higher risk of fathering children with rare mutations that cause dwarfism or a premature aging disease called Hutchinson-Gilford progeria syndrome.

But sometimes aging fathers pass along traits that can't be traced to only a single mutation. Fathers 40 and older have an increased chance that their children will develop complex disorders such as autism or schizophrenia. There is growing evidence that those disorders are caused by defects in many genes and the way genes are turned off and on.

Scientists don't yet understand the changes that age induces in sperm-making germ cells, and environmental exposure presents an even bigger mystery. People come in contact with a plethora of

chemicals every day. But it is no easy task to sort out exactly which ones, or which combinations, cause heritable problems. The effects chemicals and radiation may have on offspring don't always follow predictable patterns either.

And when researchers do find a clear link between a father's lifestyle and his children's health, it's not always clear what the data mean.

"What we can say is that we identified a group of fathers with adverse outcomes for their fetuses, but we don't have an idea of the mechanism," says Shi Wu Wen of the University of Ottawa in Canada and one of the lead authors of the study showing that babies of teenage fathers have a greater risk of birth problems.

Wen and his colleagues examined birth records for more than 2.6 million babies born between 1995 and 2000 to married, first-time, 20-something mothers in the United States. Looking at the husbands' ages, the team found that babies of teenage fathers, but not middle-age men, had an elevated risk of still birth, low birth weight, and other birth problems. The study was published online Feb. 6 in *Human Reproduction*.

'PREPOSTEROUS' INHERITANCE Some animal studies showing paternal effects emerged years ago but were roundly dismissed, says Gladys Friedler, professor emeritus at Boston University.

Four decades ago, Friedler was studying tolerance to narcotics, one of the first steps of addiction. To find out if a mother rat could pass tolerance on to her offspring along with antibodies and other immune factors, as some scientists theorized, Friedler exposed female rats to morphine before pregnancy. Babies of exposed mothers were born much smaller than average. And those babies also went on to give birth to tiny babies, even though the offspring had never encountered the drug.

Friedler also gave male rats morphine before they bred. "To my total disbelief and bewilderment, paternal exposure also affected progeny," Friedler said at the AAAS meeting.

Her adviser dismissed the result. Morphine doesn't cause mutations, so the idea that males could hand down a trait without passing along a mutation seemed preposterous. The whole thing smacked of Lamarckism, the long-rejected idea that environmental influences can change an animal or plant's structure and offspring can inherit that change.

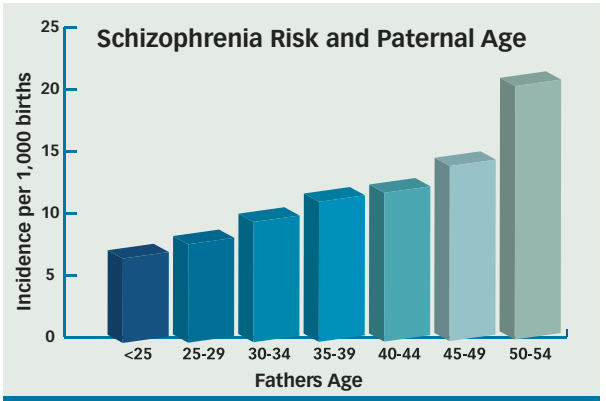
But in recent decades, scientists have discovered that chemical modifications to DNA and proteins can change the way genes are packaged and regulated without changing the genes themselves. Such modifications are known as epigenetic changes.

"What was Lamarckian is now epigenetic," Friedler says.

Epigenetic modifications act as a molecular scrapbook, preserving memories of events in parents' lives and handing them down to the next generation and beyond.

"There's a chromosomal memory," says Anne Ferguson-Smith, a developmental geneticist at Cambridge University in England. "The chromosomes remember whether they came from the mother or the father."

That memory is established in the form of a chemical mark called methylation. Methylation usually turns a gene off. At least 100 genes in humans are turned off only on the chromosome contributed by the mother or only on the chromosome that came from the father. Such genes are called imprinted genes because of the indelible impression parents leave on their offspring's DNA.



OLDER AGE, HIGHER RISK — As men age, they stand a greater chance of fathering children who will develop schizophrenia by age 34. Paternal age is only one of many factors linked to schizophrenia.

Several imprinted genes help build the placenta or encode growth factors that need to be tightly controlled so an embryo will develop correctly. "There's a contribution from both parents that is essential," Ferguson-Smith says. "One can't do without the other. They must work together to have a healthy offspring."

