

SCIENCE NEWS MAGAZINE SOCIETY FOR SCIENCE & THE PUBLIC

APRIL 16, 2016



Killer Prairie Dogs The Invisible Milky Way

R

Microbes Gum Up Health No-Frills Life

# More Truths, Still Inconvenient

Years after Oscar-winning film, scientists sharpen climate change picture

# Meet the Watch That Shook Up Switzerland

### A watch that revolutionized timekeeping

at a price equally as radical.

In the history of timepieces, few moments are more important than the creation of the world's first Piezo timepiece. First released to the public in 1969, the watch turned the entire industry on its head, ushering in a new era of timekeeping. It's this legacy that we're honoring with the *Timemaster Watch*, available only through Stauer at a price only we can offer.

Prior to Piezo watches, gravity-driven Swiss watches were the standard bearer of precision timekeeping. But all that changed when the first commercially available Piezo watch came onto the market.

The result of ten years of research and development by some of the world's top engineers, they discovered that when you squeeze a certain type of crystal, it generates a tiny electric current. And, if you pass electricity through the crystal, it vibrates at a precise frequency–exactly 32,768 times each second. When it came on the market, the Piezo watch was the most dependable timepiece available, accurate to 0.2 seconds per day. Today, it's still considered a spectacular advance in electrical engineering.

"It was like a magnum bullet shot at the most sensitive spot of the mechanical watch industry... Switzerland was terrified." Ariel Adams of A Blog to Watch.

With the *Timemaster* we've set one of the world's most important mechanical advances inside a decidedly masculine case. A handsome prodigy in rich leather and gold-finished stainless steel. The simplicity of the watch's case belies an ornately detailed dial, which reflects the prestige of this timepiece.

**Call today to secure your own marvel of timekeeping history.** Because we work directly with our own craftsman we're able to offer the *Timemaster* at a fraction of the price that many Piezo watches cost. But a watch like this doesn't come along every day. Call today before time runs out and they're gone.

**Your satisfaction is 100% guaranteed.** Spend some time with this engineering masterpiece risk-free for two months. If you're not convinced you got excellence for less, simply send it back within 60 days for a refund of the sale price (less S&P). But we're betting this timekeeping pioneer is a keeper.

#### Timemaster Piezo Watch \$299\*

Offer Code Price Only \$39 + S&P Save \$260

# 1-800-333-2045

Your Insider Offer Code: TPW110-01 You must use the insider offer code to get our special price.

Stauer® 14101 Southcross Drive W., Dept. TPW110-01 Burnsville, Minnesota 55337 www.stauer.com

\*Discount is only for customers who use the offer code versus the listed original Stauer.com price.



TAKE 87%

OFF INSTANTLY

When you use your

INSIDER OFFER CODE

Smart Luxuries—Surprising Prices"

Wear it today for only \$39

60

Stauer

TM WATE

30

Precision Piezo electric movement
Stainless steel caseback and crown • Cotswold<sup>™</sup> mineral crystal
Crocodile embossed leather strap fits wrists 6 ½"-8 ½"
Date window display • Water resistant to 3 ATM

# ScienceNews

# Features

18 Down in the Mouth

By giving microbes entry into the body, ailing gums may play an underappreciated role in heart disease, cancer and other health problems. *By Laura Beil* 

#### 22 Changing Climate: 10 Years After An Inconvenient Truth COVER STORY Though the troubling truth remains, scientists have made great progress in predicting

scientists have made great progress in predicting how rising temperatures will affect sea level, weather patterns and polar ice. *By Thomas Sumner* 

# 18

- News
- 6 It lives, with only 473 genes
- 7 Prime numbers reveal final-digit pattern
  - Moon's poles show signs of having shifted
- 8 Australia busts Africa's monopoly on fairy circles

Melanesians discover Denisovan ancestry

- 9 Smaller tyrannosaur had *T. rex* brainpower
- **10** Scientists help Alzheimer's mice recover lost memories

Carbonation puts fizz in Yellowstone's geysers

- **11** Seagrass during drought is happier with clams
- **12** Legos give a leg up to scientists designing metamaterials

Physics of fluids induces sperm to swim in groups

Ferroelectrics offer new catalytic strategy for extracting hydrogen

**14** Prairie dogs commit multiple murders (squirrels beware)

**16** News in Brief Slippery polymers

make removing ice from some surfaces easier

Tracing Zika's travels suggests earlier arrival in Brazil

Climate change messes with harvest timing for grapes used in European wines

Chemical analysis of fossil bone provides a pregnancy test for *T. rex* 



# Departments

- 2 EDITOR'S NOTE
- 4 NOTEBOOK Begging tadpoles are truly hungry; source of Mercury's darkness brought to light
- **30 REVIEWS & PREVIEWS** Disney brings ancient ape back from the dead
- 34 FEEDBACK
- 36 SCIENCE VISUALIZED Milky Way map reveals features hidden in dust

#### **SOCIETY UPDATE** 2016 Intel STS winners announced

**COVER** Scientists with NASA's ICESCAPE mission investigate the effects of climate change on Arctic ecosystems. *Kathryn Hansen/NASA* 





# Science's inconvenient (but interesting) uncertainties

Earth sciences reporter Thomas Sumner recalls seeing the documentary film *An Inconvenient Truth* when he was in high school. The climate science presented in the movie didn't surprise him too much — a science-minded student, he had already read about many of the issues.

But, he says, the film started a broader dialog about global warming.

"People started caring," he says, noting that he remembers his own family talking about it (and not always harmoniously) at the time. Revisiting the dramatic predictions made in the film proved an interesting journey for Sumner.

"The main criticism I heard was that the film had watered down the science," he says. Climate science is amazingly complex, and so is modeling effects of change — from how much sea level might rise to how a warming climate could alter hurricane patterns. Even more striking to Sumner were the sheer number of uncertainties that remain. Those uncertainties are not about whether the climate is changing, but about the details of what such changes will mean for the oceans, the atmosphere and the living things on land — and when the various dominoes might fall. Telling the future is hard, especially about interrelated complex systems, but as Sumner reveals in his story on Page 22, scientists have made steady progress in the last decade.

Another interesting point is the documentary's (and Al Gore's) role in politicizing climate science, which is fair to assume was one of the aims. "Gore was polarizing," Sumner says. "He created a conversation about global warming, but he also cemented it as a political issue."

Teeth and gums are neither political nor talked much about. But, as contributing correspondent Laura Beil reports on Page 18, scientists studying a possible role for gum disease in what ails the body must contend with a slew of uncertainties, not unlike those faced by climate scientists. The bacteria that cause gum disease, some studies find, can travel to the arteries, heart, brain and other sites where they can cause havoc. Not all studies agree, and proving the oral bacteria–disease link beyond a doubt may not yet be within scientists' grasp. But the fix is relatively simple, even if avoided by many: frequent flossing and regular visits to the dentist.

Keeping things simple was the underlying goal of the team of scientists attempting to build, from scratch, a synthetic organism with the least possible number of genes, as Tina Hesman Saey reports on Page 6. After many tries, the effort succeeded, but not without first humbling the researchers involved. In the initial attempts, their computer-designed minimal genomes didn't take. What ultimately worked was putting back some of the unknowns — genes with no known cellular job to do. Only then did the DNA inserted into the shell of a microbial cell yield a synthetic microbe capable of growing and reproducing.

Telling a good story about complex science, whether in a film or in a report on the latest research, requires some simplification. But sometimes the most interesting part lies in the uncertainty. *— Eva Emerson, Editor in Chief*  PUBLISHER Maya Ajmera EDITOR IN CHIEF Eva Emerson

#### EDITORIAL

MANAGING EDITOR Tom Siegfried EDITOR, SCIENCE NEWS FOR STUDENTS Janet Raloff DEPUTY MANAGING EDITOR, NEWS Macon Morehouse DEPUTY MANAGING EDITOR, DIGITAL Kate Travis DEPUTY MANAGING EDITOR, FEATURES Cori Vanchieri DEPUTY MANAGING EDITOR, PRODUCTION Erin Wayman ENTERPRISE EDITOR Elizabeth Quill WEB PRODUCER Helen Thompson ASTRONOMY Christopher Crockett BEHAVIORAL SCIENCES Bruce Bower **EARTH SCIENCES** Thomas Sumner LIFE SCIENCES Susan Milius MOLECULAR BIOLOGY Tina Hesman Saev **NEUROSCIENCE** Laura Sanders PHYSICS Emily Conover STAFF WRITER Meghan Rosen **REPORTER/RESEARCHER** Sarah Schwartz SCIENCE EDUCATION WRITER Bethany Brookshire EDITORIAL ASSISTANT Cassie Martin CONTRIBUTING CORRESPONDENTS Laura Beil, Susan Gaidos, Alexandra Witze

#### DESIGN

CREATIVE DIRECTOR Stephen Egts DESIGN DIRECTOR Erin Otwell ASSISTANT ART DIRECTORS Justine Hirshfeld, Molly Telfer USER EXPERIENCE DESIGNER Federico Castaneda

#### SOCIETY FOR SCIENCE & THE PUBLIC

PRESIDENT AND CEO Maya Ajmera CHIEF MARKETING OFFICER Kathlene Collins CHIEF FINANCIAL OFFICER Charlie Feeney CHIEF PROGRAM OFFICER Michele Glidden CHIEF, EVENTS AND OPERATIONS Cait Goldberg CHIEF ADVANCEMENT OFFICER Bruce B. Makous CHIEF TECHNOLOGY OFFICER James C. Moore

#### **BOARD OF TRUSTEES**

CHAIRMAN H. Robert Horvitz VICE CHAIR Alan Leshner SECRETARY Paul J. Maddon TREASURER Robert W. Shaw, Jr. AT LARGE Mary Sue Coleman MEMBERS Craig R. Barrett, Sean B. Carroll, Tom Leighton, Stephanie Pace Marshall, Joe Palca, Vivian Schiller, Frank Wilczek, Maya Ajmera, ex officio

#### ADVERTISING AND SUBSCRIBER SERVICES

ADVERTISING Kamille Davis SUBSCRIBER AND MEMBER SERVICES Kerwin Wilson PERMISSIONS Evora Swoopes

Science News 1719 N Street NW, Washington, DC 20036 Phone: (202) 785-2255

Customer service: member@societyforscience.org Editorial/letters: editors@sciencenews.org Sponsor content: ads@societyforscience.org Science News (ISSN 0036-8423) is published biweekly by Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.

Online and iPad access: Activate your subscribing member account, including digital access and the ability to opt out of print, at www.sciencenews.org/activate Subscribe: Web www.sciencenews.org/join For renewals, www.sciencenews.org/renew



Mail Science News, PO Box 1205, Williamsport, PA 17703-1205

Subscribing memberships include 26 issues of *Science* News and are available for \$50 for one year (international rate of \$68 includes extra shipping charge). Single copies are \$3.99 (plus \$1.01 shipping and handling). Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.

**Postmaster:** Send address changes to *Science News*, PO Box 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

Alliance for Audited Media

Society for Science & the Public is a 501(c)(3) nonprofit membership organization founded in 1921. The Society seeks to promote the understanding and appreciation of science and the vital role it plays in human advancement: to inform, educate, inspire. Learn more at societyforscience.org. Copyright © 2016 by Society for Science & the Public. Title registered as trademark U.S. and Canadian Patent Offices. Republication of any portion of *Science News* without written permission of the publisher is prohibited. For permission to photocopy articles, contact permissions@sciencenews.org. Sponsor content and advertising appearing in this publication do not constitute endorsement of its content by *Science News* or the Society.



# Lock in Pure U.S. Gold Eagles for only \$144 Secure New 2016 \$5 Gold Eagles Now—at a low introductory price!

Tens of thousands of people collect the American Gold Eagle. In fact it's been the country's "Gold Standard" for over two decades.

Try as they might, that makes it a very hard "secret" to keep quiet. And right now, many of those same people are lining up to secure the brand new 2016 U.S. \$5 Gold Eagle placing their orders now to ensure that they get the 30th anniversary Gold Eagle coin before thousands of others beat them to it.

# America's Most Affordable Gold Coin

Not only is the American Gold Eagle considered one of the most beautiful gold coins in the world, but the \$5 Gold Eagle is actually **the most affordable American gold coin!** Struck in a Tenth-ounce of pure gold, the beloved coin features the inspiring image of Miss Liberty carrying a torch—a design first authorized for U.S. gold coins by Teddy Roosevelt in 1907. The other side depicts a family of nesting bald eagles alongside the motto "In God We Trust".

#### Government Guaranteed Weight and Purity

Each Tenth-ounce \$5 American Gold Eagle is government guaranteed for its .917 purity,

authenticity, and legal tender status. The gold content and \$5 denomination are struck directly into the surface of the coin.

#### **Top Quality**

These 2016 \$5 Gold Eagles are freshly minted and display blazing luster and stunning, intricately sculpted details—the hallmarks of coins crafted in Brilliant Uncirculated (BU) condition. They are the perfect American gold legacy for you and your family.

# You Cannot Buy This Coin from the Mint!

The U.S. Mint does not sell Brilliant Uncirculated Gold Eagles directly to the public. You must obtain them through a distributor. Luckily, we have just accepted delivery on a fresh shipment of 2016 \$5 Gold Eagles—and are releasing them to the public at a very special low price.

Why the low introductory price? To introduce you to what hundreds of thousands of smart collectors and satisfied customers have known since 1984: that GovMint.com is **the best source for coins worldwide**.

#### **Timing is Everything**

Our advice? Keep this to yourself. The more people who know about this offer, the worse

for you. Demand for Gold Eagles has surged in recent years, and experts predict that 2016 Gold Eagles could easily surpass previous records. Our supplies are limited.

#### **30-Day Money-Back Guarantee**

You must be 100% satisfied with your 2016 \$5 American Gold Eagles or return them within 30 days of receipt for a prompt refund (*less all s/h*). Don't miss out on this exciting new release. Call immediately to secure these \$5 American Gold Eagles NOW!

#### 2016 \$5 U.S. Gold Eagle BU

**1– 5 coins: \$144 ea.** (*plus s/h*) Order 2 or more and get **FREE SHIPPING**.

Limit of 5 at this introductory price. Additional 2016 \$5 Gold Eagles may be purchased for \$154 each. Limited to 10 total coins per household.

For fastest service, call today



Offer Code GEB198-03 Please mention this code when you call.

GovMint.com • 14101 Southcross Dr. W. Dept. GEB198-03 • Burnsville, Minnesota 55337

Prices and availability subject to change without notice. Facts and figures deemed accurate as of February 2016. NOTE: GovMint.com® is a private distributor of worldwide government coin and currency issues and privately issued and licensed collectibles, and is not affiliated with the United States government. GovMint.com is not an investment company and does not offer financial advice or sell items as an investment. The collectible coin market is speculative, and coin values may rise or fall over time. All rights reserved. ©2016 GovMint.com.

Free shipping offer valid for orders with product totaling more than \$150 before taxes. Valid for domestic standard delivery orders only. Please call for expedited or international shipping rates. Not valid on previous orders.



#### THE BEST SOURCE FOR COINS WORLDWIDE™

#### NOTEBOOK



Excerpt from the April 16, 1966 issue of *Science News* 

#### 50 YEARS AGO

# Multiple sclerosis clue significant

A possible link between environment and multiple sclerosis (MS) could be a valuable tool in searching for the cause and cure of the disease.... Cases of MS seem to appear in clusters, and there is apparently some as yet unknown environmental factor that is distributed in the same way, reported Dr. John F. Kurtzke.... The highest frequency of MS is found in northern United States, southern Canada and northern Europe, where there are 30 to 60 cases per 100,000 population.

**UPDATE:** Researchers still aren't sure what causes MS, a debilitating disease in which the body's immune system attacks the insulation around nerve cell fibers. But people who grow up farther from the equator, with less sun exposure, may indeed have increased risk. The human body makes vitamin D in response to sunlight, and studies link lower levels of vitamin D to higher MS risk (SN Online: 9/10/15). Genetics and infections may also play a role in the disease. Today, MS prevalence is up to almost 150 cases per 100,000 U.S. population.



#### IT'S ALIVE

## Piggybacking tadpoles are epic food beggars

Tadpoles don't cry to get their way. But some of them sure can beg.

