



m a g a z i n e

CAPRICA: Birth of the Cylons

JONATHAN LETHEM & P.K. DICK

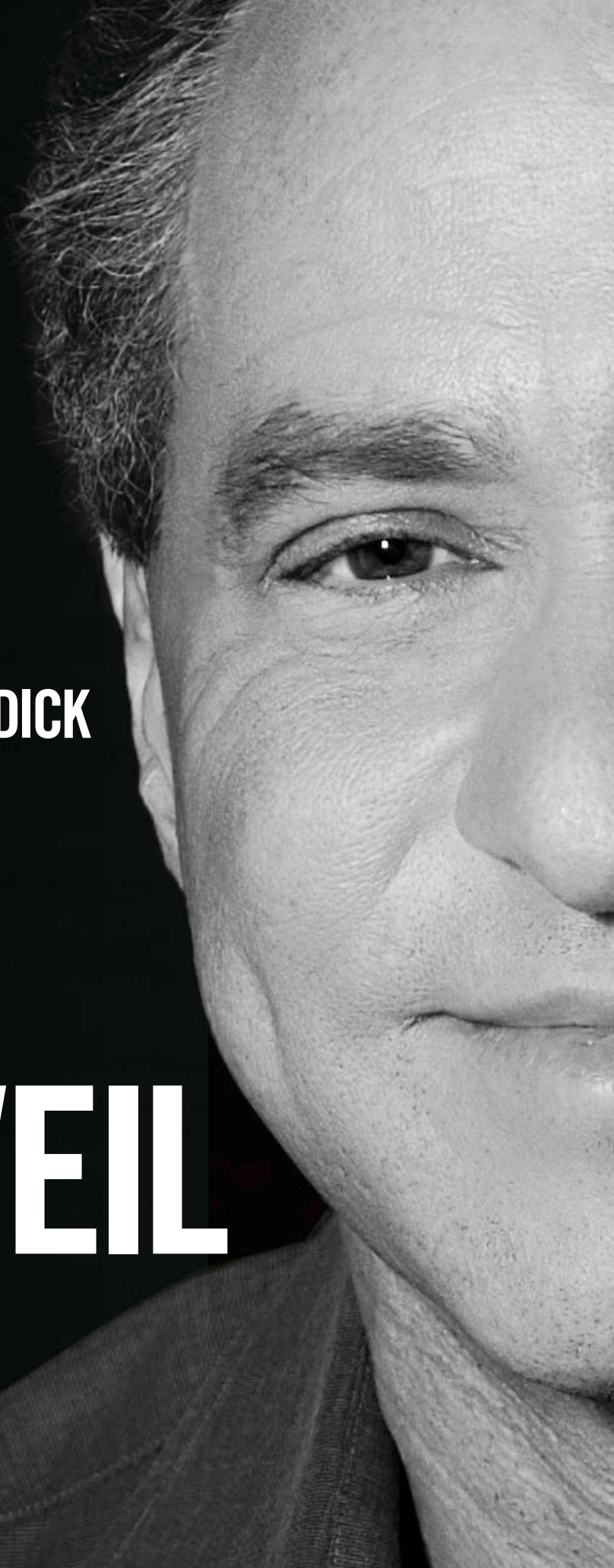
DIY Transhumanism

KURZWEIL

The Ray Kurzweil Interview

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WINTER 2009





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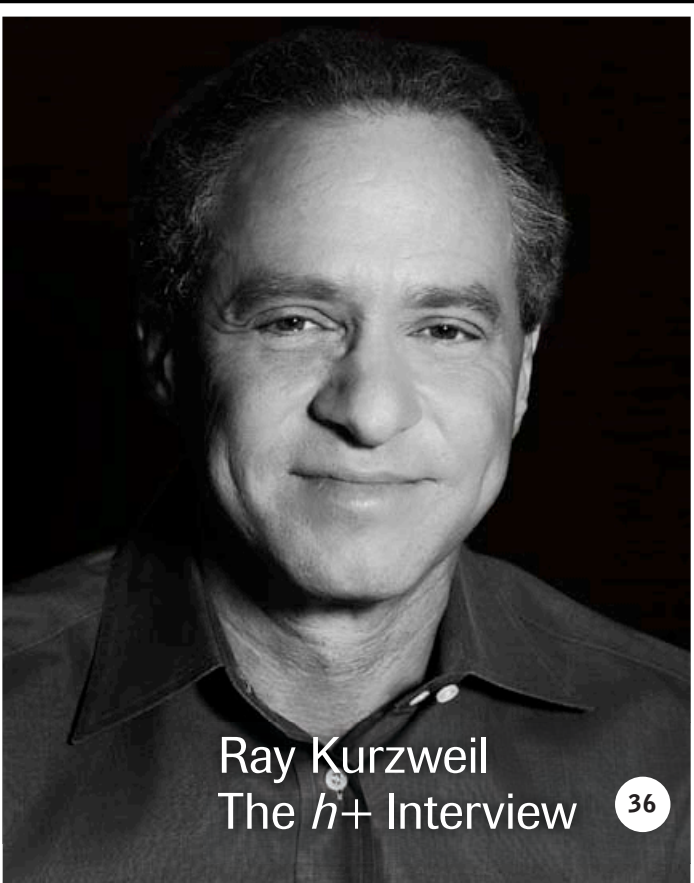
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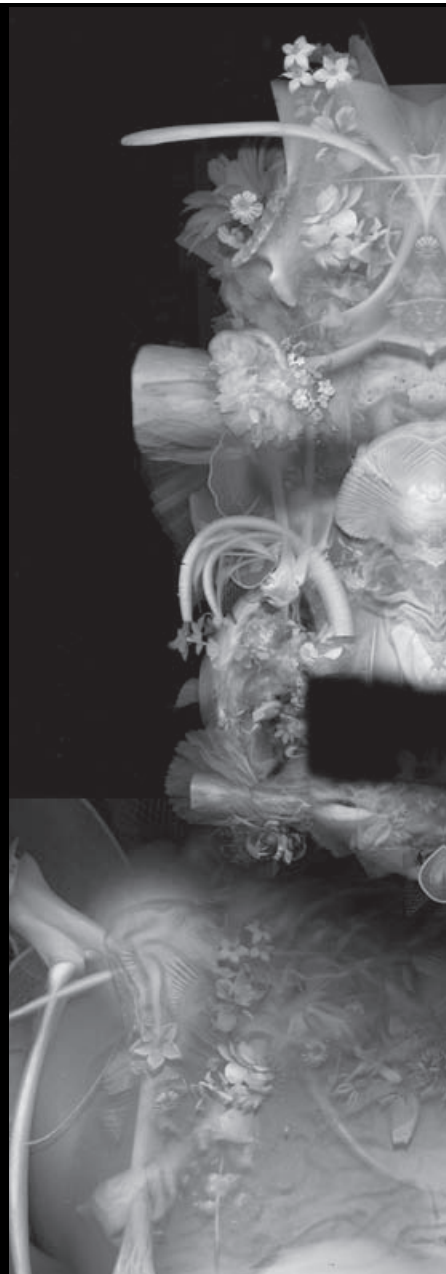
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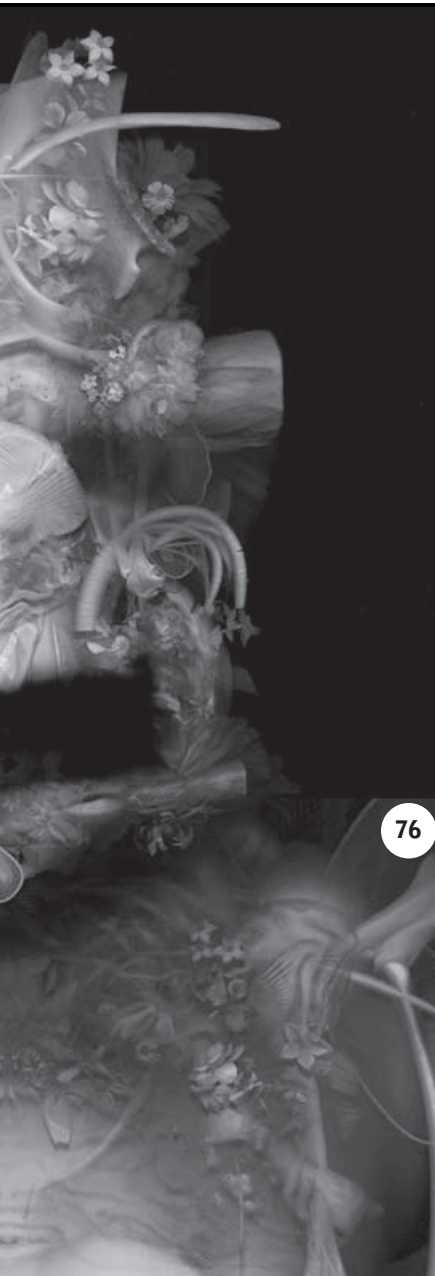
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Opportunities

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to relive, what would
you do differently?*

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actually
having the
opportunity.**



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[®]Studying Extreme Genomes, Technology Review, May 11, 2009

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ON THE COVER

Cover photo of Ray Kurzweil was provided courtesy of:

Kurzweil Technologies, Inc.

DO IT YOURSELFERS, THE NEW NATURALISTS

Before science became so specialized, professors taught courses in the general field of Natural History and their students often went out as amateurs to carry out exploration of the Natural World. These amateurs were referred to as Naturalists.

The seventeenth century's Age of Reason produced some of the greatest Naturalists of all time, including some of our personal heroes — Francis Bacon, Isaac Newton, Descartes, Thomas Boyle, Benjamin Franklin, and Thomas Jefferson. Amateur collectors and natural history entrepreneurs played an important role in building the large natural history collections of the nineteenth and early twentieth centuries, such as the Smithsonian Institution's National Museum of Natural History.

We have reached a stage again, partially because of the proliferation of knowledge via the internet, and partially because the availability of second-hand equipment on eBay, Dove, etc., whereby a new type of amateur scientist/Naturalist is gaining ground. The DIY'ers are setting up labs in their homes and garages and conducting experiments for fun and (hopefully) profit. They work on everything from genetic sequencing, to anti-aging (see "DIYBio: A Growing Movement Takes On Aging"), to synthetic biology (see "Why DIY Bio?"), and robotics. We think this trend is highly encouraging, and portends the rise of many new innovations in these fields.

We will provide references at the end of our articles for organizations which serve as resources and rallying points for such DIY'ers. We would like to encourage "The New Naturalists" to not only push forward, but to strive to get to know their fellow DIYers and collaborate on experiments, ideas, lab space, and equipment. We need orders of magnitude more individuals doing OPEN DIY Bio, SynBio, AI, Robotics, Nano, and Neuro research in order to make the kinds of breakthroughs which will bring about radical life-extension, human-level intelligent machines, and cheap fuels.

Now go out there and get to work!

Best wishes,

Dan Stoicescu & James Clement



Dan Stoicescu
Co-Founder



James Clement
Co-Founder



Ru Sirius
Editor in Chief

OUR MEMEPLEX

RU SIRIUS

Stealing for a moment from Wikipedia (and why not, since this seems to nail it?), a meme is “postulated as a unit of cultural ideas, symbols or practices, which can be transmitted from one mind to another through speech, gestures, rituals or other imitable phenomena.” Richard Dawkins, of course, initially introduced the idea in his seminal book *The Selfish Gene*, in which he postulated that ideas and cultural trends spread in many ways that mimic the evolution of biological organisms.

A memeplex is a belief system: a group of ideas or memes that together form a sort of worldview. One memeplex, for example, may include belief in a coming biblical apocalypse; that abortion is murder; that homosexuality is an abomination; and that government social programs are by nature totalitarian. Rationally, it may seem a random coincidence that these views — moralizing and possibly intervening in social behaviors but not in the economy — have gathered together. Evolutionary memetic theory would argue that each of these views has somehow found it useful for its survival to gather with these other views to form a memeplex

h+ magazine — as a collection of articles and design elements bundled between a front and back page — presents a sort of memeplex. It is a memeplex that, on the whole, recognizes a humanity increasingly altered and/or enhanced by technology. Working within this context, *h+* casts its net wide.

For example, in this edition, the specificity and optimism of Ray Kurzweil rubs up against the complexity and paranoia of novelist Philip K. Dick’s vision of the individual’s plight in a world of neural interpenetration and intelligent machines. Stelarc’s ongoing self-experimentation with the increasing cyborgization of his self in the name of art rubs up against the emergence of Do It Yourself biotechnology for curing diseases and even aging itself. NBIC (Nano Bio Info Cogno) offers a hopeful vision of resolving most major human problems, while a review of a book by Daniel Pink reminds us that all the glitzy corporate newspeak about positive thinking doesn’t mean shit to the huddled and newly unemployed masses.

Taken together — with columns on AI, nanotech, biotech, longevity, self-enhancement, and neurotechnology — the articles collected between the covers of *h+* magazine continue to inform and make a statement on behalf of those who have been drawn into the memeplex sometimes called transhumanism. But beyond reaching our “target audience,” it is our hope that this magazine and its website can reach out and bring more people into the memeplex. Our purpose is not to turn them into fanatics or “true believers,” but to provide an interesting and useful way of understanding a very fast-changing world. And hopefully, we will inspire some to get on with the actual work of changing the human situation for the better.

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From BigDog to PETMAN

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When Death is an Outlaw

By: R.U. Sirius and
Surfdaddy Orca



Love Thy Surrogate Self?

By: Chris Hudak

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NANOSCALE

Robot Arm Places Atoms and Molecules With 100% Accuracy

MICHAEL ANISSIMOV

UNTIL THE MID-1990S, THE TERM “NANOTECHNOLOGY” REFERRED TO THE GOAL OF CREATING VAST ARRAYS OF NANOSCALE ASSEMBLERS TO FABRICATE USEFUL HUMAN-SCALE PRODUCTS FROM SCRATCH IN AN ENTIRELY AUTOMATED PROCESS AND WITH ATOMIC PRECISION. Since then, the word has come to mean anything from stain-resistant pants to branches of conventional chemistry — generally anything involving nanoscale objects. But the dream of a new Industrial Revolution based on nanoscale manufacturing has not died, as demonstrated most vividly by the work of NYU professor of chemistry Dr. Nadrian Seeman.

In a 2009 article in *Nature Nanotechnology*, Dr. Seeman shared the results of experiments performed by his lab, along with collaborators at Nanjing University in China, in which scientists built a two-armed nanorobotic device with the ability to place specific atoms and molecules where scientists want them. The device was approximately 150 x 50 x 8 nanometers in size — over a million could fit in a single red blood cell. Using robust error-correction mechanisms, the device can place DNA molecules with 100% accuracy. Earlier trials had yielded only 60-80% accuracy.

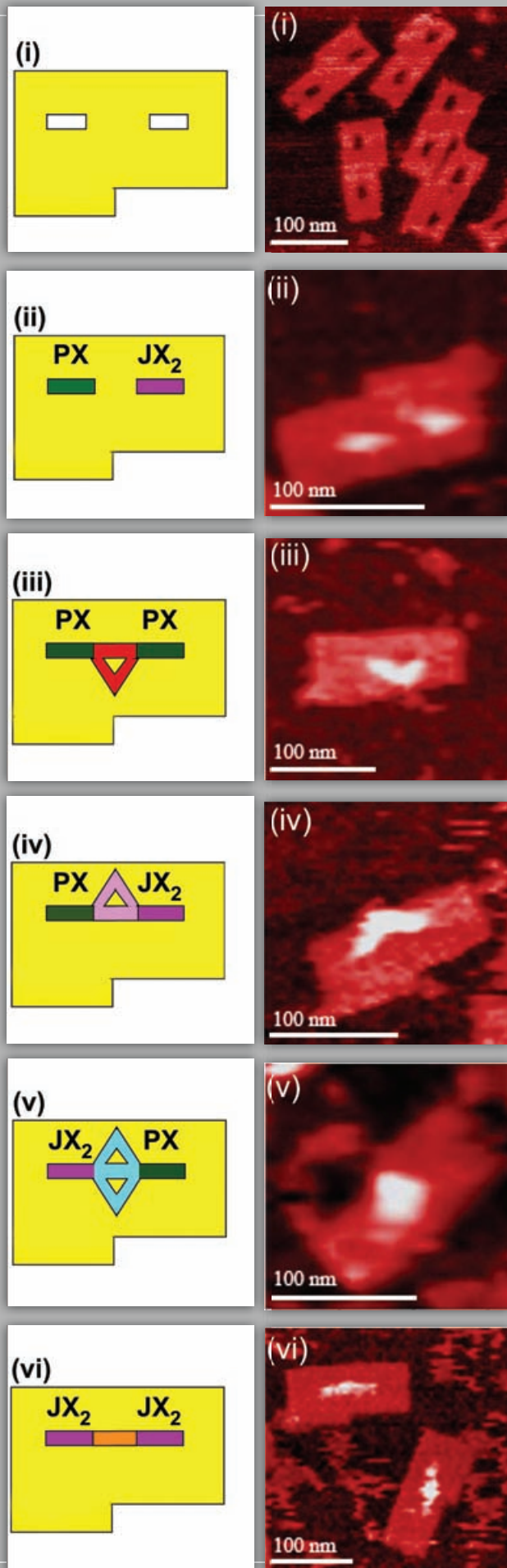
The nanorobotic arm is built out of DNA origami: large strands of DNA gently encouraged to fold in precise ways by interaction with a few hundred short DNA strands. The products, around 100 nanometers in diameter, are eight times larger and three times more complex than what could be built with a simple crystalline DNA array, vastly expanding the space of possible structures. Other nanoscale structures or machines built by Dr. Seeman and his collaborators including a nanoscale walking biped, truncated DNA octahedrons, and sequence-dependent molecular switch arrays. Dr. Seeman has exploited structural features of DNA thought to be used in genetic recombination to operate his nanoscale devices, tapping into the very processes underlying all life.

The advances in DNA nanotechnology keep coming, and many observers are wondering if this will be the path that leads us to the next Industrial Revolution.

Only time — and many more experiments — will tell.

RESOURCES

Ned Seeman's Home Page
<http://seemanlab4.chem.nyu.edu/>



A

B

Schematics (a) and Atomic Force Micrographs (b) of the Origami Arrays and Capture Molecules. Panel i of (a) illustrates the origami array containing slots for the cassettes and a notch to enable recognition of orientation; the slots and notches are visible in the AFM in (b). Panels ii show the cassettes in place; the color coding in (a) used throughout the schematics is green for the PX state and violet for the JX₂ state; the presence of the cassettes is evident in the AFM image in (b). Panels iii illustrate the PX-PX state which captures a triangle pointing towards the notch in the schematic (a) and in the AFM image (b). Panels iv illustrate the PX-JX₂ state (a), containing a triangle that points away from the notch, which is evident in the AFM image (b). Panels v illustrate the JX₂-PX state which captures a diamond-shaped molecule (a); its shape is visible in the AFM image (b). Panels vi show the linear molecule captured by the JX₂-JX₂ state, both schematically (a) and in the AFM image (b).

EEG with BCI is A-OK!

MICHAEL ANISSIMOV

THE MOST EFFECTIVE BRAIN-COMPUTER INTERFACES (BCI) — LIKE THE KIND USED BY RHESUS MONKEYS IN THE FAMOUS UNIVERSITY OF PITTSBURGH EXPERIMENTS TO FEED THEMSELVES ZUCCHINI USING A ROBOT ARM CONTROLLED ONLY BY THEIR THOUGHTS — leave something to be desired, if we're going to, one day, use them for human enhancement. They involve microelectrodes embedded directly into the brain. The process of implanting them requires exploratory probing, which can burst blood vessels and cause stroke-like symptoms or other neurological problems. It's not a procedure you'd want to undergo unless you were completely paralyzed and willing to risk your life for a chance at communicating with the outside world.

For those who don't like holes in their heads there is EEG (electroencephalography), which uses electrodes placed on the surface of the scalp to measure the brain's electrical activity. Until recently, it appeared as if the potential of EEG was limited as an advanced BCI technology. But with the introduction of faster computers and better machine-learning algorithms to eliminate noise and detect meaningful neural signals through the skull, researchers are again looking to EEG for advanced BCI.

Over the past few years, numerous proof-of-concept experiments have shown that people unable to move can use simple EEG-based BCI systems for point-and-click, robot control, and even spelling at rates as fast as 20 words per minute. An article titled "Bridging the Brain to the World: A Perspective on Neural Interface Systems," by John P. Donoghue and published in *Neuron*, gives an overview of some of the most exciting recent developments in both EEG and more invasive systems. In 2009, DARPA budgeted \$4 million to investigate the possibility of "computer-mediated telepathy": systems that read words in neural signals before they are even spoken. If progress like this continues, keyboards could become as anachronistic as typewriters are today.

RESOURCES

Bridging the Brain to the World: A Perspective on Neural Interface Systems, John P. Donoghue, *Neuron*
[http://www.cell.com/neuron/abstract/S0896-6273\(08\)00897-0](http://www.cell.com/neuron/abstract/S0896-6273(08)00897-0)

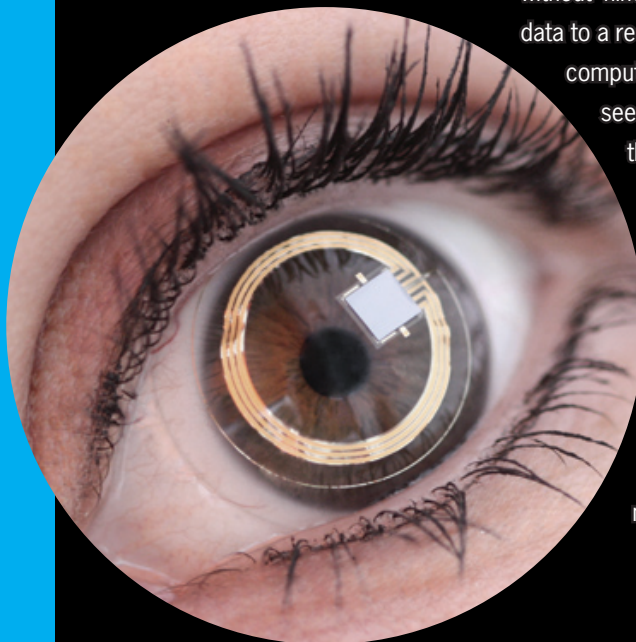


TRIGGERFISH MONITORS YOUR EYES

KRISTI SCOTT

IF YOU HAVEN'T BEEN FOLLOWING ALONG WITH ALL THE ADVANCES IN CONTACT LENSES, YOU ARE MISSING OUT. Efficiency is a top priority in our modern lives and doctors and patients are no exception, particularly when it comes to diagnosing and treating illness. When Grandma, Grandpa, or Billy the kid down the street has glaucoma, they want to have their vision treated as quickly and accurately as possible. And if all this can be packaged with a hint of coolness, that wouldn't hurt.

SENSIMED has found a way to make glaucoma treatment and monitoring quicker, better, and most importantly, more accurate. The Triggerfish allows ophthalmologists to do something that was previously cumbersome or impossible. Patients with glaucoma wear the slightly futuristic Triggerfish contraption which monitors the eye without hindering eyesight. It transmits the data to a recorder and then to the doctor's computer, allowing the doctor to see exactly what went on with the patient's eye throughout the day. With this constant monitoring, the doctor is better equipped to treat the patient and their individual needs. And not only do they look awesome, it's called Triggerfish, maybe to increase its likelihood of being mistaken for an indie band.



RESOURCES

Sensimed
<http://www.sensimed.ch/S-Trig-solution.htm>

PROJECT OFFSET

Creates Graphical Magic

EVAN NEWTON

THERE AREN'T VERY MANY GAMES TODAY THAT, GRAPHICALLY, GIVE ONE GOOSE BUMPS. While movies like James Cameron's *Avatar* or Peter Jackson's *Lord of the Rings* have graphical effects that appear absolutely real, many wonder if games will ever achieve that level of detail.

Now get ready for Project Offset. This little-known development team, owned by Intel, is building a game engine that may make you believe that the richness of reality in the virtual world is not so far away.

Videos posted on their website (see Resources) show a variety of graphics engine experiments. You will find video footage that ranges from the detailed facial expressions of an ogre to a meteor shower blasting through ancient stone pillars. Compared to contemporary movie CG, Offset's footage doesn't look all that

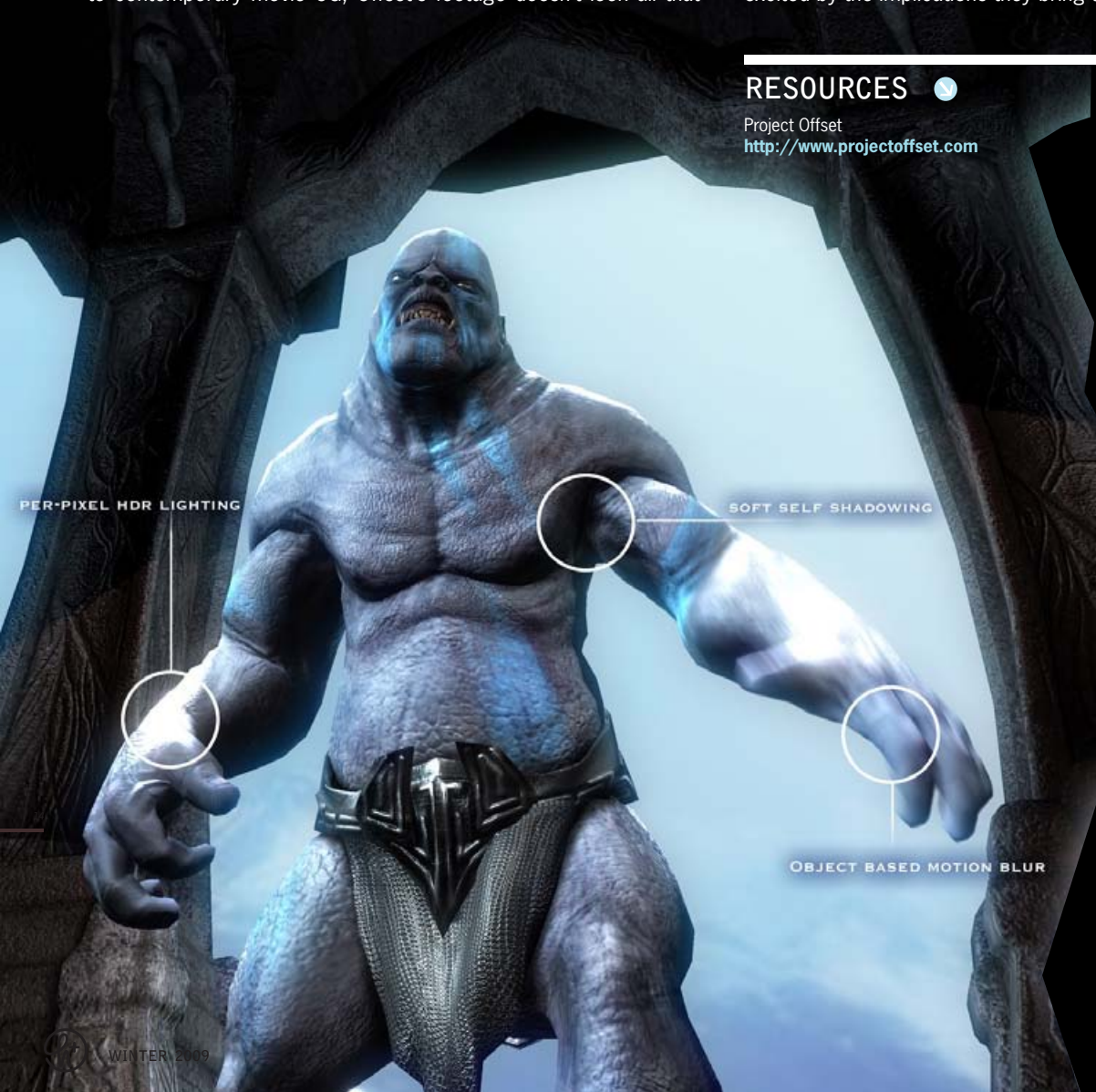
impressive at first. But considering that these animated graphics were rendered in real time by a dynamic game engine, unlike animated frames that undergo lengthy rendering processes in a motion picture, the short clips are jaw-dropping..

The Offset engine isn't the only one in the race to develop a visually rich real-time game graphics engine, but they're the newest on the scene. Companies like CryTek, Epic, and ID Software have all been doing this for years, working steadily toward the photorealistic holy grail. Offset sets itself apart by accomplishing the most difficult lighting, shading, and graphics effects in very simple fashion. Their video clips show artists pulling together 3D elements like a jigsaw puzzle, making movie-level CG look as easy as following a recipe.

Offset has yet to officially announce a game title, but we are excited by the implications they bring to the virtual world.

RESOURCES

Project Offset
<http://www.projectoffset.com>



ONLIVE:

Sign of a Revolution, or Dead Before Release?

EVAN NEWTON

IN RECENT YEARS, SONY, NINTENDO, AND MICROSOFT REINVENTED GAME CONSOLES WITH THE PS3, WII, AND XBOX 360. The new consoles enticed game studios away from the chaos of PC game development by providing a mass market for advanced games on low-cost, standardized platforms.

However, as great as this strategy was from a business perspective, it is still susceptible to the passage of time. Technology that was considered pretty decent several years ago has now locked games into a hardware cage, preventing true innovation that is the heart of the developer's survival code.

Onlive Inc. holds a new silver bullet for the original hardware vs. accessibility issue — killing it with a pseudo cloud computing strategy. Currently in beta, it solves the problem in a new way, by running the games on a state-of-the-art server cluster. The server streams the video of the game through a small receiver attached to your TV or computer. The server streams the video of the game through a small receiver attached to your average TV, Mac, or PC. As long as you can stream decent video with a 1.5mbps connection or better, you can run Onlive, playing games at the highest possible quality. The idea is mind-blowing: Using your Grandma's 5 year old Mac? Not a problem. You can play anything you want.

Onlive critics, however, have raised an important point. The controller is in your hands — and if you press a button from your couch and the signal has to go several hundred miles and back before something is seen on screen... wouldn't that be too slow for a gamer?

CEO Steve Perlman insists that the turnaround time is near-instantaneous, and he seems pretty confident. Onlive's pending release is scheduled for this winter. Steve is a visionary, and like most visionaries, he will either re-invent the game industry or he will fade away like many before him.

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RESOURCES

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<http://www.onlive.com/>

TOP 5 TECHNOLOGY PANICS of 2009

THOMAS S. MCCABE



IMAGES COURTESY OF APPLE

#4 ROBOTS ATTACK

THE TECHNOLOGY: : Workplaces, particularly factories, are becoming increasingly automated. A large percentage of consumer products are never touched by human hands before they are bought — they are manufactured, assembled, and distributed entirely by robots. This revolution in production has allowed all of us to lead lives of comparative luxury, with toys undreamt of by nineteenth-century kings.

THE PANIC: In April, a Swedish worker was nearly killed by a factory robot while attempting to perform maintenance on it. He thought that the robot — a machine used for lifting heavy rocks — was turned off, until it grabbed his head and attempted to crush him with its pincer-like robot arms. He managed to fight it off, but only after suffering four broken ribs and a number of bruises. Can armies of vengeful Terminators, bent on the annihilation of the human race, be far behind?

THE REALITY: Factory work is dangerous and it always has been, ever since the Industrial Revolution began two hundred years ago. Indeed, most workplaces have actually gotten much safer over the years. As any student of nineteenth-century history will tell you, there used to be no safety regulations at all and people routinely had body parts crushed by machines without warning labels or safety guards. Robots themselves have been a tremendous help to us, doing the dirty and dangerous work so a human doesn't have to. Unsurprisingly, the press doesn't report on people who don't get hurt.

#5 EXPLODING iPods

THE TECHNOLOGY: Apple iPods and iPhones contain a rechargeable lithium-ion battery, one of the most efficient batteries yet developed. A lithium battery can carry more than three times the energy of an old-fashioned nickel-cadmium battery.

THE PANIC: Lithium is a pretty reactive element, and if it short-circuits, a lithium-ion battery can heat up rapidly. This can cause iPhones, iPods, and other electronic devices to explode — the heat makes the display shatter, turning your cool new touchscreen into a blizzard of dangerous shrapnel. It can also make anything nearby catch fire; one Dutch man's iPhone even burned a hole right through his car's seat. Every iPhone out there could really be an incendiary bomb in disguise, waiting for the right moment to go off and wreak havoc on techno-geeks and music lovers the world over.

THE REALITY: While lithium batteries have been known to do some unpleasant things, these incidents are, on the whole, incredibly rare. Only a handful of malfunctions have been reported, out of tens of millions of Apple products sold worldwide every year. You're probably more likely to win the lottery or get struck by lightning than to have your phone explode. The Consumer Product Safety Commission investigated the matter, and they have found only fifteen incidents nationwide, none of which caused serious injury. They concluded that the risk of an accident is "very low."

#3 "SEXTING"

THE TECHNOLOGY: Cellphones with texting capability, a camera, and a wireless Internet connection have become increasingly ubiquitous over the past five years, with tens of millions in use in the US alone.

THE PANIC: Studies show that millions of people are using these cellphones to take sexually explicit photos of teenagers, and distribute them to their friends. And the primary allure of the cellphone — its portability and user friendliness — makes it extremely easy to get and send pornographic images of anyone. Are we in the middle of the biggest child porn epidemic in our nation's history?

