thirsty planet

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THE TOBACCO WARS:
E-cigarettes now surpass combustible tobacco use among 12th-graders nationwide, according to the “Monitoring the Future” survey, but are they safe? And what does it mean that the use of other things like hookah and small cigars is up? Read more in our “Expert Advice” column on p.8.
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Designers Eiko Ojala was born in 1982 in Tallinn, Estonia. From an early age he was passionate about design and art. Inspired by his father, who worked as an architect, he went on to study interior design, and eventually his path led him to illustration.
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LET US BUILD A LASTING LEGACY FOR YOU

WILL YOU HAVE ENOUGH TO RETIRE?

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Financial Times
Top 400 Advisor in 2013

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You might wonder why a magazine dedicated to health is putting a story about water on its cover. Well, this speaks to the expansive view that we take on “health” here at Johns Hopkins Health Review.

Your health is about more than just your body. It is also about the welfare of your community, the strength of your relationships, the condition of the planet, and the vitality of your brain. JHHR examines a host of topics relating to our overall well-being and illuminates the important work happening in a variety of fields.

As we go to press with this issue, California has just passed its first mandatory restriction on water use. That state’s historic drought is a sign of things to come. As reporter Andrea Appleton explains in her feature “Thirsty Planet” [pg. 56], management of water resources will have to change drastically. She tells us about some cutting-edge solutions for safeguarding our water supply.

Contending with the future of water is the kind of complex challenge that we cannot solve alone. We must work across boundaries and disciplines, which is the fundamental approach that Johns Hopkins takes in researching and solving some of the world’s most thorny challenges. It’s also the approach that we take in this magazine when presenting news affecting your health. You’ll see stories ranging from how to set up your office [“Bodies at Work,” pg. 70] to breakthroughs in sleep research [“Insomniac Flies,” pg. 34]. We also offer the latest on emerging trends and tech, like whether e-cigarettes are really safer [“Expert Advice,” pg. 8].

What are the pressing issues that you want to hear about as they relate to health? We’d love to hear from you. Visit us online at johnshopkinshealthreview.com.
While e-cigs may not be harmless, they are less harmful than smoking combustible tobacco.
David Abrams
Psychologist
JOHNS HOPKINS BLOOMBERG SCHOOL OF PUBLIC HEALTH

David B. Abrams is executive director of the Schroeder Institute for Tobacco Research and Policy Studies at Legacy and a professor at the Johns Hopkins Bloomberg School of Public Health. He has been evaluating the safety and consumer perceptions of e-cigarettes.

From E-Cigs to Hookah Pipes: Is Any of It Safe?
MAT EDELSON

While cigarette smoking continues to decline nationally, new forms of consumption are popping up. From hookah bars to legalized marijuana, the use of pipes, pot, blunts, e-cigarettes, and cigarillos is on the rise. Researchers are now clamoring to better understand the health consequences of this rapidly changing landscape.

David Abrams has been studying e-cigarettes, nicotine replacement therapies, and the nature of addiction for decades. Abrams draws an important distinction between these new categories of nicotine delivery: With hookah, cigars, and cigarettes, one is looking at “combustible tobacco.”

“It’s the combustion that kills almost all the people who use tobacco,” says Abrams. “It’s the burning of tobacco, the carbon monoxide, over 60 carcinogens and other tars that kill, not the nicotine.”

E-cigarettes, by contrast, don’t involve combustible tobacco. They’re battery operated, with the battery creating an inhalable vapor that delivers tobacco-derived nicotine. Given his druthers, Abrams would prefer that no one use any tobacco. However, if a person is already using cigarettes, cigars, or hookah, then e-cigarettes, which are used by an estimated 13 percent of Americans who smoke, may be an important step in minimizing harm and even quitting altogether. “In the last six months, the evidence is strongly accumulating that [e-cigs] are at least as effective and may be more effective [for smoking cessation] than nicotine replacement therapies” such as nicotine gum or patches, says Abrams.

Abrams is particularly passionate about preventing youth from starting to smoke in the first place. He conducts research and interprets the science for Legacy, the nonprofit anti-smoking agency that produces the highly visible and effective TRUTH campaigns aimed at youth. Abrams acknowledges that for parents dealing with smoking adolescents, conversing about the issue is getting more complex: 12.6 percent of high-schoolers say they use cigars; 22.9 percent of college-age students have tried hookah; and 17 percent of 12th-graders tried an e-cigarette with more than 75 percent of them also trying conventional cigarettes. Throw in marijuana, which is also on an uptick—23 percent of all adolescents have used it,
and this is before legalization—and we’re dealing with a very different kind of “stop smoking” talk than just a generation ago.

“It’s not a simple message,” Abrams says. “It’s: ‘I’m very worried about your using any substance. We don’t know how your brain is going to react. We don’t know who gets hooked, whose brain is allergic to these things. The best thing is to stay away from all drugs. However, if you’re using hookah or lethal cigarettes or cigars, I want you to know that although the research isn’t completely done, there’s good evidence that e-cigarettes are safer. I’d prefer you stop everything if you can.’”

E-cigarettes could prove an important public health tool, Abrams believes, but they need prudent FDA regulation, which currently isn’t the case. In the absence of regulation, he adds, many tobacco control and public health advocates are “overreacting to hypothetical and unproven fears.” FDA regulation would set product standards, including labeling that notes how to use them for “reduced harm” as compared to lethal cigarettes, cigars, and hookah.

“E-cigarettes could be an unprecedented gateway to make obsolete the lethal combustible cigarette or cigar,” says Abrams.

A just-released Bloomberg School study led by researcher Thomas Sussan found that mice exposed to e-cigarette vapor were “significantly more likely to develop compromised immune responses.” Abrams says that it is premature to generalize what this means going from animals to humans. While e-cigs may not be harmless, overall they are far less harmful and are a tool for those looking to quit more-lethal combustible cigarettes.

One thing is clear; the youngster who takes up smoking any kind of combustible tobacco faces an extremely tough road toward quitting. Based on adult data, some 70 percent of adults say they want to quit in any given year, but only about 4 percent accomplish the task. This, notes Abrams, is despite anti-smoking measures such as increased taxes on tobacco, indoor clean air campaigns, and telephone and Internet cessation programs. The glimmer of good news is this: For those with the resources to use a combination of an FDA-approved nicotine replacement and behavioral therapies, quit rates can be doubled to quadrupled. A recent study also showed that those who used e-cigarettes for one month were 6 times more likely to have quit two years later.

Either way, Abrams remains passionate about his task of ending smoking among youth. “As the surgeon general said, 5.6 million of our kids alive today, including possibly my grandchildren, who are 6 and 10, will become addicted to lethal cigarettes and half of them will die prematurely if we don’t do something more than everything we’re doing now. That’s what motivates me to say, ‘We can’t just stay the course.’”
10 Green Cleaning Supplies

**1 / Vinegar**
Spray full strength on counters and follow with hydrogen peroxide. Mixed 1:1 with water, it cleans fabric and carpet stains.

**2 / Baking Soda**
Useful against mold and stains.

**3 / Hydrogen Peroxide**
Use full strength in a spray bottle to clean surfaces. Use on colorfast clothing to treat stains.

**4 / Borax**
A laundry booster, fungicide, herbicide, and general household cleaner.

**5 / Rubbing Alcohol**
Use it to clean sinks, stainless, and chrome. Dilute with water to wash windows.

**6 / Lemons**
Rub on the surface of your wood cutting boards and rinse clean. The acidity kills bacteria.

**7 / Castile Soap**
Mild on the skin, it can be used as dish detergent, hand soap, and all-purpose cleaner.

**8 / Coca-Cola**
Cleans toilets, rusty parts, and even laundry.

**9 / Water**
The primary ingredient in most commercial cleaning products! Keep it in a spray bottle to spot clean.

**10 / Activated Charcoal**
An open container in the refrigerator or on the counter acts as an air freshener. Keep out of reach of children or pets.

_Specialist_ Mary Doyle, Registered Nurse

_Spring cleaning season is officially upon us. Just as you scour your home for a fresh new start, consider a similar overhaul of your products._ Doyle, a registered nurse who specializes in environmental health sciences, warns that many common cleaning supplies contain harmful chemicals. Bleach, for example, has fallen out of favor due to the potentially significant health effects of sodium hypochlorite. The good news is that swapping toxic cleaners with greener options is easy and cost-effective. “You can clean your house with products that you have right in your pantry or medicine cabinet,” Doyle says. “These products are cheaper, environmentally friendly, and avoid the adverse health effects that commercial cleaning products may cause.”

Mary L. Doyle specializes in environmental health sciences at the Johns Hopkins Bloomberg School of Public Health.
Leslie Pietrzyk
Lecturer in Johns Hopkins’ MA in Writing Program

I WISH THERE WERE...

a way for people mourning a loss and having a difficult day to signal to the rest of the world that they are suffering.

In 1997, novelist Leslie Pietrzyk lost her husband, Robb. He was 37 years old when he died suddenly from a heart attack. In the aftermath, Pietrzyk sought ways to process her loss, but found that the pain didn’t fit neatly into the expected stages-of-grief timeline. “It’s difficult for our culture to acknowledge that sadness continues to exist,” Pietrzyk says. “But imagine if you could wear something that said you were in mourning if you needed to. There were days when if I’d had a little armband, I would have put it on so people would understand that I was struggling.” Pietrzyk has since remarried, and she has written about the nature of grieving. This Angel on My Chest is her collection of unconventionally linked stories, each about a different young woman whose husband dies suddenly and unexpectedly. Winner of the 2015 Drue Heinz Literature Prize, it is due out this October from the University of Pittsburgh Press.
Survey

BODY/
15. Signs Cut Calories
   Hay Fever Help
16. Alternatives to Opioids
17. Glasses or a Laser?
   New Hope for Infertile Men

MIND/
18. Truth Is in the Timing
   Feeding Your Brain
19. Going With Your Gut
   Artful Diagnosis
   Time to Fast
20. Quit Smoking With
   Psychedelic Therapy
   Choking Under Pressure

FAMILY/
21. Healthier Inheritance
   Starch, With a Side
   of Sugar
22. Promising Autism
   Treatment
   Vitamin D to Prevent
   Falls
23. Trauma and Your Child
   Curriculum for Parents

WORLD/
24. Teaching Machines
   to Share
   Safer Water
   Tracking Twitter
25. Tiny Spill, Big Problem
   Better Ebola Protection
Signs Cut Calories

[HEALTHY EATING]

Could the key to losing weight be as simple as following a sign? Johns Hopkins Bloomberg School of Public Health researchers found in a recent study that signs explaining how much exercise was needed to burn off calories actually changed youth behaviors. The brightly colored 8.5-by-11-inch signs, which were placed in convenience stores, explained that it took five miles of walking or 50 minutes of running to work off the 250 calories in a typical 20-ounce bottle of soda, sports drink, or fruit juice.

Observing more than 3,000 purchases before and after the signs went up, researchers saw purchases of sugary drinks drop by 9 percent. More impressive: In interviews, 35 percent of young buyers said they saw the signs, and of those, 40 percent changed their purchases because of them.

“Six weeks after [the signs came down], the kids were still doing these positive buying behaviors,” says Sara Bleich, an associate professor in Health Policy and Management at Johns Hopkins and lead author of the study. “So there's actually a persistent effect.”

Hay Fever Help

[ALLERGIES]

Sublingual immunotherapy is one of several novel treatments for allergic rhinitis, or “hay fever,” recommended by a panel of experts in a new guideline by the American Academy of Otolaryngology–Head and Neck Surgery Foundation.

Sublingual (Latin for “under the tongue”) tablet immunotherapy, approved by the FDA in April 2014, gradually desensitizes patients to the allergens that trigger their symptoms. Immunotherapy used to require visits to a doctor’s office for injections, but patients can now take tablets or drops at home. The guideline recommends such immunotherapy for patients who test positive for a specific allergen and don't respond well to other treatments.

“Immunotherapy is the only treatment that changes the allergic patient's response to the allergens,” says Sandra Lin, a Johns Hopkins otolaryngologist and the panel's assistant co-chair. She cautions that the treatment takes up to five years to complete, and patients have had allergic reactions in rare cases.
Alternatives to Addictive Opioids

These days, if you go to the doctor with a bad back, you may be less likely to receive a prescription opioid than in the past. Nine out of 10 primary care physicians surveyed by researchers at the Johns Hopkins Bloomberg School of Public Health said that prescription drug abuse is a big problem in their communities. Nearly half said that they are less likely to prescribe opioids than they were a year ago, according to the findings reported in the journal *JAMA Internal Medicine*.

Prescription drug abuse is the nation’s fastest growing drug problem, according to a White House report released a few years ago. The numbers are staggering: Drug overdose death rates in the United States have more than tripled since 1990. The clinical use of prescription opioids nearly doubled between 2000 and 2010. More than 38,000 people died in 2010 from drug overdoses, with many of these deaths caused by prescription opioids.

But only in recent years has the medical community paid much attention to the mounting epidemic, the researchers say. “The health care community has long been part of the problem, and now they appear to be part of the solution to this complex epidemic,” said study leader G. Caleb Alexander, an associate professor of epidemiology at Hopkins.

Alexander says he hopes more physicians and patients will discuss other types of pain relievers and nondrug treatments like physical therapy, massage, and acupuncture.
Glasses or a Laser?

[EYE HEALTH]

In the last 20 years, corrective eye surgery has become increasingly common. “Those who have good vision with glasses or contact lenses but have trouble tolerating them are usually great candidates,” says Christina Prescott, an ophthalmologist at the Johns Hopkins Wilmer Eye Institute. She often treats pilots, police officers, or athletes, but just as often, it’s a mom who wants to clearly see her baby when she wakes up at night.

The most common procedures are LASIK (laser-assisted in situ keratomileusis) and PRK (photorefractive keratectomy). The recovery process varies, but one of the reasons LASIK is so popular is that there is virtually no pain and improvement to vision is almost immediate.

Those who do not see well even with glasses or contact lenses are usually not good candidates, says Prescott, but a full eye exam is the best first step.