Imprints and other methylation marks are not encoded in the DNA. Instead the epigenetic modifications decorate chromosomes like ornaments on a Christmas tree. But these ornaments are heirlooms of a different type. It's as if a seedling grows straight from the ground already gussied up with tinsel and lights in the same places its parents were decorated. If a chemical or aging alters the epigenetic pattern on a man's chromosomes, his heirs could bequeath mismarked DNA to their children, too. Some mistakes may be as benign as exchanging a red bulb for a blue one. Other alterations, akin to placing the star on the lowest branch instead of the treetop, are likely to have more profound consequences.

Male mice exposed to cocaine, for example, pass memory problems on to their pups, a 2006 study in *Neurotoxicology and Teratology* shows. The male mice inhaled cocaine in long daily sessions akin to crack binges. When they mated with females never given coke, they had pups that had trouble learning and remembering where to find food in simple mazes. The problem was especially severe for female offspring. The researchers couldn't find any obvious DNA damage in coke-smoking males' sperm, but did find altered levels of two enzymes involved in the methylation of DNA in sperm-producing tissue in the father mice. The result suggests that epigenetic changes may be responsible for the offspring's behavior problems.

FUNGICIDE LEGACY Matthew Anway doesn't know whether the rats in his lab at the University of Idaho in Moscow have methylation problems. Some studies suggest they do, but Anway doesn't yet have definitive proof.

He can prove that male rats exposed to a fungicide in the womb can pass tumors and diseases of the prostate and kidney down for at least three generations. The rats could provide the first model for how prostate disease is inherited, he says.

Male babies born to mothers that had been injected with fungicide had prostate problems that mimic those seen during human aging. The second-generation rats also had more tumors, kidney defects, and higher rates of abscesses, cysts, and other infections than unexposed control rats. Germ cells in the testes of exposed rats also died more quickly than those in the control rats.

Subsequent generations of male rats also had the prostate and testes defects, and both male and female offspring developed kidney problems and tumors.

But only male rats could pass along the defects. The exposed rats bequeathed their fungicide legacy to their sons, grandsons, and great-grandsons even though none of the later generations were exposed to the chemical.

Exposed animals decrease production of enzymes that methylate DNA, Anway says. But he hasn't yet found consistent changes in the methylation patterns in exposed rats.

It's not clear whether Anway's results have any implication for human health. The rats were exposed to extremely high doses of fungicide through the completely unnatural route of injection.

What's important is that the male shares experiences with descendants for years to come. Further research could give new insights, Anway says, into how alterations in early development could lead to adult disease in humans. ■

E. ROELL, (SOURCE: D. MALASPINA, ET AL., ARCH. OF GEN. PSYCHIATRY, 2001)

WHAT'S COOKIN'

Science is in the kitchen, and the results are good for our taste buds

BY RACHEL EHRENBERG

At minibar, a six-seat restaurant within the Café Atlántico in Washington, D.C., many menu items sound familiar: Philly cheese steak, conch fritters, corn on the cob, and mojitos. But the mojito doesn't come in a glass. It is served as a bite-sized sphere on a spoon. Calcium chloride is mixed with the traditional rum, lime, mint, and sugar. A dollop of this concoction is dropped into a bath of water and sodium alginate, a gum extracted from algae—which encloses the orb of flavor in a membrane. After a minute, it is rinsed with water to stop the gelling, transferred to a canister, then charged with carbon dioxide. A few hours later, the sphere is slightly carbonated, built to flood the taste buds in a fizzing burst of flavor.

Today, it would not be unusual to find alginate, liquid nitrogen, or lecithin in the larders of top-ranked chefs, like José Andrés of Café Atlántico, Ferran Adrià from elBulli in Roses, Spain, or Heston Blumenthal of the Fat Duck in Bray, England.

Cooks are drawing inspiration from the lab, delighting in techniques that once were the province of industry. At the same time, researchers are zealously scrutinizing food. By zeroing in on its creation in the kitchen—and destruction in the body—scientists are joining chefs in cracking the code of delicious.

Some chefs react to this new cuisine by declaring it "not real cooking." But minibar sous chef Michael Turner disagrees. "Everything is new at first," says Turner. "I'm sure when the first person sautéed something people were like, 'What the hell are you doing, you must be a witch.'"

The traditional relationship between science and food might be described as an assault, yielding Spam, plastic-wrapped cheese products, and TV dinners. "Food science," driven by the needs of industry, has been geared toward the mass production of "foodstuffs."

Now the methods of science—controlling for variables and keeping records so that results are replicable—are spilling into the restaurant kitchen. Recipes and their accompanying lore are being rigorously dissected and described in the lab. Researchers at the forefronts of their disciplines are using principles of soft condensed matter physics, biochemistry, and molecular biology to understand bread, cheese fondue, and the mystery of milky sambuca.