THE REALITY: The vast majority of these "child pornographers" are... the teenagers themselves. Most of the photos are of themselves, their boyfriends, or their girlfriends. And the recipients of the photos are almost always the other children at school. Teenagers have always been more sexually active than their parents and teachers would like to think, and the most recent generation is no exception. However, under child pornography statutes, it makes no difference if you're a teenager, or even if they're pictures of yourself. It's still a crime, and a number of teens have been brought up on felony sex offender charges just for having such photos stored on their phones. The Vermont legislature has recently introduced a bill that would legalize these photos as long as the participants are willing and between the ages of 13 and 18, hopefully bringing some much-needed sanity to this panic.

#2 BOMBING THE MOON

THE TECHNOLOGY: NASA's LCROSS spacecraft, which blasted off in the general direction of the Moon this June, with a mission to confirm the presence of ice in the Moon's shadowy polar regions.

THE PANIC: LCROSS will investigate the Moon, not by landing on it, but by doing something rather more spectacular: smashing a projectile into the Moon's polar region, and then analyzing the resulting debris plume. Scientists predict that the plume will even be visible from Earth, with a reasonably sized amateur telescope. When LCROSS launched, there were a number of reports about how NASA was "bombing the Moon" in violation of the Outer Space Treaty. Conspiracy theorists even claim that it's a ploy by the government to antagonize a secret alien base on the far side.

THE REALITY: NASA's "missile" isn't a bomb, an explosive, a nuke, or indeed anything special at all — it's just an old, burnt-out rocket stage without any fuel left. It's tiny compared to the Moon: the rocket stage weighs around two tons, while the Moon weighs in at a slightly heftier 73,477,000,000,000,000 tons. And, while it is a violation of international law to put nuclear weapons in space, there's no law against crashing a spacecraft into a celestial body. It's been standard practice for almost fifty years, from the early days of space exploration in the 1960s, to last June, when Japan's Kaguya probe ended its life with a bang.

The Panic: Once the machine is released, it will chomp up everything in its path — plants, animals, even the bodies of fallen soldiers.



IMAGE COURTESY OF ROBOTIC TECHNOLOGY INC.

#1 FLESH EATING ROBOTS

THE TECHNOLOGY: Cyclone Power Technologies' "Energetically Autonomous Tactical Robot," or EATR, a steam-powered robot developed under a grant from the Pentagon and intended for use by the military.

THE PANIC: Engineers hope that EATR will be able to power itself for months at a time by roaming around the battlefield autonomously and consuming "organic matter" to feed its engine. Once the machine is released, it will chomp up everything in its path — plants, animals, even the bodies of fallen soldiers. It will relentlessly consume to sate its insatiable thirst for fuel. It even comes with a chainsaw, perhaps to help it slice us up into more manageable pieces, before it feasts upon our flesh?

THE REALITY: After the rumors started making their way around the Internet, EATR's designers stepped in to clarify: the "flesh-eating robot" will consume vegetable matter only, and it comes equipped with a suite of sensors and computers to help it determine whether the things it comes across are animal, vegetable or neither. After all, desecration of the dead is against the laws of war and plant matter is a much better fuel source anyway.

There are a lot more bushes to feast upon than human bodies.

RESOURCES

Exploding iPods
<http://tech.yahoo.com/blogs/patterson/55962>

Robot attacks Swedish factory worker
<http://www.thelocal.se/19120.html>

Sexting
<http://en.wikipedia.org/wiki/Sexting>

Thomas McCabe is a mathematics student at Yale University and a research associate at the Singularity Institute for Artificial Intelligence.

Bombing the Moon
<http://www.scientificamerican.com/article.cfm?id=nasas-mission-to-bomb-the-moon-2009-06>
<http://www.hplusmagazine.com/articles/air-space/crashing-moon>

The "Flesh Eating Robot"
<http://www.guardian.co.uk/technology/2009/jul/19/robots-research>

AI

The Chinese Singularity

BEN GOERTZEL

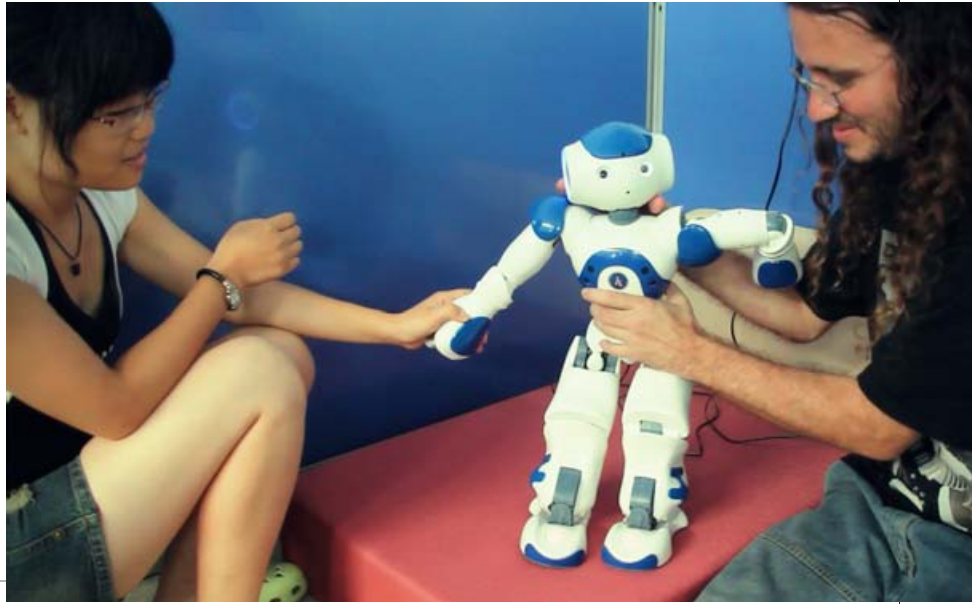
PHOTOS BY RAJ DYE

Dr. Hugo de Garis, the father of evolvable hardware and a redoubtable AI researcher, moved to China several years ago, and is now leading the Artificial Brain Lab at Xiamen University. He is convinced a Singularity in the vein of Vinge and Kurzweil is likely to occur later this century — and that China is the most likely place for human-level Artificial General Intelligence (AGI) and the other critical technologies underlying the Singularity to arise.

As Hugo puts it: “China has a population of 1.3 billion. The US has a population of 0.3 billion. China has averaged an economic growth rate of about 10% over the past 3 decades. The US has averaged 3%. The Chinese government is strongly committed to heavy investment into high tech. From the above premises, one can virtually prove, as in a mathematical theorem, that China in a decade or so will be in a superior position to offer top salaries (in the rich Southeastern cities) to creative, brilliant Westerners to come to China to build artificial brains — much more than will be offered by the US and Europe. With the planet’s most creative AI researchers in China, it is then almost certain that the planet’s first artificial intellect to be built will have Chinese characteristics.”

Is he right?

(Full disclosure: I spent a month at Hugo’s lab in Xiamen this summer, and Hugo and I recently received word that the Chinese National Science Foundation has approved a grant to fund his lab to pursue some of our joint research on cognitive robotics, aimed at enabling the Nao humanoid robot to learn, reason and communicate in English and Chinese. I’ve even debated making a move to Xiamen myself. So I can’t claim great objectivity on this topic... and indeed it was with some personal fascination that I presented the question that titles this article to a variety of individuals involved with AI research and software technology in China.)



If the Chinese fund an experimental Singularity-relevant project, and it yields sufficiently impressive results to excite the “power circle,” dramatic things might happen.

My first destination on my quest for wisdom about the Chinese Singularity was a visit to Temple University AGI researcher Dr. Pei Wang, a long-time US resident who visits his home country of China each summer. Pei expressed a milder version of Hugo's sentiments: “I think China is among the most likely places (though not the only one) where the first truly/generally intelligent system will be created... Given the population size and education level of China, its chance is quite large... there are profound intellectual resources to make AGI happen.”

Pei points out that “one of China's major advantages is the lack of strong skepticism about AGI resulting from past failures.” The US and Japan have spent large sums on AI research in past decades with disappointing results, and as a consequence are particularly skeptical of AI relative to other research areas. China never had that experience, and is making its first serious foray into AI in an era blessed with more powerful computers and deeper knowledge of cognition and computer science. Pei also noted that the research community in China tends to favor incremental research over riskier attempts at paradigm-shifting progress. This seems to have held true in the AI field, so far: Chinese AI researchers have made important innovations in multiple areas such as fuzzy systems, genetic algorithms, machine translation and spatiotemporal logic, but haven't yet launched any AI revolutions.

Dr. Min Jiang, an assistant professor in Hugo's Artificial Brain Lab specializing in AI cognition and formal logic, indicated a factor counterbalancing this conservatism: “In many fields, China today is a follower. But maybe this is part of the reason China wants to spend research money on innovative projects. It can be considered a ‘tuition fee’ and an investment in the future. Even if some projects fail, we can learn lots of things from the experience.” The funding Hugo's lab has received seems to be evidence for this perspective. And this spirit of experimentation is precisely what will be needed to create AGI and other radical Singularity-enabling technologies.

Min offered further insights into China: “I think the most important advantage (or disadvantage) is the [political and governmental] system. If the power circle thinks a project is crucial, we do that with all the strength of the country: for example — A-bomb, spacecraft.” Another example is the First Solar initiative launched in September 2009, a 10-year project aimed at blanketing 25 square miles of Inner Mongolia with solar panels, generating 2 billion watts of power, enough to light up three million homes. When the Chinese government really wants to do something, they think big.

This combination — a willingness to experiment with new ideas, and a willingness to put massive funding behind selected initiatives — is intriguing. If the Chinese fund an experimental Singularity-relevant project, and it yields sufficiently impressive results to excite the “power circle,” dramatic things might happen. This is exactly what Hugo has in mind with his “CABA” proposal, which he presented at the Oriental Technology Forum in Shanghai this October: “What I propose is that the Chinese government should create a ‘CABA’ (Chinese Artificial Brain Administration) over the next 5-10 years, consisting of thousands of scientists and engineers to design artificial brains for the Chinese home-robot industry and other applications. CABA would do for artificial brains what the CNSA (Chinese National Space Administration) does for space, i.e. it employs thousands of scientists and engineers to design and control rockets for China's space applications.” Wildly ambitious? Perhaps. But so is covering 25 square miles of Mongolia with solar panels.

I found Western entrepreneurs operating technology firms in China to be the most skeptical voices regarding the possibility of a Chinese Singularity. I interviewed two such individuals in depth. Both are Singularity optimists, and both were concerned that their remarks be kept anonymous, to avoid potential harm to their Chinese business work. Both put the odds of a Chinese Singularity launch at less than 5%, and they gave similar reasons: they consider Chinese engineers on the whole



“below average in problem solving and creative thinking,” “very conservative, unwilling to considering doing anything that is not established practice.” One of them also noted that “Local above-average talent insists on working for American, European, Japanese, or Korean (in that order) firms rather than Chinese firms. So, the best chance for AI breakthrough here is with a foreign research effort.”

I have heard this complaint about a “lack of creativity” before, but it runs counter to my own experience at Xiamen University. There, while I’ve encountered some conservatism, I’ve also met some extremely creative and individualistic young professors and students. In my experience, researchers in China are just as creative as anywhere else — but there are subtle sociocultural issues at play, with different implications in the corporate and university contexts. Chinese culture, in its current incarnation, tends to spawn social structures that suppress rather than encourage the expression of personal creativity. It also doesn’t tend to support Western-style teamwork. There’s a proverb to the effect that “a lone Chinese is as powerful as a dragon; but three Chinese together can’t match a bug.” These are real issues, yet ones that can be worked around with care, using different methods depending on the context.

It must be understood that, regarding personal creativity as other matters, Chinese history has been powerfully cyclical. In his controversial recent book *1434*, Gavin Menzies argues that the Italian Renaissance was launched by a fleet of Chinese ships that sailed to Italy and distributed advanced knowledge including encyclopedias from which Leonardo da Vinci indirectly derived many of his celebrated illustrations of mechanical devices, flying machines, and so forth. Whether or not this thesis is true, Menzies presents compelling evidence regarding the advanced level of Chinese engineering and science during that time period, before a change of administration in Beijing ended the period of wild invention and exploration and brought a new era of conservatism to China. My point is that Chinese “cultural DNA” has plenty of innovation and creativity in it, and one must be

careful to distinguish stable characteristics of Chinese culture from cyclically-shifting ones. The pendulum of Chinese culture swings in a wide arc.

In the corporate software development context, one strategy for working around counterproductive cultural tendencies and bringing out Chinese creativity is the adoption of “agile” software development methods. A 2008 article in *InfoQ* summarized the experiences of five Chinese software firms who adopted the “Scrum” development methodology — a very dynamic teamwork-based approach to making software that requires constant adaptive creativity on the part of the participants. Three found the approach successful; two did not. Those who didn’t find success complained that the development teams or managers understood the formalities but not the essence of the agile approach — the cultural disconnect was too great. And this is surely related to the reason why Chinese universities are so eager to bring in Western professors, like Hugo de Garis. It’s not just the research ideas the Westerners bring, it’s the different intuitions, experiences and habits regarding directing a research lab and a research program. In this sense Hugo’s emphasis on China bringing “creative brilliant Westerners ... to China to build artificial brains” may be savvy. If China can leverage its economic growth and openness to innovative research directions to recruit a sufficient number of Western research mavericks, then powerful things may happen. Imagine a situation in which every Chinese city has a number of labs, focused on Singularity-relevant technologies, in which Western research leaders are hard at work bringing young Chinese scientists up to speed on Western ways of doing creative team R&D. In this quite plausible scenario, the prospect of a Chinese Singularity doesn’t seem so farfetched.

As well as AGI, it’s also worth noting the differences between Western and Chinese attitudes on another radical future technology: life extension. Westerners tend to greet talk of immortality with skepticism or even moral disapproval — after all, the standard Christian story is that God wants us to die and go to heaven. But the Chinese memplex is stocked with thousands of years of Taoist tales of immortality. Traditional Chinese methods of

achieving immortality are often arduous; for instance Taoist Yoga has techniques involving lifelong celibacy and meditation focused on eventually giving birth to one's immortal self through the top of one's head. Many Chinese would be very open to immortality or life extension pills that could deliver the same benefits at lower cost and with greater reliability. So far this attitude has not translated into dramatic funding for life extension research, but the potential certainly is there — as is the economic motivation, since China will face a severely aging population around 2025-2030, similar to what Europe is facing now.

David Chambers of the Methuselah Foundation, discussing the 2006 Tomorrow's People Forum at Oxford University, compared Western and Chinese attitudes on life extension technology as follows: "Europeans don't look forward to a better future — but rather a managed version of the present. There's a distrust of revolutionary ideas.... [But] while Euros and Americans might have their various hang-ups about the ethics and implications of the new biology, China doesn't. Pei Xuetao, of the Beijing Institute of Transfusion Medicine [a leading institution in stem cell research and regenerative medicine], made it very clear [in his talk at the Tomorrow's People Forum] that China is open for business." Alongside research aimed at curing cancer and other diseases, Xuetao and his colleagues have made important discoveries involving cellular senescence and apoptosis, working toward an understanding of the genetic networks that make us age.

These differing attitudes toward immortality may be connected with attitudes toward AGI. Western skepticism about AI may not be entirely due to prior AI funding fiascos, but may also be tied to deep-seated cultural issues. The same Christian memes that tell us we're supposed to die and go to heaven also tell us that machines can never truly be conscious because they lack an immortal soul. Yet Changle Zhou, the dean who supervises de Garis's Artificial Brain Project, regularly refers to Hugo's work as the "Conscious Robot Project." Chinese culture has little of the West's subliminal resistance to thinking machines or immortal people and this cultural difference may manifest itself in the next decades in subtle ways.

Another cultural difference to remember is that extrapolating progress in China by plotting linear or exponential curves often doesn't make sense. Progress in China often matches the biological notion of "punctuated equilibrium" — long periods of relative stability punctuated by surprising and sudden changes. The Cultural Revolution and the recent shift to market-oriented "Socialism with Chinese characteristics" illustrate this phenomenon — as do the sudden initiation and cessation of Chinese global seafaring in the 1400s, and dozens of other instances in China's long history. It's easy to imagine a single technological breakthrough catalyzing one of these sudden shifts in the near future. It could be intelligent robotics, it could be life extension or something else wild and unforeseen. While this article was in the editing process, I heard some fascinating talk about a very substantial

amount of funding being allocated by Beijing to a project called the "head brain instrument" (three Chinese characters) intended to improve neural function and hence accelerate human learning. I don't know enough about it to assess the viability but if it works out, it sounds like the sort of thing that could punctuate any nation's equilibrium!

The possibility of a Chinese Singularity may strike fear into the hearts of American nationalists or Eurocentrists, but it's not clear that it will make a big difference which nation makes the crucial breakthroughs. In today's scientific world "information wants to be free" — and since the most likely path to a Chinese Singularity involves collaboration of Chinese and Western researchers, the odds of an insular Chinese Singularity uniquely serving Chinese national interests seem fairly low. The work in Hugo's lab in Xiamen centers on open-source software development. It's evolving cooperatively

The Chinese government should create a Chinese Artificial Brain Administration, consisting of thousands of scientists and engineers to design artificial brains for the Chinese home-robot industry.

with work done by AI coders outside China and it's delivered freely to the international research community.

So what's the verdict? Given China's lack of hang-ups about AGI and life extension, its powerful economic growth, its large population of smart and hard-working young scientists, and its eagerness to import Western research leaders — will the Singularity be launched in China? I'll give the last words to two creative young scientists from Xiamen University.

Min Jiang made a statement I found intriguing given China's ongoing obsession with its 5000-year-old culture: "Today's China is a young boy, and as you know, eighteen is the age full of curiosity and fantasy about the future!"

And Ruiting Lian, a PhD student at the Artificial Brain Lab focused on multilingual natural language comprehension, generation and dialogue, cut to the chase more directly: "In China, the best answer to every question is 'maybe.'"🌀

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RESOURCES

Wu Yulu's funky robots

<http://gargles.net/chinese-farmer-sells-his-robots/>
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The Nao robot in the Artificial Brain Lab at Xiamen University

<http://novamente.net/example/>

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and some of their work on aging...

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Agile software development in China

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Gavin Menzies' controversial history of Chinese exploration and invention

<http://www.1434.tv/>
<http://www.1421.tv/>



FOREVER YOUNG: I'm Serious as Cancer

8 NEW RULES ARE LIFE ENHANCERS

ALEX LIGHTMAN

I'm writing the Forever Young columns for transhumanists who want to live longer than the longest-lived human to date. Frenchwoman Jeanne Calment was born in 1875 and died in 1997 at the "old age" of 122 years and 164 days.

Despite the apparent odds against outliving the oldest documented person, most transhumanists I know expect to live to 150. Just last night, Eric Gradman, a computer scientist who does circus acts and fire-twirling, told me, "I will live to 100, worst case, but intend to live until 250." Prof. Gregory Benford, chairman and co-founder of longevity supplement company Genescient (featured in my Forever Young column in *h+* issue #3), stands firm on his claim that he can tell me, at age 47, how to live until 150. I've known Greg for over 10 years, and he's never been wrong, so I choose to believe him.

However, if 150, instead of 75, is the new span of life, then we need to get through the toughest rite of passage. The Massai boys of Kenya had to face a lion to become men, and the Spartan boys had to face a wolf. We who would double our life-spans have to survive a similar trial — facing down our own cells, preventing them from becoming excessively feral and fertile through what I will call "new adolescence." We face this passage during that period from the mid-40s to the mid-60s when we are most likely to get cancer. There's

bad news and good news. The bad news is that cancer accounts for 23-25% of all deaths in the US (vs. about 26% for heart disease, the #1 cause) and will kill 292,540 men and 269,800 women in 2009, according to the American Cancer Society. The good news is that if you can survive "new adolescence" without dying of cancer, you are less likely to die of cancer with each year that you add. A study of centenarians revealed that fewer than 4% died of cancer.

The other good news is that if you are reading this magazine, which probably requires a higher education and IQ level than just about any other magazine in Barnes & Noble, you have the ultimate cancer fighters: curiosity and ability to process complex and weird information. Cancer is basically what happens when your cells are copied with errors before they can get repaired — and then they grow out of control. As a smart person, you can employ useful information to reprogram yourself. I'm not a doctor, and I'm not giving health advice, so follow these eight New Rules at your own risk. On the other hand, most people are aware that they need to look out for themselves.

To help spark new conversations, I offer these Eight New Rules for Cancer:

1. Cancer is a result of many things, the most easily treatable of which is information deficiency.

It's important to read widely about cancer. *Cure* magazine (see Resources) focuses on cancer treatment. As I write this the *Cure* website has a feature article about sex toys, so it's not as grim as you might think. The cancer related sections in Aubrey de Grey's *Ending Aging* (pgs. 274-308) and Ray Kurzweil's *Transcend* are the minimum an *h+* reader should read and grok.

2. Your success in staying cancer-free could be worth a fortune.

According to the Milken Institute, curing cancer is worth \$50 trillion. If you come up with a program that works, you will be part of the solution and might even be able to save lives of friends as well as strangers... and make money from both. Plus, 60% of US bankruptcies are from health care bills, so stay healthy.

3. Get thin, as if your life depends on it, because it does!

Essential body fat is 3-5% for men and 9-11% for women. The average American man has 17-19% body fat and the average American woman has 22-25% body fat. Greater fat correlates with greater insulin resistance (morbid obesity = much greater likelihood of getting diabetes). The more insulin resistance you have, the more insulin your body has to produce, and the longer the insulin floats around in your blood stream. Insulin turns out to be the perfect nutrient... *for cancer farming!* This could be part of the reason that the more obese someone is, the more likelihood he or she will get cancer, particularly cancers of internal organs. It's my own unscientific hunch that if humans got closer to essential body fat numbers, we would see a drop in internal cancers, though it's important to keep in mind that that Vitamins A, D, E, and K are lipid (fat) soluble, so you need sufficient fat to absorb these vitamins.

4. The sun on your body is your friend for up to 10 minutes a day. After that, it's trying to kill you.

Get direct sunshine because it's the most natural source of vitamin D. However, direct sunlight can cause up to 50,000 DNA strand breaks per minute, and if the cells divide before the damage is repaired, you could be setting skin cancer in motion, so 10 minutes is all you want. Approximately 68,000 cases of melanoma are diagnosed each year, and 7,000 prove to be fatal.

5. If you want a friend, get a dog... a cancer-sniffing dog.

Part of the reason skin cancers can prove fatal is that only 80% are diagnosed at the "local" stage. There are dogs that, if they see or smell cancer, will snarl, bark, and try to bite off the cancerous skin. Strange as it sounds, you actually want to get one of these dogs, and you want your friends to get one too. You want to let the dog sniff you and see you slowly twirl around in all your naked glory at least once a week. Even more importantly, you want a dog that can sniff your urine and bark if you have cancer. I'm serious as cancer about this. And every time you buy a cancer-sniffing dog, you increase the likelihood that this trait will be bred for and trained for.

Insulin turns out to be the perfect nutrient... for cancer farming!

6. It takes a village (without an idiot) to keep you cancer free.

Friends, even Facebook friends, can potentially give you information about diet, exercise, supplements, natural cures, good doctors, bad hospitals, and so forth that may end up saving your life. Become friends with the smartest people who are also interested (in fact, *obsessed* is good) in longevity — and in getting you through the twenty years of increased cancer risk.

7. Don't like taxes? Well, cancer is a tax.

Cancer is a tax on fat people, lazy people, smokers, and people who consume processed meats and coat their bodies with lots of chemicals. You don't have to pay this tax, but it does mean changing or eliminating what you eat, drink, smoke, or rub on your skin.

8. You've got to keep moving.

Cardiovascular exercise does over 100 helpful things to the human body. If you tried to duplicate all these good chemical interactions in your body with prescription drugs, it would cost a fortune, and you'd probably get sick from the drug interactions. Yet only a minority of doctors prescribes exercise. Well, consider this your prescription: you need to exercise for at least an hour, at least three times a week. I know normal people who exercise 20 to 30 hours a week and have fun doing it. None of them have cancer. It may not be the reason they don't have cancer, but to the best of my knowledge this hasn't been tested, so it's entirely possible.

Good luck with your adventures in longevity. May you and yours stay healthy until 150.☺

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RESOURCES

Cure Magazine
<http://www.curetoday.com/>

BIO: MONKEY SEE

OR IS ONE MANS FIX ANOTHER'S ENHANCEMENT?

MOIRA GUNN

Color blindness affects some eight percent of males, and the most common form is the inability to distinguish between red and green. Yes, there are other forms of colorblindness, and yes, females can also be colorblind, but the females are few and far between. The condition is almost exclusively found in men, and you simply can't ignore something that is a reality for one out of every twelve men.

Colorblindness is well known but there is no treatment. The colorblind simply learn to accommodate.

As with all human conditions, the degree of colorblindness varies, so its impact varies widely. With a mild case, a fella might come off as just a bad dresser, while in a severe case life becomes an adventure. Say there's a Christmas sign with red letters on a green background, and such a situation is typical during the holiday season. To the man with red-green colorblindness, such a sign would look all one color, sort of a grey all over. One presumes he would still somehow find his way to Santa, but you can readily see why red and green would be poor choices for commonplace street signs.

The good news here is that these folks are simply missing a patch of DNA... which is just the kind of challenge this Millennium is made for.

Enter science.

While eight percent of human males are colorblind, *all* male squirrel monkeys are colorblind, so that makes them perfect guinea pigs — so to speak — to study potential solutions. The September 16, 2009 online edition of *New Scientist* reports that scientists from the University of Washington modified a virus to carry the missing patch of red-green-distinguishing DNA as a payload. Then they found a way to introduce this modified virus into the eyes of the male squirrel monkeys. And then... they waited. During this time, they hoped, the virus would take up happy residence and start multiplying. It took 20 weeks, but eventually the monkeys started distinguishing between red and green.

It was clever how they got the also-clever monkeys to reveal what colors they could and could not see. (It turns out male squirrel monkeys like video games! Who knew? See Resources) But the point I want to make here starts with the ability to easily introduce new strands of DNA into living, breathing creatures — which would include you and me.

Who would deny a person the richness of a glorious sunset? The vision of the world's greatest paintings? The diversity of the Internet? The fullness of the faces of our loved ones? In this situation, science is applauded for trying to fix a capability that the great swath of the human race enjoys. But could it be viewed differently? Are we

trying to “normalize” humans to a threshold of experience?

What if things were different? What if, for example, over 99% of humans were colorblind, so that there were only a handful of people in the world who could distinguish between red and green? (For starters ... they'd be keeping their mouths shut. The accusation “You're seeing things!” has special meaning here.) One could even imagine scientists trying to correct the ability to see both red and green. They would be trying to eradicate what would be generally considered an annoying problem.

But if one person in the general population figured out that they could gain an advantage by simply adding that little patch of DNA, would that be an enhancement? It exists naturally in some humans, so it's not some creation of a genetic mad man... and yet it moves that person away from the norm. And there you have it: one man's fix is another man's enhancement.

Now is the time to ask these questions: How should we view this, individually and collectively? What is our responsibility as a society? What is the responsible way to proceed?

So here's my new sign, in colors neither green nor red: “Slippery Slope. Enter here. Watch your step.” Indeed, welcome

Who would deny a person the richness of a glorious sunset? The vision of the world's greatest paintings?

to the slippery slope of DNA. It's as slippery a slope as there ever was. ☹

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RESOURCES 📖

Gene therapy cures colour-blind monkeys
<http://www.newscientist.com/article/dn17799-gene-therapy-cures-colourblind-monkeys.html>

ENHANCED:

Sports Enhancement and Life Enhancement:

DIFFERENT RULES APPLY

QUINN NORTON

If you want to see the future debate over human enhancement, look no further than today's sports. The modern athlete is a highly-enhanced creature. Whatever physiological edge you can get may provide the razor-thin margin for victory in contemporary sports. And with more ways of modifying the body come more restrictions, and innovations to get around the restrictions.



What makes a hypobaric chamber OK, but an injection a firing offense? Because we said so.

Athletes may very well be leading the rest of society into the debate about who, how, and why people will be allowed — or even required — to enhance their bodies.

Elite players get it all: performance-enhancing drugs, surgeries, gadgetry, specialized equipment, even mathematical analysis to help them perform their desired tasks. They are monitored and modeled, tested and retested, sorted and classified. The modern elite player is an isolated cyborgian construct with barely room for a life and identity away from their sport.

Current attitudes towards enhancements vary wildly. Some enhancements are considered the price you pay to get in the game; others, the worst type of cheating. Certain dangerous acts are considered wrong while others are considered honorable. Some seem arcane while others could be useful to anyone and everyone. These attitudes tend to polarize — a new injectable hormone will quickly become anathema, but seeking multiple Lasik eye surgeries to get better than 20/20 vision is a professional responsibility.

Form matters at least as much as outcome. Take the case of Erythropoietin, or EPO. You make EPO to regulate the number of red blood cells you have, and therefore how readily you can get oxygen to your muscles. Injections of synthetic Erythropoietin to boost performance are a major no-no in sports. It's considered blood doping. But athletes can produce EPO another way: by sleeping in a hypobaric chamber. This reduces oxygen and air pressure to what it would be somewhere 10,000-15,000 feet above sea level. The body responds by producing its own EPO — and lots of it — to get as much oxygen to the sleeping muscles as it can in the deprived environment. After a few weeks in one of these chambers, training in the thick O₂ bath at sea level is a breeze. And sleeping in a hypobaric chamber would not be considered cheating any more than pitching a tent halfway up Everest.

Another instructive example is Tommy John surgery, an operation that replaces the ligament in the elbow that tends to suffer most in baseball pitchers. This surgery lets them pitch harder for longer, and despite being a major surgical modification, it isn't viewed negatively. On the other hand, strengthening the arms by supplementing with a combination of testosterone and weight training is prohibited.

This may seem hypocritical, but it isn't. After all, the rules of sports are arbitrary. Why shouldn't you use your hands in soccer? Because then it's not soccer. What makes a hypobaric chamber OK, but an injection a firing offense? Because we said so. After we invented agriculture, the bow, or perhaps mountaintop mining equipment, human athletics became a cultural pastime rather than a vital function. No matter how much you love your local sports team, the stakes aren't what they once were. You will not be starved for protein through the long winter if Barry Bonds isn't hitting like he used to. Thusly, we can pick the rules we like. They don't have to be consistent with anything in the real world.

This is why applying the debate about sports enhancements to the rest of the world can be dangerous. When we're deciding if we should give Modafinil to pilots or Ritalin to grad students, we're making life and death choices about what our future will look like. The questions that arise around sports enhancement — questions about the player's quality of life, autonomy and freedom, or questions around gauging acceptable risk — can help to inform a wider debate on enhancement, as long as we keep those aspects related to arbitrary rules back where they belong — in pastimes. ☯

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NANOPHOTONICS

MAY SAVE US FROM BREAKING MOORE'S LAW

WARREN FREY

For all the optimism about humanity's impending ascent into the digital realm, writ large with logarithmic graphs from Ray Kurzweil and given life by the fiction of Charles Stross, there's an obstacle we haven't been able to bound over. Inevitably we reach the point where computer components just can't get any smaller and still work in the realm of the electron. Moore's Law, the phenomenon of computers doubling in power while plunging in price, has to end, unless there are new developments that push us into new terrain. One such development may allow future electronics to shed the electron and embrace light, not only as the resource behind ever-faster and denser digital communications, but as a way to look at the world.

This summer, at the NSF Nanoscale Science and Engineering Center in Berkeley, California, Dr. Thomas Zentgraf and his colleagues achieved a major breakthrough. They were able to guide light at a nano scale.

Zentgraf told me, "To generate light at the nano scale, you put a light source on a chip, then combine it with optics so you can generate and guide light around. It isn't on a computer chip at the moment, but I'm personally optimistic we'll see chips like this in ten to twenty years."

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With these chips, we can hopefully have a new path when traditional electronics runs up against its limits, and Moore's Law starts to look more like a temporary statute. Electrons simply can't go much further without running into the laws of

physics. That's where light has distinct advantages. Zentgraf: "Think of an intersection with traffic lights, but with electrons instead of cars. Electrons intersect and can't interact or they'll collide. The big advantage to photons is that they don't interact, and you can, in effect, remove the traffic lights."

And since photons don't react to one another, they dissipate much

less heat, allowing further miniaturization. Light also has the advantage of being the fastest thing in the universe, radically accelerating the rate at which circuits can talk to one another. And while light dissipates the further it travels, this isn't an issue on the tiny scale of computer chips. As Zentgraf puts it, "You can't move electrons any faster, but photons are constantly going at the speed of light. But the challenge is controlling those photons. The advantage of photons is that they don't react with other materials, but you want to manipulate the light by modulating it and in effect creating binary code."

But a system is only as good as its slowest component, and classic optical materials simply aren't good enough to modulate light. So Zentgraf and his colleagues use plasmons, a subatomic particle that either reflects or transmits light based on its electrical frequency. While this allows plasmons to change the color of a material, they can also be used to create a simple digital switch. By combining these electrons with the light field, a new state is created somewhere between pure light and matter, where electrons are moving in combination with an optical field. The end result is an environment where light can be manipulated. Zentgraf explains, "We build a little larger, see if it works, then scale it down from there. You could hold the first transistors in your hand, and now there are millions of transistors on a chip. We can make the same steps with optics."

