World Changing Ideas

Ten thoughts, trends and technologies that have the power to transform our lives

TECHNOLOGY IS ALL AROUND US, EXPANDING THE LIMITS OF WHAT IS POSSIBLE. BUT EVERY ONCE in a while, some invention or insight has an outsize effect; it creates a large discontinuity, dividing history into "before" and "after." The steam engine, the transistor, the World Wide Web—each of these ideas seemed to emerge from nowhere to change our world in fundamental ways. Which key technology will arise from today's vast cauldron of innovation to become tomorrow's world changing idea? It's impossible to know, of course, but we know it will come.

Here are 10 candidates—10 new ideas and technologies that could rewrite the rules. What if we could build robots that turn waste into fuel? Or harness the power of video games (yes, video games) to make ourselves do the right thing? What if the "junk" in our DNA is actually as important as our genes? What if insects hold the secret to fending off cyberattacks? Welcome to the World Changing Ideas 2010 edition. —*The Editors*

Photograph by Mark Hooper

COMPUTING

The Game of Life

Bringing joysticks and scoreboards into our daily routine may be the key to making us better people

by John Pavlus

ONE DAY SOON, as you stand in front of the bathroom mirror brushing your teeth, you may see, alongside the morning headlines, a scoreboard that ranks your household's current carbon footprint versus your neighbors'. Your electric toothbrush will beep to notify you that dutiful brushing twice a day every day for the past six months has earned you enough points for a 10 percent discount on your next checkup. You take a shower (a brief one, so as not to jeopardize your family's enviable energy-consumption score and the tax benefits it confers), get dressed and log in at your home-office computer for the morning meeting. Now that you and your co-workers appear on-screen as personalized avatars, you can answer

your e-mail during meetings without appearing rude. And ever since arbitrary sales quotas were replaced with personalized "life meters" (which swell onscreen to reflect real-time, positive feedback from your clients), you've felt more purpose and ownership over your daily tasks. It's going to be a great day.

A future in which almost every aspect of your life includes a gamelike experience is all but inevitable, says videogame designer and Carnegie Mellon University researcher Jesse Schell. He and a bevy of game designers and psychologists are convinced that the key to a society of healthier, more productive and more engaged citizens lies in bringing gaming into daily life. "We think of games as trivial, but they're really just a way of rapidly engaging our problem-solving abilities," Schell says. "If the game is designed well enough, any problem can go in there," from changing your diet or learning a new language to understanding Middle East conflicts or reducing your carbon footprint. "These are problems that many of us can't or don't want to engage with, but games can change that because, by definition, any successful interactive system will make people *want* to engage."

An essential ingredient of this new game of life is the proliferation of real-time data from GPS-enabled mobile devices, cheap networked sensors and other technologies. "All of this personalized data lets us start measuring behaviors that we could only measure in games or virtual worlds before," says Dan Ariely, a behavioral economist at the Massachusetts Institute of Technology. "We can see what motivates and engages people in great detail and apply that knowledge to things that people don't often find engaging, like remembering to take medication or keeping track of energy use."

"Game-ifying" a real-world system still requires more than just adding avatars and points. It requires fast, personalized feedback. Effective games "harness basic human motivational tendencies in elegant ways," points out clinical psychologist Richard Ryan. Points, for example, aren't rewards as much as a method of supplying real-time feedback for building competence. "Human beings are curious animals with a natural drive to play and master their environments," Ryan observes. "Games do a good job of tapping into the intrinsic motivation that's built into us by evolution." According to psychologists, tapping those intrinsic incentives makes us feel as though we're in control and that our actions have understandable consequences.

Yet games that work well in theory can quickly turn frustrating and counterproductive, Schnell admits. He even has a name for a future in which this kind of motivational backfiring becomes common: "the gamepocalypse." The best insurance against it, he says, is to build bridges between talented game designers and technology leaders outside the entertainment field. Psychologist and games expert Byron Reeves agrees: "There are no psychological mechanisms that work for games that don't work in real life. We have only one brain. The reward centers that are lit up by well-designed games will light up when we engage with any well-designed interactive system. They don't have to be labeled 'games' with a capital 'G.'"