Each bout of hungry-baby drama among mimic poison frogs (*Ranitomeya imitator*) occupies both parents for hours. The tadpoles get so crazy-frantic that researchers wanted to know whether the begging is an honest call for help or a histrionic scam.

Frogs can lay globs of eggs by the thousands and leave them to fend for themselves. But the two- to three-egg clutches of mimic poison frogs (the only known monogamous frogs) get coddled, says Kyle Summers of East Carolina University in Greenville, N.C. Dad repeatedly checks in, sitting on the eggs and shedding some paternal pee if they're drying out.

When the eggs hatch, dad gives each tadpole a piggyback ride to its own private pool. To find a little rainfall cupped between a leaf and stem, he'll haul youngsters four meters or so. "A bit of a hike," Summers says, since dad is only about a

This yellow frog (tadpole aboard) is the same species as the one above. Poisonous themselves, adults in four different regions "mimic" the coloring of a different local poisonous frog.



centimeter or two long himself.

These baby pools are pretty empty: home to only some algae, maybe some small insects. "The good news is that your offspring are not likely to get eaten; the bad side is that they don't have anything to eat," Summers says.

This is where the begging comes in. Frogs can't make milk like mammals or regurgitate bugs like birds. But this species is one of the rare frogs whose moms, after considerable persuading, will lay an unfertilized egg for the tadpoles' breakfast.

When parents show up on their weekly visit, a youngster stops regular swimming, noses up to a parent and goes into a frenzy of vibrating its tail. "The parent cannot miss a hungry tadpole," Summers says.

Bouts of persuasion go on for several hours as the tadpole begs, stops, begs more and then more. Mom often makes several false starts, entering the pool but leaving it without any egg action. During all this, "dad will be the cheerleader," calling in trills and stroking her, Summers says.

Analyzing tadpole frenzies in the lab, Summers' then-student Miho Yoshioka found that tadpoles on short rations begged more as hungry weeks dragged on. Parents fed these hungrier tadpoles more reliably than the babies that researchers slipped treats to, Yoshioka, Summers and Casey Meeks report in the March Animal Behaviour. Overall, the researchers conclude, the relentless frenzy shows honest need, not tadpole greed. – Susan Milius

### Dome effect \dōm ih-fekt\ n.

The lowering of the atmospheric boundary between cooler, higher-altitude air and warmer air close to Earth's surface.

Airborne black carbon, also called soot, can cause the dome effect by warming the atmosphere's top layer and blocking sunlight that would otherwise warm the surface air. The reduced temperature difference between the two layers lowers the boundary between them. This effect traps pollution around major cities, worsening air quality, new research suggests.

Researchers observed the dome effect around several of China's megacities in December 2013. The compressed near-surface layer of the atmosphere led to thick hazes of pollution, the researchers report online March 16 in *Geophysical Research Letters*. Reducing local black carbon emissions from industry, biofuel burning, diesel vehicles and coal burning would quickly improve air quality around many megacities, the researchers propose. — *Thomas Sumner* 



Atmospheric changes brought on by airborne black carbon may worsen air quality around China's megacities, such as Shanghai (shown here).

The newly identified bacterium *Ideonella* sakaiensis can break down and eat bits of a polymer called PET, which is used to make plastic bottles like those seen here.

#### INTRODUCING

### This microbe makes a meal of plastic

A newly discovered microbe chows down on polluting plastic.

For humans, polyethylene terephthalate, also known as PET, is a stiff, strong plastic fiber that's the main ingredient in polyester clothing and disposable bottles. But for the bacterium *Ideonella sakaiensis*, PET is dinner.

Researchers in Japan discovered the bacterium living in samples of soil, wastewater and recycling plant sludge, all contaminated with PET particles. PET is very stable, and few known microbes can break it down. But *I. sakaiensis* can use PET as its main food source, the scientists report in the March 11 *Science*. Tests revealed that the bacterium latches onto PET particles and releases a protein that decomposes the plastic into molecules the bacterium can munch on (*SN: 2/20/16, p. 20*).

Millions of tons of PET are manufactured yearly, and the long-lasting plastic can pose an environmental threat as it builds up in ecosystems. With its appetite for this environmental hazard, *I. sakaiensis* might be valuable in plastic waste cleanup, the researchers say. – *Sarah Schwartz* 

#### MYSTERY SOLVED Mercury's dark secret revealed

Ever since Mariner 10 flew by Mercury in 1974 and 1975, researchers have known that the planet was darker than Earth's moon. But they didn't know why.

Some of the moon's darkness comes from its iron-rich minerals, which are lacking on Mercury. Scientists suspected that graphite might color Mercury, but they had no proof — until now. NASA's MESSENGER spacecraft, which spent four years orbiting Mercury before intentionally crashing last April (*SN Online: 4/30/15*), got close enough to obtain neutron spectroscopy data from a few dark patches in and around craters. Those patches are slathered with carbon, probably from a subsurface primordial crust, researchers report online March 7 in *Nature Geoscience*.

The crater carbon was probably churned up from a layer of graphite. A steady rain of meteorites and volcanic activity mixed this graphite into Mercury's top layer, darkening the entire planet, suggest Patrick Peplowski, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., and colleagues. – *Christopher Crockett* 



Akutagawa crater on Mercury is one of three craters where the MESSENGER spacecraft found deposits of carbon dug up from the planet's original crust.

# 

#### **BY TINA HESMAN SAEY**

Scientists have built a bacterium that contains the minimal genetic ingredients needed for free living.

This bacterium's entire set of genetic blueprints, its genome, consists of only 473 genes. The precise functions of 149 of those genes are unknown, researchers report in the March 25 *Science*.

The newly created bacterium contains a minimalist version of the genome of *Mycoplasma mycoides*. Species of *Mycoplasma* already have some of the smallest known genomes. *M. mycoides* used in the experiments started with 901 genes. In comparison, other bacteria may have 4,000 to 5,000 genes. Humans have more than 22,000 genes, although not all are necessary (*SN: 4/2/16, p. 18*).

In 2010, researchers at the J. Craig Venter Institute in La Jolla, Calif., replicated the entire genome of *M. mycoides* and popped it into the cell of a different species, *Mycoplasma capricolum*, creating what some people called the first synthetic organism (*SN: 6/19/10, p. 5*). The new work strips the *M. mycoides* genome down to its essential elements before putting it into the *M. capricolum* shell, producing a bacterium dubbed "syn3.0."

Researchers hope syn3.0's uncluttered genome will teach them more about the basics of biology. Such minimal genome bacteria may also be the chassis on which to build custom-made microbes for producing drugs or chemicals.

J. Craig Venter, founder of the nonprofit institute, and a team of researchers there led by Clyde Hutchison III and Daniel Gibson set out to design an organism based on a core set of about 300 genes that researchers surmised a microbe would need to survive on its own. But when the researchers tried to bring their computer creations to life, "every one of our designs failed," Venter said in a news conference. The failure was due to leaving out genes of unknown function. About

#### GENES & CELLS

# Scientists build a minimum genome

Only 473 genes needed to keep 'syn3.0' bacterium alive

32 percent of the genetic ingredients ultimately needed to cook up even a simple organism were left out because the researchers didn't know what the genes did and didn't understand their importance. Once those genes were mixed back into the batter, the bacteria sprung to life.

"I think we're showing how complex life is in even the simplest of organisms," Venter said. "These findings are very humbling" because they show that researchers still don't fully understand even the minimal requirements for life.

The team has clues about what 70 of the 149 genes with unknown function do. For instance, one resembles genes involved in shuttling small molecules across a cell's membrane, Hutchison says. The scientists just don't know which molecules are transported. The roles of the other 79 genes, about 17 percent of syn3.0's genome, are entirely unknown.

Other teams have attempted to make minimal genomes by stripping away one gene at a time. But the Venter group built its lean microbe from the ground up, synthesizing pieces of DNA that would later be stitched into a complete genome.





Drew Endy, a synthetic biologist at Stanford University, applauds the madefrom-scratch approach. "Only when you try to build something do you find out what's truly required. Too often in biology we end up with only data, a computer model or a just-so story. When you actually try to build something, you can't hide from your ignorance," Endy says. "What you build either works or it doesn't."

In addition to the mystery genes, genes with overlapping functions also posed a challenge. The team originally classified those genes as unnecessary because deleting them from the genome had no effect on the bacteria. But the researchers soon found out that they couldn't leave out both copies of pairs of genes that do similar jobs. It's similar to a twin-engine jet: Knocking out one engine will keep the plane airborne, but removing both engines will lead to a crash, Gibson says.

Although syn3.0's genome is far smaller than those of other free-living bacteria, it may not be the minimal genome for every independent organism in every situation. (Symbiotic bacteria living inside host cells may have fewer genes but cannot survive on their own.) Other researchers have theorized that a minimal cell could consist of one single RNA-replicating gene inside a membrane, says geneticist George Church of Harvard University.

Starting with another organism or growing the bacteria under different conditions would probably lead to a different minimal set of genes, says Jay Keasling, a synthetic biologist at the University of California, Berkeley. "The minimal genome is in the eye of the beholder."

Gibson and Venter agree that they have created *a* minimal genome, but not necessarily *the* minimal genome. Syn3.0 contains a few frills. The team kept several "quasi-essential" genes that aren't strictly necessary for life but allow the bacteria to grow fast enough to make them useful in the lab.

MATH & TECHNOLOGY

# Peculiar pattern pops up in primes

Final digit in consecutive numbers is not random

#### **BY RACHEL EHRENBERG**

Prime numbers, divisible only by 1 and themselves, hate to repeat themselves. They prefer not to mimic the final digit of the preceding prime, mathematicians have discovered.

"It is really, really bizarre," says Stanford University number theorist Robert Lemke Oliver, who, with Stanford number theorist Kannan Soundararajan, discovered this prime predilection. "We are still trying to understand what is at the heart of this," Lemke Oliver says.

Generally, primes are thought to behave much like random numbers. So whenever some kind of order is revealed, it gives mathematicians pause.

"Any regularity you can show about primes is beguiling," says Harvard University number theorist Barry Mazur. "Revealing some bit of architecture where we thought there was none may lead to inroads into the structure of the mathematics."

Once primes get into the double digits and beyond, they must end in either a 1, 3, 7 or 9. Mathematicians have long known that there are roughly the same number of primes ending with each digit; each appears as the final number about 25 percent of the time.

Mathematicians assumed that the distribution of those final digits was

Final digits in primes Primes ending in 1 Primes ending in 3 Primes ending in 1 Primes ending in 3 Expected if random 2 0 1 3 7 9 1 3 7 9 Final digit in next prime

**Surprise ending** Among the first 100 million prime numbers, the final digit of a prime repeats the final digit of the prime that preceded it less often than expected. sourcE: RJ. LEMKE OLIVER AND K. SOUNDARARAJAN/ARXIV.ORG 2016

basically random. So given a prime that ends in 1, the odds that the next prime ends in 1, 3, 7 or 9 should be roughly equal.

"If there's no interaction between primes, that's what you would expect," Soundararajan says. "But in fact, something funny happens."

Despite each final digit appearing roughly the same amount of the time, there's a bias in the order in which these final digits appear. A prime that ends in 1, for example, is far less likely to be followed by a prime that also ends in 1 than a prime that ends in 3, 7 or 9.

The discovery of the final digit bias has "no conceivable practical use," says Andrew Granville, a number theorist at the University of Montreal and University College London. "The point is the wonder of the discovery."

The pattern had been noted previously, but the Stanford duo is the first to articulate a mathematical explanation for it, which they posted online March 11 at arXiv.org. When the researchers crunched the numbers, predictions based on their hypotheses fit the results remarkably, says Granville, who calls the work "rigorous, refined and delicate."

You might think this "anti-sameness" bias follows naturally from the order of numbers. After all, 67 is followed by 71, which is followed by 73. But this explanation doesn't fit the data, says Lemke Oliver, who ran computer calculations out to 400 billion primes."The bias is way too large," he says. What's more, the bias isn't equal for the nonrepeating final digits. So among the first 100 million primes, a prime that ends in 3 is followed by a prime that ends in 9 about 7.5 million times, whereas it is followed by a prime that ends in 1 about 6 million times. A final 3 is followed by a final 3 a mere 4.4 million times.

Yet as the number of primes gets larger and larger, the bias slowly disappears. This restoration of seeming randomness makes sense mathematically, but the slow rate at which the bias disappears is notable.

"It would almost be perverse if it didn't even out," says Lemke Oliver. "It would bother me a little."



#### ATOM & COSMOS The moon's poles have no fixed address

The moon's poles have slightly shifted over the last several billion years. And extinct volcanoes might be to blame.

Ancient deposits of water ice mark where the poles used to be (red and orange dots above), researchers report in the March 24 *Nature*. The deposits were left behind by water that collected in shadowed locales that were at the poles, Matt Siegler of the Planetary Science Institute in Tucson and colleagues suggest. The deposits are offset from the current poles by about 6 degrees.

The team found the poles using data from NASA's Lunar Prospector mission and other moon missions. Prospector recorded neutrons from the lunar surface and found regions lacking highspeed neutrons, which were probably slowed by hydrogen from water molecules. The hydrogen deposits (white areas above) are proxies for water ice.

Poles can wander as mass shifts in a planet or moon. In this case, an area within Oceanus Procellarum — a sea of hardened lava left behind by volcanic eruptions 3.5 billion years ago — is the most likely culprit. After lava relocated to the surface, the poles meandered as the moon rebalanced itself, the team suggests. — Christopher Crockett

#### LIFE & EVOLUTION

# Fairy circles found outside of Africa

Australian discovery adds to debate over grassland pattern

#### **BY SUSAN MILIUS**

Beyond the small mining town of Newman in Western Australia lie the first fairy circles that scientists have described outside of Africa.

These patches of bare soil dot outback grasslands in almost regular polka-dot patterns, just like the puzzling circle landscapes known from Namibia, says ecologist Stephan Getzin of the Helmholtz Center for Environmental Research-UFZ in Leipzig, Germany. He and colleagues describe the Australian fairy circles online March 14 in the *Proceedings of the National Academy of Sciences*. The team proposes that the oddities arise from lifeand-death struggles between plants.

Explaining what causes fairy circles has become ecologists' version of crop circle debates (*SN Online: 8/20/15*). Until now, the debate has focused on scatterings of circles from an arid zone in southern Africa. Getzin heard about the Australian circles in 2014 when a burst of news stories about his latest fairy circle paper inspired environmental scientist Bronwyn Bell of Perth to e-mail pictures of what she saw around Newman. "I was extremely surprised," Getzin says.

He and colleagues examined the site, finding hard-baked reddish soil in the gaps instead of the more permeable sand in Namibia's circles. But otherwise, Australia's arrays of bare spots about 4 meters wide had a fairy circle–look, with each spot circled by roughly six more.

Using a computer simulation, Getzin's team showed that the polka-dot landscape in Australia can arise from interacting feedback loops where there's not quite enough rainfall for continuous vegetation. In a short-term positive feedback loop, plants on the edge of a bare spot get a bigger share of the bare spot's rain, growing bigger themselves and thus capturing even more water. But there's also a long-term negative feedback: As plants around the rim of the bare spot



An aerial view of Australian grassland reveals fairy circles of hard, bare soil (inset) that few scientists knew about until now.

suck up more and more water, less water reaches plants farther away. Eventually, those more removed spots dry out so much that new barren spots appear.

This scenario doesn't satisfy vegetation ecologist Norbert Jürgens of the University of Hamburg. Among his objections are that soils in African circles retain some rainfall that plant roots don't draw up. Fairy circles would be filled with plants, if something weren't killing them, he says. That something, he contends, is sand termites that nip the roots of plants (*SN Online: 3/28/13*).

Termites might matter in Australia, too, Jürgens speculates. Unlike in Africa, water doesn't sink into the bare

## HUMANS & SOCIETY Melanesians carry Denisovan genes

Present-day Pacific Islanders also inherited Neandertal DNA

#### **BY BRUCE BOWER**

Modern-day Melanesians carry a twopronged genetic legacy of ancient interbreeding that still affects their health and well-being, researchers say.

Unlike people elsewhere in the world, these Pacific Islanders possess substantial nuclear DNA that they inherited from two Stone Age hominid populations, say population geneticist Benjamin Vernot, most recently at the University of Washington in Seattle, and his colleagues. At least some of that ancient DNA contains genes involved in important biological functions, the researchers find.

