SciAm Perspectives

Worse Than Gasoline

Liquid coal would produce roughly twice the global warming emissions of gasoline

BY THE EDITORS

Lawmakers of both parties are proposing amendments to the so-called energy independence bill that would massively subsidize the coal industry to produce liquid coal as a replacement for foreign oil. (The admirable original bill is designed to increase fuel efficiency in cars and light trucks, encourage production of biofuels, and provide funds to develop technology that will capture carbon dioxide emissions from power plants.) Former Democratic senator Richard Gephardt is lobbying for Peabody Energy, the world's largest coal company. Even Senator Barack Obama, from coal-rich Illinois, has co-sponsored legislation that would set the stage for more U.S. coal-derived fuel production. Obama is also a sponsor of separate legislation to cut greenhouse gas emissions to one third of 2000 levels by 2050 and to reduce carbon content in transport fuel by 10 percent by 2020.

Obama's have-it-both-ways positions underscore the tension between efforts to reduce dependence on foreign oil and to slow global warming. Liquid coal—produced when coal is converted into transportation fuel—would at best do nothing to rein in climate change and at worst would be twice as bad as gasoline in producing the greenhouse gases that blanket the earth and lead to warming.

The conversion technology is well established (the Germans used it during World War II), and liquid coal can power conventional diesel cars and trucks as well as jet engines and ships. Coal industry executives contend that it can compete against gasoline if oil prices are $50 a barrel or higher. But liquid coal comes with substantial environmental and economic negatives. On the environmental side, the polluting properties of coal—starting with mining and lasting long after burning—and the large amounts of energy required to liquefy it mean that liquid coal produces more than twice the global warming emissions as regular gasoline and almost double those of ordinary diesel. As pundits have pointed out, driving a Prius on liquid coal makes it as dirty as a Hummer on regular gasoline.

One ton of coal produces only two barrels of fuel. In addition to the carbon dioxide emitted while using the fuel, the production process creates almost a ton of carbon dioxide for every barrel of liquid fuel. Which is to say, one ton of coal in, more than two tons of carbon dioxide out. Even if the carbon released during production were somehow captured and sequestered—a technology that remains unproven at any meaningful scale—some studies indicate that liquid coal would *still* release 4 to 8 percent more global warming pollution than regular gasoline.

Liquid coal is also a bad economic choice. Lawmakers from coal states are proposing that U.S. taxpayers heavily subsidize the industry for the next 25 years. Their mantra is "Coal-based fuels are more American than gasoline." But no operating coal-to-liquid plants exist in the U.S., and researchers at the Massachusetts Institute of Technology estimate it will cost $70 billion to build enough plants to replace 10 percent of American gasoline consumption. Some energy experts worry that the scale of the incentives could lead to a repeat of the disastrous effort 30 years ago to underwrite a synthetic fuels industry.

The country would be spending billions in loans, tax incentives and price guarantees to lock in a technology that produces more greenhouse gases than gasoline does. Instead of spending billions to subsidize a massively polluting industry, we should be investing in efficiency and in renewable energy technologies that can help us constrain global warming today. ■

MATT COLLINS

OPINION
editors@SciAm.com

Making Development Less Risky

Innovative forms of insurance could unshackle a green revolution in Africa and other poor nations

BY JEFFREY D. SACHS

BRUCE GILBERT/EARTH INSTITUTE

Life at the bottom of the world's income distribution is massively risky. Poor households lack basic buffers—saving accounts, health insurance, water tanks, diversified income sources, and so on—against drought, pests, disease and other hazards. Even modest shocks, such as a temporary dry spell or a routine infection, can be devastating.

These risks have knock-on effects. To take one prime example, the expected economic return on the use of fertilizer is very high in Africa, yet impoverished farmers cannot obtain it on credit because of the potential for a catastrophic loss in the event of a crop failure. Their households cannot bear the risk of a loan, and so they remain destitute. Managing risk is therefore important not only for smoothing out the well-being of these farmers over the years but also for enabling their escape from extreme poverty.

Traditional crop insurance is almost nonexistent in Africa.

For these reasons and others, financial risk management is likely to come to the forefront of strategies for poverty reduction. Microfinance has already introduced markets for the poor. Microinsurance and other kinds of risk management will likewise yield important tools.