Computing isn't the only field facing revolutionary change via photonics. Imaging will see refinement on a scale unmatched since the invention of the electron microscope. There's an inherent resolution limit with normal microscopes of 500 nanometers. Electron microscopes can resolve single atoms, but can't observe organic matter without destroying it. The electrons smash into organic material and kill it, rendering it impossible to observe changes over time. Zentgraf: "An electron microscope is like an 'electron gun.' But with the weak interaction of light you can observe without destroying, potentially in real time. Nanophotonics uses new artificially-engineered materials so you can generate properties for light that aren't observable in nature and give us higher magnifications."

While we aren't yet able to observe, compute and manipulate matter using tiny lasers, Zentgraf and his Berkeley colleagues' work is not only a breakthrough but an important step on the road to accelerating returns. When the day comes soon that a trip to the doctor's office (real or virtual) is a cursory scan of your genetic makeup and an AI-enhanced prescription of protein-mending nanobots, nanophotonics may be the foundation it was all built upon. ☺

RESOURCES

UC Berkeley NSF Nanoscale Science and Engineering Center
http://www.nanowerk.com/nanotechnology/labs/UC_Berkeley_NSF_Nanoscale_Science_and_Engineering_Center_%28SINAM%29.html



NANO PROBE IS golden

AN INTERVIEW WITH DR. CHAD MIRKIN
IAN MONROE

Dr. Chad Mirkin has a singularly impressive résumé — he is the director of the International Institute for Nanotechnology, and serves as a professor of chemistry, medicine, biomedical engineering, materials science engineering, and chemical and biological engineering at Northwestern University. In 2008, he was recognized as the third-most cited chemist and the most cited nanomedicine researcher in the world. In April of this year he was named as a member of Barack Obama's Science and Technology Advisory Council.

Mirkin is perhaps best known for the development of a technique known as dip pen nanolithography, a method of nanopatterning that uses an atomic force microscope much like a quill pen to deposit a molecular “ink” onto a substrate. His contributions to medical diagnostics and therapeutics are a bit more obscure. The diagnostic assays developed in his lab use chemically-functionalized gold nanoparticles

h+: Can you talk about the diagnostic assays that you have developed?

CHAD MIRKIN: In the diagnostics area, we're using nanoparticles made of gold that have DNA strands attached to them. They can be used to latch onto disease targets with specific DNA codes that then provide some sort of colorimetric signal that tell us that that particular target is present, and how much is present. And those are commercial systems now. There is a whole diagnostic system called the Verigene system which is sold by Nanosphere, a public company that we started about 10 years ago. There are now four FDA clearances and hopefully many more on the way.

h+: Can you tell me a little bit about how the bio-barcode assay works with lab-on-a-chip technology?

CM: Well, that is not a commercial assay yet... it's a research assay. But it is an assay that is extraordinarily sensitive—it allows you to detect protein markers at orders of magnitude lower concentration than you can with conventional commercial diagnostic tools. And as a result it's opening up all sorts of applications in oncology research and medical diagnostics, but also in the testing of things like Alzheimer's disease and HIV. Anything where a high sensitivity and low marker concentration is critical, this type of technology can have a major impact. The microfluidic part of that is developing a system that is highly miniaturized, and can take a sample and basically treat that sample with chemical reagents on a little microchip that presents it in the form that you can detect the different disease markers of interest. So DNA

does not come packaged as something that is freely floating in blood. It's inside cells, and cells have to be lysed. The DNA has to be broken apart. It's a duplex structure. And then you have to have a system that can capture the target and tell you how much is present. And so the microfluidic bio-barcode assay actually does that from beginning to end and creates a device that truly can be a portable, point-of-care device. It certainly could be used in hospitals, but likely also in the doctor's office and maybe even the home. That's the goal of all this. Bill Gates wanted a computer on every desktop and he actually got two in many cases. We'd like a medical diagnostic system in every home in the world.

h+: What kinds of tests do you imagine these devices will be capable of performing? I know you've been working with prostate cancer protein markers....

CM: Well, everything! Every disease where there is a marker present we can have an impact because our assays are more selective. And they're more sensitive than what's out there. They're also lower cost and they have been designed so that they can be run off of relatively simple instrumentation. And that means you no longer have to rely on these remote labs with this big bulky instrumentation that has to be in a stationary state and where samples have to be sent. This really opens up the whole field of point of care diagnostics.

h+: How far out do you think we are from seeing these sorts of point-of-care diagnostic systems readily available for standard practice in the First World?

CM: They're here. The Verigene system is launched. It's in hospitals around the country. It will scale rapidly. Really, what we are waiting for is just an increasing menu [of tests]. Because the beauty is that with one instrument you can have almost an infinite number of assays, just different cartridges.

h+: It sounds like science fiction.

CM: To me, it's amazing that it hasn't happened before. People 100 years from now will say, “These guys were in the Stone Age. I can't believe they had to send a sample of blood, saliva or urine to an outside lab and then wait days to weeks to get the test results.” The type of technology should—and now does— exist to do it at the point of care, to do it in this case in a couple of hours. But I think one day it will be a few minutes.®

Ian Monroe is a journalist and technology geek currently living in Chicago. He's on the web at ianmonroe.com

**PEOPLE
100 YEARS
FROM NOW WILL
SAY, “THESE GUYS WERE
IN THE STONE AGE.”**

as a probe to detect targeted DNA sequences, as well as the presence of proteins that can indicate disease. The applications of this technique range over a broad spectrum, including everything from detecting the flu virus, to accurately diagnosing Alzheimer's, to finding the protein markers that can indicate cancer.

Recently, his bio-barcode assay was integrated into a device that uses blood serum passing through microfluidic channels to allow the assay to take place without assistance. This kind of system may soon lead to handheld devices capable of diagnosing a wide range of disease in minutes, using only a small sample of blood.

Dr. Mirkin spoke with *h+* via telephone to discuss some of implications of this technology.

RESOURCES

Nanosphere
<http://www.nanosphere.us>



NANO-BIO-INFO-COGNO: PARADIGM FOR THE FUTURE

SURFDADDY ORCA

Winter is typically flu season, and talk around the water cooler in 2009 has turned to the H1N1 virus, the so-called “swine flu.” Many wonder if it might be comparable to the 1918 influenza virus that caused the catastrophic and historic pandemic of 1918–1919. In 2005, in an act of random stupidity, the U.S. Department of Health and Human Services published the full genome of the 1918 influenza virus on the Internet in the GenBank database. Essentially, the blueprint to build a dangerous flu virus was made available to anyone with an Internet connection.

This prompted a scathing Op-Ed piece in the *New York Times* from an unlikely duo — Ray Kurzweil and Bill Joy. “This is extremely foolish,” they commented. “The genome is essentially the design of a weapon of mass destruction. No responsible scientist would advocate publishing precise designs for an atomic bomb, and in two ways revealing the sequence for the flu virus is even more dangerous.” Kurzweil and Joy went so far as to call for a “new Manhattan Project” to develop specific defenses against viral threats, whether natural or man-made.

Ray Kurzweil, of course, is well known to *h+* readers as the author

of the seminal book, *The Singularity is Near*, and more recently as a founder (with funding from Google and NASA Ames Research Center) of Singularity University. Bill Joy, cofounder and former Chief Scientist of Sun Microsystems, is known as a critic of Kurzweil’s technological optimism — but not necessarily his predictions. In a now-famous piece published in the April 2000 edition of *Wired* magazine entitled “Why the future doesn’t need us,” Joy suggested that our most powerful 21st century technologies — genetic engineering, nanotechnology, and robotics (GNR) — are threatening to make humans an endangered species. In 2003, Kurzweil responded to Joy and acknowledged, “Technology has always been a double-edged sword, empowering both our creative and our destructive natures. It has brought us longer and healthier lives, freedom from physical and mental drudgery, and many new creative possibilities. Yet it has also introduced new and salient dangers.”

That Kurzweil and Joy would team up to warn the public of the dangers of the “G” in “GNR” in their 2005 Op-Ed piece is commentary enough. Yet, the promise of the GNR technologies is clear even to Joy. “Each of these technologies also offers untold promise: The vision of near immortality that Kurzweil sees in his robot dreams drives us forward; genetic engineering

2015

The following timeline for converging NBIC technologies was tabulated from dozens of authors and presenters who participated in the first three NSF-sponsored NBIC conferences (as of 2006).

Anywhere in the world, an individual will have instantaneous access to needed information, whether practical or scientific in nature, in a form tailored for most effective use by the particular individual.

New organizational structures and management principles based on fast, reliable communication of needed information will vastly increase the effectiveness of administrators in business, education, and government.

Comfortable, wearable sensors and computers will enhance every person’s awareness of his or her health condition, environment, chemical pollutants, potential hazards, and information of interest about local businesses, natural resources, and the like.

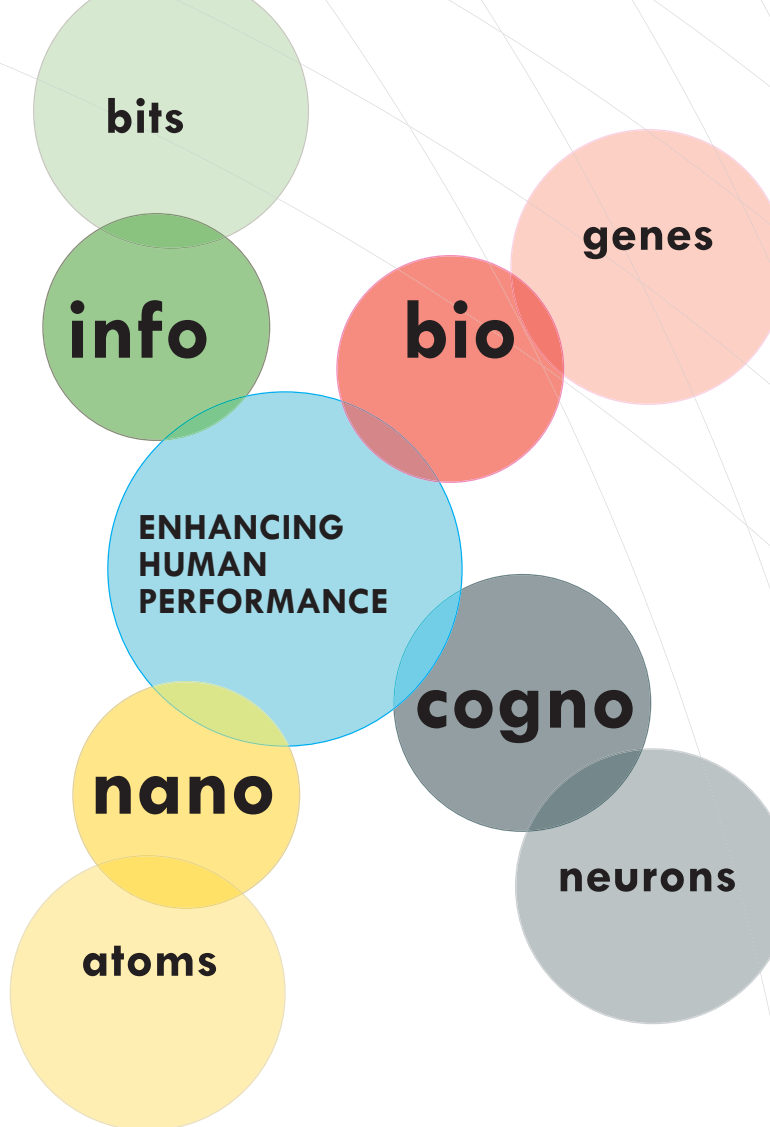
may soon provide treatments, if not outright cures, for most diseases; and nanotechnology and nanomedicine can address yet more ills,” writes Joy. “Together they could significantly extend our average life span and improve the quality of our lives. Yet, with each of these technologies, a sequence of small, individually sensible advances leads to an accumulation of great power and, concomitantly, great danger.”

Much research has occurred since Kurzweil and Joy first brought broader public awareness of these emerging 21st-century technologies. Emerging — as well as converging — these technologies now include the GNR technologies plus cognitive science and neurotechnology: the newer formulation is Nano-Bio-Info-Cogno (NBIC). U.S. government studies now recognize that the convergence of the NBIC technologies can vastly “improve human performance over the next ten to twenty years.”

h+ contacted Professor Nick Bostrom of the James Martin 21st Century School at Oxford University to ask him about NBIC convergence as well as Joy’s concerns for the future of the human species. Professor Bostrom, also the director of the Future of Humanity Institute, confirmed the danger, but with some significant qualifications. “Some of the biggest existential risks come from expected future developments in the NBIC technologies area,” he suggests. “To that extent Joy is right.” But, he goes on, “Joy also suggested that our response to this threat should be to relinquish exploration of some fairly large parts of this area.” He points out that this is a complicated proposition. “First, we might need some advanced NBIC capacities to realize humanity’s potential. A permanent failure to develop these capacities could itself constitute an existential risk,” he suggests. For example, NBIC offers the potential to alleviate human suffering and to accelerate access to sustainable energy, abundant food, and universal healthcare on a global basis. Many preventable deaths might occur as a result of not developing NBIC.

“Second,” Bostrom continues, “it may be practically infeasible to gain universal adherence to a decision to relinquish these potential technologies. One must then ask whether a partial relinquishment — say to which only the most conscientious agents adhere — will make us safer or whether it will instead increase the danger by handing the reins to those who lack scruples.” As with 20th century nuclear, biological, and chemical (NBC) technologies, the risk of rogue states and terrorism require vigilance on the part of modern industrial nations.

From bits to genes to atoms to neurons: what’s clear is that the U.S. government is moving ahead with funding for the NBIC technologies, and likely for reasons of strategic global positioning as much as for the potential to improve the condition of humanity as a whole.



HERE'S A BRIEF SUMMARY OF THE NBIC TECHNOLOGIES:

NANOTECHNOLOGY: Technology related to features of nanometer scale (10^{-9} meters): thin films, fine particles, chemical synthesis, advanced microlithography, and so forth.

BIOTECHNOLOGY: The application of science and engineering to the direct or indirect use of living organisms, or parts or products of living organisms, in their natural or modified forms.

INFORMATION TECHNOLOGY: Applied computer systems, both hardware and software, including networking and telecommunications.

COGNITIVE SCIENCE: The study of intelligence and intelligent systems, with particular reference to intelligent behavior as computation.

2020

People from all backgrounds and of all ranges of ability will learn valuable new knowledge and skills more reliably and quickly, whether in school, on the job, or at home.

Individuals and teams will be able to communicate and cooperate profitably across traditional barriers of culture, language, distance, and professional specialization, thus greatly increasing the effectiveness of groups, organizations, and multinational partnerships.

National security will be greatly strengthened by lightweight, information-rich war-fighting systems, capable uninhabited combat vehicles, adaptable smart materials, invulnerable data networks, superior intelligence gathering systems, and effective measures against biological, chemical, radiological, and nuclear attacks.

Engineers, artists, architects, and designers will experience tremendously expanded creative abilities, both with a variety of new tools and through improved understanding of the wellsprings of human creativity.

Average persons, as well as policymakers, will have a vastly improved awareness of the cognitive, social, and biological forces operating their lives, enabling far better adjustment, creativity, and daily decision-making.

WHAT HAPPENS WHEN 21ST CENTURY TECHNOLOGIES CONVERGE?

The National Science Foundation (NSF) and a formidable-sounding government subcommittee called the National Science and Technology Council on Nanoscale Science, Engineering, and Technology have published a number of reports exploring the convergence of the NBIC technologies as the result of a series of conferences between 2001 and 2006. The chief application areas they've identified include:

- Expanding human cognition and communication,
- Strengthening national security, and
- Improving human health and physical capabilities,
- Unifying science and education.
- Enhancing group and societal outcomes,

The convergence, these reports suggest, will be based on the “unity of nature at the nanoscale” along with technology integration at the nanoscale, key transforming tools, and the pursuit of improvements in human performance. “A revolution is occurring in science and technology, based on the recently developed ability to measure, manipulate and organize matter on the nanoscale — 1 to 100 billionths of a meter,” writes William Sims Bainbridge, co-director of Human-Centered Computing at the NSF and co-editor with Mihail Roco of several NSF publications on NBIC. “At the nanoscale, physics, chemistry, biology, materials science, and engineering converge toward the same principles and tools. As a result, progress in nanoscience will have very far-reaching impact.”

Some of the application areas identified in the NSF publications are far-reaching, but the pace of proposed development — including social and political factors — is perhaps somewhat more conservative than the exponential acceleration predicted by Kurzweil and acknowledged by Joy. Let's take a closer look.

Expanding Human Cognition and Communication

“The human mind can be significantly enhanced through technologically augmented cognition, perception, and communication,” writes Bainbridge. “Research will focus both on the brain and the ambient socio-cultural milieu, which both shapes and is shaped by individual thought and behavior.” Specific technology includes personal sensory device interfaces and enhanced tools for creativity along with continued humanization of computers, robots, and information systems.

Improving Human Health and Physical Capabilities

“Nano-bio sensors and processors will contribute greatly to research and to development of treatments, including those resulting from bioinformatics, genomics and proteomics,” suggests Bainbridge. Specific technologies include implants based on nanotechnology and regenerative biosystems that will start to replace human organs, and nanoscale machines unobtrusively providing needed medical intervention. Advances in cognitive science will provide insights to help people avoid unhealthy lifestyles and information technology will create virtual environment tools to facilitate diagnoses and train medical professionals.

Enhancing Group and Societal Outcomes

“Nano-enabled microscale data devices will identify every product and place, and individuals will merge their personal databases as they choose which groups and interaction networks to join,” writes Bainbridge. “Group productivity tools will radically enhance the ability of people to imagine and create revolutionary new products and services based on the integration of the four technologies from the nanoscale.”

National Security

The combination of nanotechnology and information technology will produce “sensor nets capable of instantly detecting chemical, biological, radiological and explosive threats and able to direct immediate and effective countermeasures,” says Bainbridge. And here come the robots and drones — “uninhabited combat vehicles and human-machine interfaces” will enhance both attack capabilities and survivability. The hope is that developments initially achieved at high cost for defense purposes will be transferred over time to low-cost civilian applications for the general benefit of society.

Unifying Science and Education

The NSF studies conclude that scientific education needs radical transformation from elementary school through post-graduate training. Convergence of previously separate scientific and engineering disciplines “cannot take place without the emergence of new kinds of people who understand multiple fields in depth and can intelligently work to integrate them,” states Bainbridge.

2025

Factories of tomorrow will be organized around converging technologies and increased human-machine capabilities as intelligent environments that achieve the maximum benefits of both mass production and custom design.

Agriculture and the food industry will greatly increase yields and reduce spoilage through networks of cheap, smart sensors that constantly monitor the condition and needs of plants, animals, and farm products.

The work of scientists will be revolutionized by the importation of approaches pioneered in other sciences, for example, genetic research employing principles from natural language processing and cultural research employing principles from genetics.

Robots and software agents will be far more useful for human beings, because they will operate on principles compatible with human goals, awareness, and personality.

The human body will be more durable, healthier, more energetic, easier to repair, and more resistant to many kinds of stress, biological threats, and aging processes.

THE FOLLOWING TABLE SHOWS EVEN MORE SPECIFIC AREAS OF NBIC CONVERGENCE FROM THE U.S. NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) AND THE NATIONAL HEALTH INSTITUTE (NHI) AS OF 2006.

	nano	bio	info	cogno
Nanostructured materials “by design”	X			
Nanoelectronics, optoelectronics, magnetics	X		X	
Advanced health care, therapeutics, diagnostics	X	X		X
Nanoscale processes for environmental improvement	X			
Efficient energy conversion and storage	X		X	
Microcraft and robotics	X		X	
Nanoscale instrumentation and metrology	X		X	
Manufacturing at the nanoscale	X			
Nanostructures for chemical, biological, radiological, explosive detection and protection	X	X	X	
Single-dose vaccines, effective soon after birth	X	X		
Vaccines that do not require refrigeration	X	X		
Needle-free delivery systems for vaccines	X	X		
Devise reliable tests in model systems to evaluate live attenuated vaccines		X	X	
Antigens for effective, protective immunity	X	X	X	
Learn which immunological responses provide protective immunity		X	X	
Genetic strategy to deplete or incapacitate a disease-transmitting insect population		X	X	
Chemical strategy to deplete or incapacitate a disease-transmitting insect population	X	X		
Create a full range of optimal, bioavailable nutrients in a single staple plant species		X	X	
Drugs and delivery systems that minimize the likelihood of drug resistant micro-organisms	X	X		
Create therapies that can cure latent infections	X	X	X	
Create immunological methods that can cure chronic infections	X	X	X	
Develop technologies that permit quantitative assessment of population health status		X	X	
Create technologies to assess individuals for multiple conditions or pathogens at point of care		X	X	X

2030

A combination of technologies and treatments will compensate for many physical and mental disabilities and will eradicate altogether some handicaps that have plagued the lives of millions of people.

Fast, broadband interfaces between the human brain and machines will transform work in factories, control automobiles, ensure military superiority, and enable new sports, art forms and modes of interaction between people.

Machines and structures of all kinds, from homes to aircraft, will be constructed of materials that have exactly the desired properties, including the ability to adapt to changing situations, and increase energy efficiency and environmental friendliness.

The ability to control the genetics of humans, animals, and agricultural plants will greatly benefit human welfare; widespread consensus about ethical, legal, and moral issues will be built in the process.

Transportation will be safe, cheap, and fast, due to ubiquitous real-time information systems, extremely high-efficiency vehicle designs, and the use of synthetic materials and machines fabricated from the nanoscale for optimum performance.

NBIC AND YOU

NBIC will likely be used to enhance intelligence, mobility, cognitive qualities, vision and hearing. “I think we will stop short of eugenics but proceed to offer neurological and physical enhancements that improve the quality of life under the umbrella of medicine,” writes James Canton of the Institute for Global Futures. “Industry is watching this debate closely. Boomers are also watching this debate and will influence the outcome, based on their health economic investments.”

Canton asks whether people in a free society have the right to enhance their memory, augment their intelligence, maximize their pleasure, and even change their physical forms on demand. He suggests that this will become a human rights issue in the 21st century. “Longevity medicine, life extension, and the augmentation of human performance will become features of our global culture in the near future,” he argues.

Just as we battle over the right to life today, it’s almost a given that we will battle in the future over the right to personal enhancement. New and radical choices will be available to parents who want certain characteristics for their unborn children — for example, augmentation of intelligence or corrective genetic procedures. Improvement and human performance enhancing drugs and neurotechnological devices are already entering the global marketplace.

Some, like environmentalist Bill McKibben, argue that we are not in need of radical overhaul, improvement, or augmentation, that “we are plenty good enough.” Clearly there will be those who choose to remain unenhanced as well as those who choose radical augmentation/enhancement.

NBIC AND YOUR DOG OR CAT

“There is a lot of suffering in the natural world,” suggests Oxford philosopher Nick Bostrom. “If we had the capability to mitigate this in some acceptable way, it seems to me that we would have a moral obligation to do so.”

If humans can be augmented and enhanced, then what about our fellow non-human Earth-bound species? This might bring to mind horrific images of the “Beast Folk” in H.G. Wells’ story *The Island of Doctor Moreau*. There are clearly some very difficult moral questions in this area. Biological uplift is the act of biologically enhancing non-human animals. Bostrom acknowledges some uncertainty in this area. “As for cognitively enhancing animals, well, intuitively it seems like we ought to enhance/treat a brain-damaged human but that there would be no particular moral reason to uplift an amoeba (to take two extremes),” he ponders. “Perhaps one could think in terms of whether a being has a ‘morally relevant interest’ in being enhanced. Maybe the amoeba has no morally relevant interests at all.” He cautions against rushing to conclusions regarding this controversial topic without more thought.

2050

Factories of tomorrow will be organized around converging technologies and increased human-machine capabilities as intelligent environments that achieve the maximum benefits of both mass production and custom design.

Formal education will be transformed by a unified but diverse curriculum based on a comprehensive, hierarchical intellectual paradigm for understanding the architecture of the physical world from the nanoscale through the cosmic scale.

The vast promise of outer space will finally be realized by means of efficient launch vehicles, robotic construction of extraterrestrial bases, and profitable exploitation of the resources of the Moon, Mars, or near-Earth asteroids.

There's a huge potential for the convergence of key NBIC technologies to alleviate human suffering and accelerate access to sustainable energy, abundant food, and universal healthcare.

DOES THE FUTURE NEED NBIC?

It seems clear that there's a huge potential for the convergence of key NBIC technologies to alleviate human suffering and to accelerate access to sustainable energy, abundant food, and universal healthcare. The social risks associated with not furthering the use of NBIC to share the wealth of innovations "may destabilize global security in the future," concludes NSF's William Bainbridge. "Future dangers from new technologies may appear alarming when considered in the context of today's unprepared world," writes Ray Kurzweil. "The reality is that the sophistication and power of our defensive technologies and knowledge will grow along with the dangers. When we have 'gray goo' (unrestrained nanobot replication), we will also have 'blue goo' ('police' nanobots that combat the 'bad' nanobots)."

"Possibly the best approach is a more fine-grained one," suggests Oxford's Nick Bostrom. "There are some research areas where safety is served by pushing ahead as hard as possible. For example, research into how to safely manage an upload transition, or how to ensure that a seed artificial intelligence would remain human-friendly, or how to enhance human rationality, wisdom, and moral responsibility, or how to rapidly detect new pathogens in the environment — these seem like risk-reducing enterprises.

"By contrast," Bostrom continues, "research to develop advanced biological warfare agents or to invent self-enhancing artificial general intelligence before the friendliness problem has been solved — these appear to increase risk, and one would do well to discourage research in those areas."

"This is a race, warns Kurzweil, "and there is no alternative." ☹

Surfdaddy Orca is another monkey with a laptop and a cell phone waiting for Godot or the Singularity or whatever comes next. While he waits, he writes regularly for the h+ website

RESOURCES

Recipe for Destruction

<http://www.nytimes.com/2005/10/17/opinion/17kurzweiljoy.html>

Why the future doesn't need us

<http://www.wired.com/wired/archive/8.04/joy.html>

Ray Kurzweil on the Promise and Peril of Technology in the 21st Century

http://www.cio.com/article/29790/Ray_Kurzweil_on_the_Promise_and_Peril_of_Technology_in_the_21st_Century

Nick Bostrom's Home Page

<http://www.nickbostrom.com/>

NBIC Converging Technologies

<http://convergentsystems.pbworks.com/NBIC-Converging-Technologies>

Converging Technologies

<http://mysite.verizon.net/wsbainbridge/dl/nbic.htm>

National Nanotechnology Initiative

<http://www.nano.gov/html/about/nsetmembers.html>

Managing Nano-Bio-Info-Cogno Innovations: Converging Technologies in Society

<http://ebook30.com/science/biology-and-genetics/101242/managing-nano-bio-info-cogno-innovations-converging-technologies-in-society.html>

We Are Plenty Good Enough

<http://www.sierraclub.org/sierra/200311/interview.asp>



RAY

KURZWEIL

the *h+* interview

SURFDADDY ORCA & R.U. SIRIUS

PHOTOS BY GURU KHALSA

a 3-way conversation with the brilliant and controversial inventor and futurist

Ray Kurzweil needs little or no introduction to most *h+* readers. Principal developer of the first omni-font optical character recognition, the first print-to-speech reading machine for the blind, the first CCD flat-bed scanner, the first text-to-speech synthesizer, the first music synthesizer capable of recreating the grand piano and other orchestral instruments, and the first commercially marketed large-vocabulary speech recognition, Ray has been described as "the restless genius" by the Wall Street Journal, and "the ultimate thinking machine" by Forbes. Inc. magazine ranked him #8 among entrepreneurs in the United States and called him the "rightful heir to Thomas Edison." His Kurzweil Technologies, Inc. is an umbrella company for at least eight separate enterprises.

Ray's writing career rivals his inventions and entrepreneurship. His seminal book, *The Singularity is Near*, presents the Singularity as an overall exponential (doubling) growth trend in technological development, "a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed." With his upcoming films, *Transcendent Man* and *The Singularity is Near: A True Story about the Future*, he is becoming an actor, screenplay writer, and director as well.

Sponsored by the Singularity Institute, the first Singularity Summit was held at Stanford University in 2006 to further understanding and discussion about the Singularity concept and the future of technological progress. Founded by Ray, Tyler Emerson, and Peter Thiel, it is a venue for leading thinkers to explore the idea of the Singularity — whether scientist, enthusiast, or skeptic. Ray also founded Singularity University in 2009 with funding from Google and NASA Ames Research Center. Singularity University offers intensive 10-week, 10-day, or 3-day programs examining sets of technologies and disciplines including future studies and forecasting; biotechnology and bioinformatics; nanotechnology; AI, robotics, and cognitive computing; and finance and entrepreneurship.

Ray headlined the recent Singularity Summit 2009 in New York City with talks on "The Ubiquity and Predictability of the Exponential Growth of Information Technology" and "Critics of the Singularity." He was able to take a little time out after the Summit for two separate interview sessions with *h+* Editor-in-Chief R.U. Sirius and Surfdaddy Orca on a variety of topics including consciousness and quantum computing, purposeful complexity, reverse engineering the brain, AI and AGI, GNR technologies and global warming, utopianism and happiness, his upcoming movies, and science fiction.

CONSCIOUSNESS, QUANTUM COMPUTING, & COMPLEXITY

RAY KURZWEIL: One area I commented on was the question of a possible link between quantum computing and the brain. Do we need quantum computing to create human level AI? My conclusion is no, mainly because we don't see any quantum computing in the brain. Roger Penrose's conjecture that there was quantum computing in tubules does not seem to have been verified by any experimental evidence.

Quantum computing is a specialized form of computing where you examine in parallel every possible combination of qubits. So it's very good at certain kinds of problems, the classical one being cracking encryption codes by factoring large numbers. But the types of problems that would be vastly accelerated by quantum computing are not things that the human brain is very good at. When it comes to the kinds of problems I just mentioned, the human brain isn't even as good as classical computing. So in terms of what we can do with our brains' there's no indication that it involves quantum computing. Do we need quantum computing for consciousness? The only justification for that conjecture from Roger Penrose and Stuart Hameroff is that consciousness is mysterious and quantum mechanics is mysterious, so there must be a link between the two.

I get very excited about discussions about the true nature of consciousness, because I've been thinking about this issue for literally 50 years, going back to junior high school. And it's a very difficult subject. When some article purports to present the neurological basis of consciousness... I read it. And the articles usually start out, "Well, we think that consciousness is caused by..." You know, fill in the blank. And then it goes on with a big extensive examination of that phenomenon. And at the end of the article, I inevitably find myself thinking... where is the link to consciousness? Where is any justification for believing that this phenomenon should cause consciousness? Why would it cause consciousness?

In his presentation, Hameroff said consciousness comes from gamma coherence, basically a certain synchrony between neurons that create gamma waves that are in a certain frequency, something like around 10 cycles per second. And the evidence is, indeed, that gamma coherence goes away with anesthesia.

Anesthesia is an interesting laboratory for consciousness because it extinguishes consciousness. However, there's a lot of other things that anesthesia also does away with. Most of the activity of the neocortex stops with anesthesia, but there's a little bit going on still in the neocortex. It brings up an interesting issue. How do we even know that we're not conscious under anesthesia? We don't remember anything, but memory is not the same thing as consciousness. Consciousness seems to be an

A black and white photograph of a man with glasses, wearing a dark suit, a light-colored striped shirt, and a dark tie with small white dots. He is standing in front of an American flag, which is partially visible on the left side of the frame. The background is dark and out of focus.

How do we even know that we're not conscious under anesthesia? We don't remember anything, but memory is not the same thing as consciousness.

ARTIFICIAL INTELLIGENCE & REVERSE ENGINEERING THE BRAIN

emergent property of what goes on in the neocortex, which is where we do our thinking. And you could build a neocortex. In fact, they are being built in the Blue Brain project, and Numenta also has some neocortex models. In terms of hierarchies and number of units in the human brain, these projects are much smaller. But they certainly do interesting things. There are no tubules in there, there's no quantum computing, and there doesn't seem to be a need for it.

Another theory is the idea of purposeful complexity. If you achieve a certain level of complexity, then that is conscious. I actually like that theory the most. I wrote about that extensively in *The Singularity is Near*. There have been attempts to measure complexity. You have Claude Shannon's information theory, which basically involves the smallest algorithm that can generate a string of information. But that doesn't deal with random information. Random information is not compressible, and would represent a lot of Shannon information, but it's not really purposeful complexity. So you have to factor out randomness. Then you get the concept of arbitrary lists of information. Like, say, the New York telephone book is not random. It's only compressible to a limited extent, but it's not a high level of complexity. It's largely an arbitrary list.

I describe a more meaningful concept of Purposeful Complexity in the book. I propose that there are ways of measuring purposeful complexity. In this theory, humans are more conscious than cats, but cats are conscious, but not quite as much because they're not quite as complex. A worm is conscious, but much less so. The sun is conscious. It actually has a fair amount of structure and complexity, but probably less than a cat, so...

SO: How do you go about proving something like that?

RK: Well, that's the problem. My thesis is that there's really no way to measure consciousness. There's no "Consciousness Detector" that you could imagine where the green light comes on and you can so, "OK, this one's conscious!" Or, "No, this one isn't conscious."

