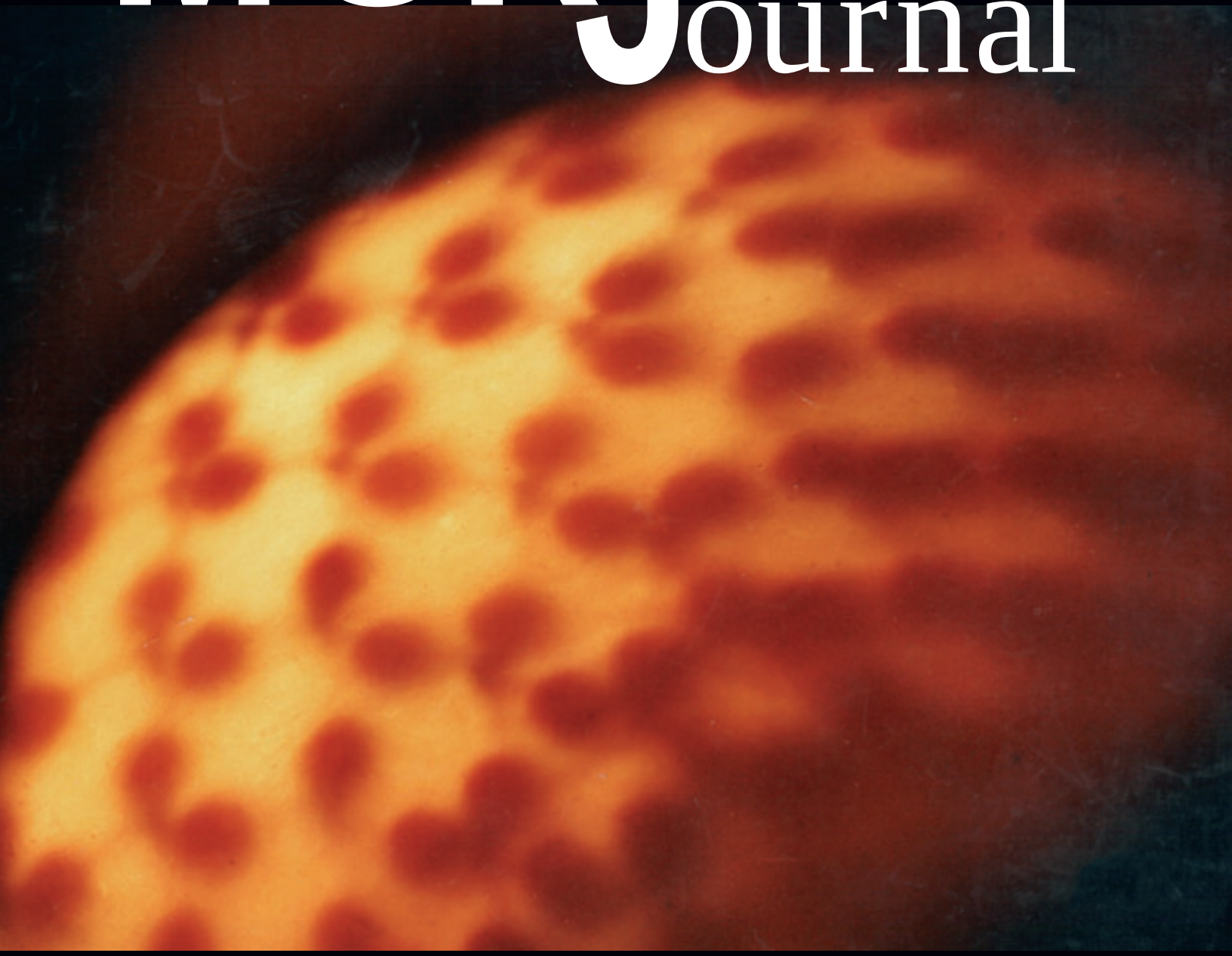
Volume 7 Fall 2002

MURJ Journal



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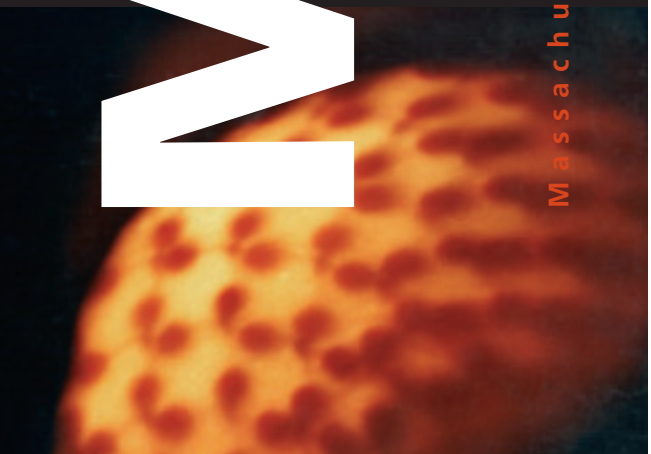

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MIT

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Volume 7, Fall 2002

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Welcome to the Fall 2002 issue of the MIT Undergraduate Research Journal. In this seventh issue of *MURJ*, we present diverse research reports, in fields ranging from architecture and music to particle physics, in hopes that our readers will delve into the world of the scientific unknown. Within these pages, we also include features examining topics such as control of population growth and the effect of the Internet on methods of news distribution.