New Hope for Infertile Men

[urology]

Not long ago, a diagnosis of no sperm in a man’s ejaculate dashed a couple’s hopes of having biological children. “That used to be true,” says Pravin Rao, director of reproductive medicine and surgery at the Johns Hopkins Brady Urological Institute. But with the advent of intracytoplasmic sperm injection, Rao says, pregnancy can be achieved with very few sperm—provided you can find some healthy swimmers.

Men with azoospermia, or absence of sperm in the ejaculate, may still produce small amounts within the testes. Surgeons like Rao can extract sperm through microsurgery. The delicate procedure entails making a small incision on the scrotum to look—under a microscope—for healthy sperm-production areas. An embryologist is on hand to isolate the sperm, which is then injected directly into an egg and implanted in the female partner’s womb. On average, it takes two to three cycles to produce pregnancy.

Rao says surgeons and others are trying to find other interventions that can improve the chances of finding sperm. Various projects underway at Hopkins and elsewhere promise to help infertile men by taking immature sperm cells and maturing them outside the body, and by creating sperm from a man’s stem cells.
Truth Is in the Timing

[BEHAVIOR]

Employees are more likely to lie or cheat when they are tired, even if they are good people. Morning people tend to act unethically at night, and night owls tend to act unethically in the morning, according to a study by a team of researchers, including Brian Gunia, a psychologist at the Johns Hopkins Carey Business School. The takeaway for supervisors? Know whether staffers are morning people or night owls, then structure schedules accordingly. Similarly, people who control their own work schedules should plan work around their sleep patterns. “If we’re a morning person squeezing [work] in at night,” the researchers write, “we create a situation in which resisting temptation may be harder than ever.”

Feeding Your Brain

[NUTRITION]

We know that eating right and working out helps our bodies age gracefully, but it turns out that our aging brains also benefit. Staving off Type 2 diabetes at age 50 through weight control and exercise can mean better cognitive function at 70, according to a Johns Hopkins study. Middle-aged study participants with diabetes had 19 percent more cognitive decline over the next 20 years. That’s like being a 60-year-old with the mind of a 65-year-old. “If we can do a better job at preventing diabetes and controlling diabetes, we can prevent the progression to dementia for many people,” says epidemiologist Elizabeth Selvin. “Even delaying dementia by a few years could have a huge impact on the population, from quality of life to health care costs.”
**Going With Your Gut**

*Cognition*

“Trust your gut.” It’s a piece of advice we might take in deciding whether to pursue a romance. But business decisions? Too subjective, right?

Not so, says economist Shabnam Mousavi of the Johns Hopkins Carey Business School. Mousavi conducts research in an area known as “fast and frugal heuristics.” Heuristics are the mental shortcuts that we develop to lessen the cognitive burden of decision making. In certain scenarios, that fast-thinking intuition is better than rational and deliberate calculation. Mousavi was lead author of an article on this topic in March 2014 in the *Journal of Business Research*.

Business leaders claim that they use objective methods when making decisions. But on closer inspection, it has been found that executives admit to relying on “gut feel” quite regularly. Rather than minimizing the value of such decision making, Mousavi says, we should recognize the evolutionary reasons humans developed these approaches and figure out when it’s best to use them. He suggests acknowledging the human tendency for gut choices, then creating a decision tree in your organization that starts with a fundamental question: “If the worst-case scenario of this proposal were to occur, could we survive?” Then go from there.

**Time to Fast**

*Neuroscience*

Recent studies suggest that adopting a shorter “eating window” benefits your brain. Mark Mattson, a Johns Hopkins professor of neuroscience, says that brain function can be optimized by periods of fasting, coupled with exercise. On an eight-hour diet, one might eat several healthy meals between 10 a.m. and 6 p.m., but ingest zero calories the remaining hours.

When you “graze” throughout the day, Mattson says, most of the glucose consumed gets stored as glycogen and becomes the body’s source of energy. But when you go 12 to 16 hours without eating, the glycogen in the liver is used up and the body instead breaks down fat to produce ketones for fuel. “Fasting basically turns a switch from using glycogen to mobilizing fatty acids, which is a very important difference. And there’s lots of evidence that ketones are good for the brain.”

**Artful Diagnosis**

*Pediatric Neurology*

Draw me how it hurts. That’s the request made by Johns Hopkins Pediatric Neurology Director Carl Stafstrom to young patients who suffer from recurring headaches. In one drawing, red spots around the eyes indicate the location of the patient’s pain, while another depicts a horse kicking the side of the patient’s head. Stafstrom turned to art in headache diagnosis for youngsters because distinguishing migraines from nonmigraine headaches can be tricky. Many children are unable to verbally describe migraine symptoms. The drawings offer invaluable insight into a child’s perception of pain.
Quit Smoking With Psychedelic Therapy

[ADDICTION]

Johns Hopkins researchers found that longtime smokers who had failed many attempts to drop the habit did so after carefully controlled and monitored use of psilocybin—the active hallucinogenic agent in “magic mushrooms.” Eighty percent of participants were still cigarette-free after six months, a rate that is much higher than the normal 10–35 percent success rate in smoking cessation trials, says Hopkins psychologist Matthew Johnson.

This does not mean you should start a DIY psychedelic drug habit to quit smoking. The hallucinogenic compound was administered as part of a comprehensive cognitive behavior therapy program that included weekly one-on-one counseling sessions and techniques such as keeping a diary to assess when and why cravings occur. “Quitting smoking isn’t a simple biological reaction to psilocybin,” Johnson says. “When administered after careful preparation and in a therapeutic context, psilocybin can lead to deep reflection about one’s life and spark motivation to change.”

Choking Under Pressure

[NEUROSCIENCE]

Why is it that humans, when under pressure, sometimes fail to perform? Vikram Chib, an assistant professor of biomedical engineering at Johns Hopkins, is a soccer fan who noticed that world-class players could miss an open shot in front of the goal. He decided to study what breaks down in the human brain at that critical juncture.

Chib and his co-researchers devised a simple video game that uses a joystick to maneuver digital balls into a square. Subjects were placed inside a functional MRI scanner and asked to play. Some were offered a monetary reward for winning. When the subjects first saw the incentive messages, their brains’ ventral striatum region—the portion known to encode reward values—recorded increased activity. Once they began to play the game, ventral striatal activity increased as the rewards increased—but only up to a point. As the rewards neared the upper limit, the part of the brain that had fired up suddenly deactivated. The higher the stakes, the greater the deactivation and the more the subjects failed at the game. “In many ways, choking behavior is irrational and illogical,” says Chib, who is now investigating how motivational cues can influence our performance, with the hope of discovering how we can improve our performance in high-stakes situations.
Healthier Inheritance

[LAGESTYLE]

Psychiatry researcher Kellie Tamashiro has given new meaning to the old saying “You are what you eat.” She’s found evidence to support an important corollary: “You don’t have to be what your mother ate.” Tamashiro’s studies focus on maternal diet and stress and their long-term effects on offspring, including obesity, impaired glucose tolerance, cognitive decline, depression, and anxiety. She’s shown that interventions—like exercise in adolescents and a more wholesome diet—can rescue the health of rat pups otherwise destined for a life of diet-induced ailments.

Starch, With a Side of Sugar

[NUTRITION]

The road to healthier school meals has been inadvertently paved with canned fruit, flavored milk, and processed carbohydrates.

Despite the good intentions behind the Healthy, Hunger-Free Kids Act passed by Congress in 2010, the resulting breakfasts and lunches served in cafeterias may not go far enough, even if they comply with the law, according to an analysis done by researchers at the Johns Hopkins Bloomberg School of Public Health.

The law requires school meals to consist of 51 percent whole grains, more fruits and vegetables, and less salt. It restricts saturated fats to less than 10 percent of a meal’s calories, imposes calorie restrictions, and allows only skim or 1 percent milk to be served and only skim milk to be flavored.

All that would be good news if it weren’t for one sweet loophole: There is no limit on the amount of added sugar in school meals. In addition, as the current standards are written, they still incentivize high-carbohydrate processed meals associated with the rise in U.S. obesity rates. Through in-depth policy analysis, the researchers found that schools may still opt to serve canned fruit, juice, and flavored milk to meet the list of required foods.

To give the law a passing grade, the researchers suggest expanding the requirements to limit added sugars and processed foods to ensure carbohydrate quality, curtailing the amount of processed carbohydrates and increasing whole grain and whole food products.
Promising Autism Treatment

[PHARMACOLOGY]

A new treatment to ease some of the behavioral symptoms associated with autism spectrum disorders may come from a simple source: broccoli sprouts.

A daily dose of the chemical sulforaphane, which is found in sprouts, showed promise in helping teenage boys and young men with moderate to severe autism improve their social interaction and verbal communication during a small clinical trial conducted by scientists at MassGeneral Hospital for Children and the Johns Hopkins University School of Medicine.

Decreases in repetitive, ritualistic behaviors were also noted in those taking sulforaphane when compared with those taking a placebo, according to the study, which was published online in the journal *Proceedings of the National Academy of Sciences*.

Both researchers and parents noticed improvement in the study subjects, who ranged in age from 13 to 27. Some treated subjects were able to achieve important firsts, like making eye contact and shaking someone’s hand.

Sulforaphane is different from most previously tested remedies because it seems to target the basic mechanisms of the disorder, the researchers said. “We believe that this may be preliminary evidence for the first treatment for autism that improves symptoms by apparently correcting some of the underlying cellular problems,” said Paul Talalay, a professor of pharmacology and molecular sciences at Johns Hopkins.

Vitamin D to Prevent Falls

[AGING]

Falls are the leading cause of death and nonfatal injuries among older Americans, accounting for more than 2.5 million visits to the emergency room in 2013. This year, the Centers for Disease Control and Prevention estimates that one-third of people age 65 and up will fall.

One way to avoid accidents may be vitamin D. “In some studies it looked like vitamin D increased muscle strength and increased gait speed,” says Johns Hopkins epidemiologist Lawrence Appel, who is leading a team that will enroll 1,200 participants in a trial looking at the effects of vitamin D on falls.

“The evidence is all over the map with vitamin D having a beneficial effect in some studies, no effect in others, and potential harm in a few studies,” says Appel. To help figure out the right dosage, the study participants—all over age 70 and at high risk of falling—will be randomized to receive 200, 1,000, 2,000, or 4,000 IUs of vitamin D daily for two years. No one knows for sure, but the right dosage might reduce falls by up to 25 percent.
Trauma and Your Child // A Curriculum for Parents

Trauma and Your Child

[POSITIVE INTERVENTION]

Nearly half of all children in the United States are exposed to at least one social or family experience that can lead to traumatic stress, according to new research out from Johns Hopkins. Having their parents divorce, having a parent die, or living with someone who abuses alcohol or drugs are some of the circumstances that threaten to increase negative long-term health consequences for kids. The good news is that training parents, providers, and communities to help children cope and build resilience may lead to later success, despite the obstacles. “Adverse childhood events don’t automatically have to have long-term traumatic impacts for children,” says study leader Christina Bethell.

A Curriculum for Parents

[EDUCATION]

The saying “It takes a village” is perhaps most true when applied to a child’s education. Since 1981, Johns Hopkins sociologist Joyce L. Epstein has studied the effects that family and parent engagement has on the health and vitality of schools. “This is about more than just making parents feel welcome at a school,” Epstein says. “The goal is to help students do better.”

Through her National Network of Partnership Schools, Epstein provides professional development to enable schools and districts to develop research-based programs for family and community involvement. Whether it’s a family reading night to help parents and children enjoy books together or a coffee klatch where parents and teachers meet to discuss the curriculum, the network has tested programs and now offers resources and publications that speak to what works and what does not.
Teaching Machines to Share
[medicine]

A prototype app for tablet devices aimed at helping reduce preventable medical errors in intensive care units is currently being tested at Johns Hopkins. Studies of U.S. hospitals show that more than 800,000 people—that’s 1 in 5—admitted to ICUs suffer some sort of preventable issue, such as blood clots. The problem, ironically, is the technology found in the ICU. Machines do a wonderful job individually, but don’t electronically “talk” to each other in a way that clinicians can easily decipher. Critical information can be missed among the estimated 200 daily tasks that nurses and doctors perform on an ICU patient.

The app, which involved input from 18 different disciplines including engineering and bioethics, improves how machines talk to one another and to people. Why an app? “When we asked clinicians, patients, and families how they envisioned the information being displayed, they didn’t want another big screen display or a display on a wall,” says Alan Ravitz of the Johns Hopkins Applied Physics Lab. “They wanted something they could hold and interact with.” A patient version of the app will also help families track the care that they can provide their loved one, such as brushing teeth or washing hair.

Safer Water
[environment]

Determining if a body of water is safe just got easier. Johns Hopkins mechanical engineer Marin Kobilarov worked on a team to develop a pollution-hunting underwater robot. Equipped with navigation sensors and monitoring instruments, it keeps tabs on everything from water temperature to blue-green algae content. “We’re getting a 4-D picture of the water, the fourth dimension being time, so we can predict how quality would evolve day to day.” Piloted last year at Lake Pleasant in Phoenix, Arizona, the technology will be further developed and let loose this spring in the Chesapeake Bay.

Tracking Twitter
[mental health]

Johns Hopkins researchers are using a computer algorithm to analyze Twitter posts and gather information about some common mental illnesses. The algorithm gathered tweets from users who publicly mentioned their diagnosis. It also looked for language cues linked to certain disorders, including words associated with anxiety and insomnia. Reviewing more than 8 billion tweets, the researchers have been able to quickly and inexpensively collect new data on post-traumatic stress disorder, depression, bipolar disorder, and seasonal affective disorder. “Using Twitter to get a fix on mental health cases could be very helpful to health practitioners and government officials who need to decide where counseling and other care are needed most,” says Johns Hopkins computer scientist Mark Dredze.
Tiny Spill, Big Problem

[ENVIRONMENT]

When gasoline dribbles from the pump’s nozzle after a fill-up, few among us think twice about the environmental impact of such a tiny spill. But the truth is, those drips add up, seeping into the concrete pads beneath the pumps and then contaminating the soil and groundwater. That’s bad news for people who live nearby and rely on well water, according to researchers at the Johns Hopkins Bloomberg School of Public Health. Roughly 1,500 liters of gasoline are spilled at a typical gas station every 10 years—and that’s the researchers’ conservative estimate. That’s a problem when the environmental and public health impacts of chronic gasoline spills are poorly understood. “Chronic gasoline spills could well become significant public health issues since the gas station industry is currently trending away from small-scale service stations,” says environmental health scientist Patrick N. Breysse.