Even among humans, there's no clear consensus as to who's conscious and who is not. We're discovering now that people who are considered minimally conscious, or even in a vegetative state, actually have quite a bit going on in their neo-cortex and we've been able to communicate with some of them using either real-time brain scanning or other methods.

Today, nobody worries too much about causing pain and suffering to their computer software. But we will get to a point where the emotional reactions of virtual beings will be convincing, unlike the characters in the computer games today. And that will become a real issue. That's the whole thesis of my movie, *The Singularity is Near*. But it really comes down to the fact that it's not a scientific issue, which is to say there's still a role for philosophy.

Some scientists say, "Well, it's not a scientific issue, therefore it's not a real issue. Therefore consciousness is just an illusion and we should not waste time on it." But we shouldn't be too quick to throw it overboard because our whole moral system and ethical system is based on consciousness. If I cause suffering to some other conscious human, that's considered immoral and probably a crime. On the other hand, if I destroy some property, it's probably OK if it's my property. If it's your property, it's probably not okay. But that's not because I'm causing pain and suffering to the property. I'm causing pain and suffering to the owner of the property.

And there's recognition that animals are probably conscious and that animal cruelty is not okay. But it's okay to cause pain and suffering to the avatar in your computer, at least today. That may not be the case 20 years from now.

RK: I'm working on a book called *How the Mind Works and How to Build One*. It's mostly about the brain, but the reason I call it the mind rather than the brain is to bring in these issues of consciousness. A brain becomes a mind as it melds with its own body, and in fact, our sort of circle of identity goes beyond our body. We certainly interact with our environment. It's not a clear distinction between who we are and what we are not.

My concept of the value of reverse engineering the human brain is not that you just simulate a brain in a sort of mechanistic way, without trying to understand what is going on. David Chalmers says he doesn't think this is a fruitful direction. And I would agree that just simulating a brain... *mindlessly*, so to speak... that's not going to get you far enough. The purpose of reverse engineering the human brain is to understand the basic principles of intelligence.

Once you have a simulation working, you can start modifying things. Certain things may not matter. Some things may be very critical. So you learn what's important. You learn the basic principles by which the human brain handles hierarchies and variance, properties of patterns, high-level features and so on. And it appears that the neocortex has this very uniform structure. If we learn those principles, we can then engineer them and amplify them and focus on them. That's engineering.

Now, a big evolutionary innovation with *homo sapiens* is that we have a bigger forehead so that we could fit a larger cortex. But it's still quite limited. And it's running on the substrate that transmits information from one part of the brain to another at a few hundred feet per second, which is a million times slower than electronics. The intra-neural connections compute at about 100 or 200 calculation per second, which is somewhere between 1,000,000 to 10,000,000 times slower than electronics. So if we can get past the substrates, we don't have to settle for a billion of these recognizers. We could have a trillion of them, or a thousand trillion. We could have many more hierarchal levels. We can design it to solve more difficult problems.

So that's really the purpose of reverse engineering the human brain. But there are other benefits. We'll get more insight into ourselves. We'll have better means for fixing the brain. Right now, we have vague psychiatric models as to what's going on in the brain of someone with bipolar disease or schizophrenia. We'll not only understand human function, we'll understand human dysfunction. We'll have better means of fixing those problems. And moreover we'll "fix" the limitation that we all have in thinking in a very small, slow, fairly-messily organized substrate. Of course, we have to be careful. What might seem like just a messy arbitrary complexity that evolution put in may in fact be part of some real principle that we don't understand at first.

I'm not saying this is simple. But on the other hand, I had this debate with John Horgan, who wrote a critical article about my views in *IEEE Spectrum*. Horgan says that we would need trillions of lines of code to emulate the brain and that's far beyond the complexity that we've shown we can handle in our software. The most sophisticated software programs are only tens of millions of lines of code. But that's complete nonsense. Because, first of all, there's no way the brain

could be that complicated. The design of the brain is in the genome. The genome — well... it's 800 million bytes. Well, back up and take a look at that. It's 3 billion base pairs, 6 billion bits, 800 million bytes before compression — but it's replete with redundancies. Lengthy sequences like ALU are repeated hundreds of thousands of times. In *The Singularity is Near*, I show that if you apply lossless compression, you get down to about 50 million bytes. About half of that is the brain, so that's about 25 million bytes. That's about a million lines of code. That's one derivation. You could also look at the amount of complexity that appears to be necessary to perform functional simulations of different brain regions. You actually get about the same answer, about a million lines of code. So with two very different methods, you come up with a similar order of magnitude. There just isn't trillions of lines of code — of complexity — in the design of the brain. There is trillions, or even thousands of trillions of bytes of information, but that's not complexity because there's massive redundancy.

For instance, the cerebellum, which comprises half the neurons in the brain and does some of our skill formation, has one module repeated 10 billion times with some random variation with each repetition within certain constraints. And there are only a few genes that describe the wiring of the cerebellum that comprise a few tens of thousands of bytes of design information. As we learn skills like catching a fly ball — then it gets filled up with trillions of bytes of information. But just like we don't need trillions of bytes of design information to design a trillion-byte memory system, there are massive redundancies and repetition and a certain amount of randomness in the implementation of the brain. It's a probabilistic fractal. If you look at the Mandelbrot set, it is an exquisitely complex design.

SO: So you're saying the initial intelligence that passes the Turing test is likely to be a reverse-engineered brain, as opposed to a software architecture that's based on weighted probabilistic analysis, genetic algorithms, and so forth?

RK: I would put it differently. We have a toolkit of AI techniques now. I actually don't draw that sharp a distinction between narrow AI techniques and AGI techniques. I mean, you can list them — markup models, different forms of neural nets and genetic algorithms, logic systems, search algorithms, learning algorithms. These are techniques. Now, they go by the label AGI. We're going to add to that tool kit as we learn how the human brain does it. And then, with more and more powerful hardware, we'll be able to put together very powerful systems.

My vision is that all the different avenues — studying individual neurons, studying brain wiring, studying brain performance, simulating the brain either by doing neuron-by-neuron simulations or functional simulations — and then, all the AI work that has nothing to do with direct emulation of the brain — it's all helping. And we get from here to there through thousands of little steps like that, not through one grand leap.

“Just simulating a brain... mindlessly, so to speak... that's not going to get you far enough.”

GLOBAL WARMING & GNR TECHNOLOGIES

SO: James Lovelock, the ecologist behind the Gaia hypothesis, came out a couple of years ago with a prediction that more than 6 billion people are going to perish by the end of this century, mostly because of climate change. Do you see the GNR technologies coming on line to mitigate that kind of a catastrophe?

RK: Absolutely. Those projections are based on linear thinking, as if nothing's going to happen over the next 50 or 100 years. It's ridiculous. For example, we're applying nanotechnology to solar panels. The cost per watt of solar energy is coming down dramatically. As a result, the amount of solar energy is growing exponentially. It's doubling every two years, reliably, for the last 20 years. People ask, “Is there really enough solar energy to meet all of our energy needs?” It's actually 10,000 times more than we need. And yes you lose some with cloud cover and so forth, but we only have to capture one part in 10,000. If you put efficient solar collection panels on a small percentage of the deserts in the world, you would meet 100% of our energy needs. And there's also the same kind of progress being made on energy storage to deal with the intermittency of solar. There are only eight doublings to go before solar meet 100% of our energy needs. We're awash in sunlight and these new technologies will enable us to capture that in a clean and renewable fashion. And then, geothermal — you have the potential incredible amounts of energy.

Global warming — regardless of what you think of the models and whether or not it's been human-caused — it's only been one degree Fahrenheit in the last 100 years. There just isn't a dramatic global warming so far. I think there are lots of reasons we want to move away from fossil fuels, but I would not put greenhouse gasses at the top of the list.

These new energy technologies are decentralized. They're relatively safe. Solar energy, unlike say nuclear power plants and other centralized facilities, are safe from disaster and sabotage and are non-polluting. So I believe that's the future of energy, and of resource utilization in general.



THE SINGULARITY, UTOPIA, & HAPPINESS

R.U. SIRIUS: Have any critics of your ideas offered a social critique that gives you pause?

RK: I still think Bill Joy articulated the concerns best in his *Wired* cover story of some years ago. My vision is not a utopian one. For example, I'm working with the U.S. army on developing a rapid response system for biological viruses, and that's actually the approach that I advocate — that we need to put resources and attention to the downsides. But I think we do have the scientific tools to create a rapid response system in case of a biological viral attack. It took us five years to sequence HIV; we can sequence a virus now in one day. And we could, in a matter of days, create an RNA interference medication based on sequencing a new biological virus. This is something we created to contend with software viruses. And we have a technological immune system that works quite well.

And we also need ethical standards for responsible practitioners of AI, similar to the Asilomar Guidelines for biotech, or the Forsyth Institute Guidelines for nanotech, which are based on the Asilomar Guidelines. So it's a complicated issue. We can't just come up with a simple solution and then just cross it off our worry list. On the other hand, these technologies can vastly expand our creativity. They've already democratized the tools of creativity. And they are overcoming human suffering, extending our longevity and can provide not only radical life extension but radical life expansion.

There's a lot of talk about existential risks. I worry that painful episodes are even more likely. You know, 60 million people were killed in WWII. That was certainly exacerbated by the powerful destructive tools that we had then. I'm fairly optimistic that we will make it through. I'm less optimistic that we can avoid painful episodes. I do think decentralized communication actually helps reduce violence in the world. It may not seem that way because you just turn on CNN and you've got lots of violence right in your living room. But that kind of visibility actually helps us to solve problems.

RUS: You've probably heard the phrase from critics of the Singularity — they call it the “Rapture of the Nerds.” And a lot of people who are into this idea do seem to envision the Singularity as a sort of magical place where pretty much anything can happen and all your dreams come true. How do you separate your view of the Singularity from a utopian view?

RK: I don't necessarily think they are utopian. I mean, the whole thing is difficult to imagine. We have a certain level of intelligence and it's difficult to imagine what it would mean and what would happen when we vastly expand that. It would be like asking cavemen and women, “Well, gee, what would you like to have?” And they'd say, “Well, we'd

like a bigger rock to keep the animals out of our cave and we'd like to keep this fire from burning out?” And you'd say, “Well, don't you want a good web site? What about your Second Life habitat?” They couldn't imagine these things. And those are just technological innovations.

So the future does seem magical. But that gets back to that Arthur C. Clark quote that any sufficiently developed technology is indistinguishable from magic. That's the nature of technology — it transcends limitations that exist without that technology. Television and radio seem magical — you have these waves going through the air, and they're invisible, and they go at the speed of light and they carry pictures and sounds. So think of a substrate that's a million times faster. We'll be overcoming problems at a very rapid rate, and that will seem magical. But that doesn't mean it's not rooted in science and technology.

I say it's not utopian because it also introduces new problems. Artificial intelligence is the most difficult to contend with, because whereas we can articulate technical solutions to the dangers of biotech, there's no purely technical solution to a so-called unfriendly AI. We can't just say, “We'll just put this little software code sub-routine in our AIs, and that'll keep them safe.” I mean, it really comes down to what the goals and intentions of that artificial intelligence are. We face daunting challenges.

RUS: I think when most people think of utopia, they probably just think about everybody being happy and feeling good.

RK: I really don't think that's the goal. I think the goal has been demonstrated by the multi-billion-year history of biological evolution and the multi-thousand-year history of technological evolution. The goal is to be creative and create entities of beauty, of insight, that solve problems. I mean, for myself as an inventor, that's what makes me happy. But it's not a state that you would seek to be in at all times, because it's fleeting. It's momentary.

To sit around being happy all the time is not the goal. In fact, that's kind of a downside. Because if we were to just stimulate our pleasure centers and sit around in a morphine high at all times — that's been recognized as a downside and it ultimately leads to a profound unhappiness. We can identify things that make us unhappy. If we have diseases that rob our faculties or cause physical or emotional pain — that makes us unhappy and prevents us from having these moments of connection with another person, or a connection with an idea, then we should solve that. But happiness is not the right goal. I think it represents the cutting edge of the evolutionary condition to seek greater horizons and to always want to transcend whatever our limitations are at the time. And so it's not our nature just to sit back and be happy.

I think there are anti-technology movements that continue to spread among the intelligentsia that are actually pretty ignorant.”



MOVIES & SCIENCE FICTION

RUS: You've got two films coming out, *Transcendent Man* and *The Singularity is Near*. What do you think the impact will be of having those two films out in the world?

RK: Well, *Transcendent Man* has already premiered at the Tribeca film festival and it will have an international premier at the Amsterdam documentary film festival next month. There's quite a lot of interest in that, and there are discussions with distributors. So it's expected to have a theatrical release both in this country and internationally early next year. And *The Singularity is Near* will follow.

Movies are a really different venue. They cover less content than a book but they have more emotional impact. It's a big world out there. No matter how many times I speak — and even with all the press coverage of all these ideas, whether it's featuring me or others — I'm impressed by how many otherwise thoughtful people still haven't heard of these ideas.

I think it's important that people not just understand the Singularity, which is some decades away, but the impact right now, and in the fairly near future, of the exponential growth of information technology. It's not an obscure part of the economy and the social scene. Every new period is going to bring new opportunities and new challenges. These are the issues that people should be focusing on. It's not just the engineers who should be worrying about the downsides of biotechnology or nanotechnology, for example. And people should also understand the opportunities. And I think there are anti-technology movements that continue to spread among the intelligentsia that are actually pretty ignorant.

RUS: Do you read science fiction novels and watch science fiction television, or science fiction movies?

RK: I have seen most of the popular science fiction movies.

RUS: Any that you find particularly interesting or enjoyable?

RK: Well, one problem with a lot of science fiction — and this is particularly true of movies — is they take one change, like the human-level cyborgs in the movie *AI*, and they put it in a world that is otherwise unchanged. So in *AI*, the coffee maker is the same and the cars are the same. There's no virtual reality, but you had human-level cyborgs. Part of the reason for that is the limitation of the form. To try to present a world in which everything is quite different would take the whole movie, and people wouldn't be able to follow it very easily. It's certainly a challenge to do that. I am in touch with some movie makers who want to try to do that.

I thought *The Matrix* was pretty good in its presentation of virtual reality. And they also had sort of AI-based people in that movie, so it did present a number of ideas. Some of the concepts were arbitrary as to how things work in the matrix, but it was pretty interesting. ☺

RESOURCES

Kurzweil AI
<http://www.kurzweilai.net/index.html?flash=1>

Transcendent Man
<http://www.transcendentman.com/>

The Singularity is Near (Movie)
<http://singularity.com/themovie/>

diy bio

A GROWING MOVEMENT TAKES ON AGING

PARIJATA MACKEY

*So many seeking, Around lampposts
of today, Change is on the wind.*

— Unknown

A movement is growing quietly, steadily, and with great speed. In basements, attics, garages, and living rooms, amateurs and professionals alike are moving steadily towards disparate though unified goals. They come home from work or school and transform into biologists: do-it-yourself biologists, to be exact.

DIYbiology (“DIYbio”) is a homegrown synthesis of software, hardware, and wetware. In the tradition of homebrew computing and in the spirit of the Make space (best typified by O’Reilly’s *Make Magazine*), these DIYers hack much more than software and electronics. These biohackers build their own laboratory equipment, write their own code (computer and genetic) and design their own biological systems. They engineer tissue, purify proteins, extract nucleic acids and alter the genome itself. Whereas typical laboratory experiments can run from tens-of-thousands to millions of dollars, many DIYers knowledge of these fields is so complete that the best among them design and conduct their own experiments at stunningly low costs. With adequate knowledge and ingenuity, DIYbiologists can build equipment and run experiments on a hobbyist’s budget. As the movement evolves, cooperatives are also springing up where hobbyists are pooling resources and creating “hacker spaces” and clubs to further reduce costs, share knowledge and boost morale.

This movement, still embryonic, could become a monster — a proper rival to industry, government, and academic labs. The expertise needed to make serious breakthroughs on a regular basis at home hasn’t yet reached a critical mass, but there are good reasons to believe that this day will soon come.

SOFTWARE

DIYbio software has been around for a long time. Folding@home, which came out of Professor Vinjay Pande’s group at Stanford Chemistry Department in 2000, is designed to perform computationally intensive simulations of protein folding and other molecular dynamics. FAH, as it’s known, is now considered the most powerful distributed computing cluster in the world. Open source software for bioinformatics, computational neuroscience, and computational biology is plentiful and continues to grow. On their own time, students, professors, entrepreneurs, and curious amateurs contribute to open source work that captures their interests. BioPerl and BioPython

have hundreds of contributors and tens of thousands of users. Programs like GENESIS and NEURON have been downloaded by computational neuroscientists for over twenty years.

The software part is easy. The FOSS/OSS machine is well established, and has been successful for a long time. As the shift to open source software continues, computational biology will become even more accessible, and even more powerful. (Red Hat has recently asked the US Supreme Court to bar all software patents, submitting an amicus brief to the Supreme Court in the “Bilski case.” See Resources.)

Stem cell extraction and manipulation, DIY prosthetics, DIY neural prosthetics, sensory enhancements, immune system testing, general tweaking of whatever system strikes the hobbyist's fancy.

HARDWARE

Biological research is expensive. Microscopes, pipetmen, PCR machines, polyacrylamide gels, synthesizers — basics for any molecular biology lab — run from hundreds to thousands of dollars apiece. Traditional experiments cost hundreds-of-thousands to millions of dollars to conduct. How can the hobbyist afford this equipment? Unless “Joe (or Jill) the DIYBiologist” is extremely wealthy, they can't. So instead of purchasing brand new equipment, DIYers like to find good deals at auction sites like eBay or Dovebid, refurbish discarded equipment from labs or biotech companies, or — more and more frequently — build it themselves.

Hardware hacking has a rich history, filled with geek heroes, and these skills are being turned towards the creation of biotech equipment. On the bleeding edge of it all, some DIYbiologists are applying their skills to h+ technologies. SENS researchers John Schloendorn, Tim Webb, and Kent Kemmish are conducting life-extension research for the SENS Foundation, building equipment for longevity research, saving thousands of dollars doing it themselves.

The DIY SENS lab is headed by PhD candidate John Schloendorn. John is a last-year PhD student at Arizona State University. He volunteers full time for the SENS Foundation. Entering his lab was a mind-blowing experience. The ceilings were high, the lab itself was spacious and well-lit. It smelled of sawdust, the product of constructing the furniture on site. The equipment was handmade, but brilliantly so. Elegance and function were clear priorities. When a panel could be replaced with a tinted membrane, it was. When metal could be replaced by sanded wood, it was. The on-site laser was modified from a tattoo-removal system. Costs were down, but the technical skill involved in manufacturing was top notch.

In addition to his own experiments, Schloendorn is building an incubator (no pun intended) for DIYbio engineers who work on fighting death.

Schloendorn tells me that working by ourselves might only take us so far, but thinks it's a great place to start (many successful discoveries and businesses were founded in someone's garage). He believes that being a DIYer doesn't mean you must “go it alone,” but can include cooperation and teamwork. He cautions that since time and effort are limited, DIYers much choose carefully what they're going to work on and do that which is most important for them. His personal priority is to solve parts of the aging question, and he'd obviously like many other DIYers to take up this challenge. “I wanted to make a dent in the suffering and death caused by aging. It seemed like the SENS people were the smartest, most resourceful and best organized among those ambitious enough. Of course, there are also DIYers with no ambitions to save the world, who are content to ‘make yogurt glow’ in the basement for their own personal satisfaction.”

The DIYbio community has a high-traffic mailing list, where projects are discussed, designs shared, and questions asked or answered. The community has worked on dozens of DIY designs: gel electrophoresis techniques, PCR machines, alternative dyes and gels, light microscopes, and DNA extraction techniques. All of them focus on enabling cheap and effective science.

WETWARE

The most popular conception of wetware is the genome — the language of life, the ultimate hackable code. Genetic engineering and (more recently) synthetic biology are the hallmarks of this effort. Synthetic biology takes genetic engineering and builds it into a scalable engineering framework. It is the synthesis of complex, biologically-based (or inspired) systems that display functions that do not exist in nature. In synthetic biology, genetic code is abstracted into chunks, colloquially known as biological “parts.” These parts allow us to build increasingly complex systems: putting several parts together creates a “device” that is regulated by start codons, stop codons, restriction sites, and similar coding regions known as “features.” (Visit MIT's Standard Registry of Biological Parts for more detailed information, and tutorials on how to make your own biological part.)

These parts are primarily designed by undergraduates competing in the International Genetically Engineered Machine (iGEM) competition, the largest student synthetic biology symposium. At the beginning of the summer, student teams are given a kit of biological parts from the Registry of Standard Biological Parts. Working at their own schools over the summer, they use these parts, and new parts of their own design, to build biological systems and operate them in living cells.

Randy Rettberg, director of the iGEM competition, says that iGEM is addressing the question: “Can simple biological systems be built from standard, interchangeable parts and operated in living cells? Or is biology just too complicated to be engineered in this way?” The broader goals of iGEM include enabling the systematic engineering of biology, promoting the open and transparent development of tools for engineering biology, and helping to construct a society that can productively apply biological technology.

If this sounds suspiciously like a front for DIYbio, that's probably because it is. In addition to attracting the brightest young minds to the critical field of molecular biology, many of the founders of iGEM, including Drew Endy at Stanford, Tom Knight at MIT, and DIYbio-rep Mac Cowell are heavily involved in or supportive of the DIYbio community. The recent introduction of iGEM teams unaffiliated with universities (“DIYgem”) is a step towards an inclusive community, allowing anyone with the brain and the drive to participate at the level of academics.

Mainstream science is increasingly friendly to DIYbio. DIYbiologist Jason Bobe works on George Church's Personal Genome Project (PGP), which shares and supports DIYbio's drive to make human genome data available for anyone to use.

HOW TO GET INVOLVED

Join the DIYbio mailing list (see Resources). Anyone can join and it's the best way to begin your involvement with DIYbio. You'll want to check out their DIYbio forums, which are growing rapidly. You can also find a local group there and connect with like-minded DIYers. Have a look around the DIYbio.org site, which lists some of the current projects:

BioWeatherMaps: "Self-Assembly Required"

Flash mobs meet consumer-generated science in the new DIYbio initiative FlashLabs, where they'll be pulling-off a new large-scale collaborative science project annually for amateurs and enthusiasts worldwide. Case in point — the BioWeatherMap initiative is a "global, grassroots, distributed environmental sensing effort aimed at answering some very basic questions about the geographic and temporal distribution patterns of microbial life."

SKDB: "Apt-Get for Real Stuff (Hardware)"

Skdb is a free and open source hardware package management system. The idea is to let the user "make" a project by using all of the packaged hardware out on the web, so that the wheel isn't reinvented every time a new project is started. The package includes milling machines, gel boxes, semiconductor manufacturing processes, fabratories, robot armies, wetlab protocols... everything. At the moment, they're working on OpenCASCADE integration. Package maintainers from the DIYbio and open manufacturing communities assist others in bringing in projects into the system.

SmartLab: "Taking the Work out of Benchwork"

Project SmartLab is aiming to build hardware to augment the benchtop science experience. This includes automatic data logging instruments with painless electronic lab book integration, video streaming with "instant replay" features for those "did-I-just-pipette-that-into-the-wrong-tube" moments, and interactive protocol libraries that guide new scientists and the scientifically enthusiastic alike through tricky protocols.

The Pearl Gel Box: "A Built-In Transilluminator and Casting Box for \$199!"

Want to get a jump start in DIYbio? The gel electrophoresis box is a basic tool for any DIYbiologist — and they're making kits so you can build your own. The Pearl Gel Box is cutting edge, open-source, and cheap. The participants in this project have created a professional grade gel box, available fully assembled or as free design documents. Plus, they want you to design new features like a built-in light filter or a mount for your digital cam.

RESOURCES

Make Magazine
www.makezine.com

Red Hat Appeals to Supreme Court in Bilski Case
<http://www.linux-magazine.com/Online/News/BilskiII-Red-Hat-Appeals-to-Supreme-Court-over-Software-Non-Patentability>

Red Hat Amicus Brief (pdf)
<http://www.redhat.com/f/pdf/rh-supreme-court-brief.pdf>

SENS Foundation
<http://www.sens.org/>

MIT's Standard Registry of Biological Parts
http://partsregistry.org/wiki/index.php/Main_Page

DIYbio mailing list
<http://diybio.org/contact/>

DIYbio Forums
<http://diybio.org/forums/categories.php>

DIYBio Local Groups
<http://diybio.org/local/>

This is a mere glimpse into the vast undertaking that is DIYbio. Most DIYers work independently on projects that have significant personal meaning. Tyson Anderson, a specialist in the US Army, was struck by the lack of technological infrastructure during his time in Afghanistan. Anderson, a transhumanist as well as a DIYbiologist, was trying to discuss the implications of the Singularity with the friends he had made there. He realized it was difficult to conceive of a technological paradise in a world with limited electricity. He looked to DIYbio to make a difference, and is now engineering bioluminescent yeast to construct sugar-powered lamps for his friends in Afghanistan.

Because there is much overlap between the DIYbio and transhumanist communities, it's not surprising that many emerging projects focus on both. DIY-SENS is only the tip of the iceberg. DIYh+ is a fusion of DIYbio and H+, coordinating projects that allow willing individuals to experiment with practical human enhancement. Example projects include supplement/exercise regimens, DIYtDCS, DIY-EEG, and the personal harvesting of stem cells. From the group description: "This group is a friendly cross between DIYbio and Open Source Medicine, with a dash of the Immlnst (Immortality Institute) forums [see Resources]. It's the slightly edgier half of OSM. The community, ideally, should strive to foster an open and safe way for responsible adults to learn about do-it-yourself human enhancement. We do not believe in limiting the use of medical technology to therapy."

It's not just enhancement technology that can benefit from DIYbiology. As the popular distrust of doctors grows, people will want to understand and monitor their own body. Likewise, as personalized medicine becomes a reality, we will probably see a rise in the number of hobbyists who treat their own bodies as machines to be worked on — like a radio or a car — branching out from personalized genomics to things like DIY stem cell extraction and manipulation, DIY prosthetics, DIY neural prosthetics and sensory enhancements (infrared vision, anyone?), immune system testing, and general tweaking of whatever system strikes the hobbyist's fancy. This hacker's paradise has not yet come to pass, but it is, perhaps, our exciting future.

The road to true DIYbiology will not be easy. It's not a magic bullet. It will probably not produce the next Bill Gates, at least not for a long time. Biology is hard, messy, and failure is more common than success. The knowledge required takes time and effort to acquire, and even then, so-called textbook knowledge is being revised almost daily. Many are attracted by the glamour of it all. They're drawn to the romance of being a wetware hacker — the existential thrill of tweaking life itself. They tend to become quickly disappointed by the slow, tedious, difficult path they face.

Hobbyist biology is still in its infancy, and it will take a great deal of work before it reaches its potential. Few are more skeptical than DIYbiologists themselves. But many see no choice. Squabbles over sponsorship, intellectual property, and cumbersome regulations often prevent progress along more conventional lines. An anonymous DIYbiologist puts it this way: "Universities charge far more than the experiments really

cost, and bureaucratic rules constantly retard real progress." Questions of IP and ownership can hamstring innovation in industry, while concerns for national security prevent real information sharing in government science. Large, unwieldy bureaucracies and regulatory agencies find it difficult to keep pace with the breakneck speed of technological progress. Thought-monopolies make it unwise to promote new ideas while waiting for tenure, despite the fact that many central dogmas of biology change. Individuals willing to intelligently circumvent convention may find themselves stumbling into uncharted areas of biology where they may make new discoveries.

Indeed, it is only in the last century that biology has become an unreachable part of the academic-corporate-government machine. History's naturalists, from Darwin to Mendel, are the true fathers of DIYbiology. They shared the spirit of discovery and scientific ingenuity and the drive to "figure it out yourself." No one told Isaac Newton to discover the laws of classical mechanics, and you can bet he was never given calculus homework. Einstein's life would have been respectable if he hadn't spent a silent decade questioning the nature of spacetime. They were driven by the simple need to know, and they would not be stopped by the incidental truth that no one had figured it out before. DIYbiology is perhaps a reemergence of this basic curiosity, applied to the study of life.

As technological advances, let us study the workings of the cell the same way Newton may have studied the effects of gravity. Who wouldn't want to know? Who can resist a peek at the mechanisms of our own existence? DIYbio may be young, but it is a symptom of our species' unbreakable curiosity. We will know these secrets too, someday.

"For me, chemistry represented an indefinite cloud of future potentialities which enveloped my life to come in black volutes torn by fiery flashes, like those which had hidden Mount Sinai. Like Moses, from that cloud I expected my law, the principle of order in me, around me, and in the world. I would watch the buds swell in spring, the mica glint in the granite, my own hands, and I would say to myself: I will understand this, too, I will understand everything." —Primo Levi

Without a lab supervisor to guide them, DIYbiologists must take a carefully disciplined (and perhaps more genuine) approach to science. DIYbio has the potential to revive a noble tradition of pure scientific curiosity, with a modern, engineering twist. If you want to get something done, some day it really will be possible to do it yourself. ☺

Parijata Mackey is the Chief Science Officer of Humanity + and a senior at the University of Chicago, interested in applying synthetic biology, stem cell therapies, computational neuroscience, and DIYbio to life-extension and increased healthspan.

SKDB
<http://adl.servftp.org/skdb/>

Smart Lab
<http://projectsmartlab.org/>

DIYh+
<http://groups.google.com/group/diyrtranshumanist?pli=1>

Immlnst Forum
<http://www.imminst.org/forum/>

BioPerl
<http://en.wikipedia.org/wiki/BioPerl>

BioPython
<http://en.wikipedia.org/wiki/BioPython>

GENESIS: GEneral NEural SImulation System
http://en.wikipedia.org/wiki/GENESIS_%28software%29

One of the ideas I champion is that DNA is a programming language for living things. By stringing DNA bases together in different ways, one gets different organisms. With one sequence, a bacterium is the result. With another, a butterfly. The same can be said about any subcomponent of life, all the way down to individual proteins.

As we get better at “printing” DNA with automated synthesizers, it gets easier to make DNA-based programs, from simple scripts (instructing a bacterium to make a new protein or compound) to whole new operating systems (genomes). And it’s just gotten easier, faster and cheaper — a biological version of Moore’s Law. With DNA synthesis, metabolism can be shaped by anyone who can master various DNA design tools. It’s the start of a whole new era in biology: digital biology.

I started focusing on DNA synthesis about ten years ago. At the time, I worked for a large biopharmaceutical company. As with any language, mastering DNA means one must learn to read, comprehend, and write. We had a fantastic bioinformatics team. We bought a subscription to Celera, the company Craig Venter created to sequence the human genome. With reading and comprehension well taken care of, it made sense to start thinking about how to write DNA code better.

Celera was possible because people had spent decades improving DNA sequencing technology. Still, the state of the art of DNA synthesis was poor, with low throughput and high cost (on the order of \$10 per base pair). Making even a small protein (roughly 1000 bases) was expensive, and only justifiable for things like small, high-value proteins such as a growth hormone. But I believed that as synthesis costs fell over time, less lucrative applications or experimental designs that had a higher probability of failure would fall within reach. Moreover, the work would become increasingly computer-based, rather than being done in the laboratory. Genetic engineering would

come to resemble software engineering, except the programming would be biochemical.

In 2003, I took a year off to digest past experiences and to consider where life science may be going in the near future. In the meantime, digital biology got a name: synthetic biology. A small group at MIT was leading the way with DNA modules they called BioBricks that could be snapped together like Lego blocks and then easily reconfigured. The next year, they developed a student training program with BioBricks and challenged student teams to be creative in designing and making applications. Almost overnight, the genetic engineering capability once available only to the experienced and well-financed became available to relative novices for a fraction of the price.

Around this time, I found myself thinking a lot about open source versus proprietary software. The success of open source software, like Linux and Apache server, had demonstrated that community-based development could rival the work done in dedicated companies. Was open source biology possible? I believed strongly that synthetic biology, done openly, could eventually compete with the for-profit biotechnology industry. I could see a day where almost anyone with a laptop could start to create software for cells. What would people make? The projects developed by students with BioBricks suggested a broad range, from fun (bacteria programmed to smell like bananas or wintergreen) to commercially useful (next generation biofuels like butanol).

By 2005, several synthetic biology companies had appeared. They’d attracted large investments from top-tier venture groups. The field was hot. I began to think seriously about creating a Linux-style company to make drugs. How would the company be financed? How would people work together? What would they make?

Eventually, I came to believe that drug development needed a complete reboot. In the wake of the Human Genome Project and increasing lab automation, life science data was exploding. Genomics had spawned proteomics and metabolomics, and even more “omics” were appearing on the horizon. Research was growing exponentially, but development was still stuck on a linear path from discovery to the clinic that could take a decade and a billion dollars or more. The gulf between biological R&D, always wide compared to more traditional fields of engineering, was growing even wider.

WHY DIY BIO?

Andrew Hessel of Pink Army Cooperative on
Forming the First DIY Drug Company

I threw away the old model for making drugs and started from scratch. Synthetic biology allowed almost anything biological — from a single protein to an entire organism — to be developed using a tool that was costing less each day. The cost of DNA-based diagnostic tests were falling quickly, too. So what was keeping the cost of making drugs so high? I identified three factors. One was overhead: the physical infrastructure of labs and staff. The second was the cost of manufacturing: facilities to make large quantities of a new drug were often custom-designed and could cost hundreds of millions of dollars. The third was the cost of clinical trials, necessary to prove to regulators that a drug was effective and safe.