That's why researchers are optimistic about game-ification as a means of radically improving our world. Microsoft has used a gamelike program to increase employee retention in one division by 50 percent. First Things First, an experimental math curriculum used in five schools in Kansas and Texas, presents high school algebra and geometry as a series of 101 levels, encouraging students to master basic concepts at their own pace before moving up, as in a video game. In the four years since the program was implemented, all five schools have seen students register double-digit increases in state math tests; students at one school improved their scores by nearly 40 percent. Ryan is collaborating with Immersyve, a health care game consultancy, on creating a "virtual clinician" that uses an avatar-driven interface to make patients feel less intimidated when seeking medical consultations.

"The game-ification of everything is not going to happen because of one system—it's going to be a million different innovations in hundreds of directions, every time some new sensor gets invented," Schell says. Each one making us a little bit better.

COMPUTING

Human Number Crunchers

When research is like a video game, computers finish second *by John Pavlus*

FOR YEARS the conventional wisdom on the relative cognitive strengths of humans and machines has held that humans excel at recognizing faces and other kinds of pattern matching, while computers rule on anything that smacks of number crunching. That may no longer be the case. The success of Foldit—an online puzzle created by biologists and computer scientists at the University of Washington—proves that human intuition can outperform computer algorithms on complex scientific problems.

Foldit presents players (all nonscientists) with a partially folded protein onscreen and challenges them to twist it into an ideal shape based on simple rules. Not only did players predict correct protein structures much more quickly than any algorithm could (a brute-force search of all the possibilities would take millions of years), they were also able to intuit solutions that a computer might never have found at all. "To fold a protein into the right shape, you might first have to bend it in a couple of directions that seem totally wrong," says Seth Cooper, a Washington computer scientist and one of Foldit's inventors. "A human being playing with a virtual object can see the big picture and recognize those tricky solutions."

At the university's Center for Game Science, Cooper and his colleagues are now developing a new wave of games to accelerate the pace of research in bioinformatics, drug discovery and even nanoengineering. "Right now there are only 15 people in the world who know how to design a molecular machine out of DNA," says Washington computer scientist Zoran Popović. "These games could increase that number by two orders of magnitude—we'd have thousands of people making new discoveries." Could a gamer one day share a Nobel Prize? Says Cooper, "That's our greatest hope."

TRANSPORTATION

Know-It-All Toll Roads

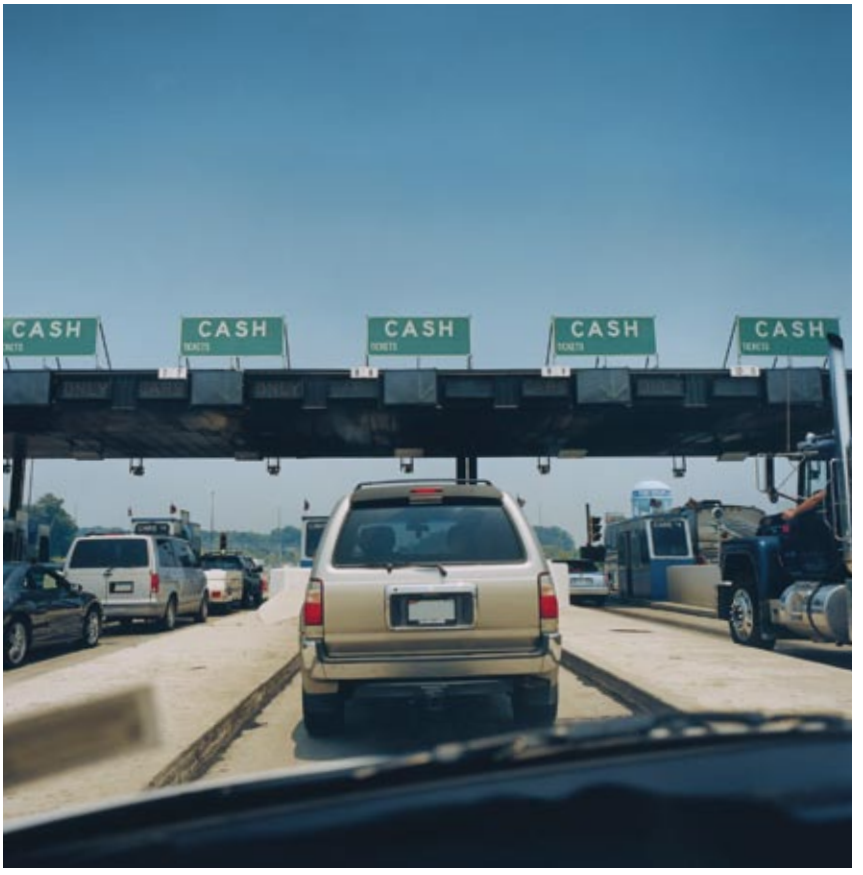
Building more roads won't eliminate traffic. Smart pricing will

by Tom Vanderbilt

THE ROAD OF THE FUTURE will look much like the road of the present, but it most certainly won't be free. "You can have your driveway," says Bern Grush, founder of Skymeter, a Toronto-based company that creates GPS-enabled devices to measure road use. "But if you're going to come over to visit me, you need to pay to get to my place from your place."