SPHERE OF FLAVOR — Calcium bonds with sodium alginate to form a jelly shell around a spoonful of mojito.

DARKO ZAGAR

"Twenty years ago there was no science of the soufflé, béarnaise, chocolate mousse, or custard," says chemist and chef Hervé This (pronounced Tiss), of the French National Institute for Agricultural Research in Paris.

FROM SPAM TO SAVORY Today there is that science, as fans of *Iron Chef America* or *Top Chef* can attest, and thanks in large part to This, one of the founding fathers of the field known as molecular gastronomy. He notes, however, that the science of food is not actually new, citing observations on the density of meat that date to the 2nd century B.C.

By the late 1700s, chemist Antoine Lavoisier, when he wasn't articulating the law of conservation of mass, carried out elaborate experiments on the preparation of meat stock. At about the same time, physicist Benjamin Thompson (later Count Rumford) had made many forays into the kitchen, inventing a double boiler and percolating coffeepot.

But Rumford and Lavoisier's ilk were exceptions. Early efforts to preserve food by canning, prompted by a need to nourish troops on the battlefield, set the tone for science's contribution to cooking for the modern era.

"Restaurants and the tradition of preparing elaborate recipes were mostly ignored," says César Vega of the food research company Mars Botanical (an offshoot of Mars Inc) in Gaithersburg, Md. "The focus was on preserving food for long periods of time. And by the way, let's do it so it tastes the same, batch after batch after batch."

The relationship between scientists and chefs, or lack thereof, troubled the late physicist Nicholas Kurti. At a presentation for the Royal Society of London in 1969 he lamented, "I think it is a sad reflection on our civilization that while we can and do measure the temperature in the atmosphere of Venus, we do not know what goes on inside our soufflés."

Kurti's now famous lecture, titled "The Physicist in the Kitchen," was a turning point, says Vega, author, with Job Ubbink, of a forthcoming review on molecular gastronomy in *Trends in Food Science & Technology*. "It was very impactful on the scientific community." The lecture was peppered with demonstrations by Kurti and his daughter Camilla. They used a vacuum to remove water vapor from meringue and presented a pork loin tenderized with pineapple juice, which contains the protein-splitting enzyme bromelin.

Another milestone, says Vega, was the publication in 1984 of Harold McGee's *On Food and Cooking: The Science and Lore of the Kitchen*, which explained physics and chemistry for the home cook.

Kurti and This became partners, giving molecular gastronomy its name and organizing the first international molecular gastronomy conference in Erice, Italy, in 1992. But they both had long been investigating the relationship between scientific advancements and cooking techniques.

Aiming to clean the culinary books for chefs to come, This zeroed in on "culinary proverbs," tips included at the end of many recipes. Many of these helpful hints have persisted for centuries without being tested, This noted, such as advice to cut the heads off suckling pigs immediately after taking them out of the oven to keep their skin crispy, or the assertion that mayonnaise will fail if it is made by a woman who is menstruating. He began collecting and testing these old wives' tales, and today he has more than 25,000 in a database, about 100 of which have been explored in his labs. (Suckling pigs: True—cutting off the head allows vapor to escape that would otherwise permeate and soften the skin. Mayonnaise: False—duh.)

FIGHTING EQUILIBRIUM Hervé This also brought science to the kitchen by developing formulas for representing changes in the physical states and arrangement of food. Using G, O, W, and S for gas, oil, water, and solid, transforming cream into whipped cream would, in its simplest form, appear as:

$$O/W + G \rightarrow (G + O)/W$$

Dubbed complex disperse systems (CDS) formalism by This, the approach appears cumbersome, but zooming out to the abstract reveals dishes that hadn't been imagined. A method for preparing an eggless chocolate mousse, or "Chocolate Chantilly" as This calls it, arose out of the above whipped cream equation (see recipe on next page). And the equation holds when chocolate is replaced by foie gras or cheese, This notes in a 2007 paper in the *International Journal of Pharmaceutics*.

To some extent, the development of this formalism "bridged the divide" between gastronomy and colloid science, says Vega. Colloids are wannabe solutions: they look uniform and smooth but are actually particles of one thing suspended in another—butter, cream, and paint are colloids. Colloid science is one aspect of soft condensed matter physics, a field that gets at the nitty-gritty of materials that can be pushed, pulled, warmed, cooled, or shocked into new shapes.

"Most foods are out of equilibrium—their structures are not what physics would like them to be," says Raffaele Mezzenga of the University of Fribourg in Switzerland. As such, foods will want to devolve toward equilibrium—a state that's usually contrary to the desires of the cook. Scientists, for example, are still figuring out how to delay chocolate's tendency to "bloom" (when old chocolate turns white), which happens when cocoa butter molecules shift into a more comfortable, stable arrangement.