Better Ebola Protection

[PUBLIC HEALTH]

After last year’s Ebola outbreak raised major concerns over the spread of the highly infectious disease, the U.S. government challenged innovators from around the world to help health care workers provide better, more timely care, while also containing the virus. A team from Johns Hopkins Center for Bioengineering Innovation & Design and Jhpiego, an international nonprofit health organization affiliated with Johns Hopkins University, is now among three global winners to receive financial support for its prototype of a health care worker suit. The suit was redesigned for quicker, safer removal and to keep workers from coming in contact with Ebola patients’ contagious body fluids during and after treatment. In addition, it is expected to keep the wearer cooler—an important benefit in hot, humid regions such as West Africa. (The cooling technology used in the garment was originally developed by Johns Hopkins cardiologist Harikrishna Tandri for cooling patients in cardiac arrest.) The suit will now undergo intensive testing to ensure readiness for production and deployment in the field.
Pain afflicts millions of lives and costs millions of dollars. Treating it has proved to be extraordinarily hard.
I hurt, you hurt, we all hurt. Pain is a human constant. Today it’s the minor burn suffered while searing last night’s pork chops. Tomorrow it’s a twinge in the lower back. Or the faint pulse of an incipient headache, the sting of a hangnail, or the constant tormenting aftermath of a neck injury that drains life of all joy.

In its 2011 report *Relieving Pain in America*, the Institute of Medicine of the National Academy of Sciences estimated that 100 million American adults suffer from chronic pain. That’s more than the number of adults with heart disease, cancer, and diabetes combined. Those numbers don’t include people suffering from acute pain, defined as pain that disappears when the underlying cause has been treated or healed. Nor do the figures include children. And public health researchers believe the problem is getting worse. A report issued in 2009 by the United Kingdom Department of Health stated, “Chronic pain is two to three times more common now than it was 40 years ago.”

“I hate pain. I’m petrified of pain,” says Allan Belzberg, clinical director of the Neurosurgery Pain Research Institute and an associate professor of neurological surgery at Johns Hopkins. “I can take out a brain tumor, I can take out a nerve tumor, I can fix a spine and I help those people, no question. But when I have patients who have chronic pain and I can help them with that, that is a dramatic change in their lives. I feel ashamed and horrific when I can’t help someone who’s in pain.”

The contemporary science of pain and its alleviation is a sophisticated multidisciplinary endeavor. At Johns Hopkins, neurologists, psychologists, psychiatrists, surgeons, geneticists, anesthesiologists, electrophysiologists, nursing researchers, and molecular biologists all work on pain. But there remains much that mystifies scientists. “Pain biology is really taking off,” says James Campbell, a Johns Hopkins professor emeritus of neurosurgery. “But pain therapeutics is limping along. There are too many people walking around who would say their pain level is six, seven, or eight on a zero-to-10 scale. If we can put a man on the moon, why should anyone have to walk around with a pain level of eight?”

*Neurologists, psychologists, psychiatrists, surgeons, geneticists, anesthesiologists, electrophysiologists, nursing researchers, and molecular biologists all work on pain.*
That medicine struggles to alleviate pain is testament to how complex it is as a physiological and psychological phenomenon. Jab your finger with a pin. The body’s first reaction comes when the point of the pin stimulates a nerve fiber in your fingertip. The fiber is part of a pain sensor known as a nociceptor. When your fingertip is jabbed, the activated nociceptor shoots an electrical impulse along the length of your arm, past a cluster of cells in the spinal cord called the dorsal horn. In the dorsal horn, the nerve impulse gets processed into the spinal cord. Neurons in the spinal cord send the signal up to the thalamus, deep in the core of the brain. Finally, the thalamus relays the information that your finger has been pricked to the somatosensory cortex (which senses it), the frontal cortex (which thinks about it), and the limbic system (which reacts to it emotionally). Ouch.

In textbooks and on medical websites, this series of steps is often represented by an infographic that portrays the nervous system as a sort of electrical circuit. Viewed this way, pain seems simple and straightforward. But the neat diagram doesn’t even hint at the baffling complexity of pain, says Jennifer Haythornthwaite, a professor of psychiatry and behavioral sciences in the School of Medicine. So much more is going on, even with a minor injury. For example, make the wound a bit more severe than a pinprick—say, a cut that requires a few stitches. The sliced tissue hurts at the point of the injury. That makes sense—the knife that slipped while you were cutting carrots damaged nerves in your finger. But the next day, the pain has expanded to an area around the cut, which is inflamed. That tissue was not injured, yet it hurts. Why? Make the injury worse again—now say the finger’s been broken in a softball game. The fracture hurts because, as with the cut, tissues and nerves around the damaged bone have suffered trauma. Eight weeks later, everything regarding the bone has mended properly, but pain persists. Why, if the bone and nerves have apparently healed, do you still hurt?
The complexities do not end there. If you are African-American, you will feel pain more than if you are a non-Hispanic Caucasian. This is not a subjective matter; laboratory research has documented that pain sensitivity is generally higher in blacks. In the same way, women generally are more pain-sensitive than men. In demonstrative cultures, people respond to pain with more emotional distress than people in stoic cultures. And that circuit diagram of pain does nothing to represent what happens in the brain, where physical perception becomes pain and often develops into the psychological phenomenon of suffering. “You can give 10 people in the lab the same stimulus and get 10 different responses and see 10 different brain images,” says Haythornthwaite.

Haythornthwaite estimates that Johns Hopkins has, cumulatively, one of the four or five biggest pain research efforts in the country. An important nexus at Hopkins is the Blaustein Pain Treatment Center. There is also the Neurosurgery Pain Research Institute, a new initiative housed in the School of Medicine’s Department of Neurosurgery. Michael Caterina directs the institute. “Pain involves a lot of learning on the part of the nervous system,” Caterina says. “A lot of changes happen when you injure a nerve or injure the tissue that the nerve innervates.” When, for example, the pain stimuli are pronounced and persistent, that experience seems to change the strength of the impulses flowing through the nervous system, like an amplifier, and the change lasts for a long time. If a period of sustained pain can change how your spinal cord functions, an effective therapy will have to do a lot more than just dampen the hurt of the original injury.

As pain scientists develop an ever more granular understanding of pain,
they get closer to explaining the baffling inconsistency and seeming illogic of pain as a physiological phenomenon. For example, Caterina cites the work of Johns Hopkins neurologists Justin McArthur and Michael Polydefkis, who have been taking skin biopsies from people experiencing pain from conditions such as diabetic neuropathy and shingles. They have found, in these patients, a marked reduction in the number of nerve endings in the biopsied skin. How is it that people with fewer nerve fibers have more pain? The researchers are testing several theories to better understand why that might be, but at this point we still don’t know.

It’s important to remember that “pain is not just a biological experience,” according to Haythornthwaite. “It is a psychological experience as well as a sociocultural experience.” Haythornthwaite works on pain-related catastrophizing—a particular cognitive and emotional response to pain. Some people hurt and stoically carry on. In catastrophizers, pain overwhelms them. The condition correlates with other psychological conditions like neuroticism and depression.

When someone in pain shows up in an emergency room, how physicians and nurses respond to them affects not only the patient’s psychological state but also their physical sensitivity. “People come to pain with a history of experiences that mold and shape their perception of pain at that moment,” says Haythornthwaite.

Inner-city hospitals like Johns Hopkins see a lot of patients with substance abuse problems in their emergency rooms. The response of clinical staff there can exacerbate pain. Campbell, who helped start the Blaustein Pain Treatment Center at Hopkins, says it is hard to distinguish whether a patient has been abusing drugs and wishes to score pain meds or is truly in pain. “We still don’t have a handle on that,” Campbell says. “So much of what we do for a patient depends on believing the patient. If you don’t believe the patient, it becomes a really frustrating encounter. Imagine it from the patient’s perspective. You have pain, and your doctor doesn’t believe you. What a double whammy that is.”

The sociocultural and emotional component of pain may be one part of the frustrating failure of so many therapeutics that seem to work in the lab on animals, then flop in clinical trials. Researchers can measure the physical response of a mouse to a pharmaceutical compound, but a mouse can’t describe its mood, can’t report that it slept badly the night before, can’t express symptoms of depression—aspects of suffering that

“So much of what we do for a patient depends on believing the patient.”
accompany chronic pain. For this reason, pain researchers at Johns Hopkins and elsewhere have begun to add to their experimental repertoire more sophisticated methods that allow the animal to indicate to the investigator, based on its actions, whether a particular intervention makes it less uncomfortable.

The challenge with pain medication is that “different drugs work in different people,” Campbell observes. “What one sees over and over again is that a particular drug therapy works great in one person but fails miserably in another. Drug trials typically measure the average response. As a result, some drugs fail to gain FDA approval even though they may be safe and effective in certain people. What is needed are ways to predict what the best therapy is for a particular individual, rather than simply depending on an empirical trial of a drug.”

Campbell had an idea several years ago: What if pain became the “fifth vital sign”? In a hospital, staff evaluate four vital signs to monitor a patient’s condition: breathing, pulse, blood pressure, and temperature. Campbell started a national campaign to make the presence and degree of pain a fifth component in the routine assessment of a patient’s condition. He started a national campaign to make the presence and degree of pain a fifth component in the routine assessment of a patient’s condition. He started a national campaign to make the presence and degree of pain a fifth component in the routine assessment of a patient’s condition. He stated in his 1996 presidential address to the American Pain Society: “Vital signs are taken seriously. If pain were assessed with the same zeal as other vital signs are, it would have a much better chance of being treated properly. We need to train doctors and nurses to treat pain as a vital sign.”

There is an arsenal of pain medications now, some of them effective for short-term treatment of acute pain. Long-term use for chronic pain is more complicated because the body builds tolerance to drugs like morphine and oxycodone and develops physical dependency. Michael Clark, the director of pain treatment programs at Johns Hopkins Medical, says physicians need to be better educated about pain therapeutics. “People would benefit from the ABCs, the basics,” he says. “Here are the drugs, here’s how you prescribe. Five hours of that would translate into a lot more patients treated well.”

Beth Murinson, an associate professor in the Johns Hopkins School of Medicine, has done significant work on better education of medical students in the medical landscape. As he stated in his 1996 presidential address to the American Pain Society: “Vital signs are taken seriously. If pain were assessed with the same zeal as other vital signs are, it would have a much better chance of being treated properly. We need to train doctors and nurses to treat pain as a vital sign.”
pain management. “This is a big topic for us,” she says. “We have built a much more robust program in pain for Hopkins medical students. What should a Hopkins medical student know about pain by the time of graduation? We developed 255 learning objectives. We used these as the foundation for a survey of North American medical schools, and results of this work were included in *Relieving Pain in America*. In that study, we found that most medical schools, over four years of instruction, are devoting less than 10 hours to pain. This is a huge deficit in light of the observation that over 100 million Americans suffer with pain, and the additional observation that about half of medical encounters involve patients with pain. We interpreted this to mean that most practitioners are simply not equipped to address a very common clinical occurrence: pain and the varieties thereof.”

Sometimes the most effective treatment regimen involves things patients do not want to do. “No matter what, the overall long-term success rate for injections, for operations, for medications, tends to be low,” says Steven Cohen, director of the Blaustein Pain Treatment Center. “The things that we know work—if you’re obese, losing weight; if you’re sedentary, exercise—nobody wants to hear. Nobody wants to come into the pain clinic and hear, ‘Lose weight and exercise more.’ People want a pill. A lot of them want narcotics.”

Amid all the sophisticated science and discussion of pain’s remarkable complexity, it is easy to overlook a far more basic form of therapy. Belzberg points to studies that demonstrate the remarkable effect of someone simply asking the patient how he or she feels. “Nurses tell us all the time that if the doctor goes in and holds the patient’s hand and asks them how they are, the nurse will have fewer complaints from the patient,” he says. “No question. Nurses have been telling us this for years.” It doesn’t have to be a doctor doing this, Belzberg says. Patients report more satisfaction with their pain management when anybody asks how they’re doing, even a member of the housekeeping staff.

“In talking to patients and trying to get a handle on this,” Belzberg says, “one thing that becomes very clear is that for somebody who is in pain, they want to know that you are listening to them, that you’re willing to help. You’re willing to listen and try to understand what it is that they are suffering.

“*Nurses tell us all the time that if the doctor goes in and holds the patient’s hand and asks them how they are, the nurse will have fewer complaints from the patient.*”
Insomniac Flies

Could studying a mutation in the genome of fruit flies someday help humans suffering from insomnia? That’s the goal of research being led by Mark Wu, an assistant professor of neurology, whose team discovered a gene mutation in fruit flies that causes the insects to have trouble falling asleep at night, similar to people suffering from sleep-onset insomnia.

After screening literally thousands of fruit flies, Wu and his colleagues, who study the molecular mechanisms underlying sleep and how sleep impacts neurological diseases, noticed one group of flies that seemed to have trouble conking out at night. They isolated and cloned the gene and discovered that “it turned out to be novel,” says Wu. “No one had ever studied that gene before.”

Researchers dubbed the new gene “Wide Awake” and began to investigate further. What they discovered was that the gene was specifically expressed in the fly’s circadian clock system, the biological mechanism that controls when animals sleep or wake. “We all have circadian clocks, and the nature of the circadian clock is a collection of neurons that tell time, but we know very little about the molecules that regulate it,” Wu says. His team started thinking that Wide Awake could be related to how an animal’s circadian clock tells it to go to sleep, he says.

Further research revealed that levels of Wide Awake increased and decreased as the day progressed, peaking in good sleepers around dusk, when the circadian clock tells the body to begin preparing for sleep. Wu and his team determined that when properly functioning, Wide Awake helps shut down arousal circuits in the brain by making them more responsive to signals from gamma-aminobutyric acid, or GABA, receptors, a class of inhibitory neurotransmitters that reduce neural excitability in the nervous system. Wu says that flies with the mutated Wide Awake gene couldn’t get to sleep because they were not getting enough GABA signals to quiet their arousal circuits at night, keeping the flies “tossing and turning.”