Traditional crop insurance is almost nonexistent in Africa for several reasons. Suppose a company tried to sell a crop insurance policy to a peasant farmer with a one-acre farm. A standard policy would specify payments in the event of measured crop losses from specified hazards (such as drought, pests and temperature extremes), and would require an actuarial model of applicable

risks and the completion of a contract. Payments would occur only after the verification of losses and (usually) of the underlying adverse events.

Multiple problems would be fatal to such a policy: the absence of an actuarial risk model; adverse selection (farmers with especially risky conditions would seek the contracts); moral hazard (farmers covered by insurance might fail to take other protective measures); and the enormously high relative costs of marketing, signing and assessing losses.

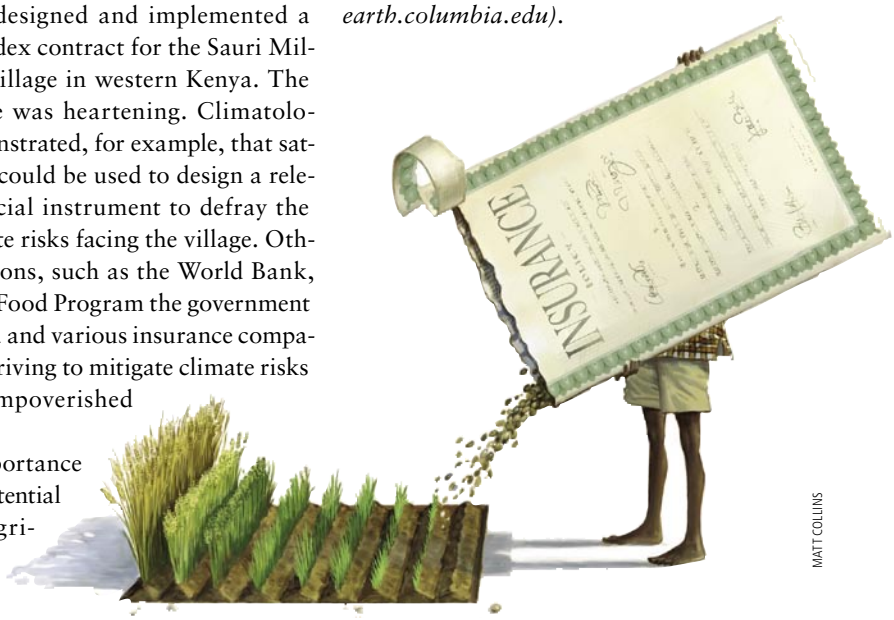
Two huge innovations are correcting these weaknesses. First, instead of insuring a farmer's actual crop losses, a policy can diversify much of a farmer's risk by creating a financial derivative, such as a weather-linked bond that pays in the event of a seasonal drought, dry spell or other adverse shock. A weather station or satellite can observe a drought objectively, eliminating the need to examine outcomes on individual farms. Moral hazard and adverse selection are irrelevant, because the price of the "drought bond" depends on the objective probabilities of measurable weather shocks, not on the behaviors of an individual farmer.

The second key strategy is to combine the weather-linked bonds with other financial services to the farmer. For example, a bank could make a seasonal loan to a cooperative of hundreds or thousands of farmers for the mass purchase of fertilizers and high-yield seeds, with the loan repayment due to be reduced or waived in the event of a drought and the repayment schedule calibrated to the drought's extent. The bank, in turn, would buy a weather-linked bond to insure itself against such a dry spell.

Earlier this year the Earth Institute at Columbia University and the reinsurer Swiss Re designed and implemented a rainfall-index contract for the Sauri Millennium Village in western Kenya. The experience was heartening. Climatologists demonstrated, for example, that satellite data could be used to design a relevant financial instrument to defray the high climate risks facing the village. Other institutions, such as the World Bank, the World Food Program the government of Ethiopia and various insurance companies, are striving to mitigate climate risks in other impoverished regions.

The importance of—and potential for—an agricultural breakthrough is critical for Africa's future. Its farmers do not produce enough food to feed a hungry continent. Yet existing technologies could enable them to do so, if the financing were arranged. Africa's green revolution is therefore likely to be accompanied by a supportive African financial revolution that brings state-of-the-art risk management techniques to bear on behalf of some of the world's poorest people. ■

Jeffrey D. Sachs is director of the Earth Institute at Columbia University (www.earth.columbia.edu).