The results mean that ancestors of people now living in the Bismarck Archipelago off Papua New Guinea mated with Neandertals as well as with Neandertal relatives called Denisovans, the scientists say online March 17 in *Science*.

In support of previous work, the researchers find that non-Africans including Melanesians — have inherited an average of 1.5 to 4 percent of their DNA from Neandertals. But only Melanesians display substantial Denisovan ancestry, which makes up 1.9 to 3.4 percent of their DNA, the researchers say.

The bits of Neandertal and Denisovan DNA carried by Melanesians encompass genes involved in metabolism and immunity, indicating that interbreeding influenced the evolutionary success of ancient humans, Vernot's group reports.

The new study reconstructs Neandertals' and Denisovans' contributions to Melanesians' DNA "in impressive detail," says Harvard University paleogeneticist Pontus Skoglund.

Vernot's team studied DNA from 35 Melanesians at 11 locations in the Bismarck Archipelago. Analyses concentrated on DNA from 27 unrelated individuals. The researchers also looked for evidence of ancient interbreeding in previously acquired genomes of nearly 1,500 modern-day individuals from different parts of the world. Denisovan DNA for comparisons came from fragmentary fossils found in a Siberian cave; Neandertal DNA came from a genome previously extracted from a 50,000-yearold woman's toe bone.

Among Melanesians, DNA sequences attributed to Neandertals and Denisovans encompass several metabolism genes. One of those genes influences a hormone that increases blood glucose levels. Another affects the chemical breakdown of lipids. Other Melanesian genetic sequences acquired through spots. Instead, a hard layer of clay sends rainfall flowing aboveground to thirsty plants at the circle's rim. "Termites or other social insects might have caused the Newman circles by transporting clay and silt to their nest sites, again and again, over long periods of time," he says.

Proponents of another possible cause for fairy circles — natural geochemical conditions such as plant-killing carbon monoxide seeping out of the earth — say they knew about Newman. Analytical chemist Yvette Naudé of the University of Pretoria in South Africa says she and colleagues got a tip about five years ago from a fairy circle enthusiast and realized that the site is visible via Google Earth. Without studying the Australian fairy circles in person, she declines to speculate about what's causing them.

For any explanation, correlation is not causation, says Walter Tschinkel of Florida State University in Tallahassee. Final proof will require an experiment that uses the proposed cause to create fairy circles. How to do that for features that stretch over whole landscapes, he acknowledges, remains to be seen.

ancient interbreeding either include or adjoin genes that help to marshal the body's defenses against illness.

These findings follow evidence suggesting that presumably once-useful genes that ancient humans inherited from Neandertals now raise the risk of contracting certain diseases (*SN: 3/5/16, p. 18*). Vernot's group reaches no conclusions about good or bad effects of ancient hybrid genes in Melanesians.

No sign of Neandertal or Denisovan DNA appears in areas of Melanesians' genomes involved in brain development, the scientists say. So brain genetics, for better or worse, apparently evolved along a purely human path.

Denisovans' evolutionary history remains poorly understood. Previous DNA comparisons suggest that Denisovans must have reached Southeast Asia. Skoglund suspects that's where the ancestors of Melanesians bred with Denisovans.

#### LIFE & EVOLUTION

# New species fills in tyrannosaur gap

Horse-sized dinosaur had brain, ears like later, bigger T. rex

#### **BY BETH GEIGER**

A fossil from a new species of dinosaur is helping to bridge a crucial 20-millionyear gap in tyrannosaur evolution.

The key fossil is a 90-million-yearold, grapefruit-sized partial skull from Uzbekistan's Bissekty Formation. This tyrannosaur braincase, the first wellpreserved one found from the mid-Cretaceous period, shows that, although still small, tyrannosaurs of the time

already had brain and ear features of later tyrannosaurs. Researchers have dubbed the in-betweener *Timurlengia euotica*, meaning "well-eared." They describe the new species online March 14 in the *Proceedings of the National Academy of Sciences.* 

The braincase sheds light on a long-standing mystery: how tyrannosaurs evolved

from an "average Joe" horse-sized predator some 100 million years ago in the early Cretaceous to the huge apex predators they became 80 million years ago in the late Cretaceous. "Our study is the first to show that the sophisticated brain and hearing of big tyrannosaurs evolved in smaller-bodied species, long before tyrannosaurs got giant," says study coauthor Stephen Brusatte, a paleontologist at the University of Edinburgh. These advantages, he adds, may have helped tyrannosaurs become such successful — and eventually enormous — predators.

Analyzed against a database of other tyrannosaur skulls, the braincase shows that *T. euotica*'s brain and ears "are almost identical to *T. rex*, just smaller," Brusatte says. In particular, the dinosaur's long cochlea, a part of the inner ear, is a signature of bigger, badder late Cretaceous tyrannosaurs. "The long cochlea



T. euotica's braincase indicates the dino's hearing was similar to that of its larger cousin, T. rex.

would have meant better sensitivity to low-frequency sound," Brusatte says. That sensitivity would have enabled *T. euotica* to detect subtle or distant sounds, giving it clear advantages over other predators.

*"Timurlengia* fills an important gap in both time and evolution," says Lawrence Witmer, a paleon-tologist at Ohio University

in Athens who was not involved in the study. "Charles Darwin couldn't have scripted it any better."

The next step is to determine if the braincase is typical of a mid-Cretaceous tyrannosaur, or just one oddball data point. "We've analyzed the heck out of each scrap of Bissekty tyrannosaur bone," Brusatte says, "so the thing that could move us forward is the discovery of new specimens in other middle Cretaceous rock units in other parts of the world."



The horse-sized tyrannosaur *Timurlengia euotica*, illustrated here, roamed what is now Uzbekistan 90 million years ago. The dinosaur already had the supersenses of the giant tyrannosaurs that appeared millions of years later.



#### **BODY & BRAIN**

### Lost memories retrieved for mice Study sheds light on early stages of Alzheimer's disease

#### **BY LAURA SANDERS**

Using flashes of blue light, scientists have pulled forgotten memories out of the foggy brains of mice engineered to have signs of early Alzheimer's disease. This memory rehab feat, described in the March 24 *Nature*, offers new clues about how the brain handles memories and how that process can go awry.

The result "provides a theoretical mechanism for reviving old, forgotten memories," says Yale School of Medicine neurologist Arash Salardini.

To recover a lost memory, scientists

#### EARTH & ENVIRONMENT

# Carbon dioxide shakes up geysers

Gas buildup lowers water's boiling point, triggers blasts

#### **BY THOMAS SUMNER**

Carbonation helps Yellowstone's geysers erupt like shaken cans of soda, scientists report in two new studies.

During the buildup to an eruption of Yellowstone's Spouter Geyser, carbon dioxide accumulates in the geyser water, researchers report in the April *Geology*. The dissolved gas lowers the water's boiling point and triggers an eruption. This phenomenon may occur elsewhere in Yellowstone. Several of the park's other geysers, including Old Faithful, also contain abundant  $CO_2$  and other dissolved gases, a separate research team reports in the March *Geology*. first had to mark it. MIT neuroscientist Susumu Tonegawa and colleagues devised a system that tagged the specific nerve cells that stored a memory — in this case, an association between a particular cage and a shock. A virus delivered a gene for a protein that allowed the researchers to control this collection of memory-holding nerve cells. The genetic tweak caused these cells to fire off signals in response to blue laser light. This system let Tonegawa and colleagues call up the memory with light delivered by an optic fiber implanted in the brain.

The findings overturn the roughly 150-year-old explanation that hot water alone fuels geyser eruptions, says Jacob Lowenstern, a volcanologist at the U.S. Geological Survey in Menlo Park, Calif., who was not involved in either study. "People always assumed that water was the end of the story," he says. "If CO<sub>2</sub> was completely absent, many of these geysers would still erupt. But they erupt more regularly and frequently because of the dissolved CO<sub>2</sub> gas."

Heat from underground magma fuels geysers in Yellowstone National Park (*SN: 5/16/15, p. 16*). Measurements in the 1970s, however, revealed that many of the park's geysers, including Old Faithful, aren't hot enough to boil pure water.

In the study reported in the April *Geology*, hydrogeologists Bethany Ladd and Cathryn Ryan of the University of Calgary in Canada analyzed water from Yellowstone's Spouter Geyser. They collected water every 10 to 20 minutes Nerve cells (green) that hold a memory in a mouse's hippocampus can be coaxed into action with lasers, causing memory recall.

A day after receiving a shock in a particular cage, mice carrying two genes associated with Alzheimer's seemed to have forgotten the ordeal; when put back in that cage, these mice didn't seem as frightened as mice without the Alzheimer's-related genes. But when the researchers used light to restore this frightening memory in a different cage, mice froze in place. (Freezing in a new venue showed that laser activation, and not environmental cues, caused the fear reaction.)

This result helps clarify the source of memory trouble for people with Alzheimer's, Tonegawa says. The mice appeared able to form and store a memory but not call it up. "It's a retrieval problem, not a storage problem," he says.

That's in line with what many clinicians believe, Salardini says. People in the early stages of Alzheimer's seem able to create new memories, but then rapidly forget them, he says. Memories

from a side vent that branches off the geyser's main channel. The measurements allowed the researchers to track the amount of dissolved  $CO_2$  in the geyser over the course of several eruptions.

The abundance of  $CO_2$  in the geyser starts low, the researchers found. During the one- to two-hour interval between eruptions, however,  $CO_2$  levels steadily increase as gases from Yellowstone's magma enter the geyser water through permeable rocks. As  $CO_2$  increases, the gas lowers the water's boiling point. Eventually, the boiling point drops below the water's actual temperature and bubbles of steam and  $CO_2$  form.

As these bubbles climb the geyser column toward the surface, they expand, displacing water and lowering the pressure inside the geyser. That pressure drop lowers the boiling point even further, causing a runaway reaction that triggers a full-blown eruption similar to that of a shaken soda can. These can sometimes be strengthened with reminders and environmental clues, suggesting that the memories are "somewhere in there," he says.

Further experiments showed that the fear memory could be strengthened by forcing it to appear multiple times. This memory boot camp boosted the number of docking sites on memory-holding nerve cells in the mice with Alzheimer'srelated genes. Usually, these docking sites - knobs called dendritic spines, which receive messages from other nerve cells-become scarcer with age. To counter that, Tonegawa and colleagues used light to repeatedly activate nerve cells that in turn activate the memory-holding cells. Compared with mice that didn't get this treatment, mice with the Alzheimer's genes that underwent this process were more fearful of the cage where they had received a shock, even six days later.

Tonegawa cautions that the results are experimental. "We have not done anything to cure human Alzheimer's patients," he says. And the experimental methods are not currently feasible for people.

eruptions can last for hours. When the eruption finally fizzles, CO<sub>2</sub> levels have dropped to about half their peak value reached just before eruption and the cycle begins anew.

In the other new study, hydrogeologist Shaul Hurwitz of the U.S. Geological Survey in Menlo Park and colleagues discovered  $CO_2$  and other dissolved gases such as nitrogen in many of Yellowstone's other geysers.

Understanding the role that gas plays in another type of water explosion, called steam eruptions, is also important, Hurwitz says. In these cases, the rapid boiling of an enclosed underground water reservoir generates an explosive blast. In September 2014, a steam eruption rocked Japan's Mount Ontake volcano without warning and killed 57 people. If  $CO_2$  helps fuel steam eruptions, then monitoring gas levels in groundwater could provide an early warning, Hurwitz says.

# Clams keep seagrasses happy, healthy In drought, breaking plant-mollusk alliance speeds degradation

#### **BY SUSAN MILIUS**

Clamming up could help underwater seagrass meadows better withstand drought, heat waves and climate change.

Breakdown of a symbiotic bond between seagrasses along the West African coast and tiny lucinid clams can exacerbate damage in hard times, researchers say online March 10 in *Current Biology*. So protecting meadows may mean worrying just as much about the partnership as the seagrasses themselves, says coauthor Tjisse van der Heide of Radboud University Nijmegen in the Netherlands.

Seagrasses aren't seaweed. They're genuine flowering plants whose terrestrial ancestors over about 100 million years adapted to a salty underwater life that would quickly kill most land plants (*SN*: *12/5/09, p. 22*).

Clams help ease one risk of this life: debris breakdown that goes toxic. The plants' own dead leaves plus floating bits of dead stuff and waste, from nearby land or sea, snag in a seagrass meadow's expanse of swaying leaves. Sea-bottom microbes that break down the rain of debris release sulfides, which can poison the plants.

In 2012, van der Heide and colleagues proposed that in some seagrass communities, clams burrowing among the plant



An underwater meadow of seagrasses off Mauritania trades oxygen for detoxification services from tiny, bacteria-fostering clams.

roots help detoxify sulfides. The *Loripes* clams and other members of the lucinid group benefit from oxygen that roots give off, and the sulfides from debris breakdown nourish symbiotic bacteria in the clams. As the bacteria feast, they leak sugars that feed their clams, and the toxic sulfides are turned into harmless sulfates.

Not every seagrass meadow has lucinid clams, but intertidal meadows at Banc d'Arguin in Mauritania do. The clam density there can average 1,500 to 2,000 small clams per square meter in the top 10 centimeters or so of mud. At low tides, mats of seagrasses lie exposed to air for hours at a time. During the severe drought of 2011, the hot, thirsty air desiccated swaths of the meadow. Dying plants faltered in oxygenating the clams and their bacteria, causing a cascade of effects that weakened the detoxification process.

As drought-stricken seagrasses and clams failed to provide each other with benefits, a feedback loop of increasingly worse performance for both partners accelerated their demise. That's the scenario van der Heide and colleagues draw from satellite data of the meadow during the drought. Seeing considerable living patches mix with dead zones at the same elevation and exposed to the same climate conditions points to something — such as a mutualism breakdown — speeding the change from leafy to bald.

Comparing seagrass patches that died with patches that survived, van der Heide and colleagues propose that maintaining the clam partnership made a difference. Of 32 plots of meadow, the half where seagrasses survived the drought had nine times as many clams as the dead zones. These survival spots also averaged only about a quarter of the toxic sulfides.

This mutualism may be important in Banc d'Arguin but has yet to be demonstrated as a more general phenomenon, says marine ecologist Carlos Duarte of King Abdullah University of Science and Technology in Thuwal, Saudi Arabia.

## MATTER & ENERGY Better metamaterials through toys

Legos can quickly test new designs for manipulating vibrations

#### **BY TOM SIEGFRIED**

Metamaterials, among the most intricate and skillfully designed configurations of matter ever devised by science, could be improved with the help of Legos.

Famous for their use in cloaking devices, metamaterials are artificial structures that play unnatural tricks with light and sound and other vibrations. Scientists have investigated the use of such materials for soundproofing rooms or protecting buildings from the shaking of earthquakes, among other things. But to do their jobs, metamaterials must be properly designed and fabricated using precisely manufactured components. Testing ideas for new metamaterials is therefore timeconsuming and expensive.

So Paolo Celli and colleagues at the University of Minnesota sought

alternatives. They considered 3-D printing, Celli said March 15. But the printing process can be slow and the "ink" isn't cheap, so they rejected that idea. "That's when we thought, 'Why don't we use Lego bricks?'" he said. Legos are relatively cheap and can rapidly be rearranged into all sorts of configurations.

Celli and colleagues arranged Lego bricks on a base plate attached to a wooden frame and investigated how the arrangements influenced vibrations traveling through the plate. For some arrangements, certain vibration wavelengths could not be transmitted. Manipulation of the Legos allowed the scientists to determine what processes created the forbidden wavelength zones (known as bandgaps), providing valuable data for future designs of real metamaterials.

Further experiments showed how

Lego arrangements could identify metamaterial architectures that might provide a shield for buildings at risk from earthquake waves. "We might be able to design a metamaterial shield that might block some frequencies that can be harmful to that structure," Celli said.

Ahmed Elbanna, a materials researcher at the University of Illinois at Urbana-Champaign, called the work with Legos exciting and said in principle it could be applicable to designing metamaterials for some applications. He said he was "a little bit more skeptical" that it could result in useful earthquake protection.

Celli emphasized that the motivation behind the work was not only to produce better metamaterials. "We've been looking for an agile and versatile experimental platform," he said, "but we were also looking for something that people can relate to.... We think that this platform is probably very powerful" for promoting this research field to a broader community.