But could Wide Awake also play a role in how the mammalian circadian clock regulates sleep? Once they knew what they were looking for, Wu and his colleagues searched for the gene in other species—mice,

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**MARK WU** is an assistant professor of neurology at Johns Hopkins who discovered Wide Awake, a gene mutation in fruit flies that suffer from sleep-onset insomnia.
rabbits, chickens, worms, and humans. In every creature they examined, they discovered evidence of the gene. Significantly, researchers were able to pinpoint the location of Wide Awake in the suprachiasmatic nucleus—the master clock in mammals, also called SCN—in mice. “Sometimes discoveries in flies don’t translate into higher-level animals,” says Wu, “but in the mouse, this version of Wide Awake is enriched in the SCN, so that really suggests that the function of this gene is conserved in mammals as well.”

Wu says he and his team plan to continue studying Wide Awake in flies and mice, with the goal of someday looking at the role this gene plays in the sleep cycles of humans. New discoveries could lead to medication that stimulates faulty Wide Awake genes into helping shut down the brain’s arousal circuitry. “The big picture is there are millions of Americans who suffer from circadian misalignment of their sleep-wake cycle and this is not good for their health,” says Wu. “So we’re trying to figure out ways in which we can help them minimize the bad things that can happen by studying Wide Awake. ... The bottom line is that we think by studying [this new gene], we can make novel insights into how the circadian clock regulates sleep.” // JOE SUGARMAN

Could Wide Awake play a role in how the mammalian circadian clock regulates sleep? Once they knew what they were looking for, Wu and his colleagues searched for the gene in other species—mice, rabbits, chickens, worms, and humans. In every creature they examined, they discovered evidence of the gene.
Virtual Hearts, Tailor-Made

The heart may seem to hold life’s deepest mysteries and intricacies, but Natalia Trayanova has figured out how to map the muscle’s intricacies using a cardiac-specific software. Realistic simulation of the heart will one day allow for more precise and personalized cardiovascular treatments, Trayanova says, including targeted treatments for heart arrhythmias and congenital heart disease, and more accurate defibrillator placements.

The process of developing a virtual heart starts in Trayanova’s Computational Cardiology Laboratory at Johns Hopkins University. Trayanova takes a series of MRIs of a patient’s heart, which serves as the “scaffold” for his or her virtual heart. The scaffold is then “populated” with cardiac cells, whose electrical behavior is simulated using a cardiac-specific software developed by Trayanova and two of her collaborators. The software, which took more than 20 years to design, uses equations to represent cardiac functions, such as those at the protein level or those representing the specific disease. Using this approach, Trayanova creates a virtual replica of a patient’s intricate heart structure and electrical behavior, including unique scarring.

Once a patient’s virtual heart has been modeled, Trayanova can manipulate it on the screen, testing the electrical behavior of that heart in ways that aren’t possible in a flesh-and-blood patient. She can also assess which treatments might be better or worse for each heart.

“We know how heart cells behave in general,” Trayanova says, “but we don’t know what kinds of arrhythmias cells will generate in a particular heart geometry and scarring.”

This breakthrough could help physicians target precise treatments for cardiovascular patients of all sorts, but especially those patients who experience disturbances in heart rhythms. These arrhythmias are commonly treated with defibrillators, which shock the heart into a normal rhythm as needed. But the process of determining which patients need defibrillators is not foolproof, Trayanova says. Annually, only 5 percent of patients with these implants actually develop irregular heart rhythms, meaning that the implants are, in many situations, unnecessary.

This is where Trayanova’s research comes in: Trayanova and her team recently created heart models for 40 patients who had suffered heart attacks and received defibrillators. They predicted which hearts were likely to develop arrhythmias in the next five years—and correctly identified at-risk patients 85 percent of the time. In comparison, the traditional criterion used to identify which patients needed defibrillators, called an “ejection fraction,” predicted only 51 percent of future cardiac events in the same study.

Trayanova explains that virtual hearts could allow for more accurate predictions of arrhythmias, as well as help cardiologists avoid unnecessary defibrillator placement. Trayanova can also use these virtual models to predict the optimal location of an implantable defibrillator in individuals with congenital heart disease.

Patients with arrhythmias are also treated with a therapy called ablation, which involves burning pieces of tissue that cause improper heart rhythms.
Once a patient’s virtual heart has been modeled, Trayanova can manipulate it on the screen, testing the electrical behavior in ways that aren’t possible in a flesh-and-blood patient. She can also assess which treatments might be better or worse for each heart.

But this therapy, too, has its downside. Trayanova highlights the fact that an ablation procedure can take anywhere from four to 12 hours as cardiologists probe the heart with a catheter to assess its electrical functioning on a point-by-point basis. In her lab, Trayanova’s virtual hearts allow her to noninvasively test various treatment scenarios before she recommends the one the model shows would be optimal for the patient. The physician can then target the exact areas in need of ablation, significantly shortening the invasive procedure, increasing the level of precision, and reducing unnecessary damage.

Trayanova, a physicist by training, notes that planes and automobiles have been built and tested virtually for years. To her, this is medicine’s natural next step toward personalized health care. “We’re missing out on simulation,” she says. “This will help the process of decision making regarding heart disease treatment to become more tailored to the individual patient.”

Where is she headed next? Trayanova says she hopes to eventually see virtual organs in every patient’s medical chart, ready and waiting prior to any kind of procedure. “For me, this is a dream and a vision,” she says. “In clinical practice, an incremental improvement can make a huge difference. This could cause a major paradigm shift in cardiac care.” // JENNI WHALEN
When the human body fights a disease, it throws a host of antibodies at the problem. The trick for scientists, then, is to pick which of the antibodies are the most effective against any given disease.

The Promise of Plantibodies

In August of 2014, a small biotech company in San Diego with just nine employees became international news. Mapp Biopharmaceutical appeared to have a cure for Ebola. Called ZMapp, the experimental treatment—shown to neutralize Ebola in animal studies—was given to two American aid workers infected with the deadly virus. The patients survived, and a media frenzy ensued. Larry Zeitlin, Mapp’s president, and Kevin Whaley, CEO, were inundated with press requests. Everyone from the BBC to Fox, ran stories on the new treatment, which was limited in quantity and had never been tested in humans before being given to the patients. Adding to the interest was the fact that ZMapp had been created using the same leaves associated with Cuba’s most famous export.

Zeitlin and Whaley are at the helm of a biopharmaceutical company that successfully manufactures human antibod-
ies in tobacco. Decades ago, researchers discovered the potential for plants, which don’t have antibodies of their own, to use their cellular mechanisms to build human proteins that could combat a range of ailments, including cancer, STDs, and toxins. But scientists only recently perfected the manufacturing process of creating these “plantibodies,” which entails inserting lab-engineered human antibody genes into a plant that then uses the DNA as a blueprint to build human infection-fighting proteins. ZMapp used three Ebola-targeted antibodies manufactured in tobacco plants.

The human immune system naturally develops antibodies to fight pathogens. Some pathogens, however, overwhelm the body’s defense system and cannot produce neutralizing antibodies fast enough. Monoclonal antibodies, which are currently used for therapeutic treatment like cancer and autoimmunity, are manufactured in mammalian cells, a process that, historically, has been expensive and time-consuming. Plantibodies take just over a month to produce and may help lower costs and increase capacity, but are not yet commercially available. Today, there’s just one FDA-approved drug made by using a plant. Called Elelyso, the drug is an enzyme manufactured using carrot cells and administered to treat the hereditary condition Gaucher disease.

Whaley and Zeitlin, who met in the lab of Johns Hopkins biophysicist Richard Cone, became interested in antibodies in the late 1980s. They left Johns Hopkins in 1999 to work for a California startup that made human monoclonal antibodies in corn plants, but the company didn’t survive. The two had learned a few things at that failed startup. “The company was making antibodies in corn,” Zeitlin says, “then people started to realize that making pharmaceuticals in food crops isn’t a good idea.” The other problem with corn: It takes too long to grow. Testing antibodies against pathogens is an iterative process that requires some guesswork. When the human body fights a disease, it throws a host of antibodies at the problem. The trick for scientists, then, is to pick which of the antibodies are the most effective against any given disease. This requires trial and error, picking one antibody, manufacturing it in the lab, testing it against the disease. The researchers needed to produce new antibodies for testing at a more rapid pace. “Where it took a year and a half in corn, it took just a week with tobacco,” Zeitlin says.

With funding from Department of Defense and NIH grants, Mapp focused on antibody research for treating deadly viruses and toxins. By 2010, the Defense Advanced Research Projects Agency created a project called Blue Angel. Plantibodies could mean cheaper, faster ways to develop treatment against virulent epidemics or man-made bioterrorism. DARPA has funded four new facilities to manufacture antibodies in plants, including Kentucky BioProcessing, where ZMapp is made. At Mapp, Whaley and Zeitlin not only seek treatments for rare and dangerous viruses and toxins—ricin, Ebola, Marburg, Junin—they have also advanced the use of human monoclonal antibodies for contraception and protection against sexually transmitted diseases like HIV.

In March, the National Institutes of Health and West African countries initiated a clinical trial of ZMapp with Ebola patients. If this trial is successful, plantibodies could hit the market sooner than expected. Whaley asks: “Can we produce antibodies at a low enough cost and at a large enough capacity so that it plays a role in global health?”

That’s what he and Zeitlin hope to find out next.

// ELIZABETH EVITTS DICKINSON
CHAD GORDON, co-director of the Multidisciplinary Adult Cranioplasty Center and clinical co-director of the Facial Transplant Program at Johns Hopkins.

Gordon was on the eight-person team that performed the 22-hour face transplant at Cleveland Clinic in 2008 making Culp’s recovery possible. Three years later, after being recruited to Baltimore, Gordon teamed up with the Biomechanical- and Image-Guided Surgical Systems laboratory and the Walter Reed National Military Medical Center to develop technologies to improve the outcome for face transplant patients and to make the surgery faster and safer. BIGSS is a collaborative laboratory between researchers at Johns Hopkins Applied Physics Laboratory and Johns Hopkins Whiting School of Engineering (within Engineering’s Laboratory for Computational Sensing and Robotics).

Culp’s surgery had been just the fourth face transplant ever performed in the world, and it was the first to include not just the skin and muscle tissue but also a jaw and teeth. While the surgery was a success, there were still challenges. “We had no computer technology or guidance to plan the operation,” Gordon says. “Because the field was so new, technology had no chance to catch up.”

Together, Gordon, APL, and Walter Reed have filed eight patents in the development of the CAPE System, short for Computer-Assisted Planning and Execution. CAPE is a combination of hardware and software algorithms that simulate and streamline facial transplant surgery.

To understand how CAPE works, you have to first consider the workflow of face transplants. Faces are a complex mix of skin, muscle, bone, and teeth, which need to be removed from the donor and lined up perfectly on the recipient, all while ensuring that the intricate network of bone, blood vessels, and nerves is reconnected properly. The patient’s face prior to surgery has been damaged by severe trauma—candidates range from veterans recovering from explosions to victims of acid attacks—and as a result, unknown bone fragments and scar tissue beneath the skin complicate matters.

CAPE networks two computer terminals, one on each end of the tandem surgeries, and tracks the donor and recipient surgeries in real time. Using a combination of off-the-shelf depth-sensing cameras and CT scans of the donor and recipient skeletons, the system monitors tissue removal and placement and gives real-time feedback to the surgeons. Any cut made to the patient’s face will be sent to a monitor near the donor team so that they can make a perfectly matched cut.

Before surgery, the medical team at Walter Reed 3-D prints custom guides that clamp onto each face, which show surgeons where to make incisions. As the tissue is transplanted, it

Faster, Safer Face Transplants

In September 2004, Connie Culp was shot in the face by her husband, who suspected her of cheating. The shotgun blast destroyed her facial bones including nose, cheeks, and her entire upper jaw, leaving Culp unable to breathe or eat without a tube. Today, she’s a motivational speaker with a black belt in karate.

“If you were to walk down the street, you’d never know her face, jaw, and teeth were brand new,” says craniofacial plastic surgeon Chad Gordon, co-director of the Multidisciplinary Adult Cranioplasty Center and clinical co-director of the Facial Transplant Program at Johns Hopkins.
Faces are a complex mix of skin, muscle, bone, and teeth, which need to be removed from the donor and lined up perfectly on the recipient, all while ensuring that the intricate network of bone, blood vessels, and nerves is reconnected properly.

stays attached to the bone as surgeons finesse its placement on the patient. Special cameras watch placement of the face, and the nearby monitor provides feedback on the placement so that the doctor may attach tissue to the right part of the face for ideal alignment.

CAPE can also perform another invaluable task: It creates a biomechanical simulation of a transplanted jaw, thereby predicting how well the patient will be able to chew. “If there’s even a little bit of malocclusion, or mismatch of the jaws and teeth, it would bother the patient forever,” explains Mehran Armand, the director of BIGSS laboratory.

Gordon and Armand hope that as they improve the biomechanical simulation inside CAPE, they can ensure that patients recover with an improved ability to chew and speak.

The technology is now aiding Gordon in complex skull reconstructions that he performs each week along with the Department of Neurosurgery (Gordon is also an assistant professor of neurosurgery). CAPE’s 3-D tracking and modeling software is being perfected to help Gordon shape customized implants for patients who have had brain tumors removed, or those who are looking to repair abnormalities in the shape of their skull, which is its own unique challenge for patients. Gordon hears from patients every day who suffer from the social stigma that comes with an injured or malformed head. “I had a 54-year-old woman who’d never left the house without a hat,” Gordon says.

The team believes that the CAPE system will be ready to test on a full human face transplant within the next year.

// MARK WILSON
person healed. But a part of them wasn’t quite right.

Sacks envisioned a 3-D soft tissue—a polite term for fat—that surgeons could customize for each patient. Imagine a synthetic material that could effortlessly fit into a gap left by surgery, and, over time, degrade as the body fills in with natural cells and fat tissue. The material would work the way dissolving sutures work, for example. Sacks helped gather a team of Johns Hopkins biomedical engineers at the Translational Tissue Engineering Center led by Hai-Quan Mao, and they created just such a scaffold. The team wanted patients to have the best of both worlds: the immediate replacement of shape that an implant provides and the natural feel of a tissue transfer.