With the emergence of wireless, location-based technologies such as GPS, it is now possible to gauge the true costs of driving and the true value of the roads. The umbrella term is dynamic road-use charging, which means essentially that drivers will pay for roads they use by the mile, rather than through other mechanisms such as registration fees or a gas tax. Only a few pilot programs are up and running at the moment, but urban planners think the idea could change our experience of driving from white-knuckled frustration to something closer to a joyride. Researchers at the Massachusetts Institute of Technology and General Motors laid out such a vision earlier this year in "Reinventing the Automobile," a study that argued that transparent trip pricing would optimize road use, reducing traffic congestion and highway deaths.

Shifting the true cost of driving onto the driver would be a radical departure from what goes on now. Drivers pay no more to use crowded roads than empty roads, a person who drives once a month pays as much in insurance as someone who drives every day, and parking meters cost the same during the busiest times as during the most quiet. The federal gas tax, which for a century has financed U.S. highways, has effectively dropped from a peak of 3.9 cents per mile (2007 dollars) to 0.9 cents today, writes Cato Institute analyst Randal O'Toole in his book *Gridlock: Why We're Stuck in Traffic and What to Do about It*. As a result, congestion levels have risen steadily in the cities and suburbs. As Harvard University economist Edward Glaeser notes, you can ration scarce goods—like urban roads—by price or by queue (also known as sitting in traffic). So far the de facto choice has been traffic.



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Results from the first pilot studies have been encouraging. The Dutch government plans to enact countrywide GPS-based "per kilometer" pricing on all roads in the Netherlands by 2016. A six-month pilot trial in Eindhoven last year showed that 70 percent of users changed their behavior as a result of pricing, by traveling either at off-peak hours or on less crowded roadways. Once the program is expanded to the rest of the country, the Dutch government expects a 58 percent reduction in traffic delays.

Per-mile pricing programs can also be used to benefit the environment. In Germany, where heavy trucks are charged not just by the mile but by their emissions (dirtier trucks pay a higher per-mile fee), the percentage of trips driven by low-emissions trucks has jumped from less than 1 percent in 2005, when the program began, to more than 55 percent.

The collapse of the Dutch government earlier this year, however, has put the future of its road-pricing program in doubt—a reminder that politicians want to be seen building new roads, not new tollbooths. The technology required can also be prohibitively expensive. In one trial, U.K. insurer Norwich Union (now known as Aviva) used on-car gadgets to measure not only where and when young drivers drove but *how* they drove. The company used in-car accelerometers to punish aggressive drivers with higher insurance rates. Even though accident claims dropped by 30 percent during the trial, the required telematics were too expensive to make the program sustainable.

Smart tolls can help alleviate another cause of urban traffic: street parking. Researchers such as Donald Shoup of the University of California, Los Angeles, argue that underpriced street parking leads to urban congestion as drivers cruise for bargains. To avoid this practice, San Francisco is implementing "dynamic parking," which uses sensors to track a car's presence in a parking spot and tally overall demand; the city then sets prices at a level that ensures a constant 85 percent occupancy. The rates can change by time of day and day of the week, although they will always be set in advance—making them much easier to predict than the amount of time you would otherwise be wasting in traffic.

BIOTECHNOLOGY

The DNA Transistor

A new approach to DNA sequencing could revolutionize our understanding of genetics *by Elizabeth Svoboda*

IN THE DECADE since researchers first sequenced the human genome, obvious links between the genes and individual diseases have been slow to appear [see "Revolution Postponed," by Stephen S. Hall; SCIENTIFIC AMERICAN, October]. Many researchers now believe that real advances in genomics will come not from simple X-causes-Y correlations but from a rich statistical understanding that emerges out of the sequences of millions of genomes—a set that reveals how our genetic code is likely to interact with the environment to make us who we are.