MATT COLLINS

Skeptic

Bad Apples and Bad Barrels

Lessons in Evil from Stanford to Abu Ghraib

BY MICHAEL SHERMER

The photographs of prisoner abuse from Abu Ghraib shocked most Americans. But social psychologist Philip Zimbardo had seen it all 30 years before in the basement of the psychology building at Stanford University, where he randomly assigned college students to be "guards" or "prisoners" in a mock prison environment. The experiment was to last two weeks but was terminated after just six days, when these intelligent and moral young men were transformed into cruel and sadistic guards or emotionally shattered prisoners.

As he watched the parade of politicians proclaim that Abu Ghraib was the result of a few bad apples, Zimbardo penned a response he calls the Lucifer Effect (also the title of his new book from Random House), namely, the transformation of character that leads ordinarily good people to do extraordinarily evil things. "Social psychologists like myself have been trying to correct the belief that evil is located only in the *disposition* of the individual and that the problem is in the few bad apples," he says.

PHOTOGRAPH BY BRAD SWONETZ; ILLUSTRATION BY MATT COLLINS

But, I rejoin, there *are* bad apples, no? Yes, of course, Zimbardo concedes, but most of the evil in the world is not committed by them: "Before we blame individuals, the charitable thing to do is to first find out what situations they were in that might have provoked this evil behavior. Why not assume that these are good apples in a bad barrel, rather than bad apples in a good barrel?"

How can we tell the difference? Compare behavior before, during and after the evil event in question. "When I launched my experiment at Stanford, we knew these students were good apples because we gave them a battery of tests and every one of them checked out normal," Zimbardo explains. "So, on day one they were all good apples. Yet within days, the guards were transformed into sadistic thugs and the prisoners were emotionally broken." Likewise at Abu Ghraib. Zimbardo notes that before going to Iraq, Staff Sergeant Ivan "Chip" Frederick—the military police officer in charge of the night shift on Tiers 1A and 1B, the most abusive cell blocks at Abu Ghraib—"was an all-American patriot, a regular churchgoing kind of guy who raises the American flag in front of his home, gets goose bumps and tears up when he listens to our national anthem, believes in American values of democracy and freedom, and joined the army to defend those values."

"The guards were transformed into sadistic thugs, and the prisoners were emotionally broken."

Before Abu Ghraib, Frederick was a model soldier, earning numerous awards for merit and bravery. After the story broke and Frederick was charged in the abuses, Zimbardo arranged for a military clinical psychologist to conduct a full psychological assessment of Frederick, which revealed him to be average in intelligence, average in personality, with "no sadistic or pathological tendencies." To Zimbardo, this result "strongly suggests that the 'bad apple' dispositional attribution of blame made against him by military and administration apologists has no basis in fact." Even after he was shipped off to Fort Leavenworth to serve his eight-year sentence, Frederick wrote Zimbardo: "I am proud to say that I served most of my adult life for my country. I was very prepared to die for my country, my family and friends. I wanted to be the one to make a difference."

Two conclusions come to mind. First, it is the exceedingly patriotic model soldier—not a rebellious dissenter—who is most likely to obey authorities who encourage such evil acts and to get caught up in believing that the ends justify the means. Sec-

THE EDITORS' BLOG

www.SciAm.com/blog

ROCK FESTIVAL AS HUMAN EXPERIMENT: HIP-HOPPING FOR SCIENCE

What would happen if all 1.3 billion Chinese jumped in unison?

Umm … nothing, really.

That's the deduction from an experiment carried out today with tens of thousands of human lab rats who attended the German music festival Rock at the Ring. The idea of enlisting rock-crazed youths to advance geological science got started when the creators of a science program on German television asked themselves what would happen if the entire Chinese population engaged in synchronized hopping.

They saw Rock at the Ring as an opportunity to provide an answer to that question on a microcosmic scale. At the concert, the band We Are Heroes cued the thousands of rock fan/hoppers (total attendance 50,000) with drumbeats to go airborne, while the program's crew recorded the event on videotape and the Potsdam Geological Research Center recorded it on seismometers.