Our reports and features, as always, are written in such a manner as to make them accessible to all members of the MIT community. We hope that this interdisciplinary journal will provide an opportunity for our readers to learn of research in disciplines other than their own. We also hope that this journal will serve as a forum for debate and discovery, through which our readers may access arguments relating to the intersection of scientific research and public policy.

We extend our profound gratitude to those who make this goal possible. We acknowledge the advice and assistance of our advisor, Dean Les Perelman, the professors who review our work, and the continued support of *The Tech.* We would also like to thank Dean Larry Benedict and the many academic departments at MIT, as well as the UROP and RLSLP offices, for their financial support of *MURJ* this semester, which made this publication possible.

If what you read piques your interest, we invite your input for the Spring 2003 issue — to either join the MURJ team or to submit reports on your own research. Submissions will be due by the beginning of February 2003. Please e-mail murj-public@mit.edu or visit our website, http://web.mit.edu/murj/www, if you have any other questions or comments.

—The Editors of *MURJ*

MIT Science News in Review

[Biological Sciences]

Microwave Radiation Treatment Enters Final Stage of Clinical Trials

The U.S. Food and Drug Administration (FDA) has given MIT researchers approval to begin the final stage of clinical trials for testing an innovative breast cancer treatment using microwave radiation. The randomized clinical trials will include the participation of nearly 220 women with early-stage breast cancer, and began on October 1, 2002, the first day of Breast Cancer Awareness Month.

The technology is based on radar research invented by Dr. Alan J. Fenn, a senior staff member at the Sensor Systems Division of the MIT Lincoln Laboratory. Fenn determined that the focused microwave technology previously studied for missile detection could possibly treat cancer cells. The clinical trials, based on Fenn's research, are being conducted by focusing microwave radiation externally on the breast, heating and killing internal tumor cells, prior to lumpectomy and radiation therapy.

The randomized clinical testing is expected to finish by February 2004 and will be conducted at various hospitals including the Columbia Hospital at the University of Oklahoma (OU), Harbor-UCLA Medical Center at the Martin Luther University in Halle, Germany, and the Comprehensive Breast Center in Coral Springs, Fla. Additional sites have applied for Institutional Review Board Approval. Past studies of microwave heat therapy have been promising. Early results from a prior phase II clinical trial showed significant tumor cell death in a majority of the patients prior to lumpectomy, which resulted in the FDA approval to begin the final phase of clinical testing. Dr. Robert A. Gardner, a breast surgeon at Columbia Hospital's Center for Breast Care in West Palm Beach, Fla., and Dr. Hernan I. Vargas of Harbor-UCLA Medical Center presented the results of the phase II clinical trials at the 2002 American Society of Breast Surgeons Meeting in April and in the May 2002 issue of the *Annals of Surgical Oncology*.

The study is funded and led by Celsion Corporation, who has developed the clinical thermotherapy system and exclusively licenses the focused microwave thermotherapy technology from MIT.

MIT Computational Biology Researchers Predict RNA Slicing Patterns

Four MIT researches, led by assistant professor Christopher B. Burge, have invented a model that predicts which genomic sequences are transcribed to proteins and which sequences get spliced or cut out.

Messenger RNA (mRNA) is a template for all human proteins. It contains exons, genetic material that codes for proteins, and introns, which do not code for proteins. A splicing mechanism then cuts out the introns, leaving the exons that signal protein formation. Sometimes, if the exons are spliced out, the protein product lacks specific functions, which can lead to several diseases. This study at MIT identified several exon-splicing enhancers (ESEs), which promote the splicing of the exons and increase the amount of mRNA containing these exons' particular genetic information.

To better understand RNA and to thus prevent diseases caused by faulty mechanisms, the researchers want to determine a set of rules, perhaps an algorithm, that will predict the splicing pattern of RNA.

This work was a collaboration between the laboratories of Christopher Burge and Phillip A. Sharp, with William G. Fairbrother and Ru-Fang Yeh, funded by the Burroughs Wellcome Fund and the National Institutes of Health.

Human Variation

Researchers from the Whitehead Institute/MIT Center for Genome Research reported in the May 24, 2002, issue of *Science* that nearly all genetic variation in the human genome is arranged into large yet tidy units called haplotype blocks. These blocks are strikingly alike in human populations from Africa, Asia, and Europe, and may be useful in tracking disease-causing genes.