This, in turn, requires a cheap genome sequencer, something that can do the job for less than $1,000. Right now it costs between $5,000 and $15,000 to sequence a genome—a great improvement from the $2.7 billion it originally cost but still far from the goal. Researchers at IBM and Roche are trying to get there by undertaking a radical redesign of gene-sequencing machines. Whereas existing dishwasher-size sequencers require expensive chemical reagents to analyze genes that have been sliced into thousands of small fragments, the so-called DNA transistor takes an almost naively simple approach. In it, an intact DNA molecule threads through a three-nanometer-wide gap in the middle of a silicon chip. As the DNA feeds through the nanopore, an electrical sensor reads it one molecular unit, or base, at a time.

Other labs have experimented with similar nanopore-based approaches to sequencing but have found it difficult to control how quickly the DNA strand feeds through the nanoscale hole. The IBM team has hit on a method that capitalizes on DNA's naturally occurring negative charge. "We thought that if the device contained electrodes in the pore itself—thin layers of metals separated by insulating material—that electric field would interact with the DNA," says Gustavo A. Stolovitzky, a research scientist working on the project. The electric field grabs the negatively charged DNA and holds it in place. When the electric field shuts off, the strand continues to move through the hole until the next base lines up for sequencing. At that point the electric field reappears, and the process repeats itself all the way down the strand.

The technique isn't a slam dunk. The pore must produce a strong electric field to hold the DNA in place. But the high voltage needed to create this field can cause what is known as a dielectric breakdown, where sparks fly and the electric field shorts out, which is especially likely to happen over such short distances. "It's as if you have a cloud very close to the earth—it's much easier for lightning to strike," Stolovitzky says. The researchers are looking for an electrode material that can withstand the necessary charge.

Despite these issues, industry observers think the DNA transistor can be a fast, cheap, efficient way to sequence genomes. "This reduces the number of steps required for sequencing—it's just literally looking at the DNA itself," says Bruce Schiamberg, a consultant who evaluates the commercial potential of biotechnology innovations. "There are no reagent costs or optical instruments needed to read fluorescent tags. The thing gets done faster."

The DNA transistor is on track to supply a complete genome sequence within the next few years for less than $1,000. Stolovitzky believes the device will help the scientific community more readily make connections between genes, health vulnerabilities and ideal drug treatments. With a statistical understanding of the connections between genes and disease, pharmaceutical companies could better target drug development, because they would already know what regions their new drugs would need to focus on. He points to one of the early success stories: herceptin, a breast cancer treatment that halts tumor growth in patients who show overexpression of a gene called *HER2*. "There are a handful of these examples," Stolovitzky says. "We would like for it to become a very common thing."

STEVEN PUETZER Getty Images

HEALTH AND MEDICINE

A Killer Water Filter

Novel materials promise better access to clean water around the world

by Melinda Wenner Moyer

ONE IN SIX PEOPLE lacks access to clean water worldwide, making diarrheal illness—a direct result of poor sanitation—the leading cause of death globally. Water filters would do the trick, but they are generally too expensive to distribute in great enough quantities. By combining nanotechnology with cheap materials such as cotton and tea bags, however, researchers have recently developed mobile water filters that can be manufactured for less than a penny.

Most conventional water filters are equipped with small pores that "trap" bacteria, but the pores have a tendency to get clogged, which requires expensive maintenance. Yi Cui found a way to use silver and electricity to kill the bacteria instead. Cui, a materials scientist at Stanford University, dipped woven cotton that he purchased at Walmart into a mixture of electrically conducting carbon nanotubes and silver nanowires. Silver works as an effective bactericide in part because silver ions damage genetic material. Additional killing power comes from a light electric current (powered by two nine-volt batteries) that breaks the bacterial cell membranes. In the lab, Cui's filter killed more than 98 percent of E. coli bacteria in water. Because the pores in the cotton are large, the filter is 80,000 times faster than filters that trap microbes.

An even cheaper invention is a kind of a tea bag filled with carbon granules coated with a microbicide. Researchers at South Africa's Stellenbosch University figured out a way to encapsulate the chemicals within nanofibers to increase their surface area and help them trap toxic substances and bacteria. The filter fits in the neck of an ordinary bottle and costs about half a U.S. cent apiece. Each bag is good for cleaning one liter of polluted water. The technology is currently being tested by the South African Bureau of Standards, after which the researchers plan to dole it out to communities in need.