Asked if he played with Legos as a child, Celli replied "a lot."

#### MEETING NOTES

#### Like birds of a feather, sperm flock together

When it comes to swimming sperm, it's not every man for himself. Instead, sperm form groups that swim together, like schools of fish or flocks of birds, physicists have found.

Understanding the physics of such behavior in animals is difficult because their actions arise in part from cognitive processes — birds, for instance, can see what their neighbors are doing and adjust their flight path. But with sperm, group swimming emerges from the physics of the medium they swim in, Chih-Kuan Tung of North Carolina A&T State University in Greensboro said March 16. That makes sperm a simpler system for studying coordinated biological action. "They don't think," Tung said. "So whatever interaction is happening, we can quantitatively describe it."

Sperm don't form groups in ordinary water, Tung said, but they do in viscoelastic fluids such as the mucus of mammalian reproductive tracts. A viscoelastic fluid combines resistance to flow with the ability to return to a previous state when disturbed. Tung and colleagues created such elasticity by adding a polymer to a fluid they used to test the swimming of bulls' sperm. Those experiments showed that it's the elasticity, not the viscosity, that encourages collective swimming. Further work will be needed to determine whether such group swimming confers an advantage to sperm seeking an egg. Tung said the new understanding of sperm dynamics could lead to improved methods for in vitro fertilization procedures. – *Tom Siegfried* 

#### New catalytic strategy could aid hydrogen fuel

For a long time now, hydrogen has been the fuel of the future. A new idea for extracting hydrogen from water might help that future arrive a little sooner.

Today, producing hydrogen requires burning fossil fuels or using water-splitting catalysts that work relatively inefficiently, says physicist Arvin Kakekhani of Yale University. But Kakekhani and Sohrab Ismail-Beigi, also at Yale, identified a way to use ferroelectric oxides to catalytically separate hydrogen from oxygen more effectively. Catalysis requires a surface that both grips a water molecule to split it and releases the hydrogen atoms separated in the process. A ferroelectric substance such as lead titanate can be prepared so that heat can switch it from a state suitable for splitting to another state good at releasing, computer simulations showed. Researchers therefore should be able to design a cycle of states that extracts hydrogen efficiently, Kakekhani reported March 17. A report on the work was also published online March 8 in the Journal of Materials Chemistry A. – Tom Siegfried

# "To you, it's the perfect lift chair. To me, it's the best sleep chair I've ever had."

Easy-to-use remotes for massage/heat and recline/lift

Complete with battery backup in case of power outage

We've all had nights when we just can't lie down in bed and sleep, whether it's from heartburn, cardiac problems, hip or back aches – it could be a variety of reasons. Those are the nights we'd give anything for a comfortable chair to sleep in, one that reclines to exactly the right degree, raises feet and legs to precisely the desired level, supports the head and shoulders properly, operates easily even in the dead of night, and sends a hopeful sleeper right off to dreamland.

**Our Perfect Sleep Chair® is just the chair to do it all.** It's a chair, true – the finest of lift chairs – but this chair is so much more! It's designed to provide total comfort

and relaxation not found in other chairs. It can't be beat for comfortable, longterm sitting, TV viewing, relaxed reclining and – yes! – peaceful sleep. Our chair's recline technology allows you to pause the chair in an infinite number of positions, including the Trendelenburg position and the zero gravity position where your body experiences a minimum of internal and external stresses. You'll love the other benefits, too: It helps with correct spinal alignment, promotes back

This lift chair puts you safely on your feet! pressure relief, and encourages better posture to prevent back and muscle pain.

Sit up, lie down

and anywhere

in between!

— J. Fitzgerald, VA

And there's more! The overstuffed, oversized biscuit style back and unique seat design will cradle you in comfort. Generously filled, wide armrests provide enhanced arm support when sitting or reclining. The high and low heat settings along with the dozens of massage settings, can provide a soothing relaxation you might get at a spa – just imagine getting all that in a lift chair! Shipping charge includes white glove delivery. Professionals will deliver the chair to the exact spot in your home where you want it, unpack it, inspect it, test it, position it, and even carry the packaging away! Includes one year service warranty and your choice of fabrics and colors. – Call now!

### The Perfect Sleep Chair<sup>®</sup> Call now toll free for our lowest price.

Please mention code 103104 when ordering.

1-888-785-0751

t6402



© 2016 firstSTREET for Boomers and Beyond, Inc.

#### LIFE & EVOLUTION

### Killer prairie dogs make good moms Females that attack squirrel

remales that attack squirrei neighbors rear more offspring

#### **BY SUSAN MILIUS**

White-tailed prairie dogs — those stand-up, nose-wiggling nibblers of grass — turn out to be routine killers of baby ground squirrels. And the strongest sign of successful white-tailed motherhood could be repeat ground squirrel kills, researchers say.

At a Colorado prairie dog colony, females that kill at least two ground squirrels raise almost three times as many offspring during their lives as nonkiller females, says John Hoogland of the University of Maryland Center for Environmental Science in Frostburg. The "serial killers," as he calls repeatattack females, rarely even nibble at the carcasses and aren't getting much, if any, meat bonus. Instead, the supermom assassins may improve grazing in their

territories by reducing competition from grasssnitching ground squirrels, Hoogland and Charles Brown of the University of Tulsa in Oklahoma propose in the March 30 *Proceedings of the Royal Society B.* 

"This really caught me by surprise," Hoogland says. Carnivorous mam-

mals killing other carnivore species wouldn't be surprising, but prairie dogs and ground squirrels eat plants. He knows of no other systematic study documenting routine fatal attacks by one herbivore species on another.

A white-tailed prairie

dog kills one of the small ground squirrels that

graze in prairie dog towns.

"It's also striking because it's so subtle," he says. He had been watching prairie dogs for decades and white-tailed ones in the Arapaho National Wildlife Refuge for a year before he noticed an attack. A female "jumped on something, shook it, shook it hard, kept attacking — and then walked away," he says. The encounter lasted just minutes.



White-tailed prairie dog moms that kill the young of another grass-eating species tend to raise more pups during a lifetime (three pups shown) than moms that don't kill.

Hoogland rushed from his observation tower to the scene of the fight and, to his surprise, retrieved a dead baby squirrel.

Once he and colleagues knew what to look for, they saw 101 such lethal attacks (mostly from females, but also from some males) over six years and inferred 62 more from carcasses. A propensity for killing ground squirrels turned out to be the only factor (among such pos-

sibilities as body mass, age and number of neighbors) that predicted a tendency toward lifetime success in raising lots of young. That success, which biologists describe as fitness, is a big deal in analyzing how populations change and species evolve.

Hoogland and Brown

propose that prairie dogs and ground squirrels compete for grazing. An analysis of the animals' diets finds at least six plant species in common, the researchers say.

Hoogland didn't directly test to see if the serial killer prairie dogs just had great territories that attracted lots of ground squirrels and thus provided more opportunities for killing. But if that were true, he says, he would predict that the holders of this prime territory would have robust body sizes, and therefore there would be some link between maternal body size and number of kills. No such link shows up, he says. The best hypothesis explaining the benefit of killing squirrels that Hoogland can think of, he says, is that prairie dogs slay the competition for food resources.

Still, the idea that prairie dogs and ground squirrels compete for plants needs more investigation, says ecologist Liesbeth Bakker of the Netherlands Institute of Ecology in Wageningen. The total of ground squirrel kills was an impressive number, she says, but it's unclear what percentage of the local population it represents. If the deaths remove only a small proportion of ground squirrels, competition isn't likely to ease much. Also, any effect would be weakened by the relative sizes of the species. "The ground squirrels are about half the size of the prairie dogs and thus eat less food," she says.

Behavioral ecologist James Hare wonders why ground squirrels venture into prairie dog territory if it's so dangerous. One idea Hoogland suggests is that prairie dog vigilance in raising alarms about other predators might make the risks of hanging out in a colony worthwhile. Hare, of the University of Manitoba in Canada, also wonders whether ground squirrels have trouble finding good habitat free from prairie dogs.

Hoogland too is left with questions, including one about the big-family bonus of interspecies killing. "Is this really unique to prairie dogs, or is this more common?" FROM TOP: SANDY NERVIG; J. HOOGLAND

# IMPORTANT HEALTH BULLETIN FROM MDHearingAid®

# 4 things every person with hearing loss MUST KNOW

Tremendous advances have been made in hearing aid technology. That's important to know, because untreated hearing loss can lead to depression, social isolation, anxiety, and symptoms consistent with dementia and Alzheimer's disease.



Board-certified physician Dr. Cherukuri believes that knowledge is power when choosing a hearing aid. He invented a medical-grade, all-digital, AFFORDABLE hearing aid to help the millions of

people who would benefit from hearing aids but couldn't afford them.



#### **A LIMITED-TIME SPECIAL OFFER:**

- FREE BATTERIES FOR A FULL YEAR (Use Offer Code CQ76)
- 45-DAY RISK-FREE TRIAL
- FREE SHIPPING in USA



# Be aware that high-tech, digital hearing aids don't have to cost a fortune.

Many hearing aid manufacturers and audiologists will run attention-grabbing ads, trying to get you to set up a free hearing exam, so they can sell you hearing aids costing \$3,000 or more!

These high hearing aid prices are the direct result of layers of middlemen and expensive unnecessary features. The **MD**HearingAid *AIR* uses the same type of top quality components as the leading hearing aid manufacturers; yet, you pay only **a fraction of the cost.** 

# 2 Don't think you need to skimp on quality or highly desired features.

There is no need to settle for cheap generic components or unregulated and inferior "sound amplifiers", that you see in magazine advertisements or on TV, to hear better.

The **MD**HearingAid *AIR* is a FDA-Registered hearing aid that incorporates world-class components from the USA and Europe. This doctor-owned company retains complete control of the hearing aid design and manufacturing process to **save you money.** 

# B Make sure you're taking advantage of new technological breakthroughs.

Hearing aid technology has come a long way in the last few years. Now you can enjoy super-comfortable, virtually invisible hearing aids without that "plugged up" feeling. So why be content with less?

MDHearingAid gives you the most-wanted features: advanced noise reduction to make speech clearer, feedback cancellation technology for virtual elimination of whistling, and a self-controlled volume dial so **you** determine how soft or loud sounds can be.

# Consider whether you want to make time for multiple fitting appointments.

Many hearing aid centers make you come back again and again for time-consuming — and ultimately, expensive — adjustment appointments.

The **MD**HearingAid *AIR* uses sophisticated technology to give you a hearing aid that works right out of the box. Rest assured, you can access a hearing instrument specialist conveniently — online or by phone — even after your purchase. No other company provides such **extensive support** to guarantee your success.

**START YOUR RISK-FREE TRIAL NOW** 

800-873-0541 www.MDHearingAid.com

MDHearingAid<sup>®</sup> AIR

#### MATTER & ENERGY

### New process encourages ice to slip, slide away

Ice removal may soon be a lot easier. Researchers have developed a way to make surfaces ice-phobic by altering the pliability and slipperiness of polymer coatings.

The process, reported online March 11 in *Science Advances*, could lead to a wide range of long-lasting ice-repellent products including windshields, airplane wings, power cables and frozen food packaging, the researchers say.

Ice easily detaches from softer, less dense materials. Adjusting the pliability of rubber polymers used to make coatings and adding silicone or other lubricants such as vegetable oil amplifies the effect, Anish Tuteja, a materials science engineer at the University of Michigan in Ann Arbor, and colleagues found.

In multiple laboratory and field tests, ice slid off treated surfaces under its own weight or when it was pushed by mild wind. The researchers further tested the coatings' durability on various surfaces such as a metal license plate and glass panels. Each coated surface performed well through a Michigan winter and retained ice-repelling properties after controlled exposure to icing and heat cycles, corrosive substances such as hydrochloric acid, and wear and tear.

The process has already yielded more than 100 different coatings tailored for specific surfaces, including metal, glass, wood, plastic and cardboard. Tuteja says his team is working on licensing the materials for commercial use. – *Cassie Martin* 



#### GENES & CELLS

## Zika may have flown to Brazil in 2013

The Zika virus may have hitched a ride on a 747 from Southeast Asia in 2013 to invade the Americas.

Oliver Pybus, an evolutionary biologist at the University of Oxford, and colleagues have retraced the virus' steps in Brazil and pinpointed its introduction there to between May and December 2013. The timing coincides with when Brazil saw a significant increase in air travelers to and from countries with active Zika outbreaks, the researchers report online March 24 in *Science*.

The team analyzed viral genomes from samples taken from seven Brazilian patients, including a newborn with microcephaly (*SN*: 4/2/16, *p*. 26). These genetic blueprints had a lot in common, suggesting that Zika might have entered Brazil just once before the country detected its first case in May 2015.

Zika arrived in Brazil from Southeast Asia or the Pacific, the researchers suggest. The American lineage came from the Asian branch of the Zika family tree and is most closely related to the virus from a 2013 outbreak in French Polynesia. In May 2013, the virus split from its French Polynesian cousin, and in December 2013, American strains started to diversify from each other.

Previous studies linked Zika's arrival to the 2014 World Cup in Brazil, but that doesn't match the new timeline. Regular air travel, rather than an individual event, is the most likely source of introduction, the study's authors argue. – *Helen Thompson* 

#### EARTH & ENVIRONMENT

# Climate change threatens quality of French, Swiss wines

Be wary, wine lovers: Climate change can muck with your merlots. By tracking the timing of French and Swiss grape harvests from 1600 through 2007, scientists have discovered that the link between high temperatures and drought conditions — a crucial combination for fine wine production — has broken down since 1980.

Warm conditions hasten grape maturation, requiring early harvests. In the past, warm springs and summers often coincided with scarce rainfall that produced good harvesting conditions. Climate change, however, produces higher temperatures in France and Switzerland independent of low rainfall. Harvest-delaying rainstorms increasingly prevent winemakers from collecting their warmth-matured crop at the optimum time, worsening wine quality, the scientists report March 21 in Nature Climate Change. — Thomas Sumner

#### LIFE & EVOLUTION

How to tell if a *T. rex* is expecting Call it a *T. rex* pregnancy test. Chemical analyses of bone can reveal whether a

*Tyrannosaurus rex* was expecting, paleontologist Mary Schweitzer of North Carolina State University and colleagues report March 15 in *Scientific Reports*.

The analyses confirm that *T. rex* had medullary bone, a type of reproductive tissue found in female birds but only when they're producing eggs, or "in lay."

Medullary bone has a distinct appearance: It fills the inner cavities of bones and is loosely woven and pocked with holes — kind of like a sponge. Other bone tissue, such as healing fractures, can mimic the look. Schweitzer's team tested tissue from a *T. rex* fossil for keratan sulfate, a chemical found in medullary bone but not other bone types. As suspected, the team saw evidence of the chemical.

Detecting medullary bone means that scientists can identify dinosaurs that were in lay. Now that Schweitzer knows her *T. rex* was female, she wants to examine it for other features that could be linked to sex. – *Meghan Rosen* 

## Guaranteed the most comfortable pillow you'll ever own!™

#### How Well Did You Sleep Last Night?

Did you toss and turn all night? Did you wake up with a sore neck, head ache, or was your arm asleep? Do you feel like you need a nap even though you slept for eight hours? Just like you, I would wake up in the morning with all of those problems and I couldn't figure out why. Like many people who have trouble getting a good night's sleep, my lack of sleep was affecting the quality of my life. I wanted to do something about my sleep problems, but nothing that I tried worked.

#### The Pillow Was the Problem

I bought every pillow on the market that promised to give me a better night's sleep. After trying them all, with no success, I finally decided to invent one myself. I began asking everyone I knew what qualities they'd like to see in their "perfect pillow." Their responses included: "I'd like a pillow that never goes flat", "I'd like my pillow to stay cool" and "I'd like a pillow that adjusts to me regardless of my sleep position." After hearing everyone had the same problems that I did, I spent the next two years of my life inventing MyPillow. Mike Lindell Inventor & CEO of MyPillow®



In the early days, Mike and his family spent countless hours hand-making each MyPillow. This hard work and dedication to "doing it right" helped MyPillow become a classic American success story.