Eric Lander, a biology professor at MIT, and other scientists discovered that each hereditary unit includes a set of single-letter DNA variations known as single nucleotide polymorphisms, or SNPs. Researchers have observed only three to five common haplotypes in the human population. Contrary to long-held belief, the pattern of genetic variation in a fruit fly, which has acted as a prototype for human biology, is more complex than that of humans.

With the knowledge from this study, scientists can simplify the task of combing through 10 million SNPs for disease genes to searching through 10,000 to 50,000 haplotypes. The next step might be the charting of a haplotype map of the human genome. Such a HapMap would facilitate the identification of genetic variations that may place a person at higher risk to develop illnesses such as diabetes and cancer.

Calorie Restriction Can Lead to Longevity

Through his experiments with yeast, MIT biologist Leonard Guarente has discovered that calorie restriction causes higher respiration rate, and therefore might promote longevity.

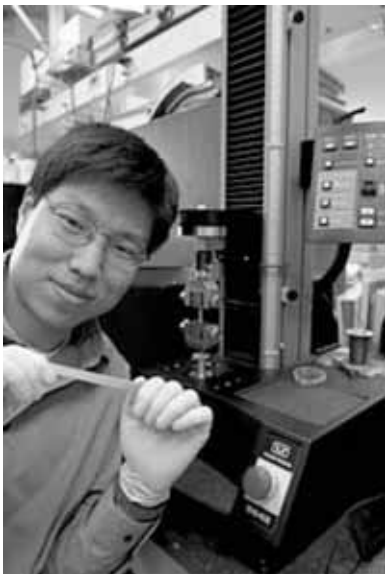
A previous theory suggests that calorie restriction functions by slowing metabolism, thereby slowing the generation of toxic free radicals, the molecular by-products from respiration that damage DNA and other cells. However, Guarente says that oxygen-free radicals do not limit the reproductive life span of yeast. Instead, restricting calories in yeast led to a higher respiration rate, which stimulates NAD, a coenzyme that then activates SIR2, an information regulator gene that slows aging by making a protein called Sir2, which promotes longevity. Guarente aims to create a "miracle pill" that enables people to lose weight and live longer. He found that, in yeast, scarcity of food led to a metabolic shift toward respiration, increasing SIR2's activity and the organism's life span. In mammals, excess carbon is converted to fatty acids and stored carbohydrate energy. The miracle pill would cause the body to use up these energy stores throughout the respiration process, and less food would be converted to fat. People could live to be very thin and very old.

Guarente's research was supported by the National Institutes of Health, the Ellison Medical Foundation, the Seaver Institute, and the Howard and Linda Stern Fund.

[Bioengineering]

Biorubber Predicted to Change the Face of Tissue Engineering

Researchers from around the globe have been contacting the MIT Langer Laboratory of Chemical and Biomedical Engineering for samples of "biorubber." This is a new material with many anticipated applications including engineered lungs, heart valves, and other elastic tissues.



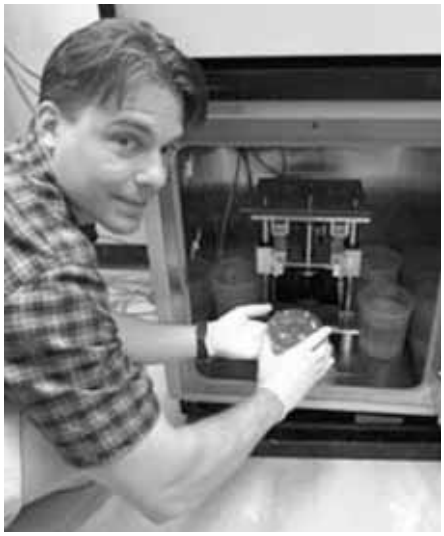
Biorubber is unique because of its superior elasticity. Tissue elasticity can often be essential to the function of a particle body tissue. For instance, researchers note that the air sacs in the lungs expand more than sevenfold during inhalation.

The other biodegradable polymers currently being used in the human body for drug delivery and tissue engineering are relatively hard and brittle. These products are in use either as the vessels for medication or as the scaffold for growing cells. Biorubber has an additional advantage versatility because its properties can easily be adjusted to a variety of specifications such as its rate of degradation. In addition, biorubber is strong, biocompatible, and inexpensive (it can be made in large batches of 400 grams per batch).

Constructed of two principal building blocks that are nontoxic, biorubber is expected to be approved by the Food and Drug Administration (FDA) for use in human beings. Although the process could take years, researchers are optimistic. In the meantime, they have turned their attention to exploring the applications of biorubber in engineering blood vessels, heart valves, the liver, and cartilage.

Cartilage in Hydrogel Implants Could Repair Joints

Professor Alan Grodzinsky and Ph.D. student John Kisiday from MIT's Biological Engineering Division have grown cartilage cells in a peptide hydrogel. When this cartilage is inserted into a damaged joint, the new cells merge with the patient's original cartilage, repairing the joint as the gel slowly disintegrates.