ROBOTICS

A Wandering, Plant-Eating Robot

It gobbles up wood chips, leaves and other "biomass" and generates electricity *by John Pavlus*

THE DAY COULD SOON come when autonomous robots roam the planet in search of raw biomass to consume for power. Such is the vision of the Energetically Autonomous Tactical Robot system, although you can call it EATR. "Imagine the robot in the movie *WALL-E*—but instead of just compacting trash, it's combusting trash for electrical energy," says Robert Finkelstein, director of the Intelligent Systems Laboratory in the Clark School of Engineering at the University of Maryland and president of Robotic Technology, the company developing EATR. The robot uses intelligent software to visually distinguish its preferential "food"—wood chips, dried leaves and other vegetative biomass—from nonuseful materials such as rocks, animal matter and metal. Then, using a robotic arm guided by a close-range laser-based guidance system, EATR grabs the vegetation and places it into a hopper leading to an external-combustion engine, which charges an onboard battery.

Such self-directed power generators could revolutionize many military, civilian and even scientific operations, Finkelstein says. "In the next few years every U.S. soldier will use the equivalent of 120 AA batteries every day to power his communications and support equipment," he says. "Using an EATR would greatly reduce the logistical burden of supplying that energy in remote locations, because [the robot] can be out consuming vegetation while the rest of the unit rests." Funding for EATR comes from the Defense Advanced Research Projects Agency.

Veggie-eating robots could also be put in service of the environment. The U.S. Forestry Service wants an EATR mounted on legs, rather than on a Humvee. In that way, it can wander the countryside in search of invasive plant species without leaving treadmarks. "The legs would let it negotiate uneven terrain without damaging that terrain as much as tires or treads would," Finkelstein says.

EATR is currently confined to a stationary test platform at the University of Maryland, but Finkelstein expects a fully mobile, foraging model to be operational sometime in 2012. The prospect sounds creepy, but he believes that a world in which robots are self-sufficient is not only desirable but inevitable. "We already have household robots that can plug themselves into an outlet to recharge without bothering us," Finkelstein says. "This is just the same idea, taken to the next level."

GETTY IMAGES

COMPUTING

Borrowing Nature's Code

Algorithms inspired by Mother Nature help us run our vast digital biosphere *by John Pavlus*

AS COMPUTER SCIENTISTS try and figure out how to manage an increasingly complex digital world, they are increasingly turning for inspiration to Mother Nature. "Life runs on sunlight and information," says Janine Benyus, president of the Biomimicry Institute in Missoula, Mont. A species is constantly evolving to find the optimal way to survive in a particular habitat. "Organisms really do lend themselves to people looking for novel ways to solve information-processing problems," she says.

Dendritic cells, for instance, would seem at first glance to have nothing to do with computer security. But these cells are Paul Reveres of the mammalian immune system, sounding the alarm on invading pathogens. Computer scientist Julie Greensmith of the University of Nottingham in England designed a "dendritic cell algorithm" that detects computer viruses and other malicious code in the same way that our immune systems sense real viruses.

Ants and other social insects have inspired another team of cybersecurity researchers, at Pacific Northwest National Laboratory in Richland, Wash. They have created "digital ants" that can roam a computer network the same way that real ants patrol a nest and quickly swarm around any perceived threat.

Such "bioinspired" algorithms are as old as Turing machines and other classical models of computation, says Melanie Mitchell, a computer scientist at Portland State University. But in a Web-connected world increasingly saturated by "Big Data"—hundreds of exabytes of information are generated every year—code based on nature may be the best way to deal with the load. "There's a huge amount of interest in new collaborations between biological and computer sciences because people are realizing that computation goes beyond what we call 'computers,'" Mitchell explains. "One of the main things that all these biological systems do so well is pattern recognition—pulling signal out of the noise even when they're inundated with information. Brains do it, individual cells do it, insect colonies do it—that's what *all* biological systems do in order to live. And we'd like computers to do that, too."

Photograph by Mark Hooper

HEALTH AND MEDICINE

One Hundred Tests

A cheap diagnostic warns couples against passing rare genetic diseases to their offspring *by Mary Carmichael*

WHAT WOULD YOU PAY to ensure that your children would not be born with disabling or fatal recessive genetic diseases? The obvious answer is "anything," but that's not what most people actually do. Individual screening tests can already identify silent carriers of many single faulty recessive genes—the kind that, when inherited in double (one copy from each parent), can lead to conditions such as cystic fibrosis and Tay-Sachs disease. But almost no one gets tested for all these mutations before conceiving because it would be too expensive—the dozens of tests cost several hundred dollars apiece. Because each potentially dangerous mutation is rare, most people choose instead to play the odds and hope their children will be healthy—a strategy that sometimes results in tragedy.