This path to equilibrium is dictated by the various interactions between molecules and the strength of those reactions at different scales and under different conditions—such as of pH or temperature. When the amount of energy needed to activate a chemical reaction is low, food's progress toward equilibrium is faster, says Mezzenga, lead author on a review in a 2005 *Nature Materials* on understanding food in terms of soft materials.

Large additions of salt, for example, can lower activation energy. The charged sodium and chloride ions act to cancel out the electrostatic repulsion of the surrounding molecules, making them more likely to bump into each other, aggregate, and precipitate out.

But creating food is usually an attempt to quench these interactions. Foods are ephemeral arrangements of ingredients and molecules, briefly pushed into shape by heat or whisks, chemistry and physics. Creating a smooth fondue, for example, means keeping molecules apart that would rather clump together—a feat made possible by heightening the repulsion of the molecules in solution, says Mezzenga.

In a cheese fondue this job falls to the wine. Caseins, the "curd" proteins of dairy, are normally bonded together into units known as micelles. Looking a bit like a head of dandelion seeds, micelles make up between 6 and 12 percent of milk and are glued together with calcium phosphate. These micelles fall apart at a pH of 4.6, leaving the caseins to clump. But adjusting the pH with a fairly acidic wine adds more hydrogen ions in the mix; the ions surround the casein molecules, charging them up so they repel each other. If the wine isn't acidic enough, a bit of lemon juice will do the same thing, says Mezzenga. "The Swiss fondue purist would maybe be upset, but it works, and can save your fondue."

Stabilizing mixtures is often all about getting oil and water to live amicably together rather than demanding to be alone. Surfactants and emulsifiers are such peacemakers. They are often tadpole-shaped molecules with oil-loving (or fat-loving) tails and water-loving heads. The oil-loving tails embed themselves in a droplet of oil, leaving the water-loving heads in the water, thereby preventing like from clumping to like. Egg yolk proteins (such as lecithin) are the emulsifiers that keep mayonnaise smooth; gelling agents, such as the plant starch pectin, other starches, and citric acid are all emulsifiers.

WHITE WINE, DECONSTRUCTED — Individual flavor notes such as vanilla, citrus, and fig are delivered within a winelike gelée. The concept is by José Andrés.

DARKO ZAGAR

OUZO EFFECT Solutions that remain stable without emulsifiers have presented scientists with a puzzle. Anise-flavored beverages such as pastis, sambuca, and ouzo are three-ingredient solutions: water (about 55 percent), alcohol (about 45 percent), and flavored oil (about 0.1 percent). These drinks appear clear in the bottle—the proportion of alcohol, water, and oil is such that the oil is soluble in the mixture and it looks clear. But when they are served as cocktails, water is added and the drinks spontaneously turn a milky white, a phenomenon known as the "ouzo effect." The added water tips the ratios, and the oil is no longer soluble—droplets form in the solution, scattering the light. This milky state is quite stable, lasting for months.

Scientists have studied this effect and the process is now used for creating nanocapsules and other tiny particles. But the mystery of the milky drink is not a closed case.

It isn't clear why the milky state remains stable. Perhaps the molecules are close enough to equilibrium that they're content to sit still. "We really don't have a model for that kind of interface," says Erik van der Linden of Wageningen University in the Netherlands. Normally, the recipe would call for an emulsifier to achieve such stability (if the bartender added egg yolk to your drink there would be no mystery).

Even a new approach to the problem, published by van der Linden, This, and Elke Scholten in the March 4 issue of *Langmuir*, offers no clear solution. The team tested an existing model of the behavior of the beverage's molecules and found that the experimental results completely contradicted the theoretical predictions.

Phenomena like the "ouzo effect" are part of the behavior of food and drink on the shelf, or in the oven or bottle. But when Kurti and This defined molecular gastronomy in 1988, they articulated an additional area of food science research that had been largely ignored: the experience of eating.

A MOMENT ON THE LIPS The industry tendency to measure properties of food outside the mouth and correlate it with what people perceive is all wrong, says George van Aken of Top Institute Food and Nutrition in the Netherlands. Now scientists are looking inward—not just at taste receptors but at the entire "breakdown path" that food travels when it's consumed. "People have been worried about how we build it but not how we destroy it," says Vega.

Researchers are examining how color and sound affect taste, and 3-D models have been proposed to illustrate how food is deformed by the mouth. Other researchers are looking at the digestive end of things.

"What is important is in your mouth," says van Aken, who reviews how soft foods behave under "oral conditions" in a 2007 paper in *Current Opinion in Colloid & Interface Science*. He points out that with soft foods, teeth play a minor role. More important are structural changes that result from heating or cooling to body temperature, the action of saliva (an adult secretes 0.5 to 1.5 liters per day), and the shearing between the palate and the tongue. "There's no tongue like the human tongue," van Aken says.