Cartilage, the soft tissue that cushions bone movement at the joints, is damaged or worn away in sport-related injuries, accidents, old age, and diseases like osteoarthritis. At present, the FDA has approved only one method of cartilage repair: Doctors extract some cartilage from a patient, culture these cells, and then implant this tissue into the patient's damaged area, a procedure that costs $30,000. The new "cartilage gel" could be inserted through a small incision, reducing both recovery time and price of operation.

In 1993, Shuguang Zhang, the associate director at MIT's Center for Biomedical Engineering (CBE), discovered that various peptides from human proteins can be modified to self-assemble into completely different natural materials. Peptides can lead to "nanosoaps" and biomedical devices, or they can be used to support nerve, bone, liver, and cartilage cells.

This particular peptide scaffold consists of interwoven fibers that are 10 to 20 nanometers in diameter. The small structure enables growth factors to attach to peptides and directly stimulate

cell growth. The gel can degrade over time. It also provides less risk of disease because the peptide is not from animal tissues and so does not pass along animal viruses. The peptide scaffold, coupled with a mechanical "exercise regimen," has resulted in a cartilagelike tissue, which provides hope for a cheaper and more efficient joint repair method.

This work was a collaborative effort among John Kisiday, Alan Grodzinsky, Moonsoo Jin, Bodo Kurz, Han-Hwa Hung, Carlos Semino, and Shuguang Zhang, and funded by the NIH and the DuPont-MIT Alliance.

[Physical Sciences]

New Design for Quantum Computer

Scientists at MIT, the National Institute of Standards and Technology (NIST), and the University of Michigan have proposed a design for a quantum computer based on a large number of interconnected ion traps using experimentally proven techniques.

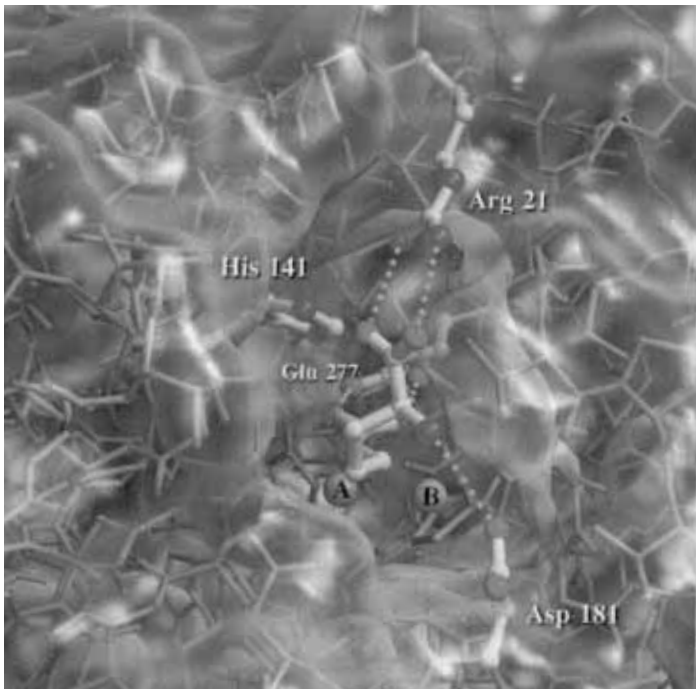
Transistor computers common today can be in only one of two states at one time, either on or off, symbolized by a 1 or a 0. By manipulating atoms or molecules to different states, a quantum computer can be in several states simultaneously, and so can process much more data than a traditional computer, performing tasks like factoring large numbers, deciphering cryptograms, or modeling weather patterns.

Previously, NIST had developed electromagnetic traps where ions can be stored, observed, and manipulated. The MIT/NIST/U of M team proposes to build a large number of these interconnected ion traps. By changing the operating voltages in separate traps, they can manipulate a number of ions in each trap or shuttle them between traps, allowing communication between sets of ions. At the NIST lab in Boulder, Colo., the scientists have constructed a pair of raps, which have been shown to maintain stable electronic states. This is evidence of a practical system from which to build a computer capable of quantum computation scalable to large numbers of qubits (quantum bits).

Structure of Complex Sugar Molecule Discovered

Using a newly developed analytical method, MIT researchers have determined the structure of heparan sulfate, a sugar molecule found on the surface of all cells in the body, and heparin, a commercial drug used to prevent blood clotting.

For decades, the structure of proteins and DNA has been relatively quick and cheap to analyze, while due to their greater complexity and structural variability, sugars (polysaccharides) have been very difficult to decipher. According to researchers, in the postgenome era, research is shifting toward the functional implications of proteins and carbohydrates. Therefore, developing newer methods of analysis of sugar molecules is greatly needed.