That isn't necessary anymore, thanks to a simple saliva test made by a company called Counsyl that interrogates the genome for more than 100 disease-causing recessive traits. In one sense, it is like having many traditional, separate tests combined; from a medical standpoint, it yields essentially the same results. But it does so in one go, at a cost of $350.

Traditional tests for recessive variants work by zooming in on specific genomic regions associated with each disease. In some cases, the tests sequence the genes to determine if mutations are present. Counsyl's test, on the other hand, does not involve sequencing. Instead it looks for single-nucleotide polymorphisms (SNPs), tiny typos in the genome where one base has been replaced with another. Some SNPs contribute to disease; others are linked to genes that do. Because SNPs are small, it is cheaper to identify one of them than it is to sequence an entire gene or region of a chromosome, which may consist of millions of bases. The company says the test picks up mutations with greater than 99 percent sensitivity and specificity—that is, it rarely yields false positives or negatives—and has recently begun to publish results to that effect.

So far Counsyl's test has mostly been used by infertility patients. Pasquale Patrizio, director of the Yale Fertility Center, is one of the doctors offering it. (He is also on Counsyl's board of advisers.) He says it is useful in treating couples who have suffered repeated miscarriages but do not know why. In some cases, their losses may turn out to be caused by recessive genes that prevent the fetus from coming to term. "For us it was really a breakthrough to have such a comprehensive screening test," Patrizio says. But of course, many people who carry recessive genes manage to conceive without the assistance of a fertility clinic. They find out about their genetic bad luck later, once their children become ill.

Couples who test positive can plan ahead. They might choose in vitro fertilization, combined with preimplantation genetic diagnosis, to choose embryos that do not carry disease genes. Or they might decide to adopt. Either way, the numbers of ill children in the population at large would drop. Most of the double-recessive diseases are research "orphans"; because they are rare, little money is put into studying them. The Counsyl test is the best present hope for ensuring that fewer people are afflicted with them.

Counsyl may run into some roadblocks on its way to wide use. Some people fear it will open the door to "designer babies." Widespread testing for rare genetic diseases, the argument goes, opens the door to testing for traits that do not indicate disease, such as height and intelligence.

Counsyl's technology can't produce designer babies, however, because it tests for single genes, not the poorly understood, multilevel genetic networks involved in complex phenomena such as intelligence. "There isn't going to be an IQ gene or a musical ability gene," says Harvard University psychologist Steven Pinker, who is advising the company on the ethical issues surrounding personal genomics. Besides, he notes, "if any group would have fears about eugenics it would be the Jews"—yet as a group they have embraced the old, expensive recessive-gene tests because Ashkenazi Jews are more likely to carry some deleterious recessive variants. Pinker, who is Jewish, carries the one that causes familial dysautonomia, an incurable disease that halts neuron development. He found out only when he took the Counsyl test. "My wife is a carrier, too," he says. "We met too late in life to have children, but if we had met a few years earlier we would have been playing roulette." At least now other couples can choose not to.

ANN CUTTING *Getty Images*

Gas from Trash

Modified microbes eat waste and "secrete" fuel

by Matthew L. Wald

TODAY THE FACTORIES THAT MAKE GASOLINE, diesel and jet fuel are huge clusters of steel pipes and tanks that consume prodigious amounts of energy, release toxic fumes, and run on an exhaustible resource, petroleum. But tomorrow they might be microscopic, and they might run on the garbage hydrocarbons that are all around us—the paper of this magazine, scrap lumber from a construction project, or the leaves you raked off your lawn last month.

The trick is to transform the hydrogen- and carbon-based molecules inside these everyday items into a liquid at room temperature, thus making them suitable for use in internal-combustion engines. The most promising efforts involve genetically modifying single-celled organisms to do this conversion work for us. Many of these organisms already build hydrocarbons out of raw materials found in the environment, though not in a way that makes the product available for human use. For example, algae are very good at turning carbon dioxide into fatty acids that can be refined into fuel, but getting the algae out of the water and the fatty acids out of the algae requires so much effort that the process is mostly used for pricey products, such as cosmetics.