#### MyPillow<sup>®</sup> to the Rescue

Flash forward eleven years and MyPillow, Mike Lindell's revolutionary pillow design, has helped 12 million people improve the quality of their sleep. MyPillow has received thousands of testimonials from customers about how MyPillow has changed their lives.

"Until I was diagnosed with various sleep issues, I had no idea why my sleep was so interrupted throughout the night. I watch Imus each morning and heard endless testimonials about MyPillow. I took his advice and ordered a MyPillow. Now I wake up rested and ready to conquer the day ahead. Thank you for helping me remember what it's like to sleep like a baby!" - Jacqueline H. Lindell has been featured on numerous talk shows, including *Fox Business News* and *Imus in the Morning*. Lindell and MyPillow have also appeared in feature stories in major magazines and newspapers across the country. MyPillow has received the coveted "Q Star Award" for *Product Concept of the Year* from QVC, and has been selected as the Official Pillow of the National Sleep Foundation.

MyPillow's patented interlocking fill allows you to adjust the pillow to your individual needs regardless of sleep position.





#### **Unprecedented Guarantee and Warranty**

I do all of my own manufacturing in my home state of Minnesota and all materials are 100% made in the U.S.A. I'm so confident MyPillow will help you, I'm offering an unprecedented 60-day money back guarantee and a 10-year warranty not to go flat! I truly believe MyPillow is the best pillow in the world and that if everyone had one, they would get better sleep and the world would be a much happier place. *God Bless.* 



Don't wait—Order MyPillow and get sleep you've been dreaming about! Save 50% when you use promo code "science13" BUY NOW AT: mypillow.com or call 800.880.6456



FEATURE Microbes from the gums may be causing a variety of diseases By Laura Beil

or centuries, the mouth and the body have been disconnected – at least when it comes to health care. Through the Middle Ages and beyond, teeth fell under the care of barbers, who could shave a customer and pull a molar with equal skill. In the 1700s, French surgeon Pierre Fauchard published the *Treatise on Teeth*, establishing dentistry as its own science.

Across the channel in England, as physicians gained stature in the 19th century, surgeons and dentists engaged in a

power struggle. In the modern United States, after medicine became linked to employer insurance and Medicare, the fissure between medicine and dentistry widened. Insurance coverage began at the throat.

So when Salomon Amar, a periodontal specialist at Boston University, began exploring links between oral bacteria and heart disease in animal studies in the late 1990s, reactions were lukewarm. "Many cardiologists thought we were a bit crazy," he says. Skepticism still abounds, but the same molecular tools that have dramatically changed understanding of the gut microbiome are now allowing scientists to track and examine bacteria in the mouth. Advocates of a connection between the artery disease atherosclerosis and microbes are hoping to find convincing proof of their suspicions, while exploring links between ailing gums and other conditions, including cancer, arthritis, diabetes and even Alzheimer's disease.

The work has profound implications for public health, given that more than 65 million American adults are thought to have periodontal disease, which occurs when bacterial overgrowth

inflames the gums and can lead to erosion of gums and bone. If it turns out that periodontal decay drives other diseases, doctors would have a new, and relatively simple, means of prevention.

Wenche Borgnakke, a dental researcher at the University of Michigan in Ann Arbor, has been making this case for years, citing "solid evidence that periodontal treatment has an effect on systemic disease." She points to a study published last year in the journal *Medicine* comparing patients on dialysis who received periodontal treatment with those who did not. Those getting treatment had an almost 30 percent lower risk of pneumonia and hospitalization from infections. Another study published earlier this year found that gum disease is associated with a roughly 10 percent higher mortality over 10 years among patients with kidney problems.

Researchers working in the field often point out that about



U.S. adults over age 30 with periodontal disease



faster Cognitive decline among Alzheimer's patients with gum disease versus those with healthy gums



greater RIsk of several cancers among nonsmokers with advanced gum disease versus those with healthy gums

half of all deaths from atherosclerosis occur in people who do not have any classic risk factors, such as high cholesterol or obesity. Something else — something as yet unknown — is also contributing to heart disease. Even the root cause of many cancers is largely unexplained. Most women with breast cancer, for instance, have no risk factors other than older age. Says Jean Wactawski-Wende, a cancer epidemiologist at the State University of New York at Buffalo: "The more I work on oral health and cancer, the more I think, 'Oh my gosh, I've got to keep my teeth clean.'"

#### **Foul mouth**

To date, more than 500 scientific papers have weighed in on the connection between atherosclerosis and gum disease. Officially, the theory remains "biologically plausible," but unproven, according to the American Heart Association's formal position. Some concepts are undisputed: For one, the microbes that live in the mouth don't stay in the mouth. The simple act of brushing allows bacteria clinging to the teeth and gums to leak into the bloodstream.

As the posters at the dentist's office attest, neglected oral hygiene encourages bacterial growth, allowing the microbes to breed on and between teeth, as well as under the gums. What the illustrations don't show is that these microorganisms form a biofilm, a tough microbial community bound together with sugar molecules in a thin coating. This is the plaque your dentist warns you about. "If you do not brush your teeth, it will sit there and accumulate. As that plaque gets thicker and thicker, there is less and less oxygen in the deepest layers," Borgnakke says. Safely sheltered, the innermost plaque starts to favor anaerobic bacteria, which, when they escape into the blood, can survive in the oxygen-starved nooks and crannies deep inside the body.

As plaque builds up, gums get irritated, swell and draw more blood into the distressed tissue. Eventually, chemicals produced by the biofilm break down the thin layer of cells that form a boundary between the gums and the blood vessels. Periodontitis officially occurs when gum and bone tissue starts to deteriorate. The space between the tooth and gums forms a pocket; dentists measure the depth of the pockets to determine the severity of infection. "We usually think of an infection as some bug from the outside that attacks the body," says Borgnakke. "In this case, it's an internal infection."

It was once thought that only a handful of microbial species were involved in the development of periodontitis, but the latest studies have revealed that many of the microbes responsible for gum disease come from "previously underappreciated species," according to a 2015 report in *Advances in Experimental Medicine and Biology*. Because many bacteria resist growth in a laboratory, only a small portion of some 500 to 700 species of oral microbes have been well characterized.

One aggressive pathogen, an organism called *Porphyromonas gingivalis*, has antennae that stick out and can pry open the space between two cells, Borgnakke says. "This is a really, really nasty bug." Within minutes of invading blood vessels, *P. gingivalis* and its gang of accomplices are ferried to distant sites, where they can set up outposts. "Bacteria that normally

**Community building** With inadequate brushing and flossing, bacteria caught between the tooth and gum coalesce into a biofilm. Eventually, oral tissue can deteriorate, allowing bacteria to infect other parts of the body.

live in the mouth are found in every organ in the body, and even muscle cells," she says.

The body doesn't take this assault lying down. The immune system gets agitated and tends to stay in a state of slow simmer. But the bacteria that cause periodontal disease have a knack for turning the body's defense on its head, according to a 2015 review in *Nature Reviews Immunology*. Case in point: Common white blood cells called neutrophils are deployed to the failing gums — where they not only fail to control the infection, but also end up releasing enzymes that further destroy tissue. The immune system also releases an avalanche of chemicals designed to help control the infection. For example, the liver starts producing C-reactive protein, a molecule that has such an important role in signaling the rise of heart disease that it is considered a risk factor by some researchers.

#### **Smoking gums**

Even after two decades of study, it has been hard to directly link periodontal dynamics to blocked arteries, despite hundreds of studies that have tried. There are seemingly smoking guns. Among them, *P. gingivalis* is commonly found lodged inside arteries, and the development of plaque in the arteries is driven by many of the same inflammatory chemicals triggered by periodontal disease. Many researchers also point to C-reactive protein, which is probably present long before atherosclerosis develops.

But people with periodontitis also tend to share well-known risk factors for heart disease, such as high cholesterol, smoking and obesity. A sugar-sweetened diet that promotes oral decay is no friend to your arteries. The relationship is also hard to

#### FEATURE | DOWN IN THE MOUTH

**Troublemakers** Hundreds of species of bacteria live in the mouth. Here are four particularly bad actors linked to a variety of conditions. SOURCES: BIT.LY/SN\_GUMDISEASE

Microbe	Evidence found in	Some related conditions	Additional traits
Porphyromonas gingivalis	Multiple locations	Atherosclerosis, arthritis, Alzheimer's and more	Clings to cells and tissues using thin append- ages called fimbriae
Treponema (various species)	Arteries, brain tissue	Atherosclerosis, Alzheimer's	A cousin of <i>Treponema pallidum</i> , which causes syphilis
Fusobacterium nucleatum	Gastrointestinal system, amni- otic fluid, colorectal tumors	Pregnancy complications, cancer	An instigator of acute appendicitis
Prevotella (several species)	Genital tract, joints	Vaginosis, pregnancy complica- tions, arthritis	Major players in the gut microbiome; thrive on a high-carb, low-meat diet

study because both atherosclerosis and periodontitis unfold slowly over time, so epidemiologists must rely on indirect measures of disease.

Experts line up on both sides. "If there is an association, it's a very weak one," says Peter Lockhart, former chairman of oral medicine at Carolinas HealthCare System in Charlotte, N.C. An expert on heart valve infections, Lockhart was one of the leaders of an American Heart Association panel that reviewed the evidence before releasing an official statement in 2012. "I think the question has been answered for now," he says. For cardiologists, the threat from periodontal disease "pales by comparison to the known risk factors that need to be focused on."

Others aren't ready to abandon the hypothesis. In 2015 in the journal *Atherosclerosis*, a team of German researchers reviewed studies released since the AHA statement. They pointed out that a large body of work published in the previous three years, using more refined tools and study design, shows that a connection between the two "cannot be ruled out." One

**Here to there** While questions remain, researchers theorize that oral bacteria can travel and infect tissues throughout the body, triggering inflammation that affects various systems, as well as a developing fetus. SOURCE: G. HAJISHENGALLIS/NAT. REV. IMMUNOL. 2015



study, published in *PLOS ONE* in 2014 from researchers at the University of Florida in Gainesville, Meharry Medical College in Nashville and elsewhere, claims to have found a causal relationship, at least in mice. A significant portion of animals that drank water containing *P. gingivalis* experienced inflammation and bacterial accumulation in their hearts and blood vessels. Very few unexposed animals did.

#### Into the brain

While the artery studies carry on, new research is finding oral bacteria in surprising places. The brain, for one. In 2013, a team of researchers from Florida and the United Kingdom compared brain tissue samples from 10 people who had died from Alzheimer's disease with samples from 10 people who had died from other causes. Signs of *P. gingivalis* infection showed up in four Alzheimer's patients but in none of the comparison patients, the researchers reported in the *Journal of Alzheimer's Disease*. In a follow-up experiment published in the same journal, the researchers inoculated *P. gingivalis* into the mouths of 12 mice genetically protected from Alzheimer's. Six months later, evidence of the same bacteria appeared in the brains of three-fourths of the animals.

Another type of oral bacteria, spirochetes called *Treponema denticola*, "are already known to enter the brain," says neuroscientist Sim Singhrao of the University of Central Lancashire in England. Traveling along the nerves that connect to the jaw, "they are a bit like jellyfish, crawling up into neurological tissue." Once nestled inside the brain, oral bacteria could trigger an inflammatory chain reaction that eventually destroys certain nerve cells and leads to Alzheimer's disease, says StJohn Crean, Lancashire's executive dean of the College of Clinical and Biomedical Sciences.

He points out that Chinese researchers, writing last year in the *Journal of Periodontal Research*, found that people carrying certain versions of *APOE*, a gene linked to Alzheimer's, were also more likely to suffer aggressive periodontal infection. Finally, a study published in March in *PLOS ONE* found that among 59 people with hallmarks of Alzheimer's disease followed for six months, those with periodontitis experienced cognitive decline at more than six times the rate as those without gum disease. "We've moved on from that 'this-can't-be-right' feeling," Crean says. He is hoping to get funding for a study that would compare progression of Alzheimer's among people who receive intensive oral hygiene, such as frequent dental-office-style cleanings, compared with those who brush and floss regularly. But he also notes that the arrow connecting gum disease and Alzheimer's could point in both directions. "When your memory goes, you're not going to remember to brush your teeth."

#### **Teeth and tumors**

Providing still more reason to invest in dental floss, new research is raising questions about cancer's link to gum health. Aside from oral cancers, the cancer connection was barely on the scientific radar before 2008, when a study appeared in *Lancet Oncology*. Some research had suggested that gum disease is associated with higher cancer mortality, but questions remained about the influence of smoking. In the study in

*Lancet Oncology*, researchers from Imperial College London, Harvard Medical School and elsewhere reviewed data for almost 50,000 men enrolled in the Harvard Health Professionals Follow-Up Study. That study found a small increased risk of cancer mortality in men with periodontal disease.

A second study, published in February in *Annals of Oncology*, found that men with advanced periodontal disease who had never smoked nonetheless had a 2.5 times higher risk of cancers associated with smoking, such as lung, bladder and esophageal tumors. The researchers hypothesize that

gum disease might trigger the same sort of immune response that tobacco does. Another study examined data from more than 73,000 participants of the Women's Health Initiative, which gathered health information from volunteers over 15 years. Participants diagnosed with periodontal disease had a 14 percent increased risk of breast cancer compared with women with healthy gums. "It's a modest increase, but when 50 percent of adults are diagnosed with periodontal disease, you could see this becoming a very important factor for prevention," says Buffalo's Wactawski-Wende, who led the study, published in January's *Cancer Epidemiology, Biomarkers & Prevention*.

Laboratory studies are also offering compelling evidence of associations with certain cancers. Almost a dozen studies conducted over the last five years have found one particular species of mouth bacteria, *Fusobacterium nucleatum*, living in seeming abundance in colorectal tumors. Like *P gingivalis, F. nucleatum* thrives in diseased gums and in low-oxygen areas. Wactawski-Wende is studying samples of various tumors to look for oral organisms.

#### **Burning questions**

Given that periodontal disease causes the immune system to remain in a state of irritation, other lines of research have tried to tie diseased gums to inflammatory diseases like rheumatoid arthritis and diabetes. Writing last year in the journal *Mediators of Inflammation*, researchers from the University of Ceará in Brazil reviewed published studies on rheumatoid arthritis, concluding that "the majority of the articles have confirmed that there is a correlation," especially among women. Both gum disease and arthritis, they wrote, could even feed off one another, amplifying a hyperactive immune system that makes both conditions worse.

A long line of research has also examined the relationship between diabetes and periodontal disease. In 2013, Borgnakke and an international team reviewed the evidence in the *Journal of Clinical Periodontology*. Of the 17 studies they found to have sufficient quality, the evidence suggests that people with poor periodontal health have a greater chance of developing early symptoms of diabetes and having greater

> complications from the disease once it develops. But she acknowledges that diabetes, and in fact all conditions under study, have multiple causes, making the role of any one culprit difficult to determine.

> It's also hard to account for the role of genetics. "You could have two patients with the same amount of plaque. One patient will have really deep pockets [between teeth and gums], and the other one will have no consequences," she says. "That's why it's so hard to say anything in general."

Even as research continues, those

involved concede that they may never satisfy skeptics, given the slim chance of ever having a long-term prospective study. That research would need to monitor the cardiac health of a large population over an extended time, half with gum disease and half without, to determine if those with periodontal problems experienced worse cardiac health. But given the length of time it takes for both gum disease and systemic disease to reveal themselves, a study would need to involve thousands of participants over many years to be definitive, Amar says. "It would be financially prohibitive." And he points out that pharmaceutical companies, which often help fund large clinical trials, would not back a study that has no product for them to eventually sell.

"Causality may not ever be demonstrated," he says. To most doctors, the mouth will probably remain unconnected to the body. Amar and others will nonetheless continue, in hopes their work may one day give health professionals a little more to chew on.

#### **Explore more**

Wenche S. Borgnakke. "Does treatment of periodontal disease influence systemic disease?" Dental Clinics of North America. October 2015.



Tissue from the brain of an 84-year-old woman who died with Alzheimer's disease shows evidence of infection with an oral species of *Treponema* (dark blue).

# CHANGING CLIMATE

"The physics and

chemistry that

we've known

about for over

200 years is

bearing out."