The technique was developed by MIT Professor of Biology Robert D. Rosenberg and postdoctoral associates Kuberan Balagurunathan and Zhengliang L. Wu, technical associate Miroslaw Lech, research affiliate Lijuan Zhang, and research scientist David Beeler. It is unusual in that it combines liquid chromatography with mass spectrometry. By means of this method, researchers can separate out heparin and heparan sulfate oligosaccharides that are three to four times larger than what was previously possible. Different labels are used to identify the key areas on the molecule critical for biological action.

Thirty years ago, Rosenberg demonstrated that heparin inhibits blood coagulation by thinning the blood. Heparin achieves this end by binding its sugar groups to its target, antithrombin, a blood-coagulation protein. In response, antithrombin increases the rate at which it inhibits blood coagulation enzymes, thereby inhibiting blood coagulation. Heparan sulfate is of interest to researchers because it plays a role in normal physiological functions, such as tissue regeneration, as well as in disease-related functions, such as developmental disorders and tumor growth.

Caught in the Act: Pulsar Found Stealing Material from Stellar Companion

MIT scientists have spotted a pulsar in a binary star system that is in the process of whittling away its companion star. The companion star has been reduced considerably, making it only 10 times more massive than Jupiter. This system has one of the lowest-mass companions of any known stellar binary; as such, it provides further evidence that neutron stars

can slowly accrete material from their companions. During this process, the spin rate of the neutron star dramatically increases, causing it to transform into an isolated, radio wave–emitting pulsar spinning a thousand times per second. The fate of the companion, once a bright orange gem with 500 times the mass of Jupiter, is extinction, growing dimmer and dimmer until it vanishes completely.

According to researchers, this rare find will help them understand the link between slow-spinning pulsars in binary systems, which are quite common, and fast-spinning isolated pulsars. A pulsar is a neutron star that emits steady pulses of radiation with each rotation. Neutron stars are the remains of a massive star that exhausted its nuclear fuel and subsequently collapsed into a sphere about 12 miles in diameter. The theory is that the powerful gravitational field of neutron stars accretes gas from its companion. Matter spirals toward the neutron star in the form of an accretion disk, a pathway that can be observed using X-ray radiation.

Pulsars have been found scattered throughout the Milky Way galaxy, but this is only the third known accreting millisecond pulsar of its kind and the second identified with the Rossi Explorer in the past two months. The advantage of this system is that its location is less crowded and observations are not as obscured by star fields and interstellar gas and dust.

Dr. Ron Remillard of the MIT Center for Space Research discovered the pulsar along with Drs. Jean Swank and Tod Strohmayer of NASA Goddard Space Flight Center. During a routine survey of the sky, using NASA's Rossi X-ray Timing Explorer, the X-ray source, named XTE J0929-314, was found in mid-May 2002. Dr. Duncan Galloway, a postdoctoral associate at MIT, conducted the follow-up observation that revealed the pulsar system's unique properties.

"It's exciting that we are finally discovering pulsars at all stages of their evolution, that is, some that are quite young and others that are transitioning to a final stage of isolation," reported Galloway.

[Cognitive Sciences]

Color Now Shown To Be Instrumental in Face Recognition

In contrast to previous studies, MIT researchers report that color is an important factor in face recognition. Experiments in which headshots are blurred show that the brain relies on color cues to pinpoint identity. Previously, color had been considered unessential to face recognition, because people were able to accurately identify faces that were artificially colored in such colors as hot pink and electric blue.

Pawan Sinha, assistant professor of computation neuroscience at MIT, and Andrew W. Yip, a recent MIT graduate, found that color was heavily relied upon by subjects looking at degraded images. Subjects used color to determine hair or skin hue. Additionally, the brain probably uses color cues to locate the start and endpoint of the hairline, for instance.

More than just providing insight into the workings of the recognition process in the brain, this further research could assist in improving machine vision systems and developing better criminal identification kits for generating sketches of police suspects based on eyewitness descriptions.

Face recognition is an integral part of human beings' role as social animals. Sinha is therefore exploring several different approaches to find out what the brain looks for in a face. To this end, he is compiling and analyzing 5,000 digitized caricatures of celebrity and noncelebrity faces. His goal is to determine the top 10 or 20 key attributes used in face recognition by the brain from the hundreds of attributes. In another ongoing project named Project Prakash ("light" in Sanskrit), Sinha is working with hospitals in India that treat blind children in order to determine whether face recognition is innate or whether the brain has to learn to use visual cues for this skill. By observing children who were born blind and have since regained their eyesight, Sinha intends to answer the question of whether some visual abilities, like language, have a critical period that makes them inaccessible to those who gain sight after the "window" has passed.

MIT Neuroscientists Research Neural Mechanisms behind Counting

Through experiments involving monkeys' recognition of numbers and counting ability, MIT researchers Earl Miller, Andreas Nieder, and David Freedman have identified neural networks in primates that explain fundamental numerical competence. These discoveries might lead to understanding of how human beings learn mathematically, which will hopefully illuminate how to resolve cognitive deficits in humans.