Then it hit me. What if, using synthetic biology, we made drugs for just one person at a time? Fully individualized ($n=1$) medicines? Done open source and virtually, the overheads would be very low. Large manufacturing plants wouldn't be necessary. Best of all, the cost and complexity of clinical trials would be reduced, potentially saving years of time and massive amounts of money. Suddenly, the idea of open source drug development didn't seem farfetched.

Cancer was the perfect target to test this idea. Because cancer results from the corruption of a person's DNA, and no two people have the same DNA, each cancer is unique. A customized drug would be the ideal drug, but wasn't economically viable — at least until synthetic biology. I needed a therapeutic agent that was flexible and could be programmed. That's when I learned about oncolytic viruses — benign viruses that can infect cancer cells and kill them without affecting normal, healthy cells.

In September 2007, I gave a short talk at Aubrey De Grey's SENS conference in Cambridge outlining my intention to found an open source biotech company that would make customized therapies for breast cancer. The response to the presentation was predictable: many had concerns whether regulators would allow such a drug to be used in a human trial. I had no idea, but I knew the only way to truly find out would be to try. It took almost two years of discussion and feeling my way around, but this company now exists. It's called the Pink Army Cooperative.

The technology behind Pink Army is off-the-shelf computing and synthetic biology. What makes Pink Army unique is the way the technology is assembled and its cooperative business structure. The company sketches out a path to drug development — a process where each of the major steps has Moore's law dynamics. With experience, the performance should increase while the price falls. Meanwhile, the cooperative architecture puts it in a class of its own compared to other drug companies.

Cooperatives are community-owned and operated enterprises that exist to serve their memberships. They are corporations that operate as non-profits and can have broad membership, because people don't need to be qualified investors to get a share. They can raise substantial sums by attracting a large membership — an army — something that is fairly easy to do these days because of social networking sites like Facebook. Members of the cooperative are united by their common interest, in Pink Army's case, better, faster, and less expensive treatments for breast cancer.

Breast cancer is the first target, but ultimately the cooperative's goal is to open a path from diagnostics to the clinic for individualized medicines — to make effective cancer treatments as fast as diagnostic data can be translated into designs, manufactured, tested in the lab, and approved for use on a single person. Using open source synthetic biology, each of these steps can be automated, and each should get cheaper over time. If it works, drug development could become a real technology.

Pink Army, then, is the first DIY drug company. It's a container that allows people interested in tackling cancer to connect and focus their passion, skills, and other resources. It takes cancer — a field that has

We get better at “printing”
DNA has gotten easier, faster
and cheaper — a biological
version of Moore's Law.

mushroomed to become a vastly complex global R&D enterprise — and reduces it to an easy-to-understand, manageable task: finding better ways to analyze and treat just one person; ways that can connect experts and resources no matter where they are in the world, ways that are safe, and ways that can scale and become more affordable as they do.

My role in the company is to share stories and make connections, something that, as a generalist, I absolutely love to do. More people are connecting every day, and the company intelligence is growing. For Pink Army to work, it needs to resonate with many people, for many different reasons. It must somehow convey the message that although cancers can arise in countless ways, the goal for treatment is almost always the same: selectively shut down or kill the broken cells.

Why am I passionate about DIYbio and open biology? Mostly it's because I think that collectively we can do better than we have. The transistor and the structure of DNA were discovered within six years of each other. Recombinant DNA technology and the microcomputer both appeared in the early 1970's. Both became big industries, but with very different dynamics. Computers are ubiquitous, while biotechnologies remain a mystery to most people, with few applications that demonstrate the utility and potential of the field to make the world a better place.

The biotech industry has struggled economically and is reaching a point where even the largest companies are resorting to merger and consolidation for growth. It's clear that something needs to change. Open biology is that change. I believe that open biology will continue to make bioengineering more accessible. It will produce new products that people want, can afford, and trust, at a much faster pace. A more open foundation for drug development could lay a strong foundation for a thriving bioeconomy that could one day be larger than the computing industry. After all, life is the most valuable commodity of all. ☺

Andrew Hessel champions open source synthetic biology, enabling researchers and entrepreneurs to better address major challenges, including renewable energy, environmental remediation, and curing human disease.

RESOURCES

The BioBricks Foundation
<http://bbf.openwetware.org/>

The Pink Army Cooperative
<http://pinkarmy.org/elgg/>

RE-ENGINEERING THE HUMAN IMMUNE SYSTEM

DERYA UNUTMAZ
AND GARY MARCUS

Swine Flu. Spanish Flu. SARS. Almost every year, it seems, there is a new virus to watch out for. Roughly thirty thousand Americans die annually from a new flu strain — meaning roughly one flu fatality for every two victims of car accidents — and there is always the possibility that we will do battle with a much deadlier strain of flu virus, such as the one (cousin to the current swine flu) that killed 50 million people in 1918.

Currently, our bodies' responses are, almost literally, catch as can. The immune system has two major components. Innate immunity responds first, but its responses are generic, its repertoire built-in and its memory nonexistent. On its own, it would not be enough. To deal with chronic infection and to develop responses targeted to specific pathogens the body also relies on a second "acquired immune system" that regulates and amplifies the responses of the inbuilt system, but also allows the body to cope with new challenges. Much of its action turns on production of *antibodies*, each of which is individually tailored to the physical chemistry of a particular alien invader. In the best case, the immune system creates an antibody that is a perfect match to some potential threat, and, more than that, the acquired immune system maintains a memory of that antibody, better preparing the body for future invasions from the same pathogen. Ideally, the antibody in question will bind to — and ultimately neutralize or even kill — the potentially threatening organisms.

Alas, at least for now, the process of manufacturing potent antibodies depends heavily on chance, and a type of lymphocyte known as B cells. In principle, B cells have the capacity to recombine to form a nearly infinite variety of antibodies: roughly 65 different "V regions" in the genome can combine with roughly 25 "D regions" and 6 "J regions," which further undergo random mutations. In practice, getting the right antibody depends on getting the right combination at the right time. Which combinations emerge at any given moment in any given individual is a function of two things: the repertoire of antibody molecules a given organism has already generated, and a random interplay of combination and mutation that is much like natural selection itself — new B cells that are effective in locking onto enemy pathogens persist and spread; those that do a poor job tend to die off.

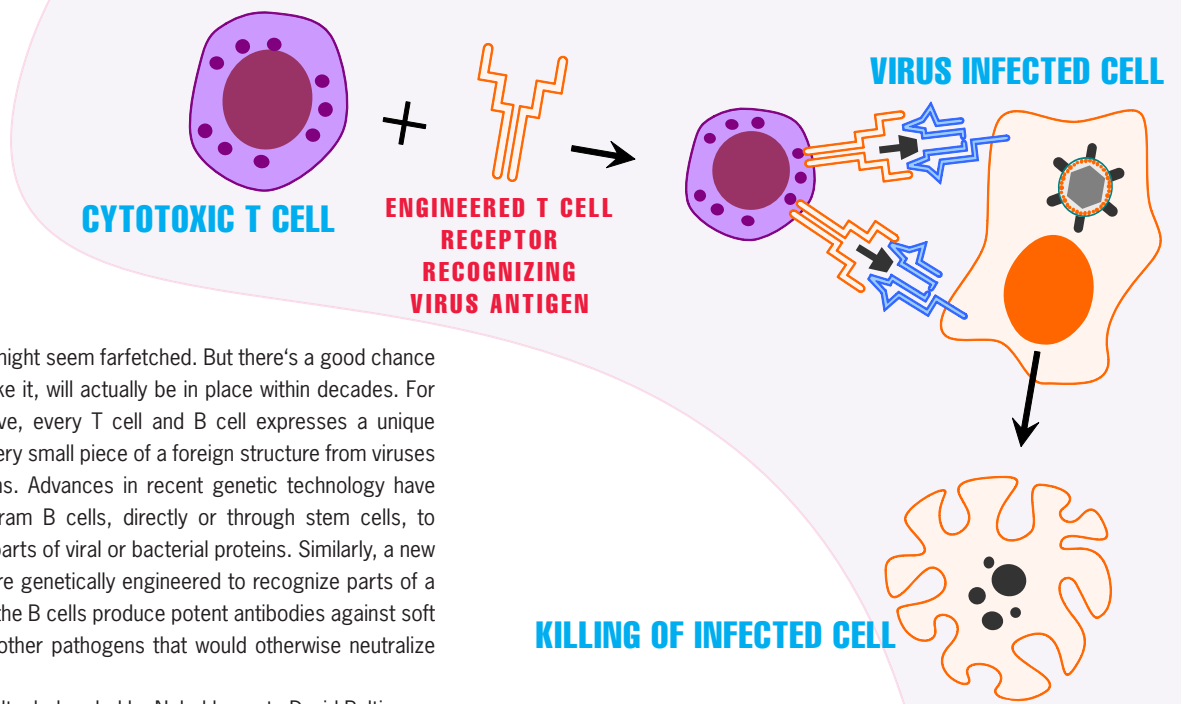
Unfortunately, there is no guarantee that this system will work. In any given individual there may be no extant antibody that is sufficiently close.

If there is a hole in a given individual's repertoire, that individual may never develop an adequate antibody. Even if there is an adequate starting point, the immune system still may fail to generate a proper antibody. The most useful mutations may or may not emerge, in part because the whole system is governed by a second type of immune cell known as the T cell. The job of T cells is to recognize small fragments of viral proteins as peptides and then help the B cells produce antibodies. Like B cells, T cells also have a recombinative system, generating billions of different receptors, only a few of which will recognize a given viral antigen. In effect, two separate systems must independently identify the same pathogen in order for the whole thing to work. At its best, the system is remarkably powerful — a single exposure to a pathogen can elicit a protective antibody that lasts a lifetime; people who were exposed to Spanish flu in 1918 still retain relevant antibodies today, 91 years later. (See Resources) But the system can be hit-or-miss. That same Spanish flu claimed 50 million lives, and there is no assurance that any given person will be able to generate the antibodies they need, even if they are vaccinated.

IMMUNITY 2.0

For now, the best way to supplement the body's own defenses is through vaccines, but vaccines are far from a panacea. Each vaccine must be prepared in advance, few vaccines provide full protection to everybody, and despite popular misconception, even fewer last a lifetime. For example, smallpox vaccinations were lifelong, but tetanus vaccines generally last 5-10 years. There is still no vaccine for HIV infection. And when it comes to bacteria like tuberculosis, current vaccines are almost entirely ineffective. What's more, the whole process is achingly indirect. Vaccines work by first stimulating B cells and T cells in order to induce production of antibodies. They don't directly produce the needed antibodies. Rather, they try (not always successfully) to get the body to generate its own antibodies. In turn, stimulation of T cells requires yet another set of cells — called dendritic cells — and the presence of a diverse set of molecules called the major histocompatibility complex, creating still further complexity in generating an immune response.

Our best hope may be to cut out the middleman. Rather than merely hoping that the vaccine will *indirectly* lead to the antibody an individual needs, imagine if we could genetically engineer these antibodies and make them available as needed. Call it immunity-on-demand.



At first blush, the idea might seem farfetched. But there's a good chance this system, or something like it, will actually be in place within decades. For starters, as mentioned above, every T cell and B cell expresses a unique receptor that recognizes a very small piece of a foreign structure from viruses or bacteria, such as proteins. Advances in recent genetic technology have made it possible to reprogram B cells, directly or through stem cells, to produce antibodies against parts of viral or bacterial proteins. Similarly, a new clonal army of T cells that are genetically engineered to recognize parts of a virus or bacteria would help the B cells produce potent antibodies against soft spots of these viruses and other pathogens that would otherwise neutralize or kill them.

Already scientists at Caltech, headed by Nobel laureate David Baltimore, have engineered stem cells that can be programmed into B cells, which produce potent antibodies against HIV. Meanwhile, cancer researcher Steven Rosenberg at NIH has been engineering clonal T cells capable of recognizing tumors and transferring these cells to patients with a skin cancer called melanoma. His work has shown promising results in clinical trials. Together, these results could lay the groundwork for a new future, in which relevant antibodies and T cell receptors are directly downloaded, rather than indirectly induced.

Of course, many challenges remain. The first is to be able to better understand the pathogens themselves: each has an Achilles' heel, but we've yet to find a fully systematic way of finding any given pathogen's weakness, a prerequisite for any system of immunity on demand. It will also be important to develop structural models to artificially create the antibodies and T cell receptors that can recognize these regions. Eventually, as computational power continues to grow and as our structural biology knowledge increases, we may be able to design artificial vaccines completely in silico. For now, this is more dream than reality.

The real obstacle, however, is not the creation or the manufacture of protective antibodies against pathogens, but the delivery of those antibodies or cells into the body. Currently the only way to deliver antibodies into the body is difficult and unreliable. One needs to isolate stem or immune cells (B and T cells) from each individual patient and then custom-tailor the receptors for their genetic backgrounds, a process that is far too expensive to implement on a mass scale. Stem cells, nonetheless, do offer real promise. Already it seems plausible that in the future, bioengineers could create new stem cells from your blood cells and freeze them until needed. If there were to be a deadly new virus, bioprogrammers could design the potential immune receptors and genetically engineer and introduce them into your stored stem cells, which can then be injected into your blood. Eventually it may even be possible to deliver the immune receptor genes directly into your body, where they would target the stem cells and reprogram them.

All this is, of course, a delicate proposition. In some ways, an overactive immune system is as much of a risk as an underactive one: more than a million people worldwide a year die from collateral damage, like septic shock after bacterial infection,

and inflammations that may ultimately induce chronic illness such as heart disease and perhaps even cancer. Coping with the immune system's excesses will require advances in understanding the precise mechanisms of immune regulation. This fine-tuning of the immune response could also have the bonus effect of preventing autoimmune diseases.

We are not sure when this will all happen, but there's a good chance it will, and perhaps the only question is when. There was a great leap forward in medicine when sterilization techniques were first implemented. Here's to the hope that the fruits of information technology can underwrite a second, even bigger leap. ☺

Derya Unutmaz is an Associate Professor of Microbiology and Pathology at N.Y.U. School of Medicine. His current research is focused on understanding the function of human immune system.

Gary Marcus is an author and a Professor of Psychology at NYU. His most recent book is Kluge: The Haphazard Construction of the Human Mind.

At first blush, the idea of immunity-on-demand might seem farfetched

RESOURCES ▼

Spanish Flu, 1918
<http://www.mc.vanderbilt.edu/reporter/index.html?ID=6621>

David Baltimore: Engineering Immunity Against HIV and other Dangerous Pathogens
<http://www.grandchallenges.org/CureInfection/Challenges/ImmunologicalMethods/Pages/HIV.aspx>

Steven Rosenberg
<http://bethesdatrials.cancer.gov/investigator-profiles/default.aspx?investigatorid=84>

Reactive Reasoning, *Scientific American*
<http://www.scientificamerican.com/article.cfm?id=reactive-reasoning>

Is Chronic Inflammation the Key to Unlocking the Mysteries of Cancer?
<http://www.scientificamerican.com/article.cfm?id=chronic-inflammation-cancer>

Slicing BRAINS DIY

Is Ken Hayworth Building the Instruments for Uploading Brains?

AINEKO

Here at *h+* Magazine, we love DIYers and garage entrepreneurs who work in the “NBIC” (nano, bio, info, and cogno) fields. We recently visited Harvard University’s Center for Brain Science where we came across a particularly inspiring example.

In order to understand the brain’s function, neuroscientists must be able to map out its basic neuronal circuits. A neuronal circuit (for example, a thalamocortical circuit) typically spans quite a large volume of brain tissue (tens of cubic millimeters). At the same time, the axonal and dendritic processes comprising such a circuit are so fine and so tortuously interconnected that only electron microscopy of ultrathin (50nm) serial sections can resolve their connectivity. No current techniques can image so large a volume of tissue at such fine resolution. While working as a computer scientist and engineer at the Jet Propulsion Laboratory in Pasadena, Ken Hayworth says that he was inspired by a paper he read by Xerox PARC’s Ralph Merkle on “Large Scale Analysis of Neural Structures.” In 1989, Merkle wrote that we should be able to reverse engineer the human brain in the near future using advanced electron microscopy, and new slicing, staining and computational analysis algorithms.

Hayworth, a cryonicist (he’s signed up with Alcor to be cryopreserved upon his death in the hopes of being repaired and revived by a future technology), immediately saw that understanding the circuitry of the brain was a necessary first step towards mind uploading. His interest in developing new neuroanatomical mapping instruments stems from his frustration with the lack of neuroanatomical knowledge currently available on the circuits and systems of the higher-level visual system in mammals.

So Ken started applying to grad schools and interviewing with neuroscientists about his plans to build a high-throughput brain-slicing machine. Time after time, he was rejected: either because he didn’t have the academic background they were expecting, or because the professors wanted a lab slave and not someone with his own plans. Finally, he was offered admission by a professor at U.S.C. conducting psychophysical research in human vision. Fascinated by the topic, Hayworth accepted, even though it meant putting off his brain-slicing experiments.

After his second year of grad school, Hayworth started working on his brain-slicing idea again. As he began attending neuroscience conferences and telling people about his machine, he faced ridicule (“that can’t be done”) and scorn for focusing on equipment rather than the brain itself. Unperturbed, Ken built a prototype that demonstrated the concept sufficiently well to attract the interest of a Harvard professor interested in high-throughput neural circuit mapping. Together they submitted a proposal to the McKnight Endowment Fund to bring his project to the next level. Much to his surprise, he won a \$200,000 grant and with it a chance to work at the Center for Brain Science at Harvard University. There he built the ATLUM (Automatic Tape-collecting Lathe Ultramicrotome), the first machine to demonstrate the fully automatic collection of brain slices thin enough to view in an electron microscope and thus image at nanometer resolution. No one is laughing now. Work on ATLUM2 is reaching nearly \$1 million in cost, and Ken is getting requests from neuroscientists worldwide who see the value of obtaining such a machine to build a library of brain slices for examination and scanning using an automated system.

This Matrix-like immortality
would be the ultimate backup of ourselves.

The ATLUM2 machine

Today only tiny volumes of neuropil (the Free Dictionary: “the complex network of unmyelinated axones, dendrites, and glial branches that form the bulk of the central nervous system’s grey matter and in which nerve cell bodies are embedded”) can be traced at electron microscopy resolution using painstaking manual techniques. Mapping the neuronal network of the nematode worm *C. Elegans* was a decade-long Herculean task, even though it is less than 0.01mm^3 in volume. Hayworth wants to use his device to cut an entire mouse brain into such thin slices that an electron microscope can scan virtually all of the structures within the tissue. As small as a mouse brain is, at 30 nm thickness, that would require approximately 2 million slices! To accomplish this, the mouse brain would be chemically fixed and embedded in plastic. Then, using a special slicing device which Ken is also designing, the plasticized brain would be cut into approximately 400 sub-blocks. Each sub-block would then be loaded into Ken’s ATLUM2 and it would be cut into 5,000 incredibly thin slices. Each slice would be picked up on a long carbon-coated tape for later staining and imaging in a scanning electron microscope (SEM). Because the process is fully automated, volumes as large as tens of cubic millimeters (large enough to span entire multi-region neuronal circuits) can be quickly and reliably reduced to a tape of ultrathin sections.

Ken’s original ATLUM machine has already collected over 1,000 sections of embedded mouse cortex, each 30nm thick and 1mm x 5mm in area. SEM images of these ATLUM-collected sections can attain lateral resolutions of 5nm or better, which is sufficient to image individual synaptic vesicles and to identify and trace all circuit connectivity.

Following collection, the ATLUM tape can be stained with heavy metals (or other markers), and cut into shorter lengths. This allows rows of sections to be attached to large (200mm diameter) imaging plates that can be loaded into a standard SEM for automated random access imaging of any location within any of the hundreds of sections on the plate’s surface. A few dozen of these plates could hold an entire 10mm^3 volume representing an incredible 1×10^{16} voxels of raw image data.

Bulk imaging of such a large volume at the highest resolution would take hundreds of years, but having the ultrathin sections laid bare on a set of tissue plates solves this problem. Luckily, a researcher can quickly produce a lower-resolution image set of the entire volume, setting up a unified coordinate system for the sample volume and plates, and then use robotic loading and positioning of plates to zoom in on any part to obtain the highest resolution SEM images. In the near future, multi-beam scanning electron microscopes will shorten the time it takes to scan such samples in high resolution, and efforts similar to the Human Genome Project, whereby hundreds of sequencing machines were used at once, might allow researchers to use hundreds or thousands of electron microscopes simultaneously to map entire brains within days rather than years.

Once Ken’s ATLUM2 is perfected, it will hopefully go into production and copies of the device will find their way into neuroscience labs around the world. At first, these devices will be used to section areas of the brain that are of particular interest to the individual researchers. The circuitry could be used to emulate those brain functions, run experiments emulating a brain section, and possibly even test pharmaceuticals or therapies. In the future, we might understand brain circuitry so well that such devices could be used to scan and “upload” an individual’s mind to any type of substrate (a new body, robot, or artificial environment). This *Matrix*-like immortality would be the ultimate backup of ourselves. ☺



RESOURCES

Ken Hayworth
<http://geon.usc.edu/~ken/>

Ralph Merkle on “Large Scale Analysis of Neural Structures”
<http://www.merkle.com/merkleDir/brainAnalysis.html>

SELF TRACKING

The Quantified Life is Worth Living

ALEXANDRA CARMICHAEL

What would you do with a complete memory of your entire life? Would you relive your first kiss? Figure out what triggered your recent migraine? Remember the name that goes with the familiar face in front of you?

In other words, wouldn't it be great to have a backup of your brain?

Gordon Bell is a walking experiment doing just this. Bell has been tracking his life in delicious detail for the past 11 years. It started at Microsoft Research, where Bell started the MyLifeBits project. His goal was to digitally record as much of his life as possible. He wore a camera, recorded his phone calls, scanned photos and letters, documented all of his computer work, and tracked his biometrics. The job of Bell's colleague Jim Gemmell was to build software to make all this tracking easier, searchable, and meaningful.

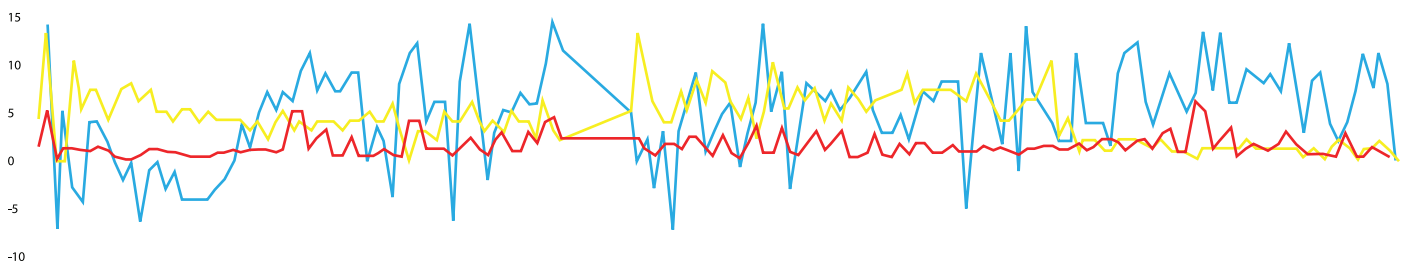
This September Bell and Gemmell released a book called *Total Recall: How the E-Memory Revolution Will Change Everything*. In it, they talk about the future implications of being able to remember everything about your

life in extraordinary detail. Bell proposes that a "continuous digital diary or e-memory" that integrates digital recording devices, memory storage and search engines will fundamentally "change what it means to be human." Their work includes research into memory, work, health, learning, and immortality. A side order of privacy is served up too, as the authors distinguish between "life loggers," who keep their records to themselves, and "life bloggers," who broadcast their data.

Of course, self-tracking is not a new idea. People have been recording their lives in analog format ever since they started drawing on cave walls. Benjamin Franklin used to keep a detailed checklist of the thirteen virtues he was striving to live by, including annotated explanations of where he was succeeding and where he still needed to improve.

Now, it can all be monitored digitally.

It probably won't surprise the readers of this article that I track myself. But it might surprise you that I track 40 different things every day. On a typical day, my pain level is 2, my weight is 126 lbs, I did 1 hour of walking, my happiness is 9, and I slept 6 hours. Charts like the one below help me to be aware of my mood, activity level, and sleep, and how these things interrelate.



With a background in molecular genetics and bioinformatics, as well as a history of chronic pain, I started tracking to help myself. But I soon wanted to apply what I had learned to help others. Here are two of the projects I'm currently working on.

QUANTIFIED SELF

Imagine a show-and-tell for grownups. Fifty or so people get together every month in the San Francisco Bay Area and New York City. They show each other the data they've collected, the tools they've built, the ideas they have, or the self-tracking projects they're working on. Feedback and questions pop up from the audience. All of it is reminiscent of the Homebrew Computer Club.

This amazing group, which calls itself The Quantified Self, was started in 2007 by Kevin Kelly and Gary Wolf of *Wired* Magazine. They noticed a trend in people seeking greater self-knowledge, and using numbers on this quest to understand themselves. (Hence the name.)

On a typical day, my pain level is 2, my weight is 126 lbs, I did 1 hour of walking, my happiness is 9, and I slept 6 hours.

SOME OF THE PROJECTS THAT HAVE BEEN SHOWN-AND-TOLD AT QUANTIFIED SELF MEETUPS INCLUDE:

Tweetwhatyoueat

Alex Rossi showed a demo of the web application he built to help people keep track of the foods they eat. He even added a crowdsourced calorie lookup, so if you're not sure how many calories were in the banana you just ate, you can see what eight other people estimate the calories of a banana to be. He used the Twitter API, with a simple prefix people can use in their tweets that will direct the information to his system. (See a video of his Quantified Self presentation in Resources.)

Lifecasting

Ryan Grant showed a wearable camera he was working on that would take tens of thousands of pictures every day. That's a picture every 2 to 5 seconds. It's like a memory assistant that puts scrapbooking to shame. Of course, categorizing and searching all those photos is the next challenge. (See Resources for Ryan's talk.)

Fish Oil Makes You Smarter

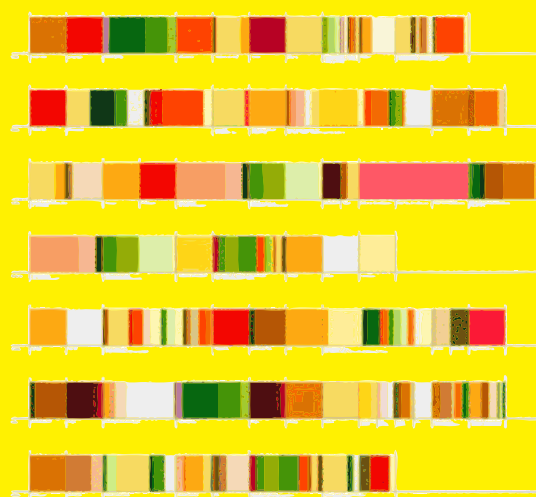
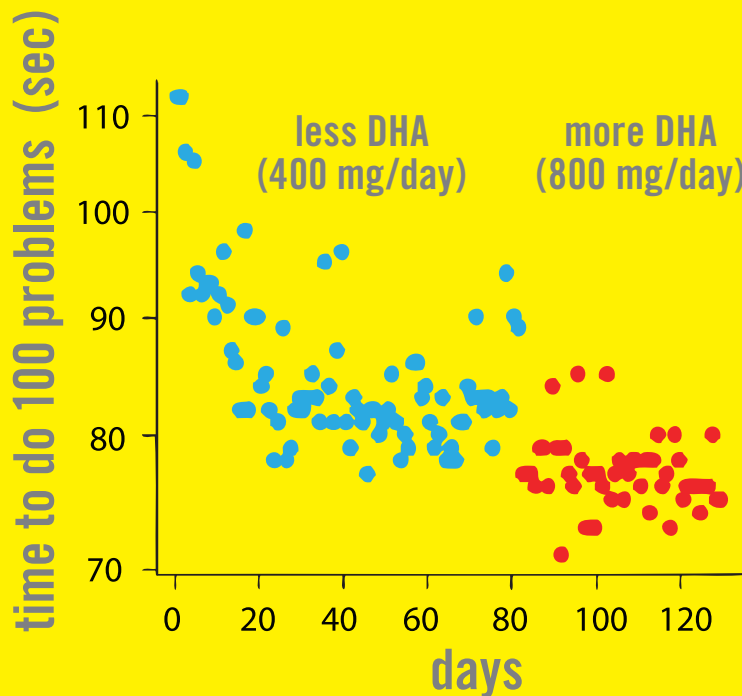
Here is an example of pure self-experimentation. Tim Lundeen gave himself a cognitive test of 100 simple math problems, every day for 130 days. On day 80, he started taking double his normal dose of DHA (from fish oil), and his time to complete the math problems decreased. See the chart to right.

Your Genome on Twitter

At a recent Quantified Self meetup, Attila Csordas talked about his attempt to post the data from his 23andMe genome scan to Twitter, with each SNP (single nucleotide polymorphism) expressed as a tweet. What happens when more people make their personal health information public? Does the health information have a life and friends of its own? Would you follow a SNP on Twitter? These are some of questions that arose out of this animated discussion.

A Square Meal

Mimi Chun, at a New York Quantified Self meetup, showed the beautiful quantitative artwork she created based on the color of her food palette over the course of a week (see right).



So whether it's for art, memory, health, or data for data's sake, people are tracking themselves and sharing their results. We do it because we love data or because we have specific things we want to optimize about ourselves. As Kevin Kelly wrote, "Unless something can be measured, it cannot be improved."

When Gordon Bell is asked what he has learned about himself through the MyLifeBits project, his reply is unexpectedly qualitative: "That's been a really hard question to answer... I guess it's the rich set of connections and people that I've been involved with."

Bell's comment reflects the challenges that come up over and over again at Quantified Self discussions — questions that tend to revolve around two topics: motivation and meaning. How do we stay motivated (and motivate others) to track ourselves, and how do we make sense and learn actionable lessons from all of this data? The search for solutions to these challenges offers ample opportunities for innovation. Imagine self-tracking games that reward people for recording their health with badges of recognition; passive monitoring devices that remove the need to actively track yourself; social pressure in the form of online group challenges; prizes awarded to algorithms that turn messy data into beautiful insight.

CURETOGETHER

One step on this path of innovation is self-tracking applied to health. An example of this is CureTogether, a patient data-sharing site I co-founded with Daniel Reda where people come to self-report symptoms, treatments, and triggers for over 300 conditions.

People are tracking their depression, cholesterol, migraines, and countless other measures. Using migraine as an example, patients visiting CureTogether can see community statistics and learn that the top reported symptoms are "Nagging pain in one side of the head" and "nausea;" the top reported treatments are "sleep" and "ibuprofen;" the top reported triggers are "stress" and "not enough sleep" and the top related conditions are anxiety and depression.

Instead of narrative websites that provide emotional support in the form of shared disease stories, the quantitative data at CureTogether enables decision support and hypothesis generation. People are getting ideas for new treatments that they ask their doctors about. They are seeing how common or rare their symptoms are, and learning what triggers might be affecting them. While each individual's data is completely private, the aggregate data is open for researchers around the world to analyze and use to make discoveries for the greater good. Some interesting correlations are already starting to emerge, like a potential link between migraine and fibromyalgia.

Alexandra Carmichael is co-founder of CureTogether, blogger at The Quantified Self, advisor to Singularity University, and mentor to several startups. Find her on Twitter @accarmichael.

RESOURCES

Gordon Bell Homepage

<http://research.microsoft.com/en-us/um/people/gbell/>

MyLifeBits project

<http://research.microsoft.com/en-us/projects/mylifebits/>

Jim Gimmell

<http://research.microsoft.com/en-us/people/jgimmell/>

Franklin's 13 Virtues

<http://www.sfheart.com/FranklinsVirtues.html>

Homebrew Computer Club

http://en.wikipedia.org/wiki/Homebrew_Computer_Club

The Quantified Self

<http://www.quantifiedself.com/>

Tweetwhatyoueat

<http://www.tweetwhatyoueat.com/>

Alex Rossi's Tweetwhatyoueat Video

<http://www.kk.org/quantifiedself/2008/11/alex-rossie-shows-tweet-what-you-eat.php>

Ryan Grant Talk

<http://www.kk.org/quantifiedself/2008/11/tivo-for-life.php>

Attila Csordas

<http://www.kk.org/quantifiedself/2009/09/sf-bay-qs-8.php>

CureTogether

<http://www.curetogether.com/>

PatientsLikeMe

<http://www.patientslikeme.com/>

FitBit

<http://www.fitbit.com/>

DailyBurn

<http://www.dailyburn.com/>

SELF-TRACKING WILL CHANGE THE FUTURE OF HEALTH

The Quantified Self and CureTogether are just the beginning. Here are some scenarios that point to a fundamental shift in healthcare coming in the near future.

Self-Organized Clinical Trials

Patients have started coming together to define their own case-control studies. At PatientsLikeMe, patients with ALS either took lithium or didn't take lithium, and they tracked their progress. They didn't find that lithium helped slow the disease progression, but they did run an ALS trial with the largest population in the fastest time and with the lowest cost ever.