His description of what goes on in the mouth brings to mind Han Solo's experience in the Death Star's garbage compactor. A piece of cheese enters the abyss as a tidy slice, but it is quickly "masticated down to small particles." As fats lubricate the tongue's surface, saliva—which has a gas, liquid, and gel phase—clumps bits into a mass or bolus. Masticating continues and flavor particles are released, which catch in the various rivulets of the tongue. The human tongue is actually quite soft, notes van Aken, unlike a cat tongue, which "you could grate cheese with."

Driven to enhance this experience in the mouth, and the few moments of presentation on the plate, some chefs, such as the team at José Andrés' Café Atlántico and minibar, have become culinary alchemists. They use science as a tool to make something crunchy, spreadable, or spoonable and to deliver flavors in a particular order. The food surprises and delights. Head chef Katsuya Fukushima, likens the science of food to modern art, which can be enjoyed even by fans of old masters.

"Food can be such a beautiful thing—we try to make it fun," says Fukushima, who doesn't like the term molecular gastronomy. He agrees that science is necessary for developing concepts. "But when it comes down to it, we are just cooks." ■

Chocolate Chantilly

Air in a chocolate-water emulsion

Ingredients:

200 ml (about ¾ plus ⅛ cup) water

225–250 g (about 8 oz) bittersweet chocolate, coarsely chopped

Put water and chocolate in a saucepan. Heat, stirring until chocolate is completely melted. Put ice in large bowl. Pour chocolate-water mix into a smaller bowl and place over ice. Whisk madly to introduce air bubbles. Stop at the consistency of mousse.

L. SAVINO, (RECIPE FROM H. THIS, FRENCH NATIONAL INST. FOR AGRICULTURAL RESEARCH)

OF NOTE

NUTRITION

Strong support for a basic diet

Body builders and grannies take note: To preserve muscle, eat salads.

A new study by researchers at the federal Human Nutrition Research Center on Aging, at Tufts University in Boston, finds that diets rich in potassium appear to protect muscle. And fruits and veggies are a primo source of dietary potassium.

Bess Dawson-Hughes and her colleagues recruited nearly 400 men and women for a 3-year dietary trial on calcium and vitamin D. The researchers wanted to keep bones strong, so the participants—all 65 or older—would suffer fewer falls and disabling fractures. However, strong muscles also help prevent falls, and those muscles usually begin a seemingly inexorable wasting by age 40 (*SN: 8/10/96, p. 90*).

So the researchers correlated the amount of muscle with other components of the participants' diets—and found a strong link to potassium. The more of it individuals consumed, the more muscle they had, all other things being equal, report the researchers in the March *American Journal of Clinical Nutrition*. Seen in people eating the most potassium, the protective effect appears to "be enough to offset a good chunk of, if not all of, the age-related decline in muscle that normally occurs," notes Dawson-Hughes.

It boils down to pH (level of acidity). The body converts protein and cereal grains, major parts of the U.S. diet, to acid residues. Excess acid triggers breakdown of muscle into components that ultimately make ammonia, which removes the acids. Potassium-heavy diets, being alkaline, can buffer those acids without sacrificing muscle. —JANET RALOFF

ANTHROPOLOGY

A hip stance by an ancient ancestor

Fossil hunters discovered remains of a 6-million-year-old human ancestor, dubbed *Orrorin tugenensis*, at a Kenyan site in 2000. Their analysis of upper-leg fossils from *Orrorin* suggested that it walked upright in a surprisingly modern way, more like 2-million-year-old *Homo erectus* than the 3- to 4-million-year-old australopithecines, the group that includes the partial skeleton known as Lucy.

A new study of the most complete *Orrorin* leg bone, which includes the shaft and knob that connected the upper leg to the pelvis, reaches a different conclusion. *Orrorin* in fact shared a distinctive hip arrangement with australopithecines, as well as with a related line of fossil species (*Paranthropus*) that eventually died out, say Brian G. Richmond of George Washington University in Washington, D.C., and William L. Jungers of Stony Brook University in New York.

So, hips conducive to walking slowly with legs wide apart evolved in *Orrorin* and remained unchanged for almost 4 million years, until the demise of australopithecines, Richmond and Jungers propose in the March 21 *Science*. Around that time, *Homo* species evolved hips designed for a rapid stride with legs close together.

The scientists compared *Orrorin*'s upper leg to corresponding specimens from 130 modern humans, 49 common chimpanzees, 14 pygmy chimps, 59 gorillas, 32 orangutans, and nine fossil ancestors of people. Fossils came from australopithecines, *Paranthropus*, and early *Homo* species.