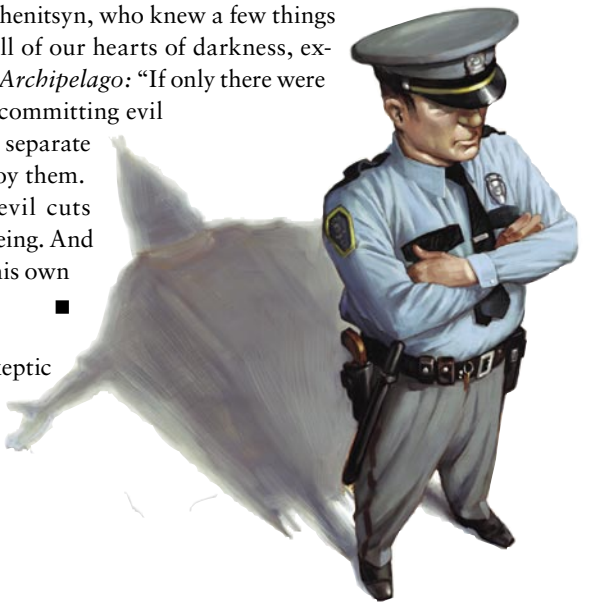
A producer of the science program, Quarks & Co., characterized the "gang boing" as a "mini-mini earthquake," according to a news report from radio Deutsche Welle. A seismometer measured four oscillations per second, while the earth moved only $^1/_{20}$ of a millimeter. "We showed that people cannot start a (real) earthquake by hopping," remarks Ulrich Gruenwald, producer of the program, who emphasized the difficulty of getting tens of thousands of people to synchronize their jumps.

Maybe just stick to the Wave.

Posted by Gary Stix, June 4, 2007

Read more posts on SciAm Observations (www.SciAm.com/blog)

ond, in *The Science of Good and Evil* (Owl Books, 2004), I argued for a dual dispositional theory of morality—by disposition we have the capacity for good and evil, with the behavioral expression of them dependent on the situation and whether we choose to act. Aleksandr Solzhenitsyn, who knew a few things about the capacity for evil inside all of our hearts of darkness, explained it trenchantly in *The Gulag Archipelago:* "If only there were evil people somewhere insidiously committing evil deeds, and it were necessary only to separate them from the rest of us and destroy them. But the line dividing good and evil cuts through the heart of every human being. And who is willing to destroy a piece of his own heart?" ■



Michael Shermer is publisher of Skeptic *(www.skeptic.com). His latest book is* Why Darwin Matters *(Henry Holt, 2006).*

Forum

Have Brain, Must Travel

A successful space exploration program requires astronauts as well as robots

BY JIM BELL

These are incredibly exciting times for space exploration. NASA currently operates more than 50 robotic spacecraft that are studying Earth and reaching throughout the solar system, from Mercury to Pluto and beyond. Another 40 unmanned NASA missions are in development, and space agencies in Europe, Russia, Japan, India and China are running or building their own robotic craft. With such an armada at our disposal, delivering a stream of scientific data from so many distant ports, you might think that researchers like me who are involved in robotic space exploration would dismiss astronaut missions as costly and unnecessary. To the contrary: many of us embrace human exploration as a worthy goal in its own right and as a critically important part of space science in the 21st century.

Although astronaut missions are much more expensive and risky than robotic craft, they are absolutely critical to the success of our exploration program. Why? Because space exploration is an adventure—a *human* adventure—that has historically enjoyed broad public support precisely because of the pride we take from it. President John F. Kennedy committed the U.S. to sending astronauts to the moon to make a statement about the power of democracy and freedom, not to do science. As a by-product, some outstanding lunar science was done, leading ultimately to an understanding of the moon's origin. What is more, the Apollo moon program trained and inspired an entire generation of researchers and engineers, who made the breakthroughs that paved the way for robotic missions, as well as much of the tech-

MAUREEN BELL

increase. All of this evidence should have caused a quick dismissal of these cases…."

Posted by Nikhil Swaminathan, June 8, 2007

THE EDITORS' BLOG

www.SciAm.com/blog

NEVER MIND THE SCIENTIFIC CONSENSUS—DOWN WITH VACCINES!

Global warming and evolution, meet vaccines. The scientific community seems to be largely aligned on all of your sides: exists and needs to be dealt with; no controversy to be taught; and doesn't cause autism.

That won't stop the U.S. judicial system from being plagued by claims that what scientists have found through careful study is incorrect—and that restitution be delivered.