LONNIE THOMPSON

10 years after An Inconvenient Truth By Thomas Sumner

ore than 25 years before the star-studded Los Angeles premiere of *An Inconvenient Truth*, glaciologist Lonnie Thompson was about as far away from the red carpet as possible. It was 1978, and high in the rugged Andes, Thompson and fellow scientists were witnessing the first glimpses of a pending worldwide disaster. Rising temperatures were melting ancient titans of ice and snow. Mammoth glaciers were disappearing at unprecedented rates and withering to the smallest sizes in millennia. The delicate balance of Earth's climate was upset.

As research mounted, scientists around the world from fields as diverse as chemistry and astronomy were coming to grips with a newfound truth: Carbon dioxide spewed by fossil fuel burning and other greenhouse gases were warming the world at an alarming rate, potentially threatening the health and livelihoods of millions of people. Despite the gravity and urgency of their findings, the scientists' warnings fell mostly on deaf ears for years.

Until 2006. Six years after his unsuccessful presidential campaign, Al Gore reentered the national spotlight to release *An Inconvenient Truth*, which heavily featured Thompson's mountaintop research. Thompson missed the premiere of the documentary because he was gearing up to return to South America's vanishing ice. But the film did what he and other researchers had been unable to do: "It got climate change on the radar," Thompson says. Last December, Gore was on hand in Paris as 195 nations committed to the most ambitious pledge yet to fight back against climate change and curb carbon emissions (*SN: 1/9/16, p. 6*).

In the 10 years since the movie sparked increased public discussion, climate scientists have made major advances. More observations, faster climate-simulating computers and an improved understanding of the planet's inner workings now provide a clearer window on how Earth's climate will change.

Some of the bold forecasts of the 2006 movie are holding, and others are on an accelerated track. A few of the most

> dire warnings need revising, says Thompson, at Ohio State University in Columbus. And plenty of questions remain. In a controversial paper in March in *Atmospheric Chemistry and Physics*, researchers argued that the effects of climate change could be even more severe and sudden than current predictions.

While a lot has changed, the fundamental understanding of climate change, dating back to the 19th century recognition that carbon dioxide

warms the planet, has held strong, he says.

"The physics and chemistry that we've known about for over 200 years is bearing out," Thompson says. "We've learned so much in the last 10 years, but the fact that the unprecedented climate change of the last 40 years is being driven by increased  $CO_2$  hasn't changed."

The far-reaching effects of climate change — from ocean acidification to disrupted ecosystems — are too numerous to examine all at once. But on the following pages are a few of the areas where climate scientists have made significant progress since 2006.

Rapidly rising temperatures have shriveled many mountain glaciers, including Montana's Sperry Glacier, photographed here in 1913 and 2008.

# Hurricanes

**2006:** The warming ocean could fuel more frequent and more intense Atlantic hurricanes.

**2016:** Hurricane frequency has dropped somewhat; hurricane intensities haven't changed much – yet.

In August 2005, Hurricane Katrina slammed into the Gulf Coast. Floodwaters covered roughly 80 percent of New Orleans, 1,836 people died, hundreds of thousands became homeless and the most active Atlantic hurricane season on record was far from over. As the last storm fizzled, damages had reached \$160 billion, meteorologists had run through the alphabet of preselected storm names and many people, including Gore, were indicting global warming as a probable culprit.

"Hurricanes were the poster child of global warming," says Christopher Landsea, a meteorologist at the National Oceanic and Atmospheric Administration's National Hurricane Center in Miami. "In reality, it's a lot more subtle than that."

Tropical cyclones, such as Atlantic hurricanes, are stirred up where seawater is warmer than the overlying air. Because climate change raises ocean temperatures, it made sense that such storms could strike more often and with more ferocity. A closer look at hurricanes past and future suggests, however, that the relationship between warming and hurricanes is less clear-cut.

Several studies in the mid-2000s examining the history of Atlantic hurricanes pointed to an overall rise in the number of 20th century storms in step with warming sea surface temperatures. Scrutinizing those numbers, Landsea uncovered a problem: Hurricane-spotting satellites date back only to 1961's Hurricane Esther. Before then, storm watchers probably missed many weaker, shorter-lived storms. Taking this into account, Landsea and colleagues reported in 2010 that the number of annual storms has actually decreased somewhat over the last century.

#### North Atlantic hurricane frequency, 1878–2008



**Steady storms** The record-smashing 2005 hurricane season raised concerns that storms were becoming stronger and more frequent. Yet, a closer look at the long-term trends revealed that Atlantic hurricane frequency has not significantly changed since 1878. SOURCE: C. LANDSEA/NHC/NOAA



Hurricane Katrina strengthened to a Category 5 storm over the Gulf of Mexico's warm waters in 2005. Rising ocean temperatures have raised concerns that strong storms will strike more often in the future.

That decrease could be explained by climate factors other than rising sea surface temperatures. Changes in atmospheric heating can increase the variation in wind speed at different elevations, known as wind shear. The shearing winds rip apart burgeoning storms and decrease the number of fully formed hurricanes, researchers reported in 2007 in *Geophysical Research Letters*.

The overall frequency of storms, however, is less important than the number of Katrina-scale events, says Gabriel Vecchi, an oceanographer at NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, N.J. Category 4 and 5 storms, the most violent, make up only 6 percent of U.S. hurricane landfalls, but they cause nearly half of all damage. Vecchi and colleagues used the latest understanding of how hurricanes form and intensify to forecast how the storms will behave under future climate conditions.

The work, published in 2010 in *Science*, predicted that the frequency of Category 4 and 5 storms could nearly double by 2100 due to ocean warming, even if the overall number of hurricanes doesn't rise. At present, however, climate change's influence on hurricanes is probably too small to detect, Vecchi says, adding that Katrina's wrath can't be blamed on global warming.

Future hurricanes will cause more damage, Landsea predicts, whether or not there's any change in storm intensity. Rising sea levels mean floodwaters will climb higher and reach farther inland. Hurricane Sandy, which stormed over New Jersey and New York in October 2012, had weakened by the time it reached the coast. But it drove a catastrophic storm surge into the coastline that caused about \$50 billion in damages. If sea levels were higher, Sandy's surge would have reached even farther inland and damage could have been much worse.

Many vulnerable areas such as St. Petersburg, Fla., are woefully underprepared for threats posed by storms at current sea levels, Landsea warns. Higher sea levels won't help. "We don't need to invoke climate change decades down the line — we've got a big problem now," he says.

# 💮 Ocean Circulation

**2006:** Freshwater flowing into the North Atlantic could shut down the ocean conveyor belt that shuttles warm water toward Western Europe.

**2016:** The ocean conveyor belt may already be slowing, but it's not much of a conveyor belt at that.

Last year may have been Earth's hottest on record (*SN: 2/20/16, p. 13*). But for one small corner of the globe, 2015 was one of the coldest. Surface temperatures in the subpolar North Atlantic have chilled in recent years and, oddly enough, some research suggests global warming is partly responsible.

An influx of freshwater from melting glaciers and increasing rainfall can slow — and possibly even shut down — the ocean currents that ferry warm water from the tropics to the North Atlantic. About 10 years ago, scientists warned of a possible abrupt shutdown of this "ocean conveyor belt." After years of closely monitoring Earth's flowing oceans, researchers say a sudden slowdown isn't in the cards. Some researchers report that they may now be seeing a more gradual slowing of the ocean currents. Others, meanwhile, have discovered that Earth's ocean conveyor belt may be less of a sea superhighway and more of a twisted network of side roads.

The consequences of a sea current slowdown won't be anywhere near as catastrophic as the over-the-top weather disasters envisioned in the 2004 film *The Day After Tomorrow*, says Stephen Griffies, a physical oceanographer at NOAA's Geophysical Fluid Dynamics Laboratory. "The doomsday scenario is overblown, but the possibility of a slowing down of the circulation is real and will have important impacts on Atlantic climates," Griffies says.

The Atlantic mixing that feeds the currents is powered by

**Every which way** Tracking the motion of floating markers dropped into the northwest Atlantic (white-rimmed circles), researchers found that the idea of an ocean conveyor belt is overly simplistic. The markers quickly split up, ending up in many different destinations (solid circles).



differences in the density of seawater. In the simple ocean conveyor-belt model, warm, less-dense surface water flows northward into the North Atlantic. Off Greenland, cold, denser water sinks into the deep ocean and flows southward. This heat exchange, known as the Atlantic overturning circulation, helps keep European cities warmer than their counterparts elsewhere in the world.

Ten years ago, scientists knew from past changes in Earth's climate that temperature shifts can disrupt this density balance. Freshwater from the shrinking Greenland ice sheet and increased rainfall make the North Atlantic waters less dense and therefore less likely to sink. Investigations into Earth's ancient climates show that the overturning circulation weakened around 12,800 years ago, probably causing cooling in Europe and sea level rise along North America's East Coast, as piled-up water in the north sloshed southward.

Tracking sea surface temperatures, researchers reported last year that the Atlantic overturning circulation significantly slowed during the 20th century, particularly after 1970. Comparing the recent slowdown with past events, the researchers reported in March in *Nature Climate Change* that the rapid weakening of the circulation is unprecedented in the last 1,000 years.

That result isn't the final word, though, says Duke University physical oceanographer Susan Lozier. Scientists have directly measured the speed of the ocean circulation only since the deployment of a network of ocean sensors in 2004. Earlier Atlantic circulation speed changes have to be gleaned from less reliable indirect sources such as sea surface temperature changes. "If you look at the most recent results, there's a decline, yes," she says. "But we can't say that's part of a longterm trend right now." And effects on Europe's climate could be masked by other factors.

Another challenge is that over the last 10 years, "the ocean conveyor-belt model broke," Lozier said in February at the American Geophysical Union's Ocean Sciences Meeting in New Orleans. From 2003 through 2005, she and colleagues tracked the movements of 76 floating markers dropped into the North Atlantic and pulled around by ocean waters. If the model was right, these markers should have traveled along the southward-flowing part of the conveyor belt. Instead, the markers moved every which way, the researchers reported in 2009 in *Nature*.

"We went from this simple ribbon of a conveyor belt to a complex flow field with multiple pathways," Lozier says. Determining past and possible future effects of climate change on ocean currents will require more measurements and a better understanding of how the ocean truly flows, she says.

Even if the overturning circulation cuts out completely, the resulting cooling effect will probably be short-lived, Griffies says. "At some point, even if the circulation collapses, it would only be 10 or 20 years before the global warming signal would overwhelm that cooling" in Europe, he says. "This is not going to save us from a warmer planet."



# Drought, Climate and Conflict

**2006:** Climate change exacerbated droughts that contributed to regional conflicts, such as the war in Darfur.

**2016:** Drought conditions worsened by climate change helped spark the Syrian civil war.

Following escalating unrest and a wave of demonstrations across the Arab world, a bloody civil war broke out in Syria in 2011. The ongoing conflict sparked an international crisis and has left hundreds of thousands of people dead and millions more displaced. While the root cause of the conflict centered on clashes between the Syrian government and its people, multiple studies argue that climate change helped stoke the flames of rebellion.

Mounting evidence from around the world has indicted climate change in several recent severe droughts from Syria to California. Computer simulations and direct measurements of weather patterns show that climate change can redirect the paths of rainstorms and cause higher temperatures that dry out soil. Drought conditions worsened by climate change helped fuel the civil unrest that led to 2011's Syrian civil war. Global security experts worry that continuing climate change will help spark more conflicts.

In March 2015 in the *Proceedings of the National Academy* of *Sciences*, researchers estimated that decades-long shifts in Syria's rainfall and temperatures doubled or even tripled the severity of the three-year drought that preceded the Syrian civil war. Using tree rings, a separate group reported this March in the *Journal of Geophysical Research: Atmospheres* that 1998 through 2012 was the driest period in the Eastern Mediterranean since at least 1100.

The recent drought upset regional food security, prompted a mass migration into urban areas and emboldened antigovernment forces, 11 retired U.S. admirals and generals wrote in a 2014 report published by CNA, a nonprofit research and analysis organization in Arlington, Va. The clash joins another conflict partly pinned on climate change: the war in Darfur, which broke out in 2003 following a decades-long drop in regional rainfall.

Since the 1970s, droughts have become longer and more severe across the globe, and scientists expect that trend to continue. Dwindling agricultural production in certain highpopulation areas such as parts of Africa could lead to food shortages that spark refugee crises, the report warned.

"We see more clearly now that while projected climate change should serve as a catalyst for change and cooperation, it can also be a catalyst for conflict," the retired admirals and generals wrote.



# 🐑 Arctic Ice

**2006:** The Arctic could see its first sea ice-free summers in the next 50 to 70 years.

2016: Arctic summer sea ice may disappear as early as 2052.

The top of the world could see its first iceless summer roughly a decade sooner than thought in 2006, according to a 2015 report (*SN Online: 8/3/15*). Simulating how sea ice interacts with the ocean using the latest understanding of how sea ice and climate interact, scientists estimated that the North Pole will be ice-free around 2052, nine years earlier than previous simulations suggested. Last year saw the fourth smallest footprint of summer sea ice in the Arctic on record. Ice-free Arctic summers would open the region to shipping and could affect climates elsewhere by redirecting the winds that circle the North Pole, the researchers wrote. The loss of reflective sea



**Open water** Rising temperatures in the Arctic have dwindled the extent of summer sea ice. Since 1979, the minimum summer sea ice extent has decreased more than 7.5 percent per decade. An expanding Arctic Ocean could have major impacts for ecosystems and economies. SOURCE: NSDIC

ice could also hasten warming as the dark ocean absorbs more sunlight. Newly open passages may also allow mingling of animals from formerly separated habitats (*SN*: 1/23/16, p. 14).



# **Antarctic Ice Sheet**

2006: Rising temperatures are warming the Antarctic and melting the West Antarctic Ice Sheet.

2016: The West Antarctic Ice Sheet could cross a point of no return.

In 2002, an ice behemoth crumbled. Antarctica's Larsen B Ice Shelf, after 12,000 years of frozen stability, collapsed. The breakdown rapidly shattered 3,250 square kilometers of ice – an area about the size of Rhode Island (SN: 10/18/14, p. 9).

"Larsen B was a real wake-up call," says Maureen Raymo, a marine geologist at Columbia University's Lamont-Doherty Earth Observatory in Palisades, N.Y. "It was like, 'whoa, this ice shelf didn't just slowly retreat on its edge - the whole thing just collapsed catastrophically over the course of two weeks."

Now with 10 years of on-the-ice research, scientists warn that the rest of the West Antarctic ice could share a shockingly swift fate unimaginable a decade ago. The ice sheet's collapse would raise global sea levels by about 3 meters (SN: 6/14/14, p. 11).

Ice shelves line about 45 percent of the Antarctic coast and help slow the flow of the continent's ice into the sea. For healthy ice shelves, the flow of ice from inland balances losses from melting and icebergs snapping off the shelf's seaward

**Farewell, ice** As Antarctica's ice melts, warm seawater will flow through low-lying channels currently filled with ice and accelerate further melting. An ice-free Antarctica (beige area) would leave less land above sea level (blue shows footprint of current continent).



edge. Rising temperatures below and above the ice can fracture and thin the ice, upsetting this balance.

The loss of just a few ice shelves in the West Antarctic Ice Sheet could destabilize the whole region, according to new research by climate scientists Anders Levermann and Johannes Feldmann of the University of Potsdam in Germany. In a computer simulation, the researchers found that the loss of a few key ice shelves around Antarctica's Amundsen Sea would trigger a domino effect. Seawater would flow into the flanks of other ice and expedite melting. Such a collapse would annihilate the entire West Antarctic Ice Sheet within hundreds to thousands of years, they predict.

Once started, this chain reaction would be unstoppable, the researchers reported last November in the Proceedings of the National Academy of Sciences. Even if global temperatures return to normal, the ice sheet would still be doomed, according to the simulation. In 2014, researchers reported that one of those keystone ice shelves, the Thwaites Glacier, is on track to recede past an underwater ridge currently stalling its retreat and undergo catastrophic collapse in as few as two centuries.

Exactly what magnitude of warming will push the West Antarctic Ice Sheet past the point of no return remains uncertain, says Richard Alley, a glaciologist at Penn State. "It's hard to predict how the ice will fracture," he says. "That's why you don't want to tiptoe up on the disaster point. The edge between 'it's still there' and 'it's had a catastrophic failure' is something to be completely avoided."