Earlier computerized tomography scans of the pattern of bone thickness in *Orrorin*'s hip connection raise the possibility that *Orrorin* also assumed apelike postures to climb trees, the researchers note.

The Kenyan fossil, which was found in several pieces and then glued together, should be unglued to examine its internal structure before drawing conclusions about how *Orrorin* moved about, remarks anthropologist Tim D. White of the University of California, Berkeley. —BRUCE BOWER

EVOLUTION

Crustacean shuffle

A modified joint might have made all the difference to scurrying crabs as they diverged from their plodding lobsterlike brethren.

Comparing leg shape, size, and motion among three living crustaceans from increasingly ancient origins allowed Andrés Vidal-Gadea, at Louisiana State University in Baton Rouge, and his colleagues to get at

the mechanics of crab walking: specifically, how some crustaceans changed their forward march into a sideways scuttle.

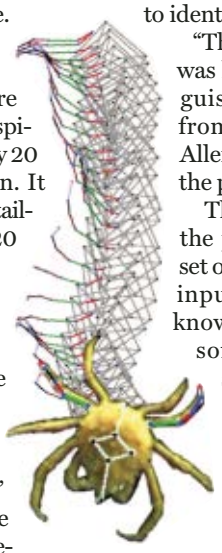
Forward-walking crayfish were the most primitive of the three lineages, and sideways-striding shore crabs the most recent. The portly spider crab, which plods sideways only 20 percent of the time, falls between. It belongs to one of the first groups of tailless crabs, which evolved about 320 million years ago.

"These guys [spider crabs] walk completely differently from sideways walking crabs," says Vidal-Gadea. "Anatomically they look like forward-walking lobsters."

In forward-walkers, each limb's movement is limited by the leg ahead or behind it. Yet as crabs' fourth leg joints evolved to be more flexible, their limbs could glide side-to-side, the team suggests in the March *Arthropod Structure & Development*. And crabs took off, moving equally fast in two directions.

Previous work suggests that over evolutionary time certain crustaceans tucked their vulnerable tails—housing the meaty abdomen—under the body. The front claws shrunk to balance the loss of hind weight. In the absence of formidable pinchers, speed saved crab lives.

With RoboLobster, a lobsterlike robot, already in use, this research may inspire a new generation of mechanical crawlers, says Vidal-Gadea. —AMY MAXMEN



SCUTTLE Analyses of walking crustaceans (pictured is a spider crab) help map the evolution from forward to sideways strides.

VIDAL-GADEA

BIOTECHNOLOGY

Fingerprinting fugitive microbes

Even in a struggling economy, the job market is booming for genetically engineered bacteria.

These microscopic machines are being put to work making everything from pharmaceuticals to fuels, raising the question of how to track the invisible critters if they ever got loose—or worse, if engineered pathogens were ever released as an act of bioterrorism.

Scientists have developed a software tool that finds characteristic "fingerprints" in the microbes' DNA that can distinguish altered bacteria from natural ones.

Typically, scientists deliver foreign genes to bacteria on plasmids, small rings of DNA that bacteria naturally swap back and forth. Researchers have designed many kinds of artificial plasmids for various uses, but because new designs are usually based on older ones, artificial plasmids typically share many of the same segments of DNA.

Jonathan Allen and his colleagues at Lawrence Livermore National Laboratory in Livermore, Calif., reasoned that they might be able to use these shared segments to identify artificial microbes.

"The biggest question in our minds was how hard it would be to distinguish these [artificial plasmids] from just natural plasmids," says Allen, a computational biologist in the pathogen bioinformatics group.

The new software tool automates the process of finding the optimal set of genetic fingerprints. The team input the genetic code for 3,799 known artificial plasmids into the software, which compared the sequences and found hundreds of matching stretches, each with about 20 "letters" of genetic code. The program then computed the smallest set of these shared snippets that can accurately distinguish artificial plasmids from natural ones.

Applying the test to another group of artificial plasmids identified 98 percent of them with no false positives, the team reports in the March 18 issue of *Genome Biology*. —PATRICK BARRY

NANOTECHNOLOGY

Power from heat

The thermoelectric effect can produce small amounts of electricity from almost any source of heat, but its low efficiency has so far limited its uses. A team has now found a simple way to make one thermoelectric alloy more efficient.

When two ends of a stick of a thermoelectric material are exposed to different temperatures, a voltage appears. The electrons in the stick act like the molecules in a gas: Just as gas expands when heated, the heated electrons move from the hotter side to the cooler side. The resulting voltage can create current.