A better solution would be to create organisms that directly "secrete" the hydrocarbon. (Commercial firms understandably don't like the more accurate, but less pleasant, "excrete.") With an organism that secretes, "you transform biomass from something you harvest into something that comes from little chemical factories," says Eric Toone, an Energy Department official in charge of making grants to companies with novel biofuel ideas.

Creating genetically modified fuel factories raises other complications, however. Many people worry about engineered organisms finding their way into the environment; vats of single-celled bugs would be almost impossible to contain.

The organisms must also be kept well fed—the question is with what? One approach is to use sunlight. In September, Joule Unlimited, a biotechnology start-up in Cambridge, Mass., won a patent for a gene-altered bacterium that uses sunlight and carbon dioxide to create components of diesel fuel.

Another strategy is to use sugars. When plants capture energy, they chemically lock up that energy in sugars located in the woody portion of the crop. Many researchers are devising ways to recover the sugars from these "cellulosic sources" and turn them into ethanol, which gets a tax credit but has a lower energy density than gasoline and does not run well in conventional cars at high concentrations.

Instead scientists and engineers hope to make more useful chemicals directly from those sugars. In July scientists at LS9, a company in South San Francisco, said they had modified *E. coli* bacteria to enable the organisms to convert sugars into alkanes, a class of hydrocarbon that is identical to many of the molecules produced in standard oil refineries. With a few more tweaks to the genome, the fuel in your tank could even come from sugars pried from the scrap heap.

Photograph by Mark Hooper

HEALTH AND MEDICINE

The Importance of Junk DNA

Biologists continue to be surprised by what was once dismissed as wasted space *by Melinda Wenner Moyer*

GENES MAKE UP ONLY ABOUT 2 PERCENT of the human genome. The rest was for many years ignored as "junk DNA." But over the past decade biologists have come to understand that this space is an incredibly important part of the genetic code, home to a vast unexamined treasure trove of information that controls how genes behave. A more thorough investigation of junk DNA could upend our understanding of the delicate interplay between genes and the environment and could lead to entirely new strategies in medicine's endless struggle against disease.

New examples of junk DNA's importance seem to emerge every few months. Researchers publishing in the September issue of *Nature Medicine* reported that the rare nervous system cancer neuroblastoma may in part have junk DNA to blame; a small piece of RNA made from junk DNA disables a cancer-inhibiting gene in people suffering from the disease. Similarly, those afflicted with a rare form of muscular dystrophy have between one and 10 copies of a particular slice of junk DNA on the end of the fourth chromosome. Junk DNA isn't just relevant for rare diseases, either: this past February a paper in *Nature* linked a region of junk DNA on the ninth chromosome to heart disease risk.

Junk DNA may also help organisms adapt to changing environments. In May 2009 scientists at the University of Leuven in Belgium reported that gene activity on a yeast chromosome is directly controlled by the number of repeats in a section of junk DNA. Because the number of repeats changes more frequently than other stretches of DNA do, this setup allows the organism to evolve more quickly.

So does junk DNA deserve a new, more respectful name? Scientists disagree. Some junk DNA may be obviously useful, but the potential benefits of the rest "may be much more subtle and hard to trace," says Kevin Verstrepen, a co-author of the yeast study. In time, though, one biologist's junk may turn out to be another's jewel.

WORLD CHANGING VIDEOS

Wheelchairs and windmills are among the winners of the 2010 World Changing Ideas Video Contest, sponsored by *Scientific American* and SciVee.tv, the online science video site. The entries showcase innovative ways to build a cleaner, healthier or safer world.

WINNER

The Leveraged Freedom Chair
Idea: MIT Mobility Lab
Video: Amos Winter and the MIT News Office
This wheelchair features a lever-powered, geared drivetrain that takes it over sand, dirt and rough terrain often confronted in developing countries. The judges hailed it as "ingenious, simple and doable now. It could change one person's whole world."

RUNNERS-UP

Sourcemap
Idea and video: Leonardo Bonanni
His crowdsourced Web site tracks the environmental footprint of product supply chains.

Urban Power
Idea: Mark Maynard
Video: Michael Garjian
This backyard wind turbine generates electricity in slow as well as fast breezes.

FIND ALL THE WINNING VIDEOS
www.ScientificAmerican.com/dec2010/worldchanging