For seven months, Miller, Nieder, and Freedman taught a 4-year-old and a 5-year-old male rhesus monkey the numbers from

one to five. Then they taught them the concept of sameness by giving them treats if they raised a lever when two pictures looked identical. Finally, the monkeys were rewarded if they responded when the images had the same number of random items (dots, triangles, etc.)

After the monkeys learned how to judge between one through five objects, the researchers identified which individual neurons reacted to each number, discovering that a neuron that responded strongly to a given number of objects would also respond less strongly to other numbers. For example, the neuron responding to "three" would respond a little less to "two" and less to "one." This shows that neurons have "tuning curves" in which response is centered around a preferred number and also preserves the ordinal relationship among numbers; in other words, numbers are not treated as separate categories. This way, our neurons can discern that three is larger than two and less than four.

Scientists must examine how the brain processes numerical concepts in order to better understand fundamental intelligent behavior. Animals have rudimentary mathematical abilities; a necessary aspect of survival is determining how many friends or foes exist, or how many fruits to forage. The prefrontal cortex might be the central core of numerical judgments and abstract categories. Knowing how the brain functions and which processes affect which neurons will help to resolve nervous disorders such as acalculia, impaired mathematical abilities.

The work is funded by the National Institute of Mental Health, the Human Frontiers Science Program, and the RIKEN-MIT Neuroscience Research Center.

World Science News in Review

[Physical Sciences]

Caffeine Overdose Fatal to Slugs and Snails

Researchers have discovered that caffeine is toxic to slugs and snails. Caffeine, which is more effective against snails than the current commercial standard, metaldehyde, could become an environmentally acceptable pesticide.

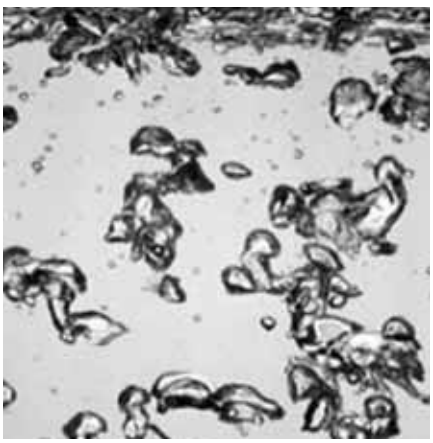
Robert Hollingsworth of the United States Department of Agriculture's Agricultural Research Service and his colleagues noted that a 1-2 percent caffeine solution killed nearly all the slugs and snails within 2 days, and even a .01 percent solution deterred pests. "Slugs turn back immediately after contacting the [caffeinated soil]," Hollingsworth said. A cup of instant coffee contains .05 percent caffeine.

Caffeine applications will kill small snails and slugs and repel the larger ones, researchers expect. According to Hollingsworth, caffeine may be used in orchid greenhouses and on fruit and vegetable crops in the future. However, toxicologist Peter Usherwood of the University of Nottingham, UK, cautions that caffeine's toxic effects may affect beneficial insects in addition to snails and slugs.

While it is not known how caffeine kills the snails and slugs, Hollingsworth suggests that caffeine may damage the nervous system. Caffeine-sprayed snails develop weak and irregular heartbeats, and caffeine-sprayed slugs writhe uncoordinatedly, researchers found.

High Energy Bubbles Clean Up Water Purification

Linda Weavers and colleagues at Ohio State University report that ultrasound can make bubbles in water that could cheaply and quickly clean ceramic filters. The energy released by the bursting of these bubbles results in tiny but intensely powerful spurts of water that clean the filter's surface and flush away debris.



Most municipal water treatment currently relies on chemical purification rather than the use of membrane filters, a more efficient and environmentally safe alternative, as the costs involved in removing or replacing fouled filters are quite high. Membrane filters have pores so tiny that they can sieve out particles as small as viruses. The downside to that, of course, is that they get clogged easily, slowing the process and increasing the cost of maintaining them.

The Ohio team hopes that ultrasound cleaning could allow for membrane filters to replace chemical purification as the water treatment of choice. They are quick, however, to point out potential problems, such as the possibility of the bursting bubbles damaging the filters. According to Menachem Elimelech, an environmental engineer at Yale University, "Ultrasound cleaning could degrade the cheaper polymer membranes that are more widely used." One possible solution posed by Weaver's team would be replacing the sand and paper filters currently in use with hard-wearing and heat-resistant ceramic filters. Further investigation is needed to determine if this is a reasonable alternative and, perhaps more importantly, to convince the conservative drinking-water industry that the costs of the switch are justified.

Current research by the Weaver group is aimed at determining how well bubbles remove different contaminants and how different types of filter can withstand the scouring induced by ultrasound.