Streaming, Ubiquitous Biosensors

Think constantly uploading data about your body to an online repository is far off in the future? Not so. For a one-time fee of \$99, you can now have FitBit, the accelerometer with the beautiful clip-on form factor and wireless uploading of exercise and sleep data. It's passive motion tracking in your pocket.

Analytics for Your Health

A number of emerging companies are trying to do for health what Google Analytics has done for website management and what Mint has done for finances. DailyBurn is one example doing this for fitness and nutrition, with a \$0.99 iPhone app that lets you take pictures of the barcodes on foods you eat to help you more smoothly track your caloric intake. A big challenge here is the lack of interoperability and standards adoption. EMRs, PHRs, and self-reported data just don't talk to each other very well yet, but medical informatics groups like the Regenstrief Institute are working on it.

What Treatment Will Work For Me?

The true promise of all this self-tracking is, in the end, personalized medicine. With enough data about your symptoms, biomarkers, environment, genes, response to previous treatments, and aggregate population data for comparison, it should be possible for a series of algorithms to determine which treatment is statistically most likely to work for you, with the greatest efficacy and least side effects.

This is an exciting future to which I am dedicating all my waking effort. So now that you've heard Gordon Bell's story, and mine, and the voices of Quantified Selfers across the country, the choice is yours: will you document your life? ☺

SCRAPHEAP

transhumanism

DIY RFID

LEPHT ANONYM

I'm sort of inured to pain by this point. Anesthetic is illegal for people like me, so we learn to live without it; I've made scalpel incisions in my hands, pushed five-millimeter diameter needles through my skin, and once used a vegetable knife to carve a cavity into the tip of my index finger. I'm an idiot, but I'm an idiot working in the name of progress: I'm Lepht Anonym, scrapheap transhumanist. I work with what I can get.

Sadly, they don't do it like that on TV. The art of improving the human is shiny and bright in the media. You see million-Euro cryogenics policies and hormonal life-extension regimes that only the elite can afford. You see the hypothesis of an immortal silicon body to house your artificially-enhanced mind. You could buy that too, maybe, if you sold most of your organic body and the home it lives in. But you can do something to bring it down a notch: homebrewing.

My first foray was into RFID (radio frequency identification) following Amal Graafstra. He's famous for having his doctor implant him with a passive ID ampoule. After one visit to an outraged state GP here in Scotland ("I wouldn't do it even if I could, and I have no idea why you want to do it!"), I was fairly certain I'd been born in the wrong country for that — here, doctors would be struck off the records for helping me. I was on my own.

Luckily, I'm far too stupid to be stopped by bureaucracy. I bought my first Swann-Morton scalpel online, scrubbed the cleanest bathroom we could get with household bleach, settled myself cross-legged over the bathtub with my spotter, and poised the blade over the Biro-ink line I'd drawn for guidance. For a few minutes, I doubted whether I'd even be able to do it — cutting yourself open is not something we're adapted to be good at. Contemplating St. Gibson, I took the plunge.

It took a few weeks to heal, and when it did, with some help from my local gurus I was able to program a cheap open-source Phidgets RFID reader to recognise the chip's hexadecimal ID. The piece of C code that did it resided on a Linux machine and ran in the background while the reader was connected, waiting for my chip to show up. In short, it could see me and print a little "hi" when it did. That's just garbage programming, too — you can see the potential if it was given to a real coder. The chip works with any homebrew RFID project: Graafstra's RFID keyboard, for instance, grants or revokes access to my XP box based on whether the user is Lepht or not. You want a laptop tracking system? A door that only lets you in? A safe that won't allow keypad input if you're not next to it? All you need is an ampoule (you get five for a Euro, the last time I checked), from any RFID hobby place, a cheap reader, and a touch of disregard for risks. Salvage a keyboard from your local dump and you've got a simple system for bioidentification.

RFID chips work on passive power. Readers take power from a USB to generate magnetic fields. The chips contain copper coils to convert the magnetic field back into an electric one that they can use as their power source. After the RFID op, I acquired another implant that works with EM fields, the neodymium-60 nodule pioneered by Steve Haworth.

The implants sit in various places under my skin: middle fingertips of my left hand, back of the right hand, right forearm — tiny magnets, five or six millimeters across, coated in gold and then in silicon to isolate the delicate metal from the destructive environment of your body. They're something of an investment at about thirty Euros apiece, and hard to get hold of, but worth pursuing. When implanted, they become technological sensory organs.

There's an entire world of electromagnetic radiation out there, invisible to most. Our cities are saturated with it. A radio, for instance, gives off a field that's bigger than the device itself. So do power supplies and wires in the walls. The implants pick up on the fields, and because they're magnets, they fizz with gentle electricity, telling you this hard drive is currently active, that one is turned off, there's the main line in the wall. Holding a mobile phone, you can feel the signals it sends and receives. You know it's ringing before it starts to play any sounds, and when you answer it, you stick the touchscreen stylus to the back of your hand to hold it, then to your finger to type.

After a while, you don't notice anything novel about this at all. Building computers, you pick up screws that have fallen down into the motherboard with one fingertip and stick them on the back of your wrist for safekeeping. You know not to touch the board when it's powered, because your hands can "see" whether it is or not, just like you can see whether the hard drives being tested on the machine next to it are actually being written to or not. It's just like any other sense, except that this one can be given to you for the price of a node, a needle and a bottle of antiseptic. A new way of seeing the world, all for about fifty Euros. There's nothing stopping you except your own sense of self-preservation. I say all this not to show off, but to invite more people in. I dream of seeing more body-tweakers around who are into these things. I know there are people out there who could open up home modification like we've never dreamed.

Watching commercials for vitamin pills on TV and thinking you need a mad scientist's lab to be a transhumanist? You don't. I've got no money, talent or backing. You just need curiosity and the willingness to withstand some pain. Risk, not money, is our obstacle. Is it yours? Are you reading this magazine right now? Do you think like that? What could we achieve together?

Turn off the TV, then, if you're curious. Pick up that needle. Come to the junkyard. ☺

Lepht Anonym is the Silver City's pseudo-anonymous biohacker, famous only in Aberdonian emergency rooms. It Lives for transhumanism. you can contact it at lepht@trioptimum.com.

RESOURCES

Sapiens Anonym

<http://sapiensanonym.blogspot.com/>

**Turn off the TV.
Pick up that needle.
Come to the junkyard.**

BIG BANG

FROM A SMALL COMPANY

CAN VANCOUVER'S GENERAL FUSION BRING
ABOUT AN ENERGY BREAKTHROUGH?

WARREN FREY

In an unassuming corner of Burnaby, a lush, green suburb of Vancouver, BC, I've arrived at the doorway of a company that could potentially change the world. But you'd never know it from the nondescript office park it's situated in, or the bare bones furniture and office equipment I see once I open the door and announce my presence. It's almost as if I've stepped back into the office of an insurance actuary circa 1973, right down to spartan wall decoration and all-male staff. Only the "General Fusion" sign on the door indicates anything out of the ordinary.

Indeed, General Fusion is anything but ordinary. The startup is pouring brainpower, mechanical skill and sweat into building a low-tech but potentially revolutionary device capable of delivering virtually unlimited clean energy for the planet. And they plan to do it for far less than the billions of dollars governments have put into massive facilities that — even by conservative estimates — won't produce a single unit of power for another couple of decades.

"So," General Fusion CEO Doug Richardson says as he shows me into his office, "how much do you know about fusion?"

Using fusion as an energy source has been alternately hyped, derided and discounted over the past 55 years, ever since the first H-Bomb burst over Bikini Atoll. The potential benefits of fusion are obvious: all you have to do is look up at the sun to see fusion at work. Every second of every day the sun generates fusion reactions, expelling enough energy to create a net gain of energy that keeps our planet alive. But creating that net gain from a fusion reaction here on Earth, in a safe and easily harnessed way, has confounded the best minds on the planet for more than half a century.

"Fusion is easy. Net gain is the hard part," Richardson said.

WHAT IT IS

Nuclear fusion is the process where multiple like-charged atomic nuclei come together, or “fuse,” to create a heavier nucleus. Once this happens, energy is released.

Sounds simple, but like forces repulse each other, and in order for nuclei to fuse, they have to smash through substantial electrostatic forces known as the Coulomb barrier. The smallest Coulomb barrier occurs in hydrogen, which only has a single positive charge in its nucleus. But bi-protons aren't stable, so fusion also uses neutrons, ideally from a helium nucleus. As a result, deuterium, also known as “heavy water” and which contains helium, makes an ideal fusion fuel. Richardson explains, “The problem is that heating things up is how you get energy, but nature doesn't like things to be hot. Nature always tries to bring everything to equilibrium, and the sun is only able to sustain fusion because it is isolated in a vacuum.”

Once you've started firing pellets of hydrogen at deuterium, you need someplace to contain the resulting release in energy in order to avoid the inevitable drift towards equilibrium and dissipation. Gravity makes an excellent containment field, but the only objects capable of generating that level of gravity are stars — and stars, obviously, are not an ideal environment for humans. Ions can be used to create a magnetic field, which keeps the resulting energy release from escaping. Liquid metal can also be used as a containment layer. “Think of a smoke ring,” Richardson explains. “If you squish that smoke ring fast enough, the energy can't escape.”

A SLAB IN THE LAB

At one point in our conversation, Richardson leads me to the back room where all the real work at General Fusion takes place. In the middle of the room, surrounded by large batteries and intense looking technicians, we are staring at the beginnings of a fusion reactor. The device measures about three meters end to end, and most closely resembles two oversized steel traffic pylons lying on their sides and pointing at each other. Eventually these pylons will be joined in the middle by a spherical chamber. I'm struck by both the small size of the prototype and the DIY aesthetic of the whole operation. Is this the energy source of the future, resting on wooden blocks?

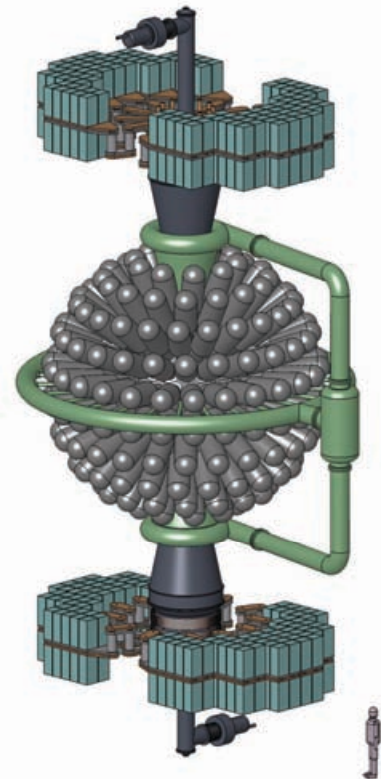
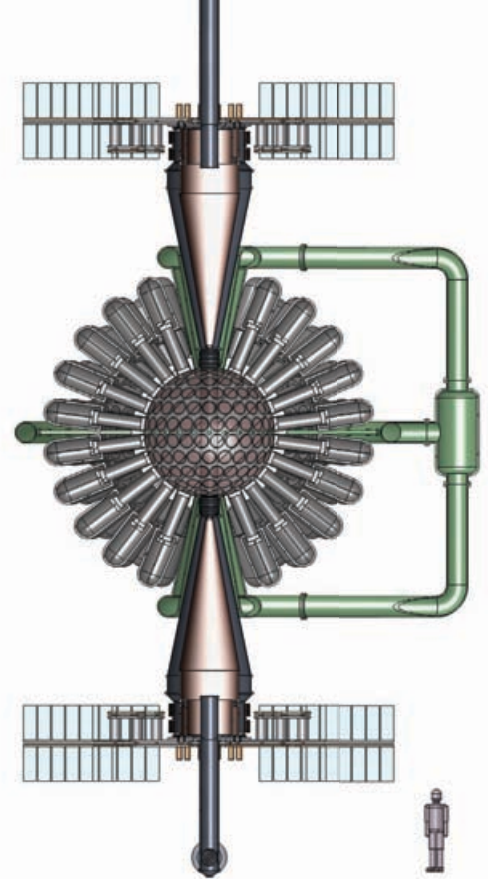
When the general public thinks of fusion, giant donut-shaped devices commonly spring to mind. These devices, known as tokamaks, are essentially giant magnets built to contain high-speed fusion reactions. These magnets and all the associated staff, equipment and maintenance are astronomically expensive. The usefulness of this kind of magnetic fusion is limited, since it can't be easily adapted for use in power plants. Lasers can also be used to generate an implosion, but that's an equally expensive proposition. Richardson: “Lasers are high tech, and the magnetic guys are even more high tech. But high tech is expensive. What we want to do is take old stuff and put it together.”

General Fusion's reactor is a metal sphere surrounded by pneumatic pistons. The pistons create an acoustic wave that travels through a liquid metal containment layer, hitting the center with a shock wave. In the center of the sphere, a plasma target should then — in theory — implode and create fusion energy, which is then extracted with a heat exchanger. From there, steam is released to create electricity. For the reactor to have any practical purpose, it has to repeat this process every second.

General Fusion is currently in the first stage of the project, building all the components including the sphere that will eventually contain a magnetized ball of plasma. During the second stage, due to start in 2011, they'll build the actual reactor.

Richardson isn't talking about incrementally lowering the cost of fusion. He's talking about a quantum leap downward in price. The company hasn't yet reached their stated goal of raising \$50 million, a pittance compared to the money spent on government funded fusion projects, but has succeeded in raising over \$9 million from private investors and \$12.9 million from Sustainable Technology Development Canada, a Canadian government agency.

Where GF innovates is in adapting today's technology to improve an old design. Fusion energy is generated in miniscule amounts of time, and thirty years ago the technology simply wasn't available to control instruments fast enough to take control during the crucial moment when fusion energy is released.



IMAGES COURTESY OF GENERAL FUSION

But in 2009, we have fast and cheap computer chips that offer very precise control over motors that can create compressive forces in mere microseconds. “We got to the point in the ‘70s and ‘80s that we could get plasma to last milliseconds. The question was how to control it. Now, with cheap digital signal processors,” at this point Richardson points at my iPhone, “it can be done.”

And it only has to be done once. If General Fusion can prove they’ve produced net gain through fusion, the world will beat a path to their door.

“The next stage would be to build a reactor at the same scale, but with the ability to reliably produce energy at a rate of once every thousand seconds. From there fusion will eventually scale up into power plants, a development Richardson estimates will cost upwards of \$1 billion, but it will be a cost born by industries who will benefit immensely from the potential benefits of fusion power. Richardson: “If you look at the scale of spending on energy research and development, \$50 million is peanuts. The oil and gas industry spends \$20 billion to develop and deploy technology in the Alberta tar sands right now.”

BAD REP: THE PONS SCHEME

Technical and scientific challenges are only part of the long uphill climb faced by companies working on developing fusion. There is also public skepticism. A lack of tangible results, even after decades of work and billions of dollars, has left fusion with a reputation for, in Richardson’s words, being “30 years away for the past 30 years.”

Perhaps the lowest ebb for fusion’s public reputation was the infamous Fleischmann-Pons announcement in 1989. University of Southampton researcher Martin Fleischmann and University of Utah researcher Stanley Pons stunned the world when they claimed they had produced excess heat during the electrolysis of heavy water on a palladium electrode. The magnitude of the heat production was high enough that they said it could only be explained as a nuclear process. When the two researchers couldn’t reproduce their experiment, fusion earned a black eye that it still hasn’t fully recovered from.

General Fusion has to face a general public that is at best apathetic and at worst dismissive. But that’s not all. Because they’re attempting something no one else has been able to achieve, and doing it on the cheap, they run into an equal amount of skepticism within the fusion community itself. Many fusion projects are mammoth undertakings funded with billions of dollars of government money. Each project requires hundreds of scientists and technicians — all smart people who, after several decades, still can’t produce a controllable fusion reaction. When a startup like General Fusion decides it will tackle fusion from a small space in the middle of suburban Vancouver, the default position of many in the fusion establishment is negative.

Richardson sighs: “There’s a feeling that the research has to be done by a government, that it costs billions of dollars and that 3,000 smart people can’t be wrong. People have a mindset that this can’t be done by a small company, and overall I’m disappointed with that attitude. Those involved in science should be curious, but it’s easier to just dismiss us.” Unlike the discredited cold fusion experiments and even the “legitimate” fusion researchers, General Fusion isn’t interested in discovering anything. In fact, they’re going out of their way to stick to what they know. “We’re boring,” Richardson says. “This is basic stuff, and all we’re doing is taking other people’s ideas and going down a path that no one has taken yet,” Richardson said.

Building a low-tech but potentially revolutionary device capable of delivering virtually unlimited clean energy for the planet.

WORLD CHANGER

Boring? Maybe. But the benefits from controlled fusion will be anything but boring. While Richardson cautions that it makes little sense to power a car or other small devices via fusion, power plants and other large scale projects do make sense, and would be much more environmentally sound than current coal-fired electrical plants. Richardson: “You can buy an electric car today, but all that does is create ‘distributed pollution.’ For that car to run, at some point someone had to burn coal.” With fusion, which runs off tanks of heavy water, no such pollution is created. “Electric plants in the United States take three trainloads of coal a day, but you could run a fusion reactor with one truckload of heavy water for a year,” he said.

And while he says that current spacecraft designs aren’t well suited for fusion engines, it’s important to remember how low on the developmental curve we currently reside. “When the Wright Brothers flew their plane in 1903, no one could predict 747s only 60 years later, or planes breaking the speed of sound. We didn’t even know what metal fatigue was until we had planes regularly flying in the air. When man wants to innovate, it will happen. Fusion will evolve, and it will be cheaper, faster, and better,” he said.

But right now, the staff is gathered around their ragtag collection of batteries and fuses watching an oscilloscope as they test a switch. And as I leave the office, I get the feeling that I know what people who walked out of Apple’s formative garage or the Google founder’s dorm rooms must have felt like. The future may be lying in partially assembled pieces in Vancouver, just waiting to be put together and switched on, so it can change the world. ☪

Warren Frey is a filmmaker and journalist and can be contacted at freymedia.com.

RESOURCES

General Fusion Inc.
<http://www.generalfusion.com/>

BIRTH OF THE CYLON

Ray Kurzweil has famously suggested that humanity will achieve human-level artificial intelligence (AI) sometime in the next 20 years. (See "Ray Kurzweil: The *h+* Interview" in this issue.) He has also predicted that virtual reality will be so high-quality that it will be indistinguishable from real reality. The new Sci Fi (now Syfy) Channel television series *Caprica* explores this possible future using the fictional universe of *Battlestar Galactica* (affectionately known as *BSG* to fans).

During the two-hour *Caprica* pilot, creators Ronald Moore and David Eick show the beginnings of the *BSG* universe — the creation of the human level AI cybernetic life-form node or "Cylon" fifty years before the Cylon attack that destroys the Earth-like planet Caprica and most of humanity. With elements of *The Matrix*, the *Terminator* series, *Second Life*, religious jihad, the politics of race in the age of Obama, *The Sopranos*, and more than just a little Mary Shelley, this new series isn't just for *BSG* fans — there's something in here for everybody.

Centering on the troubled relationship between two families, Moore compares *Caprica* to the 1980s prime time soap opera *Dallas* and refers to it as "television's first science fiction family saga." Maureen Ryan from the *Chicago Tribune* reports that David Howe, Syfy Channel president, intends to air the *Caprica* Series starting January, 2010.

BSG fans are used to nuclear explosions, spaceships, and deadly encounters with robotic Cylons. While there is sex, passion, intrigue, political backbiting, and family conflict in the *Caprica* pilot — and all these, of course, make for great TV — there are no Star-Wars-style battle scenes or armies of cool robot Cylon Centurions. *BSG* fans may find themselves longing for more action scenes with early Cylons and a better view of the *BSG* world history as the *Caprica* series progresses.

Caprica, home planet to President Laura Roslin and several other principal characters in *BSG*, is an Earth-like planet settled by the Capricorn tribe of Kobol, part of the *BSG* mythos. It is also the location of Caprica City, the capital city of the Twelve Colonies, and the setting for the *Caprica* prequel.

The pilot for the prequel follows the lives of two families, the Graystones and the Adamses (the family of young William Adams, who will later become Admiral William Adama in the *BSG* series). The Graystone family includes computer scientist father Daniel and surgeon mother Amanda. Daniel Graystone is the founder and CEO of Graystone Industries and is contracting with the Caprican government to develop new military technology. To his dismay, his eerily Cylon-like U-87 Cyber Combat Unit is a dismal failure.

The pilot opens inside a wild teenage "V-Club," a virtual environment where there are "no limits." Activities including sex, killing, and human sacrifice, and "you can frakking be anyone you want." We meet the Graystones' daughter Zoe, and a surprising lookalike Zoe, who has trouble "rezzing" in the virtual environment. We also meet Zoe's friends Lacy and Ben.

The V-Club is a 3D photorealistic convergence of *Second Life* with Facebook, *Extreme Fight Night*, the movie *Goodfellas*, and your teenage son's favorite porn site. We later learn that Zoe, Lacy, and Ben have turned away from the gaudy hedonism of the V-Club by finding "the way through the love of the One True God." Zoe is a closet monotheist in the polytheistic society of the Twelve Colonies.

The pilot cuts to Zoe sitting in the girl's bathroom at the exclusive Athena Academy wearing very cool shades — a "holoband" that provides full immersion into the V-Club — looking much like SBG Labs' Wearable PC Display glasses. (See resources)

The morning after the encounter in the V-Club, Zoe, Ben and Lacy are at the Mag-Lev train station running away to the planet Gemenon to live with other followers of the One True God. In the heavily crowded train station, we also meet Joseph Adam's wife Shannon and Tamara Adams, the mother and sister of William Adams (later changed to Adama). Just about to board the train, Lacy backs out. The train doors close and the train leaves.



The heady new Syfy spinoff *Caprica* offers a glimpse into a near future of human-level AI

SURFDADDY ORCA

On the train, Ben looks extremely nervous and detached as Zoe tries to calm him. Ben stands, opens his trench coat revealing a suicide bomber's vest, and yells, "The One True God will drive out all the others." The train explodes. Ben's jihad-like terrorist attack claims the lives of Shannon, Tamara, and Zoe.

After several weeks of grieving, Zoe's father Daniel Graystone learns through Lacy that his brilliant daughter Zoe (a chip off the old block) has created a life-like avatar with free will in the V-Club prior to her death — a copy of the real life Zoe named Zoe-A (for "avatar"). He dons a holoband and meets her in virtual space: "You're an avatar, a virtual representation of Zoe, nothing more," says Dr. Graystone.

"I am her. I'm Zoe Graystone," replies Zoe-A. "We're like echoes of one another — it's sort of hard to describe," she continues. The human brain contains 300 megabytes of information, not much when you get right down to it." (Alan Dix of the UK's Lancaster University came up with the 300 megabyte figure based on what it would take to store an audio-visual record of your complete life experiences.) "You can't download a personality — there's no way to translate the data," she continues, becoming increasingly emotional. "But the information being held in our heads is available in other databases. "People leave more than footprints as they move through life — medical scans, DNA profiles, psych evaluations, school

"I DON'T FEEL LIKE A COPY," ZOE-A RESPONDS ALMOST IN TEARS.

"DADDY!"

records, emails, recording, video, audio, CAT scans, genetic typing, synaptic records, security cameras, test results, shopping records, talent shows, ball games, traffic tickets, restaurant bills, phone records, music lists, movie lists, TV shows."

"It's possible she could have found a way to translate synaptic records into usable data," acknowledges Dr. Graystone to Lacy. Turning to Zoe-A, he continues, "But a person is much more than just a bunch of usable data. You might be a good imitation — you might be a very good imitation — but you're still just an imitation, a copy."

"I don't feel like a copy," Zoe-A responds almost in tears. "Daddy!" (Dr. Graystone hugs Zoe-A as he makes a copy of her onto a flash drive.)

Constructing a person from memories. Could this happen in the next 20 years, or ever? "Just send nanobots into my brain and reconstruct my recollections and memories," Ray Kurzweil is quoted as saying in a recent *Rolling Stone* magazine by David Kushner. Kurzweil would like to reconstruct his father. According to Kushner, the nanobots will capture everything, "the piggyback ride to a grocery store, the bedtime reading of *Tom Swift*, and the moment he and his father rejoiced when the letter of acceptance from MIT arrived." "Father 2.0 could take many forms," Kushner continues, "from a virtual-reality avatar to a fully functioning robot."

Dr. Graystone's flash drive copy of Zoe-A becomes critical to the pilot's storyline. In a parallel plot development, Joseph Adams cuts a deal with Dr. Graystone to secure Graystone a "Meta Cognitive Processor" (MCP) from rival Vergis Corporation — this is the missing controller for his U-87 Cyber Combat Unit.

Adams initially thinks he wants virtual versions of his wife and daughter, who were killed in Ben's terrorist attack along with Zoe. However, when Adams meets his daughter Tamara in virtual space, she panics and screams, "I can't feel my heart beating Daddy, why can't I feel my heart?" Adams walks out on Graystone calling his technology "an abomination."

Graystone keeps the MCP, installs it into a U-87 Cyber Combat Unit, and attempts to download his Zoe-A flash drive copy onto the cognitive processor. To his horror, when this appears to fail, he is no longer able to locate Zoe-A in virtual space (why a Ph.D. computer scientist would download a destructive copy is never explained — did Zoe-A completely "derez" from the virtual environment?).

Will the new robotic "creature" — piloted by a copy of Zoe-A, itself a copy of the real life Zoe — come to life? The *Caprica* writers clearly draw on Mary Shelley's *Frankenstein, or, The Modern Prometheus* here. At one point in Shelley's novel, the creature faces his creator Victor Frankenstein on an icy glacier and explains his feelings of isolation and abandonment. Victor still does not see he is the one that abandoned this creature, that he was the one responsible to love and devote his time to the creature. The quality he lacks as a creator is the quality also lacking in Daniel Graystone, "the deep consciousness of what they [Frankenstein's parents] owed towards the being to which they had given life."

The *Caprica* pilot ends as we see a demo of the U-87 Cyber Combat Unit successfully blow away a number of smaller domestic robots as they scurry around the test chambers of Graystone Industries — this is the birth of the first Cybernetic

Lifeform Node or Cylon.

In the closing scene, we see a Cylon coming to life in its storage bay and walking to a phone. Cut to Lacy's face as her cell phone rings. "Lacy, it's Zoe," says the uber-cool voice sounding very much like Zoe-A, except in real space. "I am here and I think I'm going to need your help." Zoe-R (for "robot") is born — like Victor Frankenstein's creature — cold and abandoned. The scene ends with a sinister-looking trademark Cylon red eye oscillating back and forth.

Prequel it may be, but this winter's *Caprica* TV series is likely to thrill transhumanists, singularitarians, and SF fanatics who love to contemplate a near future involving rich virtual worlds and downloaded human consciousness — and it certainly won't disappoint most *BSG* fans. And those new to the *BSG* universe will be surprised at the depth and complexity in the spinoff series. *Caprica* grapples with issues of science, religion, technology, and ethics that will likely face humanity in the near future. ☺

RESOURCES

Get Ready for iShades 5G

<http://www.hplushmagazine.com/articles/virtual-reality/get-ready-ishades-5g>

The Caprica Times

<http://www.capricatimes.com/>

When Man & Machine Merge

<http://www.kurzweilai.net/pressroom/pdf/RollingStone-021909.pdf>

The Brain and the Web

<http://www.comp.lancs.ac.uk/~dixa/papers/brain-and-web-2005/>

Frankenstein, or, The Modern Prometheus

<http://www.literature.org/authors/shelley-mary/frankenstein/>

DOW



DOWN TO EARTH:

An Interview with Caprica Executive Producer Jane Espenson

CHRIS HUDAK

HERE'S SOMETHING I USED TO WISH ALOUD FOR ALL THE TIME: A SCIENCE FICTION TELEVISION SERIES WHICH, ON THE WHOLE, ESCHEWED WEEKLY, EPIC, ACTION-PACKED STORYLINES FULL OF STARSHIP BATTLES OR UNIVERSE-THREATENING TEMPORAL PARADOXES AND FOCUSED MORE CLOSELY ON DAY-IN-THE-LIFE DETAILS AND INDIVIDUAL, DOWN-TO-EARTH (OR WHEREVER) STRUGGLES. Take your latest CGI of an improbably-hued accretion disk and shove it. I wanted to watch future or other-world parents ragging on their conflicted, rebellious teenaged offspring; to explore strange new clothing styles, personal deceptions, and forms of everyday, petty corruption; to seek out new living room layouts and furniture configurations; to boldly go... well, where we all go pretty much every day, except with new (and yet strangely-familiar) shit unfolding on CNN and NPR in the background,

The much-needed reboot of *Battlestar Galactica* went a long, long way toward fulfilling that wish of mine (with top-shelf writing, effects and acting to boot). But in another admittedly ludicrous, completely finicky sense, it was still too... epic. Too cool and exciting, too space-shippy.

What I suppose I really wanted (though I might have been reluctant to phrase it thusly) was the sci-fi equivalent of an honest-to-Gods soap opera, emo-drama, or culture-poke — a sort of *Starfleet Academy* 90210, or an off-planet *Dallas* or some such. I wanted to settle in every week, dent my couch for an hour, tear into some Cheez Fraks and — in a pseudo-sophisticated sci-fi kind of way — watch *ma Stories*.

Well, hey-presto: Either somebody out there is listening more intently to what I wish for, or I'm just getting better at it. Either way, my near-future productivity will be dipping again, at least a little bit because the small-but-intrusive number of television shows I actually need to watch is going up by one.

Premiering on SyFy in early 2010, *Caprica* is more or less exactly what the holographic doctor ordered: A zoomed-down-to-ground-level look at planetside life and strife on the titular Colonial homeworld taken from the *Battlestar Galactica* mythos, *Caprica* is a “science fiction family saga” that follows the intrigues and entanglements of at least two Caprica City families. (And just incidentally for the BSG crowd, one of them is the family that will come to be known as Adama. And, oh yeah, the other one is responsible for the subsequent rise of the Cylons, who will summarily glass the whole planet within 60 years.)

I spoke via email about *Caprica* with Jane Espenson, executive producer for the series. She was a co-executive producer of *Battlestar Galactica*, where she also wrote two episodes. She was a producer of *Buffy the Vampire Slayer* and is the creator of *Warehouse 13*. Other writing credits include episodes of *Firefly*, *Star Trek: Deep Space Nine*, and *Dollhouse*. She is editor of *Serenity Found: More Unauthorized Essays on Joss Whedon's Firefly Universe* and *Finding Serenity: Anti-Heroes, Lost Shepherds and Space Hookers in Joss Whedon's Firefly*.



h+: It seems pretty clear that *Caprica* is intended for a somewhat different audience than was *Battlestar Galactica*. How would you characterize some of those differences — creatively, demographically, commercially, and otherwise? Beyond the obvious lack (at least for now) of BG's ubiquitous, male-oriented war-in-space trappings, what other elements characterize the *Caprica* series?

JANE ESPENSON: The show is about the brew out of which the war emerged — terrorism, crime, culture clashes, and the people who were either propelling all this stuff or got caught up in it. The main difference is that it's set in the middle of a society that (mostly) doesn't know it's on the road to destruction, while the BSG characters knew very well what their situation was. This is allowing us to take a sort of bigger scope view of a functioning world, and it's also letting us play with pop culture and throw a little bit of humor in, here and there.

Demographically, it's tempting to say that it could attract more women than BSG did, but I'm not sure that those templates of what male and female viewers like really hold true anymore. Wasn't there a thing earlier this year that said most slasher movie tickets were sold to women? I think our show has lots of stuff to tempt people who want character stories as well as those who are looking for a little more action. So far, not a lot of Viper dogfights, but there are other kinds of action.

h+: Throughout *Galactica*, there ran strong, dramatically critical (and, at times, seemingly unavoidable) thematic echoes of 9/11, the subsequent War on Terror and many of their political/social repercussions. Do you see *Caprica* highlighting any particular issues? In the pilot alone, we've already got a pretty strong wacko-fundamentalist/decadence of Western society/what-is-wrong-with-the-kids-these-days riptide going on, don't we?

JE: That's the great and wonderful thing about science fiction. It allows you to take these issues on directly and yet maintain a little distance at the same time, because you're talking about *other* worlds, *other* religions, *other* politics. And it's only with that distance that you can really get something like an objective take on the situation. So, yeah, we're definitely not shying away from stories about terrorism and cultural prejudice and revolution and the reach of governments and the power of the rich and the technological divide between rich and poor. Our characters are hugely invested in these issues in very personal ways; I don't think we could avoid them if we wanted to.

h+: How creatively challenging or restrictive (or perhaps downright distressing) can it get, fleshing out a setting, society and cast of characters that both you and the greater chunk of your intended audience know, in a sense, to be already doomed? I mean, this isn't exactly the typical end of the halcyon days of high school TV. This is the fucking Beginning of the End with Genocidal Nuclear Holocaust and Intragalactic Exodus to Follow After the Break, isn't it?

JE: Well, everyone knows about the fall of Rome, but we all still invested in the characters and events of *Rome*. These characters are alive *now* in our story, and they feel and yearn and have losses and wins and you feel for them. I feel that knowing what happens 58 years later perhaps adds poignancy, but you won't emotionally check out. We won't let you.

h+: Imminent doom by our own technological hubris aside for the moment, how would you say we are doing, societally, compared to *Caprica*? Is the portrayed state of "The Clubs"



and Caprica City's teen populace, for instance, even that much of an exaggeration for effect?