Since the 1950s, researchers have known that the alloy bismuth antimony telluride is a good thermoelectric material, says Gang Chen of the Massachusetts Institute of Technology. But Chen wondered if the effect could be made better. Chen and his colleagues ground up the alloy and recompressed it. The grinding reduced the size of the alloy's crystalline grains by about a factor of a thousand. This change slightly improved the material's ability to conduct electricity but, most crucially, made it a worse heat conductor. That was good because heat conduction tends to equalize temperatures, counteracting the whole thermoelectric principle.

The researchers made the alloy 15 to 30 percent more efficient without substantially increasing its cost, Chen says. The results appeared online March 20 in *Science*.

The material could have applications, including in a new kind of solar panel that harnesses the difference in temperature between the panel's hot, sunny side and its cool, shaded side. Such panels, the researchers say, might turn 5 to 7 percent of solar energy into electricity—less efficient than traditional photovoltaics, but potentially at a lower cost per watt. —DAVIDE CASTELVECCHI

PLANETARY SCIENCE

Titan may harbor underground ocean

Before the Cassini spacecraft began observing Saturn's largest moon, Titan, researchers had suggested that a vast ocean of methane and ethane covered the hydrocarbon-shrouded body. But the craft's penetrating radar, along with a probe that descended to the moon's surface in 2005, revealed a different portrait. Icy Titan appears to contain small hydrocarbon lakes, not oceans. Now, Cassini researchers have evidence that Titan may have a global ocean after all—100 kilometers below the surface and consisting of water and ammonia.

Ralph Lorenz, of the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., and his colleagues base their findings on Cassini radar observations recorded from 2005 to 2007. During that time, hydrocarbon mountains and other prominent features on Titan shifted position by up to 30 km, the team reports in the March 21 *Science*. That displacement wasn't in sync with the moon's expected rotation because winds in Titan's dense atmosphere rocked the crust back and forth, the researchers propose. But they say the winds could do that only if the moon has an underground ocean, decoupling the icy crust from the core.

If so, Titan would be the fourth known solar system object—after three of Jupiter's moons—with an internal ocean. "Large reservoirs of water, a condition for life to form and develop," would therefore be common in the solar system, note Christophe Sotin of NASA's Jet Propulsion Laboratory in Pasadena and Gabriel Tobie of the University of Nantes in France in an accompanying commentary.

To test their hypothesis, researchers will look for seasonal changes in the shift in coming years, as the winds change, Lorenz says. —RON COWEN

Books

A selection of new and notable books of scientific interest

NETS, PUZZLES, AND POSTMEN: An Exploration of Mathematical Connections

PETER M. HIGGINS

In the 1730s, the famous Swiss mathematician Leonhard Euler tackled a difficult mathematical riddle. If the city of Königsberg, Prussia, has seven bridges that span the two branches of the river Pregel, and those bridges divide the city into four sections, can a person walk each of the bridges once and only once? The answer is no, but it's the process Euler took to arrive at this answer that makes the question special. Euler drew a network. Today, people use networks every day—when they travel on a highway, surf the Internet, or mingle at a party. Yet few people consider the math that underlies their movements. In this book, Higgins, a mathematician at the University of Essex in England, explains the numbers behind networks and explores the history of the field. He also offers some mind-puzzling examples along the way. ***Oxford Univ. Press, 2008, 248 p., b&w figures, hardcover, $29.95.***

THE FISH OF PENNSYLVANIA FIELD GUIDE

DAVE BOSANKO

Ever caught a fish and not known what to call it? This field guide by fisherman and biologist Bosanko could help. It's one of a series that includes a book for each of eight states so far. Targeted to anglers and anyone who's curious, each guide includes color illustrations and descriptions for more than 75 species. Minnow, pike, salmon, and sunfish make appearances in the pocket-sized, waterproof guides. For each species, the guides also discuss habitat, range, reproductive behavior, and other, similar-looking fish. The New York entry on the grass pickerel, for example, notes that while this species has a bar under its eye, the northern pike does not. Each book also includes record-setting catches for each fish, so anglers can compare their catches to the best. The largest rainbow trout caught so far in North America weighed 42 pounds. If you pull in a whopper like that, you can brag and have the numbers to prove it. ***Adventure Publications, 2008, 192 p., color illus., paperback, $13.95.***