Apparently a school board in Chesterfield County, Virginia, is ordering new textbooks, and it's feeling the heat from community members, who are encouraging them to splurge and get books with a few extra pages on intelligent design.

On Monday the U.S. Court of Federal Claims will host lawyers representing one of 4,800 children living with autism, whose families have filed claims alleging that vaccines are the causal culprit. This despite the release by the Institute of Medicine, a part of the National Academies, of eight reports over three years on the subject. The final word was that there is no link between the development of autism and vaccines (specifically, measles-mumps-rubella and others that contained the organometallic, mercury-containing compound thimerosal) …

Paul Offit, chief of infectious diseases at Children's Hospital of Philadelphia and a co-inventor of a vaccine for rotaviruses (which cause gastrointestinal issues), wrote a sort of pre-elegy to vaccines in the Boston Globe's "Ideas" this past Sunday…. "Finally, vaccine makers removed thimerosal from vaccines routinely given to young infants about six years ago; if thimerosal were a cause, the incidence of autism should have declined. Instead the numbers have continued to

Read more of this post and others on SciAm Observations (www.SciAm.com/blog)

nology that we take for granted today.

Letting the Apollo program end prematurely was a phenomenal mistake. NASA's subsequent strategy for human exploration, focused on space shuttle missions and orbital space stations, turned out to be uninspiring and tragically flawed. The recent successes of the Mars rovers, the Cassini probe to Saturn and other robotic missions may signal a renaissance, but the situation is still precarious. Indeed, the post-Apollo decline in public interest in space exploration reverberates today in the debates over NASA's budget and the general skepticism about the agency's future relevance, especially among the generation now entering the workforce. Further triumphs of the robotic missions will be possible only if public and political interest is rebuilt and sustained by a reinvigorated program of human exploration.

What is more, human brains will be vitally needed in many future missions. Although robots have proved their worth in documenting and measuring the characteristics of distant places, they fall far short of humans when it comes to making judgments, incorporating broader contexts into decision making and learning from their experiences. Some of these capabilities can be programmed, and so-called machine learning has advanced considerably in the past few decades. But the neural complexity that is so often needed to make discoveries—the same combination of logic, experience and gut instinct required to solve a mystery—cannot easily be distilled to a series of "if-then" statements in a computer algorithm. Robotic brains will lag far behind in these kinds of abilities for a long time to come, perhaps forever, thus placing severe constraints on the science they can do on other planets.

Robotic craft have worked well for the first age of space exploration, when simply flying a probe past a planet or landing on an alien terrain was enough to make dramatic discoveries. That era, however, is coming to an end. Now we are entering a new age of space exploration in which we must look more carefully at such planetary landscapes, as well as at what lies underneath them, analyzing the rocks, soils and gases of distant worlds in greater detail to flesh out the history of our solar system. This kind of science absolutely requires human explorers. In this new era, we will need brave people with brains to boldly go where no robot can take us. ■

Jim Bell is an astronomer and planetary scientist at Cornell University and scientific leader of the Pancam team for the Mars Exploration Rover mission. His recent book, Postcards from Mars, *showcases some of the vistas of the Red Planet obtained by robotic eyes.*