The other half of the Antarctic continent has shown more resistance to climate change, and hasn't kept up with the global warming trend of the last few decades. That's good news, since the East Antarctic Ice Sheet holds more water than its sibling – enough to raise sea levels by about 60 meters if it fails.

Last year, however, researchers using radar to penetrate the Antarctic ice announced that East Antarctica's largest glacier, Totten Glacier, is still vulnerable. It may be at risk from encroaching ice-melting seawater. Radar maps revealed two seafloor troughs that could allow warm ocean water to melt the glacier's underside, the researchers reported in Nature Geoscience. The glacier alone holds enough water to raise global sea levels by at least 3.3 meters, though its collapse could take centuries, the researchers noted.

# 🚇 Sea Level Rise

**2006:** Melting ice and expanding seawater are raising global sea levels.

**2016:** Historical evidence suggests sea levels can rise more than 10 times as fast as they are now.

In the Indian Ocean, a city seems to rise out of the waves. The island of Malé, the capital of the Maldives and home to more than 150,000 people, sits just two or three meters above sea level (*SN: 2/28/09, p. 24*). The residents of Malé are a small portion of the approximately 200 million people worldwide living along coastlines within five meters of sea level. By the end of the century, as sea levels reach inland and coastal communities grow, the population at risk of rising waters may balloon to as high as 500 million.

The global average sea level currently rises about three millimeters per year, with a meter of total sea level rise expected by 2100 if carbon emissions aren't curtailed. Some areas, such as the U.S. East Coast, are experiencing even faster sea level rise.

In February, researchers reported in the *Proceedings of the National Academy of Sciences* that 20th century sea level rise was faster than any other century since Rome was founded (*SN: 4/2/16, p. 20*).

While sea levels are rising fast, they have the ability to climb even faster. Scientists are looking further into the future and investigating just how fast sea level rise could get, especially with a hypothetical collapse of the Antarctic ice sheets. Results

gleaned from past warm periods suggest that sea levels can rise much faster than suggested just a few years ago — more than 10 times the present rate.

"Sea level is probably the biggest irreversible risk of global warming," Columbia's Raymo says. "I expect a hell of a lot more people are going to be personally impacted by a one-meter rise in sea level than by the extinction of the grand ladybug of something or other."

Most records of ancient climates provide only a snapshot of how high sea levels have reached at a given time, not how



Expanding seawater and melting ice threaten the very existence of many island nations, including the Maldives. As climate change continues, rising sea levels could reshape Earth's coastlines.

quickly they moved up or down. But on a 2005 expedition to Tahiti, a research team caught a break. Because coral reefs require plenty of light to thrive, they typically take root in waters shallower than 10 meters deep. As sea levels rose in the past, corals moved higher up the newly submerged coastline.

> Off the coast of Tahiti, the researchers sampled fossils of ancient corals from the last 150,000 years buried in layers of ocean sediment. Dating the corals using the known decay rate of radioactive uranium into other elements, the researchers created an accurate, long-term sea level record.

> Around the end of Earth's last glacial period, about 14,650 years ago, sea levels rose about 14 to 18 meters, the researchers reported in 2012 in

*Nature*. What surprised those researchers is how quickly this rise happened: Sea levels rose at least 46 millimeters per year during that period. The scientists concluded that at least half of the 14 meters of sea level rise during this bout of warming originated from melting Antarctic ice.

"The scary thing, and this is why it's kind of apocalyptic, is that once you start these things, they don't stop," Raymo says. "Everything we see shows that, if you look in the past, each increment of warmth seems to correlate with increasingly higher sea level."

**Raising the stakes** Projections of future sea level rise vary, but scientists warn that even a small increase in sea level can worsen flooding and change coastlines. Sea level rise primarily stems from two sources: the thermal expansion of seawater and meltwater from land-based ice. Source: NOAA, GLOBAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES NATIONAL CLIMATE ASSESSMENT 2012

#### Global average sea level rise by 2100: four scenarios

Scenario	Rise in meters	Influences
Highest	2.0	Increased rate caused by ocean warming combined with maximum potential glacier and ice sheet loss
Intermediate- high	1.2	Increased rate caused by ocean warming and limited ice sheet loss
Intermediate- low	0.5	Increased rate caused by ocean warming only
Lowest	0.2	Linear extrapolation of historical rate since 1900 (no increased rate)



KLEMENR/ISTOCKPHOTO

Approximate number of people worldwide living along coastlines within five meters of sea level



# Extreme Temperatures

**2006:** Warming temperatures will cause more frequent and more deadly heat waves.

**2016:** Humidity may make future heat waves deadlier; cold snaps are on the decline.

Last summer, sweltering heat waves scorched India and Pakistan. The extreme temperatures killed thousands of people and were two of the deadliest heat waves since 1900. Such lethal heat will become more common as the planet continues warming, climate scientist Ethan Coffel of Columbia University said last December at the American Geophysical Union's fall meeting.

The problem, Coffel said, is that climate change will raise humidity in many places alongside temperature as hot air wicks up more moisture. The evaporation of sweat keeps people cool when it's hot, but high humidity can slow or even shut off this skin-cooling evaporation. Rising humidity will make rising temperatures more deadly than previously feared, he said. By the 2060s, Coffel predicts, 250 million people worldwide could face deadly levels of heat and humidity at least once a year.

While heat waves worsen, researchers say that another killer weather phenomenon will become less common. The frequency of abnormally cold periods in North America will decrease by roughly 20 percent by the 2030s, researchers reported last year (*SN Online: 4/2/15*). The work overturned previous projections of a rise in cold snaps over the coming decades as climate change redirects frigid Arctic winds. From 2006 through 2010, about twice as many people in the United States died from cold-related causes, such as hypothermia, than from excessive heat.





# 🙆 Climate Action

**2006:** The long-term effects of climate change deserve immediate action.

2016: Taking action comes with other, more immediate perks.

After decades of troubled negotiations and false starts, 195 nations from around the world gathered last December in Paris and agreed to take action on climate change (*SN: 1/9/16, p. 6*). The new commitment, to reverse the rise in greenhouse gas emissions and limit global warming to 2 degrees Celsius above the preindustrial level, would have seemed impossible 10 years ago. Delegates will meet in a few years to decide whether to target a more ambitious limit of 1.5 degrees.

What's changed is motivation, says Andrew Jones, a system dynamics modeler at Climate Interactive, a nonprofit organization in Washington, D.C., that works in partnership with MIT's Sloan School of Management. Rather than focus on

global climate benefits of curtailing fossil fuel emissions, which will take years to pan out, climate action is now increasingly driven by more immediate benefits, he says, such as improving public health. In February, researchers estimated that ambitious climate action in the United States would improve air quality enough to prevent 295,000 premature deaths by 2030 and save the economy hundreds of billions of dollars in medical costs.

"Waiting for climate results is delayed grati-

fication — it's difficult to motivate continued action," Jones says. "But if you reduce burning coal, air quality improves almost immediately."

China, the world's largest greenhouse gas emitter, backed the new climate deal after years of dragging its feet. The change of heart was chiefly driven by a desire to cut air pollution, not combat climate change, says MIT atmospheric scientist Kerry Emanuel. Earlier in December, smog-filled Beijing issued the country's first pollution red alert and shut down the city until conditions improved.

Scouring recent climate change pledges, Jones and colleagues



Nearly 10 years after An Inconvenient Truth, 195 nations agreed to try to curb climate change. While Al Gore (above) argued in the film that swift action was needed to prevent long-term problems, politicians are now increasingly motivated by immediate benefits.

found that 60 percent of commitments, including those made by the United States, Mexico and South Korea, were explicitly motivated by short-term public health and economic benefits. Jones helps maintain C-ROADS, a climate simulator that forecasts the long-term outcome of climate action plans.

> Understanding and embracing the benefits of climate action will be essential to paving a path forward, Jones says, because C-ROADS has demonstrated that there are "hundreds" of ways to meet the 2-degree warming goal.

> "We've moved from whether we're going to do this to how we're going to do this," he says. "And that is very encouraging."

> Meeting the challenges posed by climate change will be hard, but Lonnie Thompson remains optimistic. "Three-and-a-half years

ago I had a heart transplant," he says. "At any other time in human history, this would have been thought of as impossible — my father died at age 41 of a heart attack. As human beings we've made tremendous progress on so many fronts. There will always be this resistance to change, but as a species, we're capable of dealing with those changes."

#### **Explore more**

Lonnie Thompson. "Understanding global climate change: paleoclimate perspective from the world's highest mountains." Proc. Am. Philosoph. Soc. June 2010.



"Waiting for climate results is delayed gratification.... But if you reduce burning coal, air quality improves almost immediately."

#### ANDREW JONES



FILM

## Disney's The Jungle Book resurrects giant extinct ape

In the 1967 animated Disney film *The Jungle Book*, the feral boy Mowgli encounters a jazz-singing orangutan named King Louie, who implores Mowgli to teach him the secret of fire. King Louie presented a challenge for the producers of Disney's live-action, CGI-enhanced remake of the film, opening April 15. "We had this notion that we would be as authentic as we could be to the region," says producer Brigham Taylor. The problem: Orangutans are not native to India.

In fact, King Louie himself is not native to Rudyard Kipling's original stories. But instead of scrapping the character, the filmmakers got creative. While researching India's wildlife, the film's art department learned that a colossal

ape named *Gigantopithecus* once roamed the region. Various species of *Gigantopithecus* lived in India, China and Southeast Asia from about 6.5 million years ago until as recently as a few hundred thousand years ago. The ape was truly gigantic — by some estimates, twice as big as a gorilla.

So King Louie morphed from orangutan to *Gigantopithecus*. The switch was a "fun justification," Taylor says, to keep the character and play up his size while still staying true to India's fauna. (Yes, the ape is extinct, but this *is* a movie about talking animals. And fossil evidence does suggest that

the ape at least mingled with the

human ancestor Homo erectus.)

they could find on the Internet.

visual effects artists imagined how

tive. The movie ape has shaggy hair,

flaring cheeks and a saggy pouch that

Using the scientific information



By studying fossil teeth and jaws (one shown), researchers have reconstructed *Gigantopithecus*' diet.

walt disney studios

The Jungle Book

**OPENS APRIL 15** 

hangs from the throat like a double chin — and towers about 12 feet tall.

It's difficult to judge how accurate Disney's rendering is. Despite possibly having been the largest primate ever to have lived, *Gigantopithecus* left behind few fossils. Scientists have just four lower jaws and over a thousand teeth, says biological anthropologist Russell Ciochon of the University of Iowa. That's not much to go on, but Ciochon and colleagues

made their own reconstruction a couple decades ago.

The researchers took a jaw from China and made an outline of a skull that could fit such a jaw. Because most primate skulls scale to body

size, Ciochon says, his group could estimate *Gigantopithecus*' weight, 800 to 900 pounds, and height, about 9 feet from head to toe. (The species that lived in India was actually probably smaller.) Adding other details like hair to the animal is a matter of conjecture, Ciochon says.

But the teeth do offer some solid details about the ape's lifestyle. Wear patterns and microscopic debris stuck to the teeth indicate *Gigantopithecus* dined on fruits, leaves, shoots, roots and perhaps even bamboo. Last year, researchers confirmed those details after analyzing the ratios of carbon isotopes in teeth found in Southeast Asia. The analysis also determined that *Gigantopithecus* was a strict forest dweller, even though it also lived near grasslands in some areas. In fact, the researchers contend, *Gigantopithecus*' reliance on forests and its big size — and therefore big appetite — may have been the animal's undoing. As Southeast Asia's jungles gave way to expanding grasslands during the last glacial period, *Gigantopithecus* may have been unable to cope.

Perhaps if our ancestors had shared the secret of fire with *Gigantopithecus*, the giant ape would still be around today. – *Erin Wayman* 



# 'Wild Ways' depicts need of isolated animals to move from here to there

Thousands of national parks have been established around "I the world to preserve wildlife. But towns, farms, ranches and roads have grown up around many of these parks, creating islands of wilderness in a sea of humanity. If the creatures inside are to thrive, they need ways to travel between the islands, contends "Wild Ways," a new documentary from the TV series *NOVA*. **Wild Ways** 

Isolation can be especially troublesome for large predators, such as lions, that live alone or in small groups. In some areas of Africa, lions can move

between populations to avoid inbreeding. But some lions, such as the few in Tanzania's Ngorongoro Crater, are cut off from other groups. In such populations, cubs are born smaller, die younger and are more susceptible to disease. And drought or overhunting could easily wipe them out, the show notes.

To connect these smaller populations, conservationists are now building wildlife corridors between parks. One of the most ambitious projects is the Yellowstone to Yukon Conservation Initiative, which aims to create connections between grizzly bears in the Canadian Arctic and the western United States. Other large wildlife corridors are being planned in Central America, eastern Australia and the Himalayas. But there are often roadblocks. It can be difficult to persuade people to spend money on wildlife, and it can be even harder when those animals kill livestock or humans.

"It is important that we provide incentives for local communities, in particular, who should now look at wildlife as some form of economic asset to themselves," says Simon Munthali of the Kavango-Zambezi Transfrontier Conservation Area, which is attempting to connect parks in five countries across

> southern Africa. With the right incentives, people will be more accepting of wildlife moving across land and may even benefit from it, he says in the documentary. Botswana, for instance, has developed a large ecotourism industry that provides jobs

and money for local people, motivating animal protection.

The documentary is a bit too optimistic about the removal of hurdles that stand in the path of wildlife corridors, especially in the American West, where there is ongoing debate about how to manage public lands. And then there is the question of whether these corridors can be created fast enough to save the world's dwindling animal populations. But, as Michael Soulé, one of the founders of the field of conservation biology, says: "It's our last chance to protect the diversity of life on Earth." "Wild Ways" makes a convincing case that we should be willing to try. *— Sarah Zielinski* 



AIRS APRIL 20 PBS | NOVA

# SOCIETY UPDATE





#### Meet the 2016 Intel Science Talent Search winners

The three top winners of the 75th annual Science Talent Search (STS), sponsored by Intel, tackled some of society's most pressing problems head on. Winning projects addressed water pollution, lung disease, heart disease and cancer.

The winners were announced during a black-tie gala in Washington, D.C., on March 15. Astrophysicist and science communicator Neil deGrasse Tyson delivered an impassioned keynote speech. "These 40 finalists give me confidence," he said.

Intel and the Society for Science & the Public awarded three top prizes of \$150,000 each. The Basic Research prize went to Amol Punjabi, 17, of Marlborough, Mass., who created a computer program that finds new targets for treating cancer and heart disease. Paige Brown, 17, of Bangor, Maine, took home the Global Good prize for a filter she designed to clean polluted waterways. And Maya Varma, 17, of Cupertino, Calif., claimed the Innovation prize for creating an inexpensive device for diagnosing lung disease.

"The finalists are not only talented scientists, they also are well-rounded individuals," said Maya Ajmera, President and CEO of the Society for Science & the Public. Addressing all 40 finalists at the gala, she said, "We are betting on you to make the world a better place."

Clockwise from top: Amol Punjabi, Paige Brown and Maya Varma took the top prizes at the 2016 Intel STS awards; Punjabi displays a model of a protein identified by a computer program he designed to find new drug targets; Intel STS 2016 finalists pose on the steps of the U.S. Capitol; (from left) Catherine Jessica Yihui Lai, Maria Elena Grimmett, Beverly Ge and Augusta Uwamanzu-Nna walk to the National Geographic headquarters to exhibit their projects.

#### FIRST PLACE (\$150,000 PRIZE)

Amol Punjabi, 17, Marlborough, Mass. First Place Medal of Distinction for Basic Research

Paige Brown, 17, Bangor, Maine First Place Medal of Distinction for Global Good

Maya Varma, 17, Cupertino, Calif. First Place Medal of Distinction for Innovation

#### **2016 INTEL STS WINNERS**

#### SECOND PLACE (\$75,000 PRIZE)

Meena Jagadeesan, 17, Naperville, III. Second Place Medal of Distinction for Basic Research

Michael Zhang, 18, Berwyn, Pa. Second Place Medal of Distinction for Global Good Milind Jagota. 18, Bethlehem, Pa.