[Technology]

Missile-Tracking Technology Could Help Diagnose Dyslexia

Research has revealed that eye-tracking glasses originally developed to enable fighter pilots to direct missiles could be able to spot symptoms of dyslexia. Qinetiq, a part of the United Kingdom's former Defense Evaluation and Research Agency, recently received a grant to produce prototypes of these glasses for children.

It is thought that dyslexia, a learning impairment that affects between 5 and 10 percent of the world's population, may be caused by a failure of the eyes to remain steady as they scan written words. Therefore, tracking eye movements may offer clues as to why dyslexics struggle to read and write. According to dyslexia researcher John Stein of the University of Oxford, "Until now, we've lacked a means of measuring eye movements accurately." Tony Varey, manager of the Qinetiq project, states that the glasses should allow scientists to compare how dyslexics and nondyslexics scan images and determine whether "a subject's eyes are looking at the same thing or if they are simply not coordinated."

Research is now aimed at formulating a measure of unsteadiness able to predict future reading problems, allowing for this new technology to be used in primary schools for diagnosis. Because the causes and symptoms of dyslexia are so diverse, however, these glasses would only form a part of the dyslexia-detection kit.

The development of these glasses is being funded by the United Kingdom's Invest to Save Budget, who endorses joint ventures between public institutions for innovative technologies.

Tiny Flying Robots May Explore Mars One Day

Based on understanding of insect and bird flight, researchers around the country are trying to design tiny, nimble flying robots that could be used to spy on enemies or explore the surface of Mars.

Scientists at the University of California, Berkeley, and elsewhere have learned much about insect and bird flight in recent years, and they seek to apply that knowledge to the development of devices that mimic the size, weight, power, and elegance of a fly. After all, Tim Sands, a professor of materials science and engineering at Berkeley, noted that a fly can lift its own weight, turn more quickly than a fighter jet, fly on torn wings, and land on a ceiling.

SRI Internation in Menlo Park, along with the Pentagon's Defense Advanced Research Projects Agency (DARPA), has funded research at the University of Toronto for the development of a four-winged flapping robot called "Mentor." In February, Mentor became the first flapping robot, or ornithopter, to successfully hover. Mentor is now one foot across and weighs one pound. The goal is to shrink it to hummingbird size and weight.

While researchers are able to build wings that flap, it is difficult to control that flapping to sustain flight. A fruit fly, for example, beats its wings 200 times a second and relies on three distinct mechanisms each stroke to provide lift. Robert Michelson, a principal research engineer at the Georgia Institute of Technology Research Institute, claims that it is too difficult to build a robot relying solely on flapping wings for stability and control. The Mentor uses four tail-like fins to direct the downwash of its flapping wings, and Michelson is developing an ornithopter that will use bursts of gas produced by the device's chemical propulsion system to adjust lift.

According to Michael Goldfarb, an associate professor of mechanical engineering at Vanderbilt University, technological limitations will prevent the tiniest ornithopters from taking off. Goldfarb's attempt to build a flapping robot with a 6-inch wingspan, for example, was unsuccessful. He said, "Our conclusion to that study was it's not doable with state-of-the-art technology."

[Biological Sciences]

With Falling Fish Populations, What (or Who) Will Sharks Eat?

Overfishing in the Atlantic Ocean has depleted stocks of menhaden, a common shark prey. Atlantic sharks searching for food are thus swimming closer to shore, where they may mistake swimmers for food, according to Louisiana State University oceanographers.

Richard Condrey, associate professor of oceanography and coastal studies at Louisiana State University, said that the Atlantic menhaden population has dwindled to a 3 percent reproduction rate. According to Condrey, "The reduction in availability of menhaden for Atlantic sharks may have resulted in a change in their foraging strategy."

The shark attacks last summer at Virginia Beach, for example, may have been a result of the menhaden decline. Virginia Beach is next to Chesapeake Bay, a primary nursing ground for menhaden. Sharks unable to locate menhaden may have swum closer to shore and mistaken humans for prey.

After studying the stomach contents of blacktip sharks daily for three years, Condrey and LSU graduate student Kevin Barry learned that blacktip sharks need a constant supply of food, mostly menhaden fish, to support their rapid growth rate.

In order to minimize chances of a shark attack, the International Shark Attack File (ISAF) advises swimmers to stay in groups, avoid water during darkness or twilight hours, avoid shiny jewelry and bright-colored clothing, and be careful when swimming between sandbars and steep dropoffs.

Teaching an Old Owl New Tricks

The September 19, 2002, issue of *Nature* suggests that adult brains can slowly become rewired to a new environment. Brie Linkenhoker and Eric Knudsen of the Stanford University School of Medicine taught adult owls to adapt to wearing prism glasses with increasing

visual shifts. Gradually, adult owls reorganized their existing knowledge of sound to match their new visual environment.

Neuroscientists previously believed that once the brain region known as the tectum developed during an animal's critical period it lost its plasticity. The tectum coordinates a bird's maps of its auditory and visual senses, allowing it to hunt prey.