In lab studies, the composite material was able to immediately fill the defect, then slowly degrade, allowing the material to act as a platform while the body’s native fatty tissue and blood vessel network grow into it. “I like to think of the material as a conducive template, attracting both the growth cues and cells from the surrounding tissue to regenerate new,” Mao says.

The team realized early on that they needed something strong enough to hold the shape and size left by surgery while the body regenerated tissue.

**Man-Made Fat**

Justin Sacks, a plastic surgeon at Johns Hopkins, has performed thousands of reconstructive surgeries and couldn’t accept not being able to make a person whole again. He would be asked to reconstruct a small defect after a tumor was removed, for example, but the resultant hole would be too slight for an implant or tissue transfer from another part of the body. Yes, the cancer was removed. The
Here, biodegradable hydrogel promotes the growth of new blood vessels from pre-existing ones, while nanofibers give fat stem cells something to cling to and grow on, like the process of making rock candy along a string. The nanofibers slowly degrade. “You don’t want the material to break down too quickly, as you’re not giving the body enough time to regenerate and reproduce those nice new healthy fat cells,” says Georgia Yalanis, a doctoral student and one of the lead researchers who has spent the past year testing the new material. “While [it] degrades, your body’s own fat grows into it. It shrinks with you, enlarges with you, depending on how your weight fluctuates. That is all very appealing.”

For storage in the O.R., the material can be prepared with any tailored shape and stored in dry form. Surgeons can later rehydrate the material and cut it into whatever shape is needed.

Yalanis says this new reconstructive surgery material can be a means to reclaim comfort in one’s own skin. “We place high value on our physical appearance, not just beauty but small things that people take for granted,” she says. “How you present yourself to the world has value.”

Sacks says that since the materials used in the 3-D composite have a good safety record of clinical use, the goal is to bring this technology to consumers as soon as possible.

// GREG RIENZI
Since January 2014, a few dozen people in the United States had partially restored to them something they thought they had lost forever: the power of sight. Given a revolutionary retinal prosthesis system, these blind individuals could now see a doorway across a room or the shadowy outline of a loved one.

Their “sight” was returned via a cutting-edge prosthesis system called Argus II, which includes not just a surgical implant in the eye but also wraparound glasses fitted with a tiny video camera that “sees” the outside world. A holster unit worn by the patient interprets the video and sends signals back to the retinal implant. The image is not pristine. The 60-pixel, grayscale images are akin to watching a black and white TV, with the action obscured by screen snow. And while the system is life-changing, it’s also somewhat cumbersome and the visual quality is not consistent from patient to patient.

Now, the Johns Hopkins University Applied Physics Laboratory is working on a next generation retinal prosthesis system, with the help of a $4 million grant from the Mann Fund, and in collaboration with Second Sight Medical Products, a Sylmar, California–based company that develops, manufactures, and markets the Argus II for people who are blind. APL will develop glasses that use real-time computer vision and eye-tracking sensors and will allow the wearer to better identify obstacles like doorways, hallways, and household objects. The information will be distilled into a format that can be projected into the retinal prosthesis, bypassing the damaged rods and cones in the retina. While not approaching 20/20 vision, the system could allow a grandfather to recognize the face of a granddaughter across the room, for example. “With the current system there’s a camera situated on the head and you have to move your head, rather than just your eyes, to scan a scene,” says Scott Dunbar of Second Sight. “But APL’s work with eye tracking will allow a more natural scanning of the scene. That’s something people have been working on since the 1980s, but nobody has got it to work quite right.”

The new retinal prosthesis will overlap with the vision system in Harmonie, APL’s existing prosthetic limb control prototype. The Hybrid Augmented Reality Multimodal Operation Neural Integration

**Vision Quest**

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Environment uses off-the-shelf components such as Microsoft Kinect (the motion-sensing input for the Xbox) to detect a graspable object in the scene, and then communicates with the prosthetic arm to move it. “Our approach is to leverage this work to allow blind people to better perform basic visual navigations and tasks like following a crosswalk, finding a doorway, and reading using 3-D sensing technologies,” says APL project manager Kapil Katyal.

The ultimate goal is to create a more advanced video data system housed in a smaller, more aesthetically pleasing pair of glasses. Katyal says that the developers hope to have hardware ready for market in three and a half years. // GREG RIENZI

“APL’s work with eye tracking will allow a more natural scanning of the scene. That’s something people have been working on since the 1980s, but nobody has got it to work quite right,” says Scott Dunbar.
Memory loss over time is natural, but researchers have found that you can take action now to build a better brain. Here are ways to offset some of the cognitive decline as you age, as well as new research into memory’s most vigilant foe, Alzheimer’s.
Most of us have done it. We climbed to the second floor of our house, for example, and paused on the landing to wonder why we’d made the journey. Had we come to fetch the phone charger? To collect towels for the washer? As we stand there casting about for a reason, we might also wonder: Is this just a normal hiccup in memory or could it be something more?

Memory loss and difficulty with recall are natural consequences of aging. They can start as early as our 30s and make simple tasks, like remembering a word or a person’s name, take a little longer. While normal, these lapses of recall can be scary. We wonder if it portends something more serious.

In fact, surveys have shown that more people are afraid of losing their memory through Alzheimer’s or some other form of dementia than they are of dying from cancer, according to Constantine Lyketsos, director of the Johns Hopkins Memory and Alzheimer’s Treatment Center. “What makes us people are those higher functions [like memory],” he says. “It cuts close to the bone to think we are going to lose our personhood by losing those very unique capacities.”

Memories form the very essence of self. “Our memories are unique records of our personal histories,” says Jason Brandt, a professor of psychiatry, behavioral sciences, and neurology at Johns Hopkins. “It’s what gives us a sense of who we are.” When personal history goes missing, we feel at a loss. Brandt has patients who suffer severe amnesia, and while they are still bright and articulate, they describe feeling “disconnected” from their lives. “When you reteach them facts from their personal past,” he says, “they feel like they are learning someone else’s biography.”

There are important distinctions, however, between usual memory decline due to aging, which is characterized by a slowing in the retrieval of information, and the complexities of brain trauma or forms of dementia, like Alzheimer’s. These conditions can be conflated, even in our daily lexicon. We forget where we put the car keys and quip: “It’s the Alzheimer’s setting in.” There are so many common misconceptions about memory that doctors who deal with these issues routinely begin by explaining the differences. “Memory loss,” in fact, is a misnomer at times. “It implies that memories that were previously stored are suddenly gone,” Brandt explains. Rather, a natural decline in memory with aging is more about inefficiencies in memory than literal loss.

First, some decline in memory with aging is normal. The brain shrinks with
age and certain cognitive abilities decrease. Neurons are not dying, but the connections between them are fraying, and other mechanisms scientists still don’t fully understand are changing our ability to process information and recall events.

On the other hand, dementia is a general category for a variety of disorders that cause more extreme memory loss or affect thinking and reasoning abilities. For example, one or more strokes can lead to vascular dementia, which is when damaged blood vessels restrict the flow of blood to your brain. Parkinson’s disease can also cause dementia.

Alzheimer’s is the most common cause of dementia, affecting 60 to 80 percent of people with dementia. It is a degenerative disease of the brain marked by the accumulation of two proteins, beta-amyloid and twisted fibers called tau. These alterations ultimately cause nerve cells in the brain to die and block the free flow of information between cells.

While we can’t yet prevent Alzheimer’s, research shows that there are things we can do to help fend off memory loss in general and to maintain our wits as we age (and it has nothing to do with shelling out money for so-called “brain games.”) Meanwhile, new studies into Alzheimer’s have found ways to provide better care now for people with the disease, while compelling research is yielding insight into how the disease itself works.

Researchers have found that you can take action now to build a more robust brain that can delay the future onset of some disease. “If you lose some nerve cells as a function of normal aging, but you have a lot of ‘cerebral reserves,’ you have brain power to spare,” Brandt says. “On the other hand, if you have a brain with little reserve, you are going to notice age-related cognitive losses and find yourself in trouble.”

Building those reserves happens in large part through both mental and physical exercise. While the exact mechanics are not fully understood, it is believed that this allows the neurons to make more connections with other cells.

Marilyn Albert, who directs the Division of Cognitive Neuroscience at Johns Hopkins, collaborates with an interdisciplinary group of researchers to study the earliest phases of Alzheimer’s. “We understand the biology much better now for Alzheimer’s,” Albert says.

One of the studies she is leading allows people to be evaluated with imaging tools that measure the structure and the function of the brain. Albert hopes to get a sense of what is going on in the brain much earlier, before Alzheimer’s symptoms are too advanced and when treatment could be more effective. Albert sees these tools as a valuable way of searching for pre-dementia. “Me, I don’t
even want to wait until we see symptoms in patients, I want to ID them when they’re normal,” she says. The goal is to intervene as early as possible.

These studies are also looking at protective factors that might help the brain, like exercise. What researchers believe is that variety matters: It’s not simply how much energy you expend, but also how you mix it up. It is better to burn 500 calories jogging and 500 swimming than to torch 1,000 calories by jogging alone, Constantine Lyketsos says. “Think of the brain as a muscle,” he says. You have to stimulate the circuits you want to maintain. “If you do some jogging and some swimming, then you are stimulating two circuits.”

“You don’t have to be running miles or going to the gym every day,” Albert says, “but moderate activity really helps.” She cautions that specifics about exactly what kind of physical exercise and how long to engage in it are still being researched.

Better yet, Lyketsos says, are activities that cross over from mere physical stimulation to social and mental engagement. Things like ballroom dancing or sightseeing on foot combine social, mental, and physical exercise at the same time. “So the more of that you do, the more of your brain you are engaging,” Lyketsos says.

Since strokes can affect a person’s memory, regular exercise and a good diet serve a dual function as we age. “What’s good for your heart is good for your brain,” Lyketsos says. Lyketsos is a proponent of the Mediterranean diet, which, he says, consistently produces better brain health later in life. Rich in olive oil, fish, and vegetables and light on carbohydrates and red meat, this healthy diet is also better than simply opting for dietary supplements or vitamins, he says.

A daily mental workout might also reap age-defying brain benefits. “Learn a new language; take adult ed classes; work your brain hard,” says Brandt, who also works with elderly persons at the Copper Ridge Institute, an affiliate of the Johns Hopkins School of Medicine. “We always encourage patients and others concerned about their potential for dementia to stay active cognitively.”

There is no scientific evidence that intellectually engaging tasks will prevent Alzheimer’s, but there is research indicating that mind exercises help keep the brain healthy and may delay dementia. This does not mean that you have to start playing the increasingly popular “brain games,” which promise improved cognition. In fact, research shows that many of the brain game companies’ claims are overblown. Brandt says you should save your money.

“In general, doing something is better than doing nothing, but what that something is really doesn’t matter, as long as it is novel, interesting, and challenging,” says Brandt. “There’s no indication that any one product is better than any other; or, in fact, better than doing the New York Times Crossword Puzzle. Don’t go for these expensive programs when there are plenty of things you can do for free that challenge your brain.”

The key is doing something that you truly enjoy. “If you really love to play bridge, do it. If you like to play along with Jeopardy on TV, do that. Or if you prefer reading novels or nonfiction, fine. Just keep your brain active at a high level,” Brandt says.
Humans are social animals. At least, we’re wired to be. So if you want to cut out of work early to make dinner for friends, you can dispel the voice in your head that chides you for being a slacker. Such socializing has a positive, long-term impact on your memory. Scientists still aren’t sure why this is the case, but so far they’ve seen an impressive connection. “Most of the studies that have looked at this have been observational,” says Albert. In such a study, “we take a thousand people, measure a bunch of things about them when you know they are doing reasonably well, and then follow them over time to see who is maintaining a high level of function.”

Regular social engagement comes up repeatedly among those who maintain better memories as they age. “We don’t really understand yet what that means at a biological level,” Albert says, describing this area as the one most in need of more studies.

Ongoing research now focuses on whether such social engagement decreases stress—and that’s why it’s helpful—or whether it is connected more directly to the mental activities above, since keeping an active social life means a brain workout as we navigate social dynamics, revisit memories with our friends, meet new people, and thus learn new things.

It’s also important to remember that forgetting is a part of life, and we should employ tools to help keep track of our busy, modern lives. In fact, some of the memory experts themselves struggle to navigate this very terrain. “I’m one of the most forgetful people I know,” says Brandt. “I carry a pencil and index cards in my pocket all the time.”

Brandt says he relies on little notes to himself to prompt his memory and he asks his patients if they do the same. Do they use day planners, datebooks, or cell-phones for notes to themselves? “Many of them say, ‘No.’ When I ask them why, they say, ‘That would be cheating.’ I say, ‘That’s not cheating! This isn’t a game. This is your life!’ ”

Regular social engagement comes up repeatedly among those who maintain better memories as they age.
The causes of Alzheimer’s disease are still unknown. Research suggests the disease is influenced by genetic makeup, oxidative damage to neurons, serious head injuries, brain inflammation, and environmental factors. With no clear bulls-eye to target, scientists have tested multiple approaches to prevent Alzheimer’s or to slow the disease’s progression. Researchers are digging in deep—in a variety of directions—supported in part by a $122 million increase in funding for Alzheimer’s research and care, which President Barack Obama signed into law last year. This is, though, a drop in the bucket of funding needed for such complex research.

“Everyone wants to know: When are we going to cure Alzheimer’s?” says Lyketsos. “We are 30 or 50 years off.” Statistics show that 130 million people will develop dementia of some kind in the next 30 to 40 years, he explains, and “we aren’t going to have cures for them.”

But not having a one-size-fits-all cure on the horizon doesn’t mean patients should lose hope, as a number of treatments are showing potential to enhance quality of life. “As a field, we have taken a big bet on amyloid-busting drugs,” Lyketsos says, explaining that such studies haven’t shown much promise for those with advanced dementia. However, new studies are investigating whether amyloid-preventing drugs might be effective if administered to patients who haven’t shown symptoms but may be carrying deterministic genes or have PET scans showing they have some damage to the hippocampus.