BIG BONE LICK: The Cradle of American Paleontology

STANLEY HEDEEN

The fossils uncovered at northern Kentucky's Big Bone Lick, also known as the tomb of the mammoths, captivated a nation. The Shawnee people first discovered the site, and the giant femurs, massive jawbones, and pumpkin-sized molars later drew the attention of Daniel Boone, George Washington, and Benjamin Franklin. But it wasn't until 1807, when William Clark collected roughly 300 fossils for President Thomas Jefferson, that the wider world recognized this paleontological treasure trove. In this book, Hedeen, a biologist and former dean at Xavier University in Cincinnati, tells the story of the site that not only introduced the world to a plethora of extinct mammals (including mammoths, mastodons, and giant sloths), but also jump-started paleontology in North America. Hedeen begins with Shawnee myths of man-eating monsters. He describes the geology behind the lick (a natural salt deposit), explaining why so many mammals congregate there. Finally, he discusses the philosophical and religious changes that the discovery of these mammals—once living but now extinct—engendered. ***The Univ. Press of Kentucky, 2008, 200 p., b&w illus., hardcover, $24.95.***

ADVENTURES IN TORNADO ALLEY: The Storm Chasers

MIKE HOLLINGSHEAD AND ERIC NGUYEN

With some common sense, tornado-chasing is not risky—or so says Hollingshead modestly. He's a "chaser" who intentionally pursues storms across the Great Plains in his black Ford Mustang. First-hand accounts from Hollingshead, as well as from meteorologist and fellow chaser Nguyen, reveal heart-thumping moments for those who prefer to stay inside, or at least out of apparent danger. Visions of lightning amid swirling clouds and golf ball–sized hail may inspire readers to learn more about the effects of rising and expanding air. If so, they can refer to the final chapter on the life cycle of storms, written by Chuck Doswell, a meteorologist and storm chaser who's been in the business since the 1970s. Dramatic photographs from daredevils who drive opposite fleeing traffic in vehicles equipped with radio receivers, pressure monitors, and cameras may be as close as many of us will ever come to observing nature's wrath. Hollingshead lets it be known: "I always chase alone." ***Thames & Hudson, 2008, 187 p., color photos, paperback, $29.95.***

ELEPHANTS: A Book for Children

STEVE BLOOM AND DAVID HENRY WILSON

An elephant's tusk can weigh up to 200 pounds—about three times heavier than you, Wilson tells his young readers. His humorous comparisons between elephants and kids are intended to widen the eyes of children ages 4 through 10. Well-known for displaying sophisticated social behaviors, elephants indeed make endearing subjects. In photographs, they appear to celebrate the birth of a young one or stand still to mourn the death of a family member. Bloom, an acclaimed wildlife photographer, offers a glimpse of what readers may never see in person—elephants fighting tusk-to-tusk, swimming, and elaborately painted with pictures of birds and flowers for celebrations in India. The authors clear up misperceptions propagated by *Dumbo*: Those ears are in fact used to cool off or to give the appearance of a bigger, more intimidating, head. ***Thames & Hudson, 2008, 63 p., color photos, hardcover, $19.95.***

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LETTERS

Why switch to grass?

Regarding "Switchgrass may yield biofuel bounty" (*SN: 1/19/08, p. 46*): Distilleries have been around since the dawn of time, including barleycorn (whiskey), maize (whiskey), potatoes (vodka), sugarcane (rum), and arcane brews distilled from beets, bread crumbs, and bamboo. The ethanol molecule cares not one wit about its particular provenance, so what is so special about a soil-depleting broom like switchgrass, when economically important sources have been around for millennia?

DAVID C. OSHEL, CEDAR RAPIDS, IOWA

It's true that just about any plant matter can be used to make ethanol. But because switchgrass is not a food source, high demand for switchgrass-based ethanol wouldn't directly affect market prices for food commodities, as the demand for corn-based ethanol has done for corn prices. Also, switchgrass can be grown on land not suitable for food crops, and it requires relatively little energy to grow, which improves the net gain in energy from the ethanol produced. Using switchgrass leaves the other crops available for other purposes. —PATRICK BARRY

Kudos

Your recent article by Susan Milius about increasing levels of CO_2 in the sea ("The Next Ocean," *SN: 3/15/08, p. 170*) was extremely well written! It was engaging and clear. Thank you!

KATHERINE MUZIK, OKINAWA, JAPAN

No data without scientists

Unfortunately for the success of the Encyclopedia of Life project ("Biological Moon Shot," *SN: 2/2/08, p. 72*), development of browser-friendly portals to scientists' data does no good unless there's also someone hiring scientists to work on each species. There are not enough jobs for scientists working on systematics, especially invertebrates and protists, to generate the necessary data.

DAVID CAMPBELL, TUSCALOOSA, ALA.

Correction *The editing process introduced two errors into the story "Female bird brain notes male attention"* (SN: 3/22/08, p. 180). *The researcher Sarah C. Woolley was said to be from Columbia University, but she is at the University of California, San Francisco. Also, the ZENK protein was misidentified as the ZINK protein.*

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