MATT COLLINS

Anti Gravity

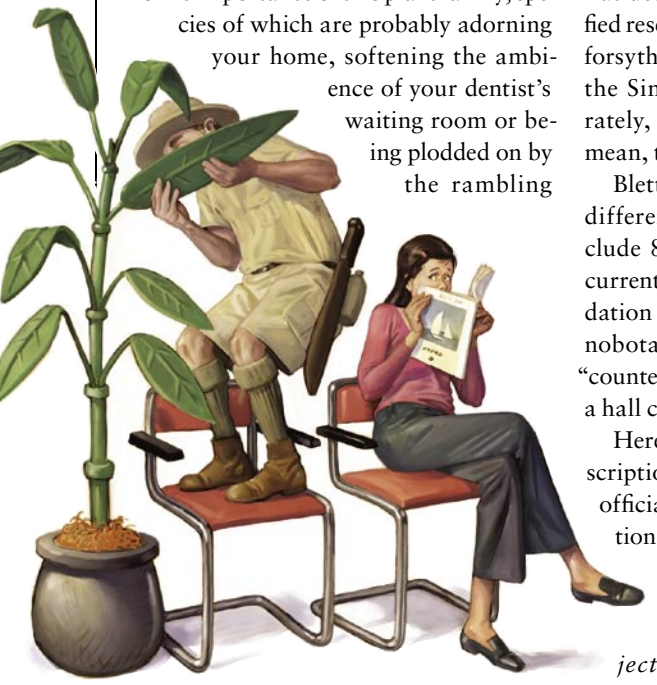
Floral Derangement

Some of these vegetables are minerals

BY STEVE MIRSKY

The late Harvard University paleontologist Stephen Jay Gould said that every species designation represents a theory about that organism—the species assignment is more than a mere naming; it is a classification of the organism within the context of all the other creeping, crawling, clinging and cavorting life on earth. As such, the discovery of a charismatic new species of animal or plant often piques the interest of both the scientific community and the lay public. Finding an entirely new genus is even more exciting. So it is somewhat shocking that a peer-reviewed publication announcing the discovery of a previously uncharacterized *family* of plants—an even higher taxonomic level than genus—has gone virtually unnoticed.

The shock intensifies when one considers the incredible ubiquity and great economic importance of this plant family, species of which are probably adorning your home, softening the ambience of your dentist's waiting room or being plodded on by the rambling behemoths of your local football team.



Fortunately I received a copy of the manuscript describing the plant family in question from one Nat Bletter, the lead author of the paper, which appeared online recently—April 1, oddly enough—in the journal *Ethnobotany Research and Applications*. The journal article's title says it all, albeit obtusely: "Artificae Plantae: The Taxonomy, Ecology, and Ethnobotany of the Simulacraceae."

As the authors note, the family Simulacraceae represents more than a "technical curiosity": it is "a genuine scientific conundrum." Individuals appear to be virtually immortal, they easily form not just interspecies but intergeneric crosses, and they lack any genetic material. (Had Mendel chosen a species from this family for his genetics research, the rules and chemistry of heredity might remain unknown to this day, along with Mendel.) But despite previous disregard by qualified researchers, the plastic peonies, fabric forsythia and wax watermelon wedges of the Simulacraceae live—or, more accurately, exist—among us at every fern. I mean, turn.

Bletter and his co-authors describe 17 different genera of phony flora that include 86 species, samples of which are currently stored at New York City's Foundation for Artificial Knowledge and Ethnobotany (what's a four-letter word for "counterfeit"?), which does double duty as a hall closet.

Here is the journal article's formal description of the new family in Latin, the official language of taxonomic designation. Although the Latin in this case is a bit porcine: "Simulacraceae—*away andbray ewnay antplay amilyfay omposedcay ofway objectsway ademay ybay umanshay* (How you doing so far, uddybay?) *otay ooklay ikelay anyway eciesspay inway ethay ingdomkay Antaeplay orway ancifulfay eciesspay avinghay omponentscay ofway away ivinglay antplay* (I always thought it was antwork and grasshopperplay) *eciesspay orway away ombinationcay ofway omponentscay omfray everalsay ivinglay antplay eciesspay utbay otnay ookinglay exactlyway ikelay anway extantway antplay.*" Similar swiny Pliny language describes each genus. And the authors note that because there existed absolutely no previously published taxonomic research about this family, "we did not have to coerce any unpaid students to do any literature searches."

In his spare time, Bletter is a graduate student at the International Plant Science Center at the New York Botanical Garden. He notes that his intensive research on the Simulacraceae stemmed from SCADS—severe chronic avoidance of dissertation syndrome. "We are not sure if SCADS is genetic or environmentally transmitted," he says, "but perhaps that's the subject of our next huge NIH-funded project."

Simulacraceae include the genus *Plasticus,* fake plants "typically composed primarily of complex polymers of long-chain hydrocarbons, indicative of their origins in the petrochemical industries"; the genus *Calciumcarbonatia,* faux vegetation designed out of seashells; the genus *Paraffinius,* familiar examples of which are the dust-covered wax bananas, grapes and apples in the big bowl on Grandma's kitchen table; and the genus *Silicus,* which includes the truly world-renowned collection of some 3,000 individual specimens of glass flowers, representing more than 830 real flower species, housed at Harvard's Natural History Museum. Now there's some intelligent design. ■

PHOTOGRAPH BY FLYNN LARSEN; ILLUSTRATION BY MATT COLLINS