Another line of research is offering hope for patients with what’s called amnestic mild cognitive impairment, or aMCI. Patients who suffer from aMCI have memory problems that are worse than would be expected for their age, and the condition can signal risk for Alzheimer’s. One study, led by Johns Hopkins neuroscientist Michela Gallagher, found that low doses of the epilepsy drug levetiracetam may help the brain by calming hippocampal hyperactivity in patients’ brains. In their study, which involved 84 patients, the researchers found that low doses of the drug improved memory performance in some. They hope next to study the drug in a larger-scale, longer-term clinical trial. “What we want to discover now is whether treatment over a longer time will prevent further cognitive decline and delay or stop progression to Alzheimer’s dementia,” Gallagher says.

Another ongoing study at Hopkins takes a different approach and is also showing some success. A possible cause of Alzheimer’s in some people is the disruption or resistance to insulin in the brain. But insulin, injected the way a diabetic
“Don’t go for these expensive programs when there are plenty of things you can do for free that challenge your brain.”

does, doesn’t reach the brain. Researchers in a large, multicenter trial, including Hopkins, are experimenting with patients inhaling insulin through their noses.

Lyketsos is a principal investigator in a study looking into whether a mechanical device can stimulate the brain and counteract some effects of memory impairment in Alzheimer’s disease. “We implanted 42 brave people around the country with a pacemaker-style device,” Lyketsos explains. The device sends a series of small, continuous shocks into the fornix, a C-shaped bundle of fibers in the brain that carries signals from the hippocampus. As with a cardiac pacemaker, the patient feels nothing, but the hope is that by stimulating the brain in this way, it will halt or slow the memory loss Alzheimer’s patients experience.

This study targets the same area of the brain as Gallagher’s research above, Lyketsos says, and while one stimulates the brain and the other calms it, it’s not uncommon to see varying approaches when researching Alzheimer’s. “There is a scientific foundation that both, or one or the other, or neither, might work,” he explains, which is why multiple approaches are being tested. Results from Lyketsos’ “deep brain stimulator” study will come out later this year.

The momentum to find a cure and eliminate the disease, Lyketsos says, builds each year. And scientists are working hard to develop better ways to care for affected people and support their families, friends, and caregivers. “I have an optimism that is mostly focused on my sense that the current standard of care is actually pretty good,” he says, explaining that an individually tailored “package of interventions” ranging from antidepressants to caregiver training has improved the quality of life for patients, allowing them to stay in their homes longer, and staving off many of their attendant medical complications. These interventions were part of an experimental care program developed at Hopkins known as Maximizing Independence at Home, and its success in keeping people with dementia at home longer has garnered significant attention from organizations like the National Institute on Aging.

In the next two to five years, he says, there will be a big boost in the dissemination of research and best practices thanks to federal funding and an organized, concerted effort by researchers. “It’s not curative, but it will make a real difference in people’s lives.”
How Do We Estimate the Calories in Food?

BY JOE SUGARMAN

By November, every chain restaurant or establishment with 20 or more locations that sells prepared food will be required by the Food and Drug Administration to post caloric content of their meals “clearly and conspicuously” on their menus. The idea is that consumers will think twice before downing daily Mocha Frappuccinos at Starbucks (410 calories, by the way), and restaurants might respond by creating healthier, lower-calorie options. But how do scientists actually measure the number of calories in our foods and beverages anyway?

“Basically, they use a bomb,” says Emily Dubyoski, a dietitian at the Johns Hopkins Weight Management Center. “An oxygen bomb inside an insulated container.”

Before we delve into explosions involving Chicken McNuggets and bacon double cheeseburgers, some basic science: A calorie, Dubyoski explains, is the amount of energy needed to raise one gram of water at 15 degrees Celsius by 1 degree. But because that amount of energy is too small to conveniently describe the energy content of food, nutritionists use kilocalories (1,000 calories) or Calories, with a capital “C.” Scientifically speaking, that’s really what you’re seeing on dietary labels and menu boards, the Calorie, or the amount of energy required to raise a kilogram of water by 1 degree. (Outside the lab, most people simply refer to Calories as calories.)

To measure the number of calories in food, Dubyoski says that for decades scientists have employed what’s called a bomb calorimeter, a desktop contraption composed of two sealed chambers. Researchers put a small, weighed sample of the food to be tested inside the interior chamber, which is full of oxygen, and then ignite it. Water contained in an insulated outer chamber rises in temperature due to the explosion within. “The heat released from combusting the [food] sample is actually absorbed by the water that surrounds the bomb, and that change in temperature is how the amount of calories contained in that food is determined,” says Dubyoski. “A higher calorie sample is going to release more heat upon combustion, and thus result in a greater change in water temperature.”

So a piece of carrot would cause a slight rise in temperature, whereas a sample of Subway’s double meatball sub with cheese would give off enough energy to practically power a light bulb.

Although bomb calorimeters have been around since French chemist Pierre Eugène Marcellin Berthelot invented the contraption more than 125 years ago, Dubyoski says contemporary research shows that calorie counting is not necessarily an exact science. “The calories you see on the nutrition label are a prediction, based on research, as to how much of that food your body will actually use,” she says. “While we know that each person has different...”
energy needs based on age, gender, height, weight, muscle mass, and activity level, what is still being worked out is how additional factors potentially play a role in absorption of that energy, such as the types of bacterial colonies in a person’s gut.”

But don’t think your speedy metabolism means you’re ingesting fewer calories than the 467 in a Big Mac. It’s still a close estimate. “The take-home message is to pay attention to what you are eating and how your body responds, in this case by weight monitoring,” says Dubyoski. “Nutrition labels are a great resource, but it is also good to be aware that even with the best efforts of science, the calories listed on the label will be close but maybe not 100 percent accurate.”

“Nutrition labels are a great resource, but it is also good to be aware that even with the best efforts of science, the calories listed on the label will be close but maybe not 100 percent accurate.”

—Emily Dubyoski
thirsty planet

With climate change comes uncertainty about our water reserves—and scientists say that in the United States, we’ve essentially tapped all of our pristine water sources. We’re at a tipping point. So what are we doing about it?

ANDREA APPLETON
Illustrations EIKO OJALA
“If you look at population growth in the United States, we’ve essentially tapped all of the so-called pristine water sources,” says Ed Bouwer, a Johns Hopkins environmental engineer. Factor in the likely future impacts of climate change, and “we’re at a tipping point” for water, he says.

A recent large-scale study found that by 2100, even using conservative estimates, up to one-fifth of the world’s population could experience severe water shortages as a result of climate change. Regions that are already dry, like the Southwestern United States, will be most at risk. While our wealth as a country may shield us from the acute suffering scarcity is already bringing to developing countries, even here, our approach to water will have to change drastically.

Researchers under the umbrella of the Johns Hopkins Water Institute are devising ways to help us meet our water needs in a hotter, more crowded future. The institute brings together faculty from across the university with expertise in public health, medicine, engineering, economic development, and other fields. Projects range from encouraging collaboration on water management along the Israeli-Palestinian border to learning to build resilient water systems in Ethiopia given the uncertainties of climate change.
Under the aegis of the Water Institute, Bouwer and several of his colleagues from the Johns Hopkins Whiting School of Engineering are working closer to home. They are looking at new ways for developed countries like the United States to save and reuse water. Some of these projects are aimed at making the clunky elements of our infrastructure more efficient; others entail entirely new systems of water capture, treatment, and delivery.

The annual “water footprint” of the average American—the total amount of water needed for all the food, goods, and services we use—would fill an Olympic-sized swimming pool, the largest per capita consumption in the world. Technological innovations such as high-tech filtration systems will help us survive the dry times ahead, but citizens will also need to change their water use habits and their mindsets. As the research described below indicates, some of these changes may be difficult to swallow. But swallow them we must. After all, as civil and environmental engineer David Sedlak puts it in his book Water 4.0: The Past, Present, and Future of the World’s Most Vital Resource, water is the “essential ingredient of civilization.”

Last summer, a water main ruptured and shot a powerful geyser aloft over Los Angeles’ Sunset Boulevard. Over the next four hours, an estimated 20 million gallons of treated drinking water flooded the neighboring UCLA campus, stranding motorists and causing tens of millions of dollars in damage. The busted pipe represented just one of the roughly 240,000 water main breaks the United States experiences in a year. It’s largely because of these breaks, along with slow leaks, that a sixth of our treated water—an estimated 2.1 trillion gallons—never reaches the tap.

The pipe that burst in Los Angeles was nearly a century old, like many still in the ground all over the country. The American Society of Civil Engineers recently concluded that “at the dawn of the 21st century, much of our drinking water infrastructure is nearing the end of its useful life.” That is especially true of older urban areas, including many in the mid-Atlantic. Baltimore, for instance, has around 1,000 pipe breaks a year and routinely loses more than 20 percent of the water it treats.

In a perfect world, water utilities would conduct routine inspections of all their pipes to identify those in danger of rupture. But urban water delivery
systems are composed of thousands of miles of pipe and city budgets tend to cover inspections for only a tiny percentage. As a result, most pipes are replaced only after an obvious break.

Johns Hopkins University systems engineer and risk analyst Seth Guikema hopes to help water utilities become more proactive. He is devising a computer program to predict which pipes in a given system are most at risk of a slow leak or break. With that information, utility companies should be able to conduct more targeted inspections and, it’s hoped, reduce the amount of water lost to pipe breaks.

“I had been reading a lot about what terrible shape water distribution systems were in,” he says of his initial interest in the project. “And I thought this was a pretty interesting and challenging statistical problem.”

Ideally, Guikema’s algorithms include information from a utility’s pipe system map as well as detailed historical, geological, geographical, and environmental data. The locations of previous pipe breaks are key. It’s important to know a pipe’s age, the material it’s made of, and the type of soil that surrounds it. Repeated exposure to vibration can also weaken a pipe. “In some cases,” Guikema says, “we’ve looked at proximity to major transportation corridors like highways, airports, and rail lines.”

Weather is another important variable. Pipe breaks tend to spike in the winter in cold areas, while precipitation can increase or decrease the likelihood of a break depending on the surrounding soil. These are just a few of the dozens of factors that can lead to a break. And as one might expect, all of these variables interact in complex ways. Some soils, for example, are more corrosive to steel pipe than to other types. And even under harsh temperatures, snow cover can have an insulating effect, lowering the risk of a break. In the face of such complexity, it’s clear why the traditional pipe inspection strategy—simply checking where pipes have broken before—is less than effective.

Once a user has Guikema’s computer program in hand, he or she will plug in the weather forecast, among other variables. Out will come a color-coded map showing pipe segments at high, moderate, or low risk of breaks. “It tells you that those [high-risk pipes] should be the priority for inspection,” Guikema says.

The algorithms Guikema’s team is developing are, of course, only as effective as the data a given utility provides. The quality of that data varies a great deal from utility to utility, Guikema says. A bigger problem is that some cities don’t have the budget for even a targeted pipe maintenance program. “Our system can provide information, but we can’t provide them the money to act on it,” Guikema says.

The American Water Works Association recently calculated that it would cost more than a trillion dollars to replace the country’s buried water infrastructure. Unless public attitudes about water change, that’s not likely to materialize anytime soon; Americans pay relatively little for water compared to citizens in other developed countries.

“We take water for granted,” Bouwer says. “It’s very hard to pass a 10 percent rate increase. People just scream about that. Yet we’ll pay for cable TV, cellphones. If you think about banking for our future water supply, we aren’t paying the true costs now.”
Ending pipe breaks in this country would save enough water for every American to take more than 100 extra baths a year. (Not, it should be noted, the wisest use for such water.) But even a brand new underground pipe system would not eliminate future water scarcity. Before long, many cities—particularly those in arid regions—will have to turn to lower quality options. One of those is stormwater.

Once upon a time, when it rained, water percolated into the soil or meandered downhill to join the nearest stream. In the process, it recharged groundwater and replenished waterways. Then, we paved our cities. Water no longer soaked into the earth, and in places where the ground was flat, huge puddles formed. As a result, cities built storm drains. Storm drains swiftly transport water to sewage treatment plants or waterways, keeping our streets dry. But this system prevents natural filtering processes from removing pollutants—everything from oil to pesticides. As a result, polluted water ends up in rivers, streams, and oceans.

Water treatment engineers have begun to advocate recapturing that stormwater and storing it for later use. Once that might have meant channeling it to a reservoir. But surface reservoirs have fallen from favor in the developed world in recent decades. They are prone to high rates of evaporation and can quickly fill up with silt. (Dams also have a notorious impact on aquatic ecosystems.)

Instead, water treatment experts like Bouwer say stormwater could be rescued via a method that mimics natural processes. So rather than funnel water away through storm drains, “we could inject water underground when it’s available in excess and then pump it out later when it’s a drought,” Bouwer says. “It’s a way of stretching the available water.” Known as aquifer storage and recovery, this system is already in use in a few American coastal resort areas.

The benefits go beyond saving wasted stormwater. En route to storage, untreated water can be injected through the banks of a river or lake to help make it potable. Europeans have used this technique, known as riverbank filtration, for more than a century. Research indicates it can remove many of the same contaminants as conventional water treatment. The soil binds to contaminants and mechanically removes solids from the water, while a naturally occurring biofilm—the slimy film of microorganisms that forms on wet surfaces—does the rest. Bacteria and other organisms in the biofilm consume the organic matter, pathogens, and other contaminants in the water, allowing purified liquid to pass through.

One of Bouwer’s studies found that riverbank filtration also appears to lower concentrations of chlorinated byproducts formed during water disinfection. Amer-
icans unwittingly gulp down hundreds of these byproducts every day, and some are potentially carcinogenic. (Many other developed countries have stricter standards on their presence in drinking water.) More recently, Bouwer and his colleagues have found that biofilms are a promising way to filter out pharmaceuticals and personal care products, a class of contaminants that includes everything from prescription and illicit drugs to antiseptics to soap. These have been detected throughout the country in waterways exposed to treated sewage. (Most water treatment systems are not designed to remove them.)

The effects on human health are unknown, but studies indicate that even at low concentrations, some pharmaceuticals and personal care products delay development and alter behavior in aquatic organisms. Estrogens in treated wastewater, for example, can lead to hermaphroditic fish. “If every one of these substances is at a low concentration, but you have a hundred of them, the sum of the hundred could cause harm,” Bouwer says. “We’ll need to be able to take out these chemicals as we go to more water reuse.”