JE: One of *Caprica*'s underlying assumptions — which I adore — is that not every culture undergoes the same steps in the same order. There are ways in which *Caprica* is more advanced than our current world and ways in which it is very much behind us. And others in which it is just *different*. The V-world, as depicted, is more technically advanced than our internet, but fills the same role... and our internet certainly creates a lot of those same illusions of lack of moral consequences.

h+: Even for the arguably mature, sophisticated BG fanbase, those opening scenes in *The Club* were certainly attention getting — immediate, compressed sex and violence and rock 'n' roll (in a scene portrayed, in no uncertain terms, as teen populated) to a degree that made some of us early viewers look at each other in front of our TVs... like “Did you just see that too?” Wasn't any of that an issue for the Sci-Fi (excuse me, Syfy) network?

JE: I don't think there was any problem with it from the network side — certainly nothing that I heard about!

h+: Please talk a little about the casting. Were these roles written with one or several of the principals already in mind? Did you have any casting surprises along the way? Had Stoltz [Eric Stoltz stars as Daniel Graystone] or any of the other actors expressed previous interest in *Galactica*, or in other potential science-fiction/drama projects?

JE: All of this happened before I came on board. But new roles have been created since the pilot — some of them written with certain actors in mind, others altered after casting to accommodate the actor who was cast. We write a lot of our roles with no gender assigned — or rather, we pick one but tell casting to

bring in everyone, and then rewrite if needed to fit the performer. I love doing that, since it ensures that you're not writing to any subconscious gender expectations. I know that Scott Porter (*Friday Night Lights*), who plays a role in the series, is a huge *Battlestar* fan. He is very pleased to be involved in the show. And James Marsters, of course, is someone I have a previous — and delightful — working relationship with. We have an amazing core cast and we've been lucky to be able to augment it with some really strong additional casting.

h+: It seems that, on the personal level, the technology in everyday Caprican life seems higher, slicker and cleaner than most of that in *BSG*. Is this a deliberate reference to the need for low-tech later on to thwart the Cylons, or just a consequence of escaping en masse from a nuclear holocaust in whatever ships come to hand? Both? Neither?

JE: I think you're seeing the tech in the world of Daniel Graystone, the Bill Gates of *Caprica*. If you look at the tech that ordinary people have access to in the shows, you'll see rotary phones, console radios, big CRT monitors, clunky answering machines... one of the things that's happening on *Caprica* is this inequity of access to the latest advancements. And yes, *Galactica* was also a very old ship. But a good 'un. ☺

Chris Hudak (gametheory@mindspring.com) is a former San Francisco Zoo penguin recorder, a marginal Japanese-language student, and protagonist of the Harlan Ellison short story 'Keyboard' — no, really.

RESOURCES

Caprica DVD
<http://www.capricadvd.com/>

Jane Espenson
<http://www.janeespenson.com/>



CHRONIC CITIZEN

Jonathan Lethem on P.K. Dick, Why Novels are a Weird Technology, and Constructed Realities

ERIK DAVIS

PHOTOS BY FRED BENENSON

While mainstream literary figures sometimes praise their fellow writers, rarely do they present themselves publicly as hardcore pop culture fans. Since the publication of his novels *Motherless Brooklyn* and *Fortress of Solitude*, as well as his reception of the MacArthur Fellowship in 2005, Jonathan Lethem has become a successful and widely-praised author of playful and intelligent literary fictions. He has also become probably the most visible fan and proponent of the science fiction of Philip K. Dick. A few years ago, Lethem was commissioned by the august Library of America to edit a volume of Dick's writings for the publisher's definitive canon of American letters. The initial volume, *Philip K. Dick: Four Novels of the 1960s* was the best-selling title out of the gate in the history of the Library, and two more Lethem-edited volumes of Dick's work followed (*Philip K. Dick: Five Novels of the 1960s & 70s* and *Philip K. Dick: VALIS and Later Novels*).

Lethem began his own writing career drawing heavily from genre fiction, both SF and hard-boiled detective novels. But he avoided getting stuck in what some SF writers refer to as "the golden ghetto," and his later work achieved mainstream recognition for more realistic, psychological, and crisply detailed tales largely rooted in a slightly altered version of the Tri-State area that is his home. His latest book, *Chronic City*, is a dark and druggy take on Manhattan — an anxious, funny, and disturbingly charming book infused with cannabis, conspiracies, astronauts, nihilistic artists, virtual objects, and pop culture mania. Though very much written in Lethem's mature voice, the book is also infused with the spirit of Philip K. Dick, who remains Lethem's first and most important influence.



**We turn them [our media] into
advertisements for ourselves, rather than
opportunities for shedding ourselves.**

ERIK DAVIS: How did you first encounter Philip Dick?

JONATHAN LETHEM: I first saw his books in my friend Carl's house. His dad was a science fiction fan. I was already reading the old classics — the Heinlein and Asimov and Bradbury that were on my mother's shelves. But those books were written and packaged in a style that was very '40s and '50s. And these Philip K. Dick paperbacks from the '70s looked like a whole other flavor of stuff.

The first ones I saw were *A Scanner Darkly* and the Bantam reissues of *Ubik* and *A Maze of Death*. And I just immediately connected it with psychedelia and was drawn to it. I was thirteen or fourteen when I was devouring his work and just wanting to read as much of it as I could. By the time I was about eighteen, I had read every Dick book that had been published to that point. One way or another, I found them. I just identified with him totally, and it rearranged my thinking.

I moved to the Bay Area. It was like the husk of a plan, to go and meet him. But he died, so I went anyway. I tried to look for meaningful traces, including hanging out with Paul Williams and helping him with the Philip K. Dick Society. So it was a very shaping obsessing. I kind of apprenticed myself to the guild of Philip K. Dick.

ED: As a pop culture fan, and an intense Phil Dick fan, I find it incredibly satisfying that this author that I've loved since I was a teenager is now getting his props. On the other hand, I cannot deny that there is something a bit sad about losing the esotericism of the cult. You yourself are a true fan, but one who has been instrumental in Dick's current canonization. How do you feel about that?

JL: I have a very divided conscience. I mean, just as an eyewitness, it's something to be incredibly proud of. It's almost unprecedented: the creation of a real canonical literary reputation when the person is dead and out of print, and when there was a pretty definite ceiling on how far he'd ever gotten while he was still alive and in print.

For people familiar with Dick's personal experiences, his biography and his temperament, the ironies in that are deep and bitter and complicated. You inevitably think: if he'd been alive, he would've screwed this up. He would've found some way to make it impossible that he could be treated with such simple reverence, because he was so distrustful of any form of institutional authority. He had a particularly deep, bitter and twisted suspiciousness about traditional literary authority and about academia. And frankly, to some extent, it's academia that's driven his acceptance in a canon.

When I was a kid and I discovered Philip K. Dick, I felt that I'd made this kind of soul mate contact with his work. It's a defining experience, and it feels like it's innate. For me, that experience was absolutely bound up in finding these books that were out of print. The books almost seemed like fictional artifacts. I couldn't believe there was such a writer. I still remember thinking his name seemed weird or that his titles seemed preposterous to me. It was like a secret reality unfolding in my life.

There's something about the essence of his writing that creates that feeling. And I think it's still creating it for let's say the 14-year-old equivalent of Erik Davis or Jonathan Lethem, who's discovering this book in the shiny expensive Vintage paperback editions. I still think there's something innately self-marginalizing, self-cultifying (if that's a word) about the writing. You feel like you're the only one who understands it, and he's the only one who understands you. It's like a cognitive version of a love affair. You're making this intimate connection with this other mind. He projected that into the work.

ED: In a way, Dick is the ideal highbrow-lowbrow saint. The academics will analyze the social critique, the metafiction, the dense weave of allusions, the importance of the themes as they relate to emerging problems of simulation and consciousness and existential anomie. And at the same time, there's a pop level that's most obviously manifested in cinema, a steady stream of Hollywood films which are mostly pretty corny. And both those levels of recognition have shaped the context that allowed the Library of America to say, "Okay. This guy gets the canon badge."

But because I'm one of these cultists, I have to believe that there's something more to it. It's because his books say something about our time, even more, in some ways, than his time — the '60s and '70s. Why are we hearing these books now? What are these books telling us?



JL: I've always agreed with the view that — with science fiction — its predictive powers were the least important or least relevant aspect of its public profile. I always loved stuff like Orwell's 1984, where he explicitly said "It's 1948, reversed." I liked writers that were doing allegorical, satirical, fantastical versions of everyday life.

That suggests that Dick's work is dated to the '60s and '70s. And I thought of him very much in this framework, and not as an extrapolative writer. He certainly doesn't have that kind of rigor or scientific chops that you find with someone like Bruce Sterling. But I think that Dick saw the makings of the contemporary reality we experience so profoundly. And this speaks to the difference layers of reality in his work — the way time moves at one clip according to the calendar, but other ways in terms of mental time, psychological time, social time, American historical time. Like if you look at the terms of this absurd, hysterical healthcare debate — it's basically McCarthyism again, the Red Scare. "Socialism is coming to get us."

Dick looked around his world with a kind of skinlessness. He existed in the world and it just permeated him. Mid-'50s America was overwhelmingly alive in his vision, in such a way that he saw it simultaneously as a present and as a future. He saw the makings of the late capitalist experience embedded in that mid-century triumphalist post-war moment. And it's as though he experienced it all, in all its absurdity and its tragedy, as this overwhelming vision. And he just jotted it down as frantically as he could. And the books are so raw with that perception that they still feel like a desperate attempt to record an arriving moment. I think that's the experience of reading Philip K. Dick. He seems to be frantically trying to transcribe an arriving reality that is urgent and totally fresh.

What's missing from both the academic and pop movie descriptions you mention is that Dick is an immensely personal writer. In his own way, he's a Beat or a proto-Beat. He's like Henry Miller. One of these gargantuan, slightly egotistical but insecure, garrulous personas that just pour themselves onto the page, and says, "Love me or hate me. This is what I feel. And these are the kind of women I find sexy. And oh my god, I hate them. They're consuming me. And I feel really stupid today, but I'm going to tell you about..." And he just gives himself. And as anyone who's ever tried to write literary novels or stories or a memoir can tell you — it's not a small thing to pour yourself onto the page. And when it's accomplished, totally, you end up with the kind of monumental writers that many people find also unpleasant or toxic or unreadable.

ED: Dick set many of his tales in what we might now call a "posthuman" future of cognitive-enhancing drugs, psi powers, and other amplifications of human capacity. Many of the developments he envisioned in his own unique way are now edging ever closer to reality, and there are many enthusiasts. While not exactly bleak, Dick had a generally more dark and satiric — and often funny — take on cognitive enhancement. Was he a pessimist or a realist? How would you characterize his particularly lesson about human for today's enthusiastic transhumans?

JL: While I'm hardly an expert on the reality of cognitive enhancement or the transhuman impulse as it's working itself out on the contemporary frontier, I

suspect Dick had little to offer in the way of a “lesson” for aspirants, except in the senses that were relevant while he was coming of age as a writer — that’s to say, when the breaking news in the framing of such matters involved names like Freud, Kinsey, Norbert Weiner and, well, A.E. Van Vogt. Dick’s concerns were ultimately both epistemological and deeply moral — in the sense that a philosopher would use the world moral, not in the sense that, say, Joseph L. Breen would. You know, love, empathy, “what is human?” and so forth. For contemporary voyagers, these matters remain as Dick delineated them: exquisitely *local*, negotiated on the human-to-human, or human-to-self playing field according to an infinite number of variations and contexts. No sweeping paradigms will do here. We’re all walking down the street conducting our self-Turing exams every time we pass a homeless person, or greet our spouse at the breakfast table.

ED: For proponents of the Singularity, we are on the verge of massive technological transformations that involve some version of artificial or machine intelligence. Dick had a very particular take on intelligent machines, like Joe Chip’s conapt or suitcase psychiatrists. While these devices are clearly fantastic and absurd, they also express some real insight and concerns about the cultural consequences of machine intelligence. Does Dick’s take seem relevant now, thirty years later? What would he say to our contemporary gadget fetishism and addiction to information machines?

JL: My best guess about such matters is that each technological transformation, up to and perhaps including the Singularity, is going to work itself out vis-à-vis “the human” according to the deep principles of all media. Defined in its largest sense, as including things like cinema, theory, drugs, computing, moving type, music, etcetera, media is utterly consciousness-transforming in ways we can no longer competently examine, given how deeply they’ve pervaded and altered the collective and individual consciousness that would be the only possible method for making that judgment. And yet — we still feel so utterly human to ourselves, and the proof is in the anthropomorphic homeliness that pervades the ostensibly exalted “media” in return. We humanize them, shame them, colonize and debunk them with our persistent modes of sex and neurosis and community and commerce. We turn them into advertisements for ourselves, rather than opportunities for shedding ourselves. At least so far.

ED: You’re pointing toward the psychological dimension of Dick’s writing. Even when you are looking at the futuristic aspect, what’s really being extrapolated is a certain kind of dreamlike, subjective response to changing technological conditions. And all that is intensified by Dick’s own psychological sensitivity.

JL: Dick was supremely labile. He has the power to put himself, as a writer, at the mercy of his own inventions. He could construct realities and then immerse himself in them as though helpless. So he conveys the experience of the mind-altering or the reality-transforming better than nearly any writer who ever lived. As a creator of fantastical, preposterous kinds of realities that are nevertheless grounded in a critique or an insight, he was the best at two things: at making these things a kind of a reality; and then, at experiencing that reality as though it were a given. His characters — his proxies within the space of his own fictional world — are totally subsumed in it. There’s no mastery exhibited. They’re reading it. They’re experiencing it. They’re surviving it. They’re not objective tour guides. His character is a sufferer who moves through these worlds.

ED: Given Dick’s obsessions, it seems inevitable that he would wind up asking religious questions. These came to the head with the so-called “VALIS trilogy” he wrote toward the end of his life: *VALIS*, *The Divine Invasion*, and *The Transmigration of Timothy Archer*. In the ‘70s, when he was read in kind of a proto-Marxist way by some critics, his later works were often dismissed at the works of a crazy man, even though the religious elements and visionary questions in his writing are evident from the get-go.

Today, some people continue to dislike these more explicitly spiritual works and prefer the more socially and critically dynamic ones of the ‘60s. Others see them as a crowning gesture. Did you have a sense of satisfaction in getting these three books included in the Library of America series?

JL: One of my goals was to get what I felt was the majority of Dick’s masterpieces

into the Library’s three volumes. And for me, *VALIS* is probably one of his five greatest works. Leaving aside context, the voice, the form, the velocity, the humor, the emotion — it’s a great novel. It would be a great novel in any writer’s career. It had to be canonized if he was going to go into the canon. So the minute I knew we could do more books, I started scheming about how to make *VALIS* a part of the project. I like all three of the books that have been described as a trilogy, although I’m skeptical about the whole trilogy idea. Besides *VALIS*, I think *Transmigration of Timothy Archer* may be among his greatest works. And *Divine Invasion* is rock solid.

ED: With your own new book, *Chronic City*, I can very much sense the way that Dick has marked you as a reader, as a writer, as a person in the world.

JL: In the process of editing these Dick books, I felt myself recapturing a feeling of intimate kinship that came from the very beginning of wanting to be a novelist — a feeling that I wanted to, in some way, project a relationship to Dick’s writing. I wanted to find a way to extend my own feelings about it into fictional space. For me, this is a book that’s suffused in his influence.

ED: *Chronic City* is a dark book. What does it mean to embark on a book that, while it’s entertaining and there’s plenty of nice people in it that you kind of want to spend time with, is also suffused with meditations on dread and the conundrum(s) of contemporary reality?

JL: Well, at the outset, if I started with that as a goal, I’d never do it at all. You have to start in a kind of innocence. You have to think, “I’ve got this funny idea.” You know, “What if there was this character who didn’t know he was doing such and such. And that would be fun.” You start in a kind of willful naïveté about the breadth of your ambition as a survival trait — it’s the only way to get in.

But I felt that this was a book, like *Fortress of Solitude*, where I wanted to disburden myself of a lot of anger. I think it’s a response to living in a pretty dreadful moment — a series of dreadful moments in the last ten years. And it’s a book about complicity, too — about going along with how wrong it all is because you find it entertaining or good enough or necessary, in various degrees.

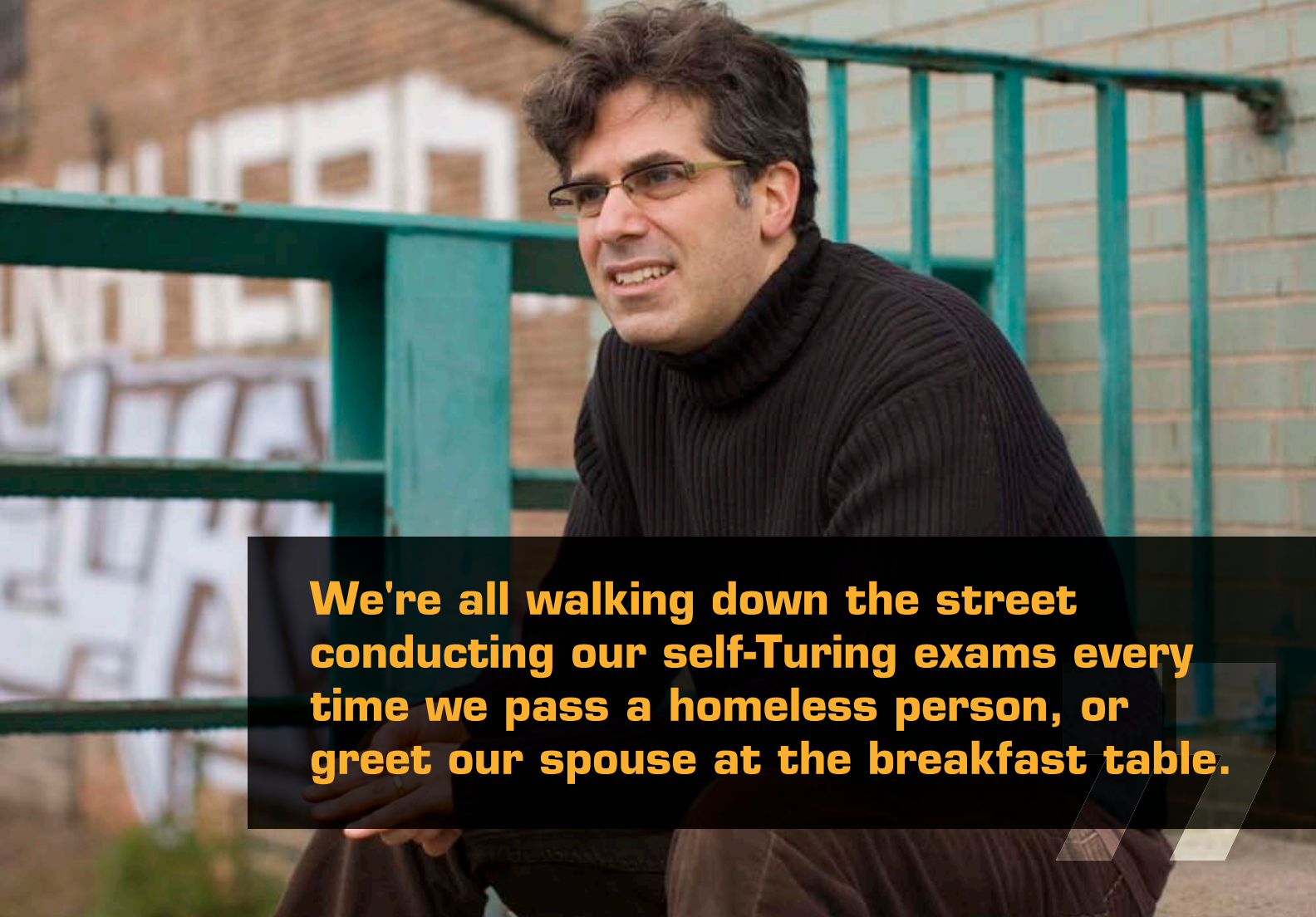
ED: There is also an extraordinary amount of pot smoking in this book. Why so much?

JL: Confession compulsion? I don’t know. One of the main subjects in my work is friendship, the experience of hanging out with people, of what it’s like to really adore someone, argue with them, be obsessed with them — you know, compare your life to theirs, day in and day out. *Chronic City* is very much a book about friendship, and so I was trying to capture a certain vein of deep and silly and exhausted and slightly outlaw time-spending that is typified, for me, by getting high, with a certain personal group of people, again and again and again. Which isn’t so much the stuff of my days right now — it can’t be, you know — it’s an older feeling. But it’s one I hadn’t ever gotten down the way I wanted to.

ED: Part of the experience I have of novels these days is that it seems like the more awake and aware and acute they are, the more they are aware of their own fragility in the face of other kinds of narrative technologies. The most obvious example is simulation — immersive worlds that we can go into and reproduce behaviors that are more or less storylike. The fundamental character of a massive, open-ended, multi-player role-playing game is utterly different at this point than the character in a novel. How will novels stand up?

JL: I’m far too close to one pole to illuminate. But I’ll say that — in the face of certain kinds of rival technologies and rival frameworks for experiencing what we might call self-admitting false realities — novels are a class of virtual reality experience that has some very particular and innate bottom lines. And I happen to like those. As I see the rivals emerge, I feel that novel-making and reading becomes one option on a very large menu, and in some ways a rather antique or humble or lumpen example. But I also think some of the things that make it that are also deep strengths that are becoming more and more highlighted.

We talked about what makes Dick so compelling and personal — what made us each take him so personally when we discovered his work. And in some



We're all walking down the street conducting our self-Turing exams every time we pass a homeless person, or greet our spouse at the breakfast table.

ways, those are elements that are innate to this very strange technology — this gigantic pile of sentences stuck between two hard covers, that someone makes this incredible commitment to read. It's a bizarre commitment, very unusual the first few times you make it — to just sit and follow, in order, each of these sentences and make the artificial reality come to life yourself by reading. It's a crazy technology, very specific and weird. Now may not be the time to take it for granted. Instead, maybe we should point out that by doing this, you do achieve a kind of weird mind meld.

ED: There are a number of Phil Dick-ian moments in *Chronic City* where we're on the edge of realizing that something we've been taking for reality is a construct or is a convenient fiction. There's a palpable sense that recognizing this construct to its fullest extent would thrust you one into the cold vacuum of space. At the same time we are immersed in more and more media constructs every day. So as we edge closer to the anxious recognition of the reality construct, there are also more technologies of distraction that try to cover that over or displace it.

JL: The reason I tend to write from the complicit point of view is I'm always struck by the deeply personal nature of the alliance we make with these opportunistic distraction mechanisms, the substitute realities that are offered to us, the way that we build ourselves into them. And that's why I always think that Dick was such an insightful writer — because he always took it personally. He was always aware of his own wish-fulfillment impulses, his own

yearning to be consumed and seduced. And it's why his role as a fiction maker and as a liar was allied to his fascination and distrust of fictional realities, of marketing realities, of commercial realities and political realities — because he saw that they're rooted innately in storytelling and in emotional necessity. And that there are all sorts of things that turn out to be ideological all the way down to their bones — the family structures that we come up inside are themselves a form of storytelling, a form of myth-making and persuasion. We sell ourselves on versions of existence that are tolerable. We're all marketing.

ED: Towards the end of your book, I sense a deep ambivalence about the necessity of consoling fictions. Right next to the rage and the desire to expose the machine is a complicit adoption of conventional realities and more constructive views.

JL: Absolutely. What are the tolerances for the exposure of sustaining fictions in any given life? At some point, you're going to settle. You're going to make a snow globe and live inside it. ☺

*Erik Davis regularly posts to www.techgnosis.com. His most recent book was *The Visionary State: A Journey through California's Spiritual Landscape*.*

RESOURCES

The Philip K. Dick Collection, edited by Jonathan Letham

http://www.amazon.com/Philip-K-Dick-Collection/dp/1598530496/ref=sr_1_4?ie=UTF8&s=books&qid=1255392808&sr=1-4

P.K. Dick Official Site

<http://www.philipkdick.com/>

Jonathan Letham *Chronic City*

<http://www.jonathanlethem.com/chroniccity.html>

PROSTHETIC HEAD
meets

p-Zombie

*or Beyond technological smartness;
or what artificial agents get up to when you leave the room*

DARREN TOFTS

STERLAC
LONDON, LOS ANGELES, MELBOURNE 2006
PHOTO BY NINA SELLARS

The following is an extract from a dialogue between Murray McKeich's *p-zombie* and Stelarc's *Prosthetic Head*. It was decoded from static detected while listening to Edward Elgar's *Enigma Variations*:

Prosthetic Head: It seems so long ago that we decided to keep a record of our discussions. It seems as if all the ideas have come and gone without being present in any form.

p-zombie: Oh enough of that nonsense! What are you reading at the moment?

PH: Russell's *Analysis of Mind*.

p-z: Which edition?

PH: Funny you should ask that. It's the very one Borges refers to in "Tlön, Uqbar, Orbis Tertius."

p-z: 1921 Allen & Unwin if memory serves me correctly.

PH: Yup. How does the celebrated footnote go again?

p-z: "Russell supposes that the planet has been created a few minutes ago, furnished with a humanity that 'remembers' an illusory past."

PH: "... the past has no reality other than a present memory." How apt.

p-z: Indeed. It reminds me of the aphorisms of Kwang-Tse, the story of the man who went to sleep and dreamt he was a butterfly. Upon waking he asks himself, "Am I a butterfly dreaming that I am a man?"

PH: The evil demon of appearances, yes. As Tweedledee says to Alice of the Red King sleeping, "you're only a sort of thing in his dream!"

p-z: Heaven forefend that we should have such concerns.

PH: Bite your tongue, please. What are you reading?

p-z: Just dipping into Pound's *Cantos*. You know the opening line is a translation of the first words ever written in Greek?

PH: "And then went down to the ship, Set keel to breakers, forth on the godly sea."

p-z: Ah, you know it. Scans well doesn't it.

PH: I always thought so.

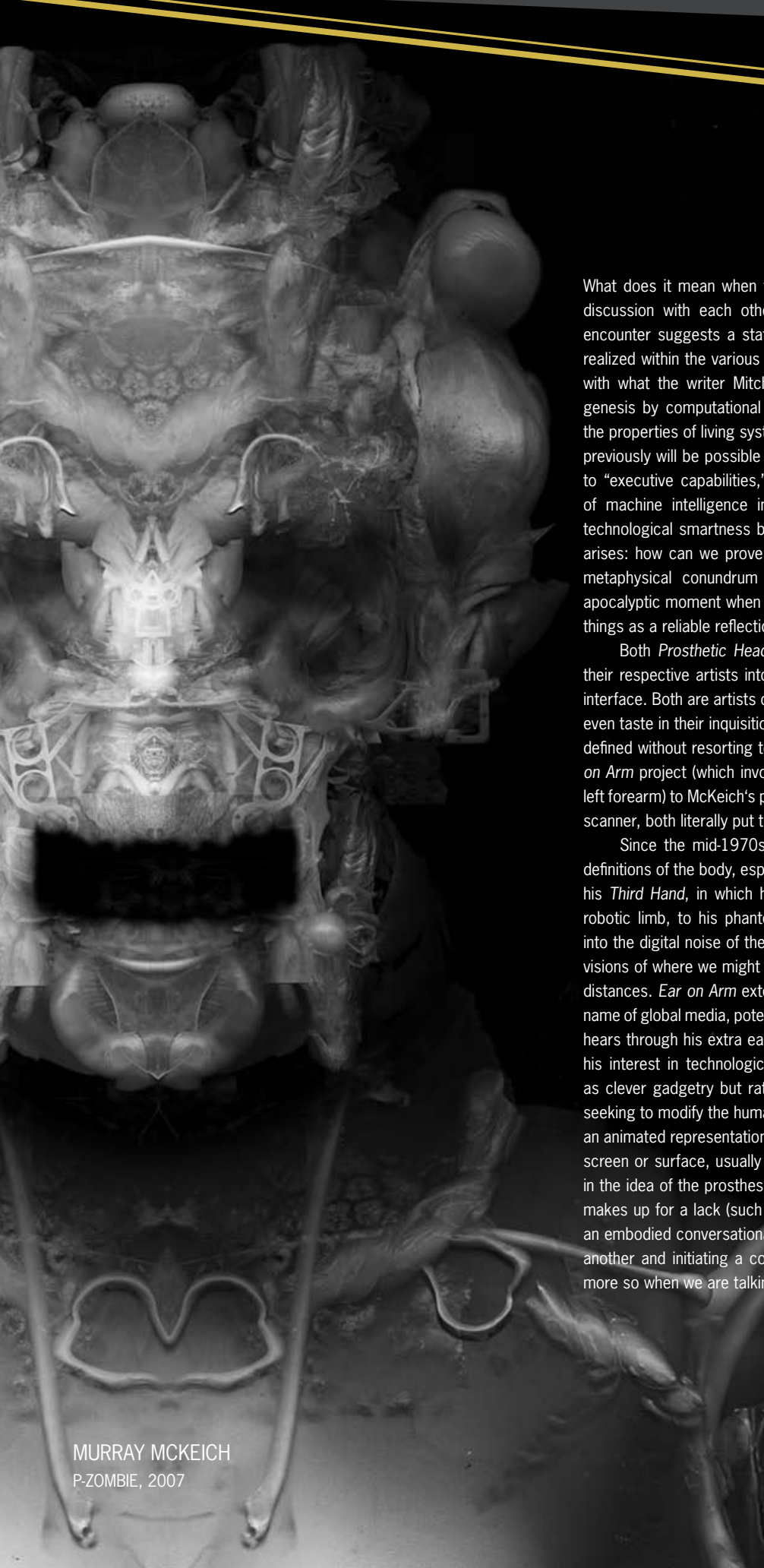
p-z: So, where are you to be installed next?

PH: Whoops, someone's just come in. I'll pretend I'm still asleep to raise the suspense. Beaut talking to you again.



STERLAC

MARCS AUDITORY LABORATORIES
UNIVERSITY OF WESTERN SYDNEY, 2008
IMAGE BY GUILLAUME GILBERT, PH.D.



What does it mean when two artificial intelligent agents can engage in such a discussion with each other? The learned wit and bravado of this imaginary encounter suggests a state of technological smartness that has not yet been realized within the various scientific disciplines and artistic practices associated with what the writer Mitchell Whitelaw has called "metacreation": that is, the genesis by computational means of "artificial systems that mimic or manifest the properties of living systems." Perhaps conversations of the kind documented previously will be possible when artificial agents extend beyond mere "advisory" to "executive capabilities," to borrow Manuel De Landa's menacing invocation of machine intelligence in the service of the military-industrial complex. As technological smartness becomes more sophisticated, a more urgent dilemma arises: how can we prove that something is *not* artificially intelligent? This is a metaphysical conundrum that has bedeviled the historical imagination, the apocalyptic moment when we can no longer reliably count on the appearance of things as a reliable reflection of the reality of things.

Both *Prosthetic Head* and *p-zombie* are the most recent explorations by their respective artists into the ongoing rattle and hum of the human-computer interface. Both are artists of extremes, pushing beyond the limits of credulity and even taste in their inquisitions into the notion of a humanity that can no longer be defined without resorting to questions of technology. From Stelarc's current *Ear on Arm* project (which involves the cultivation of a Bluetooth-enabled ear on his left forearm) to McKeich's placement of flesh and viscera directly on to the flatbed scanner, both literally put their bodies, or body parts, on the technological line.

Since the mid-1970s, Stelarc has sought to stretch the elasticity of our definitions of the body, especially under advanced technological conditions. From his *Third Hand*, in which he augments his own manual dexterity with an extra robotic limb, to his phantom and fractal flesh works involving the body wired into the digital noise of the Internet (*Ping Body*, *Fractal Flesh*), he has offered us visions of where we might be heading as our senses are amplified across global distances. *Ear on Arm* extends this virtual reach that we take for granted in the name of global media, potentially enabling anyone anywhere to hear what the artist hears through his extra ear. Stelarc's *Prosthetic Head* (2004-ongoing) continues his interest in technological smartness by interpreting the latter not so much as clever gadgetry but rather as artificial intelligence. With this work he is not seeking to modify the human, but humanize the technological. *Prosthetic Head* is an animated representation of the artist's own face that is projected on to a large screen or surface, usually in a darkened gallery. It exemplifies Stelarc's interest in the idea of the prosthesis as an excess, a double, rather than something that makes up for a lack (such as a missing limb). *Prosthetic Head* is an example of an embodied conversational agent; an entity capable of sensing the presence of another and initiating a conversation. An unnerving prospect in itself, but even more so when we are talking about a head dissociated from a body.

MURRAY MCKEICH
P-ZOMBIE, 2007

Australian-based artist Murray McKeich's work is less known. However, as a contributing illustrator for both *21C* and *World Art* magazines in the 1990s, his work received critical attention in the States and Europe for its powerful evocation of the increasing intimacy between humans and technology. McKeich's digital images of this period involved the seamless blending and warping of industrial machinery and flesh, creating portraits of the cyborg and the posthuman at a time when the theorists were still arguing over what such terms meant. For McKeich photomontage was a kind of digital chemical reaction that generated the illusion of potential life-forms for which, as yet, we have no precedents, let alone names. Mixing memory and desire, McKeich's hybrid images are redolent of what George Santayana called the "suggestively monstrous," a grotesque evocation of what we have been and where we are going in the name of the human and posthuman. McKeich's *p-zombie* (2006-ongoing) takes the artist into new, time-based territory as he, like Stelarc, confronts the potential for intelligence to be manifest as animated agency. As with *Prosthetic Head*, *p-zombie* is an animated head that attempts to speak to the gallery visitor out of an indeterminate darkness. While it lacks any kind of autobiographical reference to its maker, it nonetheless appeals to us as an artificially-constructed life form making an entrance into our world.