Second Place Medal of Distinction for Innovation

#### THIRD PLACE (\$35,000 PRIZE)

Kunal Shroff, 17, Great Falls, Va. Third Place Medal of Distinction for Basic Research

Nathan Charles Marshall, 17, Boise, Idaho Third Place Medal of Distinction for Global Good

Kavya Ravichandran, 17, Westlake, Ohio Third Place Medal of Distinction for Innovation

#### SOCIETY FOR SCIENCE & THE PUBLIC | INFORM. EDUCATE. INSPIRE.

### 

Night Proofs<sup>™</sup> Briefs are virtually leak proof, comfortable and so absorbent you'll sleep through the night without needing a change.

t's a problem no one likes to talk about, but over 25 million Americans suffer from urinary incontinence. For those people, the problem is embarrassing, uncomfortable and can lead to a variety of other health issues such as skin irritation. Now there's an adult diaper that fully absorbs the liquid and pulls it away from the skin leaving little opportunity for skin irritation, or other incontinence-related problems. Plus for many, a good night's sleep uninterrupted, leak-free is the best news of all. Adult diapers have been on the market for years, but because most are sold to hospitals, where frequent changing is not an issue, they simply have not been designed to last through the night. Night Proofs<sup>™</sup> Briefs are–and they do!

#### Our Leak-Proof Test:

Take a Night Proofs<sup>™</sup> Briefs and pour eight full 12-oz glasses of water into it. The water will be fully absorbed and the surface of the lining will remain dry. (If you attempt this test with other adult diapers, you better try it over the sink!)



#### Night Proofs<sup>™</sup> Briefs are different:

They are one of the most absorbent adult diapers on the market today Just one look tells you that Night Proofs<sup>™</sup> Briefs are very different from store brands.

No skin irritation

Discreet packaging

- They are much thicker with a superior design that keeps working all night so you can sleep in peace.
- The polyethylene back prevents leaks and provides 12-hour protection. Water passes through cloth diapers, but it doesn't penetrate the poly back. It's that simple.
- They are designed for home use, with refastenable tabs, leak-proof leg cuffs and a wetness indicator that caregivers really appreciate. They're also adjustable, breathable, and latex-free as well as odor resistant and discreet.

#### Why spend another night without them?

Call now to take advantage of our special introductory offer. Helpful product experts are standing by for your call. The Night Proofs<sup>™</sup> Briefs are not available in stores, and you won't have to risk running into one of your former high school classmates with a shopping cart full of adult diapers. They come in three sizes, including x-large for up to a 67-inch waist, so they'll fit perfectly. Don't hesitate, call today!

## Night Proofs<sup>™</sup> Briefs

Waist Sizes: M (28"-43"), L (39"-60"), XL (43"-67")

#### Call now toll free and get our

### **Special Introductory Price**

Please mention promotional code 103103.



ADVERTISEMENT

#### FEEDBACK



FEBRUARY 20, 2016

## Naming Nine

Online readers proposed some clever names for Planet Nine, the hypothetical orb described by **Christopher Crockett** in "Hunt for Planet Nine heats up" (*SN*: 2/20/16, p. 6).



Planet Diana, Goddess of the wilderness. Angus Gordon-Farleigh

There's Endymion, the shepherd. This planet presumably "shepherds" many other objects into their orbits. Elthko Kennins

It should be called Tobe Ra'ah, for its shepherding qualities, and the exotic sound of the name. William Maddock

If and when "Planet Nine" is confirmed, it should be named "IX" (pronounced "icks") in honor [of] the Dune series by Frank Herbert. **Michael Shea** 

#### Join the conversation

E-MAIL editors@sciencenews.org MAIL Attn: Feedback 1719 N St., NW Washington, DC 20036

#### Connect with us



#### **Ocean outlook**

Earth's oceans are a hot mess. They absorb heat at twice the rate that they did nearly 20 years ago, Thomas Sumner reported in "Ocean heating doubles" (SN: 2/20/16, p. 18). Meanwhile, phytoplankton release more heat during photosynthesis than previously thought, Chris Samoray reported in "Ocean flora flunk photosynthesis test" (SN: 2/20/16, p. 12). And the trillions of plastic particles littering the oceans are creating new habitats for microbes with unknown consequences, Samoray wrote in "Floating fortress of microbes" (SN: 2/20/16, p. 20). Anna Carter wondered if these findings are connected. "Is it possible that phytoplankton are contributing to ocean warming?" Carter asked. "How might the organisms now collecting on all the plastic in the ocean be related?"

Heat produced by phytoplankton doesn't have a large impact on ocean temperature, says Sumner. "The phytoplankton are catching sunlight that otherwise could warm the water," he wrote. "Another thing to keep in mind is that the oceans are colossal. At its deepest, the Pacific Ocean is about as deep as the cruising altitude at which most commercial airliners fly. Phytoplankton live in the top sliver of the water column, so any effect they have will be minuscule compared with the size of the ocean." As for plastic-dwelling microbes, there is still so much to discover, Samoray says. Their contribution to ocean warming is currently unknown.

#### Ants on the move

Florida harvester ants may be the Frank Lloyd Wrights of the animal kingdom. They construct intricate and mysterious nests, **Susan Milius** reported in "Restless architects we don't understand" (SN: 2/20/16, p. 4). Researchers investigated why ants frequently build and abandon elaborate nests, and scatter charcoal around nest openings.

Readers had their own ideas about the unusual behavior. "[Charcoal] is an effective absorber of organics. Is it possibly used for absorbing their scent as a protective measure against predators?" **Mark Ayers** asked. **Walter Tschinkel**, the Florida State University scientist featured in the story, says that the scorched plant matter ants use may not be as effective for these purposes as commercial charcoal. Field tests found no sign that charcoal would deter attacks by other ants.

Reader **Joe De Vita** speculated that colonies abandon their nests because of waste buildup. **Tschinkel** notes that this hypothesis has yet to be tested. "Digging up the vacated nest often reveals chambers with matted, blackened floors, presumably from fungus and other microorganisms, but whether this condition has any negative (or for that matter, positive) effects on harvester ants is unknown," he says. An experiment to test this hypothesis is possible, but "ain't all that easy. Still, stay tuned."

#### Milk for spills

Researchers have created a fibrous membrane made from milk proteins and carbon that could filter toxic heavy metals from severely polluted waters, **Sarah Schwartz** reported in "Altered milk protein cleans up pollution" (SN: 2/20/16, p. 14). In lab tests, the membrane removed over 99.9 percent of lead from a contaminated solution.

"It is a very exciting method," wrote Janece Von Allmen. "Has anyone thought to test this method in the real polluted waters of Flint, Michigan?"

The filters are still in an early stage of design, **Schwartz** says. The membranes work in the laboratory to capture heavy metals and radioactive particles, but testing in the real world is a must. "Bodies of contaminated water are most likely chemically different from labmade lead solutions and could change the membrane's performance," she says.

Whether or not these membranes would work in the Flint River is unclear because the river is not the original source of lead. The toxic heavy metal accumulates as the water passes through corroding pipes. The good news is the prototype shows signs of being efficient and is relatively cheap to produce. The only universal optical instrument...

#### **PANSCOPE** (the complete optical system) from us only \$59.95 (Why pay more?)\*

BUT READ THIS MESSAGE FOR AN EVEN MUCH BETTER DEAL.

This is a little optical marvel. PANSCOPE (only 2" long) contains a complete optical system in its tiny body. You may use it as a 3x telescope or as a unique 3x telescope-loupe. In its magnifying mode, it delivers magnifiers and loupes at 5x 10x and 15x enlargement. And to top it all, it also functions as a 30x microscope of laboratory quality.

A special stand for long-term observation for 15x and 30x microscope is included.PANSCOPE is the indispensable first choice of scientists and professionals and of just about everybody who wants and needs to see the infinite detail in life that is not readily available to the unaided eye. \*And here is the even better deal: Buy two PANSCOPES for \$119.90 and we shall send you a third one, with ours compliments -- absolutely FREE! You will be delighted with this wonderful instrument. Do yourself a favor and order your PANSCOPE(s) today!

 PANSCOPE is beautifully gift-boxed, comes with its neatly fitted leather case and with a plastic "tripod for extended observations at 15x and 30x.

#### How to order

You may order by toll-free phone or mail and pay by check or AmEx/ Visa/ MasterCard. Please give order code shown below. Add \$9.95 for one, \$12.95 for three instruments for shipping/insuranceand sales tax for WA delivery. You have thirty-days refund and three-year warranty. We do not refund postage. For customer service or wholesale information please call (425) 264-6393. **Please give order code Z019** 



330 SW 43rd St., Ste. K 333, Renton, WA 98057

Order by toll-free phone: 1-800/600-2777 Visit our website at www.jomira.com





The Klein Bottle Opener Designed by a sculptor, 3D printed in steel, lasts a lifetime. If you use math and drink beer, you need one! \$66 at www.bathsheba.com





## There's more to the Milky Way than meets the eye

The pale arch of light from the plane of our galaxy can be a humbling sight on a clear, dark night. But it's just a sliver of all the treasures lurking in the Milky Way. Dense clouds of interstellar dust block visible light from remote regions of the galaxy but allow longer wavelengths to pass through. In February, astronomers completed a new map of our galaxy as seen in submillimeter light, which is shorter than radio waves but longer than infrared waves.

Submillimeter light can penetrate dust clouds, revealing details at the center of the galaxy and in stellar nurseries not visible at other wavelengths. The map was produced by ATLASGAL, a project using the APEX telescope in northern Chile to map part of the Milky Way. The project charted one-third of the band of galactic light that encircles our solar system; the images above show a narrow slice toward the constellation Sagittarius.

Combined with images from the Spitzer and Planck satellites, the ATLASGAL map (top row) creates a detailed atlas of some of the cold structures in our galaxy. Dust clouds in places like the Trifid and Lagoon nebulas (circled, left), both a few thousand light-years away, glow faintly, as do filaments of detritus in the center of the galaxy (circled, right), 28,000 light-years from Earth. At near-infrared wavelengths (center row), these regions nearly vanish behind obscuring curtains of dust. The galactic center remains hidden in visible light (bottom row) as well, though hot stars in Trifid and Lagoon radiate pools of hydrogen gas, making them glow.

- Christopher Crockett



# Discover the Secrets of the Writer's Craft

Writing great fiction isn't a gift reserved for the talented few. There is a craft to storytelling that can be learned, and studying writing techniques can be incredibly rewarding—both personally and professionally. Even if you don't have ambitions of penning the next *Moby-Dick*, you'll find value in exploring all the elements of fiction.

From evoking a scene to charting a plot, **Writing Great Fiction: Storytelling Tips and Techniques** offers a master class in storytelling. Taught by novelist James Hynes, a former visiting professor at the famed Iowa Writers' Workshop, these 24 insightful lectures show you the ins and outs of the fiction writer's craft. A wealth of exercises will inspire you to practice the many techniques you learn. Professor Hynes is an able guide, showing you what has worked for him and other novelists, and pointing out pitfalls to avoid. **Writing Great Fiction** is truly an exceptional course for anyone interested in storytelling.

### Offer expires 05/01/16 THEGREATCOURSES.COM/4SN 1-800-832-2412

### Writing Great Fiction: Storytelling Tips and Techniques

#### Taught by Professor James Hynes NOVELIST AND WRITING INSTRUCTOR

#### LECTURE TITLES

- 1. Starting the Writing Process
- 2. Building Fictional Worlds through Evocation
- 3. How Characters Are Different from People
- 4. Fictional Characters, Imagined and Observed
- 5. Call Me Ishmael—Introducing a Character
- 6. Characters—Round and Flat, Major and Minor
- 7. The Mechanics of Writing Dialogue
- 8. Integrating Dialogue into a Narrative
- 9. And Then—Turning a Story into a Plot
- 10. Plotting with the Freytag Pyramid
- 11. Adding Complexity to Plots
- 12. Structuring a Narrative without a Plot
- 13. In the Beginning—How to Start a Plot
- 14. Happily Ever After—How to End a Plot
- 15. Seeing through Other Eyes—Point of View
- 16. I, Me, Mine—First-Person Point of View
- 17. He, She, It-Third-Person Point of View
- 18. Evoking Setting and Place in Fiction
- 19. Pacing in Scenes and Narratives
- 20. Building Scenes
- 21. Should I Write in Drafts?
- 22. Revision without Tears
- 23. Approaches to Researching Fiction
- 24. Making a Life as a Fiction Writer

#### Writing Great Fiction:

Storytelling Tips and Techniques Course no. 2541 | 24 lectures (30 minutes/lecture)

# SAVE UP TO \$190

#### DVD <u>\$269.95</u> NOW \$79.95 CD <u>\$199.95</u> NOW \$59.95

+\$10 Shipping, Processing, and Lifetime Satisfaction Guarantee Priority Code: 126593

For over 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free mobile apps for iPad, iPhone, or Android. Over 550 courses available at www.TheGreatCourses.com.

#### Purity DiamondAura®

#### **Ring features:**

- 2.50 carat emerald-cut center stone
- 8 marquise-cut stones
- 22 round-cut stones
- 6 baguette-cut stones

#### \*\*\*\*

#### Stauer clients love DiamondAura®

"I am enjoying the ' looks' that I am getting from the ladies as they can't help but notice my beautiful ring." — K. J., Keosauqua , Iowa Independently Appraised at \$650<sup>†</sup>

> TAKE 71 % OFF INSTANTLY! When you use your INSIDER

OFFER CODE

# **URGENT: Diamond Ring Recall**

Experts warn that millions of rings may be "romantically defective" when compared to the spectacular 4.75 total carat Purity DiamondAura® Emerald-Cut Ring.

She loves natural diamonds. She loves you even more. But when even the skimpiest solitaires sell for thousands, it's time to reconsider your relationship...with diamonds. Have you recently overpaid only to be underwhelmed? Send it back. You can do bolder. You can do brighter. You can own the Stauer 4.75 total carat *Purity DiamondAura* \* *Ring* for under \$90.

When "cute" is a four-letter word. If you want to make a romantic impression, go big. Cute doesn't cut it. Your love deserves to be wowed. If you're a billionaire with money to burn, turn the page. Everyone else? What you read next just might change your love life. There's only one way to find out...



We rewrote the rules of romance. Only Stauer's exclusive lab-created Diamond*Aura* gives you the luxury look and feel of large-carat diamonds for a fraction of the price. The ingenious Diamond*Aura* process involves the use of rare minerals heated to incredibly high temperatures of nearly 5000°F. After cutting and polishing, scientists create an impeccable marvel that's optically clearer with even more color and fire than a "D" flawless diamond.

Our exclusive Diamond*Aura* jewelry features all of the classic specifications, including color, clarity, cut and carat weight and is hard enough to cut glass. You get the romance,

flash, and excitement of natural stones without the outrageous cost.

**Experience the luxury of money in the bank.** We "built" our own similar mined diamond version of this ring online at a popular

jewelry site at a cost of more than \$70,000! Today you can wear this lab-created Diamond*Aura* emerald-cut ring, accented with 32 gleaming Diamond*Aura* stones in fine .925 sterling silver for **only \$875**!

**That's good, but you deserve better.** Order now and we'll include the Diamond*Aura* stud earrings totalling an additional 1 carat... absolutely **FREE!** That's right, nearly 6 carats of Diamond*Aura* in luxurious sterling silver for under \$90.

Your satisfaction is guaranteed. If for any reason you don't absolutely adore your *Purity DiamondAura Ring*, return it within 60 days for a full refund of the sale price and keep the stud earrings as our gift. But we promise that once you get a look at the *Purity DiamondAura Ring* up close, you'll see love in a whole new light.

#### Purity DiamondAura® Ring (4.75 ctw) \$299\*

Offer Code Price Only \$8750 + S&P Save \$21150!

You must use the offer code to get our special price.

# 1-800-333-2045



Please use this code when you order to receive your discount.

Stauer®

ACCREDITED BUSINESS Rating of A+ \* Special price only for customers using the offer code versus the price on Stauer.com without your offer code.

Burnsville, Minnesota 55337 www.stauer.com

† For more information concerning the appraisal, visit: http://www.stauer.com/appraisedvalues.asp.

2.50 carat emerald-cut DiamondAura<sup>®</sup> center stone • 36 brilliant-cut accent DiamondAura<sup>®</sup> stones • Rhodium-finished .925 sterling silver setting • Whole ring sizes 5–10

Smart Luxuries—Surprising Prices™