Reuse? Here we come to another potential future source of drinking water. It’s abundant, accessible, and reliable. It’s just something we’d rather not think about.

The process goes by many names: potable reuse, water reclamation, water recycling. Among critics, it’s known as “toilet to tap.”

Wastewater was converted into drinking water for the first time more than 50 years ago, but the idea has failed to gain traction nationally. Public opinion has been the major obstacle. In 2011, psychologist Carol Nemeroff of the University of Southern Maine reported the results of a five-city survey that asked people whether they were willing to drink recycled water. Only 38 percent said they were.

Those surveyed might be surprised to learn that they are already drinking wastewater. As David Sedlak blithely puts it in his book, “Since piped water first enabled us to easily dispose of our wastes in rivers, drinking water supplies have frequently contained sewage.” Most surface waters are composed of 5 to 15 percent wastewater, according to Bouwer. The Mississippi River, for example, passes through any number of major cities. In each place, drinking water is drawn from the river and treated wastewater is dumped back in. By the time it gets to New Orleans, the river’s
waters have been treated and consumed many times over. In the business, this is called “de facto reuse.”

Given water scarcity projections, we will have no choice in the future but to deliberately use treated wastewater. “We have to think more creatively now and tap into all the resources we can,” Bouwer says. An efficient water treatment and reuse plan could extend available water by 75 percent, he says. (We currently recover only 5 percent of it.)

One option is to reserve reclaimed water for uses like watering lawns and supplying fire hydrants. The problem is that most of the country currently operates on a one-pipe system, and using two sets of pipes—one for potable water and one for nonpotable—means an expensive overhaul to existing infrastructure. Purifying wastewater to the degree that it is drinkable would stretch our resources and require fewer changes in infrastructure.

One technology currently used to make waterwater reusable is a thin sheet of polymer called a membrane, riddled with pores of varying sizes. Contaminated water, when forced through the membrane, leaves behind anything that doesn’t fit through those pores. The membranes with the smallest pores are capable of removing the majority of contaminants from water, including organic matter, viruses, and bacteria.

Semipermeable membranes are used in both water recycling and desalination plants. In desalination, seawater is converted to drinking water through a process called reverse osmosis. Powerful pumps push seawater through tight membranes, removing the salt. Because seawater contains so much salt and dissolved salts pass through all but the tightest membranes, a vast amount of pumping energy is required. In most places, desalination is thus unlikely to represent the sole long-term solution to water scarcity problems. (In areas with cash and few alternatives, like Saudi Arabia and Singapore, desalination is proving helpful.)

It requires much less energy to treat wastewater using reverse osmosis; salts are less abundant in wastewater and contaminants generally larger. Yet one serious problem plagues both desalination and water recycling plants. All those contaminants that are successfully filtered out have a tendency to cling to the membrane, clogging or “fouling” it. The culprits range from particles of clay to microorganisms. Before long, the membrane must be either cleaned or replaced; either way, a plant’s operating costs shoot up.

Johns Hopkins University environmental engineer Kai Loon Chen is working on creating membranes that clog less frequently. He is targeting living foes, the bacteria that tend to form biofilms on membrane surfaces. Biofilms are helpful in some water treatment scenarios, including those used in many sewage treatment plants. But for membrane processes like reverse osmosis, they are a hindrance. They slow the flow of water, degrade membranes, and are extremely difficult to clean off.

Chen is looking for ways to stop biofilms from forming. One method he’s devised, through funding from the National Science Foundation, involves “polyelectrolyte multilayers,” a technique borrowed from the biomedical
field. Thin sheets of polymer carrying opposing electrical charges are layered one on top of the other, resulting in what Chen describes as “a lasagna-like structure.” When a membrane is coated with this structure, it retains water. The membrane is now “hydrophilic,” or water-loving. Bacteria typically have trouble adhering to extremely hydrophilic surfaces. “It actually pushes the bacteria away and doesn’t allow them to stick to the membrane surface,” Chen says.

Even under this scenario, a few bacteria inevitably pass through to the membrane itself; it only takes a few to form a biofilm. So Chen’s lab is working on a backup strategy. In the days before refrigeration, silver coins were often used to preserve milk. That’s because silver kills bacteria and other microbes. Now engineers are increasingly turning to silver nanoparticles as potential antimicrobial agents in the water treatment process. Chen hopes that by embedding these nanoparticles within his “lasagna-like structure” of polymers, he can zap those few rogue bacteria that elude the polymers.

Chen hopes his research will help extend the life of membranes and make processes like water recycling, and perhaps even desalination, more sustainable in the future.

If we hope to preserve our way of life in this country, technological fixes to our urban water systems—such as those Chen, Bouwer and Guikema are undertaking—will one day be necessary. But they alone will not suffice. A real water scarcity crisis could require a fundamental rethinking of how we manage water.

The typical American urban water enterprise consists of a complex, often energy-intensive network of pipes, storm sewers, and treatment plants. Our drinking water, wastewater, and stormwater are transported to and from centralized locations and then to desired endpoints. It’s taken thousands of years to develop this system. But engineers are beginning to question its efficacy. “Perhaps the best long-term solution to our water problems will be to abandon centralized water systems altogether,” notes Sedlak in Water 4.0.

Guikema agrees. “The historical approach,” he says, “is very much about separation of drinking water and waste from the environment. It’s not leveraging natural treatment processes.” Guikema, along with an interdisciplinary team, hopes to come up with a new design. He has submitted an ambitious proposal to the National Science Foundation for
a grant to develop a new water system from scratch. Guikema wants to unite human, natural, and engineered systems, to the benefit of both human beings and the environment.

The project, if funded, would use Baltimore as a case study. Experts in ecology, water treatment, human behavior, policy analysis, and statistical modeling would come together to redesign the water system, as a modeling exercise. The team would study how an array of engineering enhancements involving natural features, like capturing stormwater, could improve water quality and local ecology. In this virtual Baltimore, buried streams would be unearthed and local wetlands put to use as natural water treatment systems. The new model would rely on the public much more heavily than the system currently does. The team plans to study how consumers might react to new water scenarios—like drinking reclaimed wastewater and reusing water from the sink or shower—and shape their system accordingly.

Designing a statistical model is a far cry from actually calling in the construction crew, of course. “If we take the ‘clean slate’ approach, we’ll come up with an ideal system that we’ll never actually get to,” Guikema says. “We know that. But it will give us a goal that we can start to decide policies against.”

Bouwer is part of the team submitting the proposal. He dreams of someday treating water on a local scale, perhaps employing some of the natural methods he studies, like riverbank filtration. “Right now, the idea’s in its infancy,” he says. “But I could see ‘local’ meaning perhaps 50 homes, at the smallest scale.” Much less energy would go toward distribution, Bouwer says, and the public would have more of a vested interest in conserving water and keeping pollutants out of storm drains and local waterways.

Such dramatic changes are unlikely in the short term. “Right now, our infrastructure, we’re really stuck with what we have,” Bouwer says. “We really can’t change overnight.”

But, he adds, we’ll live to regret it if we don’t plan for future water scarcity now. “A hundred years from now, we’re going to have a lot of problems,” he says. “We can’t just keep doing it the way we’re doing it.” /
1 / Symptom checker
Input your symptoms—cough, abdominal pain, etc.—and a new online tool says what might be ailing you. Symcat.com, developed by former Johns Hopkins medical students, uses anonymous data from millions of patient records to estimate disease probability.

2 / Forecasting abuse
To prevent and respond to relationship violence, look for the warning signs. The One Love My Plan app, populated with decades of research from the Johns Hopkins School of Nursing, spots omens of an unhealthy or unsafe relationship. The discreet, password-protected app asks questions about your current or ex-partner, allows the user to identify priorities for safety, and provides a risk-factor score and personalized action plan with links to national and local resources.

3 / Under the sea
Ever want to swim with dolphins? How about swimming as one? Shark Eaters: Rise of the Dolphins is a physics-driven game for tablets that allows the player to feel the joy of lifelike movements under water as a dolphin or other cetacean. The team of neuroscientists and engineers behind its creation believe the game bridges cognition and motor control. Down the line, they hope its principles will be used to design games combined with robotic hardware as therapy to help patients recover from stroke and other forms of brain injury.
### 4 / As the virus turns

**Viruses. Bad.** Mutating ones? Even worse. Scientists at the Applied Physics Laboratory have invented the oRACLE chip to help researchers drastically reduce the time it takes to mimic the natural evolution of a virus. In mere hours, the droplet-based tool can determine mutations, automating work that would take years to perform by hand. *(EPIDEMIOLOGY)*

### 5 / Diaper diagnostic

**Your baby’s poop** color is telling you something. Fecal color and consistency are well-known markers of digestive health, and paying attention to a newborn’s stool shade can help diagnose a life-threatening liver disease. Free mobile app PoopMD uses color recognition software so parents may snap photos of stool and receive feedback within seconds. Parents then have the option of sending the photos to their pediatrician. *(PEDIATRICS)*

### 6 / Tracking cancer

**Johns Hopkins engineers** have invented a device that gives cancer researchers a microscopic look at metastasis, the complex way that tumor cells spread through the body. The small, transparent chip could uncover new ways to keep the killer disease in check. *(ONCOLOGY)*

### 7 / Surgical aid

**Remember the game** Operation? Don’t touch the sides or, buzz! The AccuSpine pedicle probe enables safe and accurate spine screw placement through real-time feedback to the surgeon. The wandlike device, designed by biomedical engineering students, uses vibration and flashing LED lights to warn of breaches. *(SURGERY)*
A Healthy Company Culture Is Good for Business (and People)

It’s time we leverage the workplace as a venue to improve public health.

In this issue, writer Amanda Hurley looks at how creating a healthy work environment improves health and well-being. Certainly, creating a positive physical environment can boost worker productivity (see page 70), but there’s more to fostering a healthy workplace than just furniture and physical design. What about the health of the company itself? Roughly 156 million Americans go to work each day and spend more than half their waking hours there. And yet, when we think about public health, we don’t usually consider the workplace as an important venue for health promotion. Why not leverage the workplace as a setting for improving public health?

There are many companies throughout the United States that have built healthy company cultures with an intentional purpose of improving their workers’ health and simultaneously achieving a healthy bottom line. In fact, new research shows that companies that care about the health and safety of workers outperform the overall stock market.

Ron Goetzel is a senior scientist and director of the Institute for Health and Productivity Studies at the Johns Hopkins Bloomberg School of Public Health, as well as vice president of consulting and applied research for Truven Health Analytics.
So what does this look like? Imagine an environment that promotes nutritious eating, physical activity, safety, work-life balance, high levels of trust, and respect throughout the organization. Healthy food choices are available in vending machines and company cafeterias; food items are labeled with their nutritional content; and healthy items are priced lower than unhealthy ones.

To promote physical activity, the company has made staircases more welcoming, built fitness facilities on site, and offered membership to local gyms. It allows for flexible work schedules that include walking breaks and provides bike racks and showering facilities.

The company has a strict “no smoking” policy but also provides counseling and access to medications for employees who want to quit. A wellness committee implements state-of-the-art behavior-change programs. When employees succeed in achieving a health goal, they are recognized and rewarded. Importantly, improving employees’ health and well-being is communicated as a core value of the organization and is embedded into vision and mission statements.

This isn’t a Pollyanna list—it is actually happening around the country. With support from the Robert Wood Johnson Foundation, my team at Johns Hopkins has identified the key success factors for creating exceptional health promotion programs. To find out how companies build and sustain cultures of health, we conducted extensive interviews and site visits. Some of the organizations we visited were winners of the C. Everett Koop Award, which recognizes organizations with documented data proving that they enhanced workers’ health while saving money. Citibank, Dell, Johnson & Johnson, Lincoln Industries, LL Bean, and USAA are just a few such companies.

Most important to establishing a healthy culture, we learned, is having leaders who are vocal and committed to establishing a healthy workforce across multiple dimensions that include physical, emotional, social, financial, and “purposeful” health. As one leader explained, “I want my workers to leave the company at the end of the day healthier than when they first came to work.”

Equally important is measurement and evaluation. “You can’t manage what you can’t measure,” is a constant refrain heard from company leaders. Valid and reliable data are needed to document program accomplishments. That may mean achieving engagement of employees and families in health-promoting activities; demonstrating behavior change and risk reduction; “bending the cost curve” on health care spending by reducing the rate of increase to manageable levels; reduced absenteeism and “presenteeism” (being physically at work but not performing at an optimal level because of health problems); and attracting and retaining top talent.

Our mission now is to disseminate what we have learned over the past two years so that more companies can replicate the successes of best practice companies. The Institute for Health and Productivity Studies website includes stories describing our site visits, along with videos from inside some of these healthy companies. The bottom line is this: Coupling public health with business health makes absolute sense—workers gain as does the economy. /
From treadmill desks to $1,000 chairs, the marketplace for health-conscious office furniture is booming. But what do you really need to invest in? Johns Hopkins specialists in occupational and environmental health weigh in on the latest trends so that you may set up a work environment that fosters both physical well-being and productivity.
i

If sitting is the new smoking, I have a pack-a-day habit.

Like most Americans, I lead a sedentary life. I’m a writer, and in the run-up to a big deadline, I might sit at my desk for 12 or 14 hours a day. I belong to the growing cohort of home workers, so my morning commute is a mere seven steps from bedroom to office. How convenient—and yet how bad for my body, hunched over a laptop again when it could be ambling down the street or even standing upright in a packed subway car. Sure, I intend to take yoga breaks, to get up and stretch. Then a new email pops up. And then another ...

In an era of instant communication and rocketing productivity, there’s still no hack that can change our mortal nature. We are flesh and blood, prone to all that entails, whatever we do for a living. “We all bring our bodies to work,” says Dr. Francesca Litow, co-director of the Occupational and Environmental Medicine Training Program in the Johns Hopkins Bloomberg School of Public Health.