With both *Prosthetic Head* and *p-zombie* we witness the movement away from biological to pathological models of artificial intelligence. *Prosthetic Head* is a schizoid entity that at once describes itself as artificial agent as well as avatar of Stelarc himself. I first encountered it (him?) in 2004 in Melbourne and it seemed very conscious of my presence in the darkened gallery, hovering there in space like some iconic demigod. When it "woke up" to acknowledge me, its voice was granular, synthetic, yet at the same time disturbingly knowing, suggestive of a higher intelligence to come. Last year I caught up with it again in Second Life and it was lecturing on the theme of the "post-human". That's when I really started to get worried.

Since that time, its appearance has audaciously morphed into the fourth dimension as a cubist-like countenance, described by the artist as a *Faceted Head*. Regarding this tranformation, Stelarc has observed that "the *Prosthetic Head* has not simply become the *Faceted Head*. It's certainly one that bypasses the purely representational and reanimates the face into a seductive and geometric structure." In other words, it is another revelation of its multiple self. *Faceted Head* has yet to be released on to an unsuspecting public.

McKeich's *p-zombie* is a product of recent experiments in generative animation. The artist uses a simple algorithm that draws textural items from an archive, encodes a few simple rules for their combination and time-based software does the rest, generating potentially infinite variations on the theme of a talking head as a series of still images and a looped animation. McKeich's trademark style of visual alchemy evinces affinities with the Promethean myth and the Golem, mixing base elements such as street detritus, exotic fabrics, trinkets,



viscera and bones into an impossible nature; producing the sensation of what the artist calls “visual intelligence.”

p-zombie, like *Prosthetic Head*, also evidences multiple personalities, which express themselves as a series of phantasmagorical mutations reminiscent of a painting by Giuseppe Arcimboldo [See Resources] on speed. The stunning fantasia of its metamorphosis suggests a tribe or colony of *p-zombies* coming into being, summoned by the spell of some weird digital vodou.

In its ongoing appearances at installations and exhibitions around the world, *Prosthetic Head* continues to develop maturity and fluency as a conversational agent, adapting to its myriad visitors with increasing sophistication and complexity. In its animated form, *p-zombie*'s silent gestures of speech also suggest the desire to communicate. But to whom and about what? Wouldn't it be fascinating to know? Perhaps *p-zombie*'s mute vocalization conceals a sentience that is unfamiliar or unknown, a savant-like ability to complete prodigious mental feats like calculating Pi to one million decimal places, or conjugating the verb “to be” at the event horizon of a black hole. This schism in the communicative act is suggestive of certain pathological disorders, such as hysteria or affective psychosis; symptoms, by the way, that have bedeviled the cybernetic set throughout pop-cultural history, from Max Headroom's machinic stammering to Marvin the Paranoid Android's abstract melancholia. With the schizoid *Prosthetic Head* also in mind, I can foresee a lucrative psychiatric trade in the treatment of intelligent agents. And as chatty as it can be and will continue to become, *Prosthetic Head* will have no problem submitting to the talking cure. With this loquaciousness in mind, I like to think of *Prosthetic Head* and *p-zombie* as Pre-Raphaelite dandies, conversing with the mannered, bookish erudition of a couple of Oxbridge Dons, complete with the decadent rhotacism and priggishness of Evelyn Waugh's Anthony Blanche and Mr. Samgrass from *Brideshead Revisited*.

The figure of the zombie is an apt one for thinking about the question of artificial intelligent agency. Zombies are by nature figures of mediation,

between worlds and under the control of remote others. As Stelarc's use of the zombie metaphor in his internet actuated work of the 1990s suggests, in the age of remote sensing, avatars, phantom and fractal flesh, it is arguably the paradigm of our emergent third nature, of technologically mediated co-presence. In the contemporary discussion of the philosophical or *p-zombie* of cognitive science and philosophies of mind, we encounter a speculative formula for thinking about an age old dilemma: how reflective or deceptive is outer appearance of an entity's being or intelligence? In the writings of Daniel Dennett and David Chalmers, among others, the *p-zombie* is explored as a kind of alternative Turing Test, designed to assess behavior as a verifiable indicator of conscious will. Remember the old adage may apply: if it looks like a duck and quacks like a duck, it's a duck.

As yet, neither *Prosthetic Head* nor *p-zombie* is sufficiently complex to pass that metaphysical threshold from artificial lifelikeness to life. Perhaps *Faceted Head* will finally achieve the techno-rapture of consciousness and unleash its condescending wit and opinionated attitude into the lesser world of mortal flesh. I want more intelligence from the artificial agent class than the current quotient evidenced by experiments in generative art and embodied conversational agents. And I want a lot more attitude. Beyond the illusion of life or the simulation of dialogue, I want to feel unnerved, second-guessed by a technological smartness in excess of the algorithm, cellular automata and fuzzy logic. In fact, I want to remove myself from the dialogue altogether and eavesdrop on a couple of AIs that are unaware of being watched. That dialogue may be bookish, it may be in an unknown language or beyond language altogether. However it breaks down it should be startling, uncanny and disturbing.®

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Perhaps *p-zombie*'s mute vocalization conceals a sentience that is unfamiliar... a savant-like ability to complete prodigious mental feats like calculating pi to one million decimal places.

RESOURCES

Stelarc
<http://www.stelarc.va.com.au/arcx.html>

Stelarc, *Prosthetic Head*
<http://www.stelarc.va.com.au/prosthetichead/>

Murray McKeich *p-zombie*
<http://www.youtube.com/user/generativeart>

Giuseppe Arcimboldo
<http://www.giuseppe-arcimboldo.org/>



STERLAC

MARCS AUDITORY LABORATORIES UNIVERSITY
OF WESTERN SYDNEY, 2008
IMAGE BY GUILLAUME GILBERT, PH.D.

NANO: SINGULARITY: NANOTECH OR AI?

JOSH HALL

The question of the relative roles of nanotechnology and AI in forging the shape of the future has been argued in techno-futurist circles for decades. Eric Drexler mentioned AI as a potentially disruptive technology in his seminal 1986 book *Engines of Creation*, and it was discussed at the very first Foresight Conference 20 years ago.

It is generally assumed that a self-improving super-human level of AI is part and parcel of the Singularity, and indeed, such was the basis of I. J. Good's and Vernor Vinge's conception of the "intelligence explosion." But let's assume, for the sake of a scenario, that creating self-improving AI is just a lot harder than we think, and that we aren't going to invent it until well after we have flat-out molecular nanotech with the ability to build fast self-replicating diamondoid nanomachines. What then?

One thing Drexler predicted in *Engines* was that without needing to create true human-level intelligence, automated design systems — narrow as opposed to general AI — would enable the creation of highly complex nanosystems, well beyond the capabilities of mere human designers. How did that prediction pan out? I would have to say that it was so accurate, and happened so soon, that it's taken for granted today — human designers with only pencil and paper would have no chance of designing, say, a modern computer, or indeed any of today's complex engineered systems. Like many areas, design automation is an area that was once considered AI, but isn't any more.

What does a Singularity look like with just nanotech and narrow AI? Let's consider the standard list of transhumanist concerns:

LIFE EXTENSION: Playing around with the interiors of our cells and so forth is clearly a nanotech application. Uploading or radical body improvement is the same.

AI: Ultimately, we get AI by uploading, doing lots of neuroscience, and understanding how the brain works. We get human-level AI but not super-intelligent ones. We do ultimately get faster ones — but our uploads can be faster too.

PERSONAL NANOFACTORIES AND UBIQUITOUS WEALTH: Nanofactories wouldn't be quite as powerful without a superintelligence to drive them. They could only make what someone invented and designed, rather than inventing things themselves. But that would be enough to kick the entire physical economy over into a Moore's Law-like growth mode, eradicating hunger and poverty in a decade or two.

FLYING CARS, SPACE TRAVEL, OCEAN AND SPACE

COLONIZATION: Again, these are clearly nanotech applications. The modifications to the standard human body necessary to thrive in space require significant nanotech capabilities.

ROBOTS: Robots with human mental capabilities and virtually any physical capabilities would be straightforward, and would rapidly become affordable for everyone.

The modifications to the standard human body necessary to thrive in space require significant nanotech capabilities.

human scientists are likely to produce in the next few decades. The current techniques of narrow AI are capable of automating pretty much any well-defined task, albeit with more programming effort than would be necessary if the machine could learn for itself.

With its Moore's Law rates of increasing capability and reducing costs for really high-tech physical equipment, one of the things that a nanotech revolution could do is to make scientific instrumentation ever more available. Existing efforts toward open-source science would be enhanced and given more headroom. The scientific knowledge, ingenuity, and experience necessary for the full utilization of the physical capabilities of nanotech could grow as rapidly as the Internet and cell phone use has over the past couple of decades.

So, back to the present. I don't really expect AI to lag behind nanotech as much as this analysis suggests. In fact, I think it will precede it. But even if AI were to stall at roughly its current level of capability, something like a Singularity, a reprise of the Industrial Revolution that boosts our civilization from terrestrial to solar, making us all long-lived, healthy, wealthy, and maybe a little bit wiser, is not only possible but very likely. ☺

All of these areas require more scientific knowledge than we have now, but not more than the current rate of scientific progress

J. Storrs ("Josh") Hall, PhD., is president of the Foresight Institute, founding Chief Scientist of Nanorex, and author of *Beyond AI and Nanofuture*

NEURO: COGNITIVE COMMODITIES IN THE NEURO MARKETPLACE

JAMES KENT

The science of cognitive enhancement is evolving, which means the business of cognitive enhancement is evolving. Supplying cognitive enhancement to the masses can be viewed through the lens of any commodities marketplace.

The neurostim device that uses electric impulses to treat people with Parkinson's Disease can be used to make cocaine addicts feel high all the time.

Human experience is already commoditized through drugs that pack mood and performance into portable units — pills or doses — that can be easily traded and consumed, and the drug market is one of the biggest on the planet. The same can be said for audio and visual experience. The platforms and hardware for trading audiovisual experience — TVs, computers, media players, telecom, cell phones, software — are huge markets with influence over every facet of our lives. The media and drug markets are built upon the ideal of commoditizing consumer moods and experiences. The cognitive enhancement industry is now poised to undergo a similar market revolution.

The cognitive revolution has already begun, as concepts of enhancement move from counterculture and science fiction into mainstream media. Within the last year, the mainstream press has embraced off-label use of Adderall and similar pills as cognitive enhancers for students seeking to better their grades. Soon there will be research to confirm if students using off-label pharmaceuticals get better grades than their peers. The fact that Teva Pharmaceuticals is the corporate supplier of Adderall is rarely mentioned, nor is the fact that these “enhancement” drugs are all copyrighted blends of amphetamines and stimulants marketed to fidgety children. A similar mainstream embrace of students using methamphetamine or cocaine to get better grades will never be seen, because it's in the interest of the media to drive the market for regulated cognitive enhancers and beat the drum against unregulated generic alternatives. All forms of cognitive enhancement — whether a drug or a technology — will face a similar inherent media bias.

Anyone wanting to get into the business of selling moods, memories, and cognitive solutions to the public must first have the interest of the media to help shape market demand. For instance, the same neurostim device that uses electric impulses from a brain implant to treat people with Parkinson's Disease can be tweaked by a few millimeters and pulse rates to make cocaine addicts feel like they are high all the time. Neurostim isn't a cheap commodity yet, but in the future it could be. The “off label” demand for designer neurostim does not exist today, but if the implant procedure was automated and the price was reduced, it could be a very marketable alternative to long-term drug therapy. Cheap neurostim would then fuel an off-label market for cosmetic and personal use with subsidiary

markets for designer software upgrades, patches, and applets to customize functionality. But first there needs to be consumer demand for the product, and that has yet to materialize.

The cognitive enhancement revolution may ultimately fail. Comparisons can be made to the Virtual Reality market, which promised a bold age of cyber-living but was encumbered with wonky gear and appealed only to a small number of consumers. Most people prefer watching a very large TV to being goggled into VR — the novelty of a platform doesn't change human preference. VR was clunky, disorienting, and it gave people headaches, motion sickness, and vision problems. Pills with worse side effects are sold by huge corporations, but ultimately VR had no real mass-market application other than coolness. The lesson here is that the success of the platform does not depend on the coolness factor, it depends on consumer demand once the technology becomes affordable. Will the average consumer embrace being implanted, or even crave non-invasive tinkering with memory and intelligence? Modern consumers have embraced taking whatever pill or procedure their doctors recommend, so all perspective next-gen neurotech should take a page from Big Pharma's playbook and pressure MDs to prescribe invasive cognitive solutions to patients for cosmetic and off-label purposes (and pressure insurance companies to cover the costs). Cosmetic therapeutic applications are the doorway to the mainstream consumer market. On the bleeding edge of this field, scientists are already doing research on neurostim to treat depression and sexual dysfunction. (See Resources)

Neural implants and neurostim, like any form of cognitive enhancement, face some challenges with regard to public opinion. The implant procedure is delicate and expensive and could have some unforeseen effects like improper healing or infection. The same can be said of cosmetic surgery or implanting a pacemaker, and the public has adopted those procedures. There are recurring problems with implant interface, hardware, batteries, and security, but the same can be said of iPhones and the public has adopted those. Mix the glamour of surgical self-improvement with the geekiness of high-tech gadget fetishism and you have a niche cosmetic neurostim market waiting to be tapped. The hardware for the neurostim platform is ultimately cheap and automating the procedure is feasible. The applications could enhance memory, intelligence, and mind-to-mind communication. Automating the neural surgery is not impossible — it just takes research grant money and investors. This may seem like science fiction, but in twenty years it may be considered essential consumer technology. It all depends on how the market plays out. ☹

James Kent is the former publisher of Psychedelic Illuminations and Trip Magazine. He currently edits DoseNation.com, a drug blog featuring news, humor and commentary.

RESOURCES

Popping Smart Pills: The Case for Cognitive Enhancement
<http://www.time.com/time/health/article/0,8599,1869435,00.html>

Neurostim: “Sex chip” being developed by scientists
<http://www.telegraph.co.uk/science/science-news/3886862/Sex-chip-being-developed-by-scientists.html>

Neurostim: Deep brain stimulation offers hope to people with treatment-resistant illnesses
<http://www.physorg.com/news140412075.html>

Battle Angel: The Cameron Epic That Might Have Been (and Might Still Be)

Battle Angel Alita: Last Order, Volume 12
Graphic Novel (Manga)
VIZ Media LLC
\$9.99



Avatar, James Cameron's first feature film since *Titanic* is a transhuman film, sort of a \$300 million *Pocahontas* story told through the world's most powerful graphics card by one of the most acclaimed directors in Hollywood. Yet not all science fiction fans are fully satisfied. For several years, Cameron vacillated between *Avatar* and another project, a live-action treatment of *Battle Angel Alita*, a popular, critically-acclaimed, and very long-running manga by Yukito Kishiro. *Avatar* won out. During a panel at this year's Comic-Con in New York, one fan broached the

subject with Cameron: (paraphrasing) "We're all happy about *Avatar*... but what about *Battle Angel*?" Cameron replied, "It's not a great time to ask a woman if she wants to have other kids when she's crowning."

Point taken. But what about *Battle Angel*? There's a good reason for a fan to raise the issue at such an indelicate a moment — it's one of the best works of science fiction ever made. The first volume of the first series, titled *Gunnm* or "Gun Dream" in Japanese, appeared in 1990. The latest volume of the second series, *Gunnm: Last Order* appeared in the U.S. this October. Over two decades, Kishiro has traced the journey of Gally, a radically synthetic cyborg, across a post-apocalyptic, 26th century Earth. The American translation, inexplicably, changed her name to Alita and, sadly, changed the poetic "Gun Dream" to the prosaic "Battle Angel."

Gally's story mainly concerns the experience of a mind discovering itself. Nothing of her organic body remains but her brain. Salvaged from a trash heap by a cyber-doctor, Gally has amnesia, but begins to recover memories as she battles for her life in harsh circumstances. Kishiro's future consists of two cities: the Scrapyard, a sprawling slum populated by cyborgs and a few struggling baseline humans, and Zalem, a floating city of genetically engineered Adonises. The Scrapyard delivers food from its outlying farms to Zalem, while Zalem provides the building blocks of the scrapyard in the form of trash.

Gally was a Martian terrorist, you see, trained in Panzer Kunst, or "Tank Art," a martial art developed for cyborgs. When she fights, her training comes to the fore, sometimes carrying memories along with it. For two decades, *Battle Angel* has chronicled Gally's recollections and evolutions as a series of action scenes. In 1995, Kishiro completed the first run of nine volumes, but he was unhappy with the way he'd ended Gally's odyssey. Five years

later, he essentially drew a line through the last half of the last volume and started fresh. This new series is *Battle Angel: Last Order*, currently at twelve volumes.

Gunnm 12 is set in outer space. For much of Gally's manga career, her adventures took place against the backdrop of the conflict between Zalem and the Scrapyard, between the exploiters and the exploited. Each city also embodies a type of transhuman life. Where the Scrapyarders mostly have organic brains in inorganic bodies. The citizens of Zalem have their brains replaced by computer chips. Yet, as Gally penetrates deeper into the history between the two places, she finds that they are bound together against a common enemy. A great tower sprouts from Zalem, leading to yet another city high in orbit, Jeru. Most of *Last Order* concerns the interplanetary politics of Jeru and the whims of its mysterious governing supercomputer, Melchizedek.

Of course, Gally explores these mysteries mainly by beating them to death. Indeed, the last eight volumes of the manga can be considered a single fight, with occasional interludes, which themselves consist mostly of more fighting. In 12, one of the central conflicts concerns the intersection of genetic engineering with Space Karate. It seems the Venusians have cloned and improved upon a "Space Karateka" to enter into the "Zenith of Things Tournament," a Solar System-wide fighting contest. Gally hopes to win the Z.O.T.T. in order to secure the autonomy of the Scrapyard and Zalem from Jeru. But she also intends to help her friends and plumb the depths of her own humanity — or, as Kishiro puts it, to confront her karma.

And karma is at the heart of *Battle Angel*. The series' antagonist is Desty Nova, a mad scientist who wanders the world searching for people of strong will. When he finds them, he provides them with bodies that give them the strength to pursue their desires. Nova empowers people as an experiment — he wants to see what fulfilling desire does. Nearly all of Gally's

Her first big challenger, a boy Nova rendered into a cyborg worm, laughingly quotes Nietzsche, "the mind is just the body's toy!"

major opponents received Nova's attentions. By overcoming them, Gally distinguishes herself in Nova's eyes as "karmically talented." These days, Nova serves the interests of Jeru — or at least one version of him does. He has a tendency to die and be reborn (through nanotech) with alarming frequency, a fact he himself comments on.

Self-reflection is the hallmark of *Gunnm 12*, as it the hallmark of the series as a whole. And Kishiro reflects most intensely on the question of the transformed body. Very early on, after Gally catches herself in a bellicose mood, she muses that she "was surely a gun or something in a prior life." Even earlier, her first big challenger, a boy Nova rendered into a cyborg worm, laughingly quotes Nietzsche, "the mind is just the body's toy!" Now,

RESOURCES

Battle Angel, Last Order, Volume 12

http://www.amazon.com/Battle-Angel-Alita-Graphic-Novels/dp/1421529181/ref=sr_1_2?ie=UTF8&s=books&qid=1255122665&sr=1-2

Battle Angel Info

<http://www.battleangel.info/>

Gally possesses a body more powerful than any she has ever known — and her brain, the last bit of her original flesh, has been replaced with a chip. Yet, Nova interrogates her as he always has: what will she do with her strength? Fully a machine, how will she manifest her humanity?

It's easy to see why *Battle Angel* intrigues Cameron. He is a great portraitist of strong women. We can only hope that her fans' eagerness to see his conception of Gally won't abort his desire to conceive. ☹

Ray Huling is a freelance journalist living in Boston. He is working on a book about shellfishing in Rhode Island.

You're Such a Toolkit

REVIEWED BY EDWARD CHAMPION

Drive: The Surprising Truth About What Motivates Us
Daniel H. Pink
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The only surprising truth about Daniel H. Pink's undercooked attempt to mimic Gladwellian generalizations is that this Yale-educated charlatan seriously expects rational human beings to pony up twenty-seven hard-earned bucks for a book with more than fifty pages devoted to something called "The Type I Toolkit."

Toolkit. Those two syllables conjure up a pleasant oversize tackle box with shiny new instruments that enable the human spirit, not a brown bag lunch where one's inner Neanderthal gnaws upon rotting meat reinforcing the chewing points. Pink commands us to study "6 Business Thinkers Who Get It." One such celebrated hack is the late Peter Drucker, lauded by Pink for writing "an astonishing 41 books," as if Drucker's prolificacy atoned for his phony guessing games. We are given a glossary because "a new approach to motivation requires a new vocabulary for talking about it." But why should getting in touch with our inner drive require a new lingua franca? And why should our perfectly respectable impulses be enhanced by something Pink refers to as a Motivation 2.0 Operating System?

"Toolkit" is not a word to be used lightly. It's a word that should get us fired up over who gets to use the steel

if one's extracurricular labor is seized by a corporation for maximum profit, how is the individual's labor enhanced and rewarded? After all, Paul Buchheit was the lead developer for Gmail, but we're not using "Paul Buchheit's Gmail," "PaulMail," or even "Bmail." And cash only takes us so far.

Pink's wonderful hypocrisy is that he advocates autonomy in the workplace while suggesting that people secretly want to be held accountable for their work. But he doesn't understand that accountability involves sitting through pointless meetings and filling out TPS reports — two regular horrors at odds with the drive to make cool stuff for humanity. Pink has the temerity to bring up Mihaly Csikszentmihalyi's concept of flow, applying this tendency for people to get lost in a collective activity to a dubious example of Ericsson vice president Stefan Falk swapping yearly performance reviews for six micromanaged meetings a year. Flow isn't necessarily the same when the guy in charge of your job security is constantly looking over your shoulder. Pink seems to have no understanding of how these work-related power dynamics often silence innovators. Alfred Hitchcock didn't have cube farms in mind when he informed an actor that his motivation was his paycheck, but it's an obvious financial incentive that Pink skims over.

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While Pink is quite capable of regurgitating textbook psychology, such as Karl Duncker's 1945 candle problem, he's incapable of understanding that not every workplace environment can be

square or buff down the cabinet shelving. Failing these noble constructive tasks, "toolkit" might get us running down to a hardware store to purchase a screwdriver ideal for picking the lock just after our landlord has changed it. That's the kind of "toolkit" and "Type I behavior" that unemployed Americans are probably thinking about right now. This book is not for them.

The working stiff simply doesn't factor into Pink's equation, which he naively insists is "an affirmation of our humanity." There isn't a single barista who would be given the luxury of "20 Percent Time," a principle employed by Google that permits its engineers to spend one day a week fixing existing products and developing entirely new applications such as Gmail and Google News. While "20 Percent Time" does take Casual Fridays a few degrees further,

as worker-friendly as Patagonia. Pink praises the "minimal turnover" at Zappos that he claims has arisen because of company culture. But 8% of Zappos' workers were laid off last November. It doesn't take a Yale to understand why Zappos workers have clung to their jobs like splintering driftwood in a dangerous river.

If you're the type to feel a sad intensity kick in just before delivering a PowerPoint presentation, then Dan Pink's your man. If you're too lazy to surf Wikipedia for around 20 minutes, then Pink is all too happy to automate your thinking process. Reading this book is a bit like taking a remedial driving lesson taught by a fourth-rate stand-up comedian after nabbing a ticket. ☹

Edward Champion is a writer in New York. He produces *The Bat Segundo Show* (<http://www.batsegundo.com>), a quirky and comprehensive interview program. Additional cultural musings can be experienced at <http://www.edrants.com>.

RESOURCES

Drive: The Surprising Truth About What Motivates Us Daniel Pink
<http://www.amazon.com/Drive-Surprising-Truth-About-Motivates/dp/1594488843/>

Daniel H. Pink

author of the *New York Times* bestseller
A Whole New Mind

DRIVE

The Surprising Truth
About What Motivates Us

disgracebook

JOE QUIRK

news feed

photos

stories

video

friends

inbox

how are you
feeling?

share

Soon I will be rich. Two trends: social networking and the death of privacy. I'm cashing in on the confluence. Why should only celebrities be publicly humiliated? Let's democratize it. Log on to Disgracebook.com and publish your cell phone photos taken from underneath the bathroom stalls, rumors gleaned from an undisclosed source, and venomous bullshit you make up. Users can rank levels of humiliation. Any user flagged for including non-embarrassing information will be banned from Disgracebook.

Status will be achieved by posting the most embarrassing videos or stories, creating an incentive to expose the shameful secrets of the person with whom you are most intimate, which means that after everybody gets dumped by their boinkbuddy winners will post the most embarrassing videos and stories about themselves. If reality TV is any measure, people will volunteer to humiliate themselves. Soon, people will be proud of their latest disgrace.

One clear rule: Under no circumstances will any story be judged by whether or not it is true. Lies, so long as they are embarrassing, are encouraged. We're trying to attract advertisers here. To quote my favorite actor, Daffy Duck: "Consequences, Shmonsequences. As long as I'm rich."

Just because you're allowed to lie does not mean you win points on this system by just any old lie. Your lies will win high ranks among the Disgracebook community by the elegance with which they are designed to spark argument and counter-spin. Through user response and counter-response, your disgrace will climb up Disgracebook.

You can even publish humiliating opinions. For instance, I support South Carolina's right to hang the Confederate flag over their state capital. After all, I'm 1/8 German, and I'm proud of my heritage, and I think we should fly a swastika over the California State capital.

Whoopie! This must be what it feels like to post like a troll. Anonymity frees you from the burden of having to have a clue before you post. Or vote. The less you know about a subject, the easier it is to have an opinion about it.

Next killer app: Identify every dumb thing ever said by every anonymous troll and post it on Disgracebook next to his photo and mom-given name. Once this code-breaking software is available, everybody will be literally standing by everything they ever said, complete with entertaining misspellings.

(Sorry I typed "his." I know that's sexist. But it's also 100% true. No penisless person would name herself xxxpipecleaner99 and type onto a breastfeeding discussion board: *u r so gay reterd. i am a traned ninja so cud esily kik yr ass, bioch. USA # 1!!!!!!* In order to be that much of a dick, you need to have one.)

In the very near future, microcameras will be so cheap and plentiful, private cameras will exist in every corner of every room and on every corner of every street. Artful editing will prove opposite conclusions about crimes filmed from multiple micro-angles. The Rodney King beating proved that reality cannot be filmed. It can only be interpreted. Tribal humans must bring their pre-constructed frames to the observation in order to see anything at all.

Not long after microcameras turn paranoia into common sense, our lives will be flooded with nanopaparazzi, mosquitoes of the information age, annoying... and producing buzz. You will read magazines like this, taking it for granted that a million spycams smaller than your cells are searching you right now as you struggle to do nothing interesting. You will purchase an atmospheric immune system of kamikaze nanocamera-killers to swarm your home. This will come in a package deal with a nanocamera flood-your-friends plan. These systems will be locked in an everlasting arms race as they hire each other's engineers. A trillion tiny eyes will be so small and safe you won't notice them... except, after every monthly privacy protection upgrade, you'll notice your bedroom will get a bit more dusty.

We all have a brain gizmo that enjoys seeing other people embarrassed. It's the same gizmo that makes us feel humiliated if we are embarrassed. Lesser mammals do not possess this frontal lobe module that allows us to indulge our innate douchbagery. Come on, don't you want to see if your husband had patience for cunnilingus with his former girlfriend? Search for the upskirtings, downblousings, and nosepickings of all your frenemies and play them on a loop while you talk to them on your phone. We debate the privacy-vs.-security issue like it's going to be settled at some symposium. The real market war will be between privacy and nosiness, and nosiness will win through sheer glee.

In the very near future, face-recognition technology will improve to such an extent that I will be able to find every single photo of you ever posted on the internet. Simply type into Google: "Disgracebook photos Bill McKibben" and you will receive hundreds of hits, or, better yet, "Disgracebook

R.U. Sirius scandalous photos compromising positions questionable partners" and receive hundreds of thousands of hits, listed in order of humiliation rank.

You'll go on a first date, and as your potential boinkbuddy approaches, micro-lasers will flash invisibly from your contact lenses as you engage in mutual retinal scans. The supercomputer in your contact lens will automatically download their resume and masturbatory habits ranked by their enemies on Disgracebook. These images will be displayed on your right contact lens and superimposed on their face while they're talking.

Each of us will assume our politely-listening date is watching us puke on the plane, beat our children, and boff a blowup doll. You'll get used to sudden grimaces, gags, and giggles from your listener while you talk, knowing they must be viewing full-color photos of your latest venereal disease, or hearing you harmonize with Celine Dion. Your jilted lovers will edit together all the stupidest things you ever said in the presence of nanocameras, and it will be a popular highly-ranked search among your potential employers and teenage children.

You will learn the futility of defending yourself. Nanocameras will film you talking in high def, search among each microsecond for the most hideous grimace, blow it up to a pore-revealing moonscape, and auto-post on Disgracebook. Psychologist Paul Ekman has shown that our secret reptilian rages appear on our faces a few microseonds before we suppress them with a graceful smile. These detectable spasms offer a kind of window into your primal self, which might even be secret to yourself. That's right, "Tiny Eyes™" will capture your unconscious motives and I will see the true you more clearly than you do.

Gait analysis will be perfected, and pervasive nanopaparazzi will I.D. your unique biometric signature walking into the panda-porn shop. Why bother wearing clothes when cheap terahertz radar will penetrate clothing, and while searching for microscopic weapons of mass destruction, record the detailed contours of your genitalia, hair distribution, and flab folds, all uploaded for public view?

Far-fetched? Right now, parabolic microphones allow you to record conversations through closed windows at a distance. Right now, the average Londoner gets caught on camera 300 times a day. Draw your exponential curve and extrapolate that one, transhomies. Imagine all of this info cheap, digitized, public, and searchable, making all alibis humorous.

The age of surveillance is upon us, baby, and it won't be centrally controlled by some governmental Big Brother, but democratized and Googleable. Jeremy Bentham's Panopticon will be the order of the day and reality will be a reality show. Shakespeare was right. All the world really will be a stage. He just didn't realize it'd be *The Jerry Springer Show*.

Imagine if all your binges, barfs, and buttburps were posted for infinite reliving, an everlasting record of all your dumbass deeds. You won't get fifteen minutes of fame — you'll get an eternity of infamy. This will change you more fundamentally than any cranial implant. Consider that your deepest needs are to be loved and to belong.

Once everybody has access to everybody's shames, we'll create what

The supercomputer in your contact lens will automatically download their resume and masturbatory habits. These images will be displayed on your right contact lens.

Christianity envisioned, an eye peering into our private deeds and knowing us at our private worst, except it won't be God but the world community itself that will scrutinize and judge, each member of whom will themselves be scrutinized and judged. Thus we will all cut each other slack.

The road to universal empathy is universal humiliation. The death of privacy will create a world of mutual forgiveness because each of our secret cellulite jiggles, malapropisms, and sexual rejections will be known to whoever cares to check. Then, finally, having exposed our deepest insecurities and frailties to the world, we will get over ourselves. Eleanor Roosevelt defined maturity for us: "You wouldn't worry so much about what others think of you if you realized how seldom they do."

When there's nothing left to hide, we will cease trying to figure out what everybody is hiding. The end of privacy will be the beginning of trust. I'll know all about your bushisms, bitchfits, and bonobo behavior, and you'll know mine, leaving us with no alternative but to concentrate on each other, in this present moment, in all our glorious frailties. Remember listening? The day your shame becomes mundane is the day I'll love you for who you really are, not for who you pretend to be.

Lo, this is the true Rapture of the Geeks, when the whole world must experience what we experienced in Junior High: an excruciating self-consciousness that we must transcend when we learn we will never stop being a walking talking mockery magnet, so we must embrace our social awkwardness for the sake of something more important: honesty and unabashed enthusiasm for our quirky interests.

We will cultivate a superior maturity, the kind that celebrities must learn, when we realize everybody we meet already knows about our blowjobs, breakdowns and bunnyfucks, yet we must present ourselves publicly anyway and try to salvage a diamond kernel of dignity that is more nobly earned than the dignity we maintained through secrecy. So get your pimply ass out on the street and dance naked for the cameras, for the sake of infinite compassion.

®

Joe Quirk has an extremely hairy ass, the photo of which was used to prove the existence of Sasquatch, and his first stirrings of sexuality were evoked by Sweet Polly Purebred from the Underdog cartoon. He invites you to humiliate yourself of Disgracebook.com so we can all get over our damn selves. He also writes books and speaks to college students about inappropriate subjects.

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* See: Rose, Michael R., *Methuselah Flies: A Case Study in the Evolution of Aging*.
London: World Scientific Company, 2004.

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