Work isn’t easy on our bodies, and it’s not only people with physically strenuous jobs who pay the price. According to the U.S. Bureau of Labor Statistics, musculoskeletal disorders—including repetitive-strain disorders—accounted for 33 percent of occupational injuries and illnesses requiring days off work in 2013. Recent news stories have made us hyperaware of the danger posed by what seems like the most innocuous workday activity: sitting down.

This January, a widely reported study published in the *Annals of Internal Medicine* found that the amount of time a person sits during the day is associated with a higher risk of heart disease, diabetes, cancer, and death, even if the person gets regular exercise (although that can lessen the effects). The researchers looked at 47 previous studies on sitting and mortality to reach their conclusions. American workers are understandably alarmed, and many of us are rethinking our daily routines. We’re buying standing desks or hitting the gym with a stack of reports—anything to avoid more time parked in a chair.

Litow says that we should try not to panic. Usually, people who are experiencing discomfort on the job—or who are hoping to avoid it—can improve their health in their work environment by making small, targeted changes. Most of these are cheap or free. “You can certainly find a $1,000 chair,” Litow says. “You can also find a much less expensive chair that is fine.”

In fact, some of the products being marketed to make us healthier, such as treadmill desks or sitting balls, have their own significant drawbacks. Here are the evidence-based strategies that Hopkins experts recommend for staying healthy at work without chasing fads or spending a small fortune.
Sit for Shorter Periods

“Sitting Is Killing You,” blared a recent headline in *Time* magazine. Well, thanks for the death warrant. Coverage of the sitting “epidemic” can sound hysterical, but there’s no question that we are sitting too much, and for too long without shifting posture. Sitting for more than an hour causes changes in how the body produces the enzyme lipase and how it metabolizes glucose, leading to the deposit of fat in tissues. Sitting down also burns about 20 percent fewer calories than standing up.

This might prompt you to ask if standing is the answer. In a word: No. “Standing all day is not a piece of cake, either,” says James Bukowski, director of Occupational and Environmental Safety at Johns Hopkins Medicine. It increases circulation, which is a good thing, but it also puts more pressure on our back, feet, and joints, and it raises the risk of developing varicose veins.

Sitting less doesn't necessarily mean standing more—after all, you burn more calories when you’re on the move, even if it’s just swinging by the break room for a water refill. Litow and Bukowski recommend taking frequent mini-breaks, getting up from your chair to stretch and walk around every 15 minutes or so. “The worst case is that you sit for your entire work shift,” Litow says. Bukowski suggests setting a timer to go off, and there are multiple apps, such as Stand Up! for the iPhone, Time Out for Mac, and Breaker for Windows, that allow you to do that.

But maybe you want or need to stand for part of the day. Sit-stand desks have surged in popularity in recent years. One Cadillac model, released just this year, nudges you to stand at intervals, moving up and down slightly when you’ve been seated long enough. At a cool $2,990, it’s an investment, like other top-of-the-line products in this category. Bukowski says you don’t have to shell out for a sit-stand desk, and more affordable models like the Ergotron WorkFit and the Varidesk work fine. Some research has found that users end up not standing all that much, another reason not to spend a lot of money.

The amount a person sits during the day is associated with a higher risk of heart disease, cancer, and death.
Sit the Right Way
Even if you’re a sit-stand convert, that doesn’t cancel out the need to sit correctly for the periods when you are in your chair. Perhaps the most important thing you can do to avoid strain is to make sure your work chair is fully adjustable, with a pneumatic height lever; that it offers lumbar support for your lower back; that it has a separate chair back and seat pan; and that it is comfortable to sit on, with a “waterfall” front (curved down, so there’s nothing hard pressing against the back of your thighs).

And just possessing the chair isn’t enough—you have to actually adjust it, or get someone who’s knowledgeable about workplace health and safety to do it for you. People often don’t realize how much they can adjust their chairs and other equipment (“You don’t get operating manuals,” Bukowski notes), or they become passive about it.

Another crucial thing is foot position. Tucking your feet under your chair can hamper circulation, and if your feet don’t reach the floor, you probably need to adjust your chair. When she is called to do a workstation assessment, Litow says she always begins by placing the person’s feet on the floor.

Stay Neutral
The goal of ergonomics, which is the study of people at work, is to reduce stress and eliminate injuries caused by bad posture, overused muscles, and repeated tasks. “The first thing we’re looking for, ground zero, is that you want to make sure you’re in alignment,” says Bukowski, who has been doing ergonomics surveys at Johns Hopkins for almost 20 years. Awkward, misaligned postures can take small and surprising forms. Maybe you talk on the phone a lot, jamming it between your ear and one shoulder. (Consider using a headset.) Maybe you have a box or computer tower under your desk and sit with your legs to one side of it. (Move it somewhere else.)

The Occupational Health and Safety Administration has a detailed checklist for anyone who wishes to perform a self-assessment. The short version: Maintaining a neutral posture is key, Bukowski and Litow say. If you’re seated, sit back in your chair and face forward, with your lower back supported. The angle between your torso and legs should be between 100 and 110 degrees. When you’re typing, your elbows should bend at approximate right angles and your shoulders should be relaxed. “The only thing you should try to keep straight [is] your wrists,” Bukowski says.
Repetitive flexing and extending of your wrists increases the pressure on the carpal nerve tunnel. The link between hand and wrist movements and carpal tunnel syndrome is still not clear, but it can contribute to other problems, like cramping and tendonitis. “Awkward postures and typing can increase your risk for developing CTS, but it will not affect everyone equally,” Bukowski says.

“The first thing we’re looking for, ground zero, is that you want to make sure you’re in alignment.”
“It’s worth noting that increases in body fluid retention increase your risk of carpal tunnel syndrome. For example, it’s well-established that pregnancy is strongly related to developing CTS.”

Despite all the discussion of whether and how to sit, the proper setup of your computer monitor has a big effect on posture, too. Seated or standing, you want to be able to touch your monitor without much effort, and the top of it should be at or slightly below eye level. If you use two monitors, the midpoint between them should be right in front of you so there’s no extended rotation of the neck to view either one. Bukowski observes that people who wear bifocals often tilt their heads back to look at their computer screen, which can cause strain. He recommends getting a special pair of “computer glasses” (an optometrist can make the right lenses).

Establish an Action Zone, and Keep It Clean
Keep the items you use regularly—your keyboard, mouse, and phone, for starters—in an “action zone” within easy reach. Litow says she sometimes finds herself playing interior designer, organizing people’s desks so go-to items are close at hand. Equipment you use less often can be kept farther away, even much farther. Consider putting the printer on the other side of the room so you’re forced to get up and walk to it, Bukowski advises.

Laptops aren’t designed for long-duration use. Their screens are too low, and the keyboards are too small, which promotes deviation of the wrist. If you use a laptop, get a docking station with a separate monitor and keyboard. An ergonomic keyboard isn’t essential, unless you have a hand or wrist condition, but it’s a good idea.

Once your action zone is established, keep it clean. Bacteria and viruses can live on work surfaces. Wipe them down, especially if you share a desk or your phone. It should go without saying to wash your hands before you eat and after you go to the bathroom, especially during cold and flu season. And stay home when you’re sick.

Check Your Building
Finally, if you’re experiencing frequent headaches at work or stubborn upper respiratory problems (nasal congestion, a cough), the building could be a factor. There may be a problem with the heating, air conditioning, and ventilation system. “Often when people say they don’t feel well at work ... the cause of that is [that] the ventilation system was designed for one setup, then over time the office [was]
Given the increased interest in staying healthy at work, lots of products are being marketed to that end. Not all of them are worth the time or money. Here are the ones that Hopkins experts say to think twice about or skip altogether.

**Sitting balls.** "We don't recommend ball chairs at all," Bukowski says. There's a risk of injury (people fall off), and some models have no lumbar support. Research suggests they have few advantages over a conventional chair. However, Litow acknowledges that some people really like them, and you can put them in cradles so they don't escape.

**Treadmill desks.** Bukowski calls these "the pet rocks of office ergonomics." They're expensive and take up a lot of space, and there are many tasks you can't perform well on a treadmill (try moving data between two spreadsheets while walking in place). A sensible compromise: When you have a conference call or want to listen to a webinar, hit the treadmill at the gym.

**$1,000 chairs.** Unless you really want to drop a lot of money on a chair (say, a Herman Miller Aeron), there are plenty of less expensive, equally serviceable options.

**The “chair-free office.”** Designers in the Netherlands have taken the office layout to the next level with a concept for a chairless office. It looks like a carnival funhouse, minus the fun. Maintaining a neutral posture in this room of irregular blocks would be challenging, to say the least.

redesigned,” Litow says. If the interior space has been reconfigured without appropriate changes to the HVAC, there may be too few air exchanges (or, less commonly, too many). Tell your manager or HR about your symptoms.

Of course, that’s not an option if you work from home. A home office is not a respite from the problems outlined above—in some ways, it’s more of a Wild West since it’s not subject to the usual workplace safety regulations. People who work from home should buy the right furniture and equipment, change their air filters regularly, and not fall into the “just for a little while” trap. We tell ourselves we’re going to work for a few minutes, sitting on the couch or lying in bed with an iPad, and then we lose track of time.

Which reminds me: I’ve been sitting here for a while. Time to get up, walk around, and change the air filter. /
"In the summer of 1989, two FDA officials testified in front of Dingell’s subcommittee that they had accepted manila envelopes stuffed with several thousand dollars from the executive of the generics firm Superpharma. In exchange, regulators had orchestrated the slowing of reviews for competing generic products, burying key files in desk drawers while speeding others through the regulatory machinery."

Jeremy A. Greene admits to a bias when he began researching the history of generic drugs for a book. He was a physician who regularly prescribed and took generic drugs. He gave them to his children and saw generics as a valuable alternative to expensive brand names. “I had thought that the generic drug industry had a moral gloss attached to it, that it was good and virtuous and part of a beneficial public-minded policy,” he says. Then Greene, a medical historian, researched the late 1980s, when several generic firms misled regulators with test samples of the actual brand-name drug instead of their generic. In one instance, a company simply sandpapered the pharmaceutical company’s logo off a pill and submitted it as its own creation. They got caught.

In Generic: The Unbranding of Modern Medicine (Johns Hopkins University Press, 2014), Greene uncovers the sometimes-sordid past of the generic drug business. In 1960, fewer than 10 percent of drug prescriptions in America were for generics. By 2010, that number had jumped to 80 percent. Today, generic drugs are a trillion-dollar industry. In 2012, Americans spent less on prescription drugs for the first time in almost six decades.

Greene’s research takes on everything from the mom-and-pop operations of the mid-20th century to the multinational corporations of today, airing all the dirty laundry, politics, and controversy along the way. But his intent was not to discredit the industry. Generics, he points out, are a rare success story in a health care industry bloated by inefficiency and expense. “My goal was not to make people distrust the system but to suggest that it helps to be conscious of those systems and to insist on as much transparency as possible.” // ELIZABETH EVITTS DICKINSON
Chris Kraft, a certified sex therapist, is a licensed psychologist at Johns Hopkins Hospital and on the faculty at Johns Hopkins University.

Relationship expert Chris Kraft offers his top five picks for anyone hoping to strengthen intimacy.

1 / (2007)  
Mating in Captivity  
Esther Perel  
HARPER PERENNIAL

2 / (2014)  
What Do Women Want?  
Daniel Bergner  
ECCO

3 / (1999)  
The Seven Principles for Making Marriage Work  
John M. Gottman and Nan Silver  
HARMONY

4 / (2014)  
The Myth of Sex Addiction  
David J. Ley  
ROWMAN & LITTLEFIELD

5 / (2012)  
A Billion Wicked Thoughts: What the Internet Tells Us About Sexual Relationships  
Ogi Ogas and Sai Gaddam  
PLUME

Touch: The Science of Hand, Heart, and Mind  
David Linden

An engaging and often witty examination of how the sense of touch shapes our interaction with the world. Linden, a Johns Hopkins professor of neuroscience, lucidly explains how sensory and emotional context work together to distinguish between pleasure and pain. He argues that interpersonal touch is crucial to social bonding and individual development.

Making a Splash  
Carol Reiley

Originally conceived as a gift for the author’s niece, the book advocates the growth mindset philosophy that says intelligence is malleable and can be developed through hard work. Reiley, a Johns Hopkins doctoral student studying surgical robotics, tells the story of how two siblings differ in their attitudes toward learning. The takeaway: It’s not how smart you are; it’s how smart you can become.

Labor’s Love Lost: The Rise and Fall of the Working-Class Family in America  
Andrew Cherlin

Drawing from more than a hundred years of census data, Johns Hopkins sociologist Andrew Cherlin offers a new historical assessment of how social and economic transformations have contributed to the collapse of a once-stable class and what this cultural shift means for the nation’s future.
**My worst day**

My hair has been thinning since I turned 30. I knew what was coming. The hairline just gradually worked its way back and then a bald patch appeared. One morning, I stood in front of a mirror and thought, ‘Enough is enough.’

**What I did to get better**

Some friends and family advised me to let nature take its course, or just shave it all off. But I wanted my hair back. A friend had a hair transplant procedure done and referred me to Dr. Lisa Ishii. It’s an outpatient procedure. They harvest hair follicles from the back of your scalp and then graft them in where needed.

For me, the worst part was hearing the scalp being cut, but you don’t feel it because they anesthetize you. Once they cut the area out, they hand it to a technician who is literally splitting hairs for the next two to three hours. Then they staple the area back together. Later, they numbed my forehead and I’m counting the holes [the doctor] is making with this tool where the grafts will be placed.

**Me now**

I had the first procedure in fall 2010 and three more since. The results are wonderful. I’ve seen people who’ve been butchered by transplants or just look OK. But my hair looks full and natural. How I come across to clients was certainly part of the thought process going into this. I think it’s helped business. I can tell you, it certainly hasn’t hurt.
The Johns Hopkins Center for Talented Youth, with programs around the United States and around the globe—from Washington, D.C., to Hong Kong—is dedicated to developing the world’s brightest K-12 learners. Visit our website to learn more about our signature summer and online courses.
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Anne Arundel Showroom at 8031 Ritchie Highway. 410-761-5700
McLean Showroom at 1359 Beverly Rd. 703-734-6102
Gunston Showroom in Lorton at 10440 Furnace Rd. 703-690-4045

www.stuartkitchens.com