Linkenhoker and Knudsen observed larger changes in the adult birds' brains using an incremental approach versus drastically shifting the birds' visual knowledge only once. Older owls' brains, however, are still less flexible than those of younger birds.

DNA Test for Sharks Helps Conservationists

Due to the popularity of noodles made from shark fin cartilage in the United States and around the world, millions of sharks are harvested every year, threatening the existence of several species. However, researchers have developed an innovative genetic test to determine the identity of the fins used for such practices.

Status quo markets encourage the "finning" of over 100 million sharks a year, while conservation agencies are left without a method for determining which species such fins came from. Geneticist Mahmood Shivaji from the Guy Harvey Research Institute in Fort Lauderlade, FL, has pioneered the new method to genetically identify shark fins. Although his team has only created methods for six species of commonly found sharks, they hope to expand their test to include an additional 29 major species.

Because of the long maturation times, limited reproduction rates, and lengthy pregnancy periods, sharks are particularly at risk for irreversible effects from overfishing. By using the new DNA identification method, conservation agencies can begin to understand which sharks are targeted, eventually, using this information to guide enforcement in regions where targeted species are more prevalent.

Fungus Provides Clues to Radioactive Cleanup

Edible mushrooms may provide clues as to how to clean up radioactive waste and fall-out. Researchers say that such mushrooms contain pigments that can grasp and hold radioactive atoms such as caesium-137.

Anne-Marie Albrecht-Gary of the University Louis Pasteur in Strasbourg, France, and colleagues hope that such pigments can be used to coat a paper that "sticks" to radioactive elements that contaminate and pollute the environment. Pigments may also be utilized for radiotherapy: Mushroom-created molecules might carry radioactive isotopes around the body and target specific tissues.

The most promising of the molecule studies is norbadione A; its affinity to radioactive isotopes such as caesium-137 is self-perpetuating. Although optimization and further study on the potential uses of norbadione A are necessary, current research remains hopeful.

A New Addition to the Human Fossil Record

Paleontologists have located the skull of what might be the oldest member of the human family. Michel Brunett located the 6- to 7-million-year-old skull in the Saharan Desert of northern Chad. He named it Toumai.

Toumai had raised questions over the most fundamental assumptions of chimpanzee and human evolutionary divergence. Although brain size is limited to that of a chimp, *Sahelanthropus tchadensis* (Toumai's scientific name) has thick tooth enamel, small canines, and shows evidence in the back of the skull as having walked upright.

Later fossils do not show the advanced features seen in Toumai, features that reappear in even later fossils. Some hypothesize that Toumai was a hominid, while others argue that the skull was likely part of a species that would be considered neither human nor chimpanzee. Still others posit that the fossils showing discrepancies with the evolutionary development prescribed by Toumai may be misplaced. Despite this disagreement, Toumai is solid evidence of ancient hominids' existence in Africa.

Epstein-Barr Virus Research Ends its Dormancy

Epstein-Barr Virus (EBV) is commonly written off as the "kissing disease," whose worst-case effects are mononucleosis. However, current research is drawing attention to this disease, which may be linked to several more complex and destructive illnesses. Both Burkitt's lymphoma, a B cell cancer,

and nasopharyngeal carcinoma, a tumor usually occurring at the back of the throat, may be linked to EBV.

Research on EBV suggests that the virus exists in two main types of cells — epithelial cells and B cells. After infecting epithelial cells which line the throat and replicating, the virus infects B cells and spreads throughout the body. The virus can lie dormant within these cells for years, during which time it transmits itself through the saliva of the host.

Recent evidence indicates that EBV resides in memory B cells and that it may even manipulate a naïve B cell's DNA to convert it into a memory B cell. By inserting DNA for the LMP1 and LMP2 proteins into the host and releasing those proteins as signals to the body, EBV protects the cells from destruction and from suicide. Once it is no longer dormant, the virus uses the B cell to replicate, leading to the harmful effects.

The question of how the virus replicates and transmits its DNA has also been investigated. For the time being, it is hypothesized that EBV inserts its own loop of DNA into the nucleus, which is replicated during the cell division process. As more is understood about the virus' mechanism of action, pharmacotherapy may become a more realistic development.

New Drug Kills Only Cancer Cells

Researchers in Germany have found a new drug that selectively kills cancer cells in mice.

While it is unknown whether the drug works in humans, the drug is a first step toward a human cancer drug that would leave healthy cells unharmed, and thus eliminate severe side effects, such as a depressed immune system, that normally accompany chemotherapy.

Chemist Lutz Tietze and colleagues at the University of Gottingen in Germany implanted human tumors in mice, then gave the mice an enzyme that stuck only to human tumor cells and ignored healthy mice cells. The new drug that was then administered was harmless until it encountered the enzyme that had stuck to cancerous cells. Once activated, the drug proceeded to destroy the tumor cells. According to the researchers, the tumors shrank without causing any visible side effects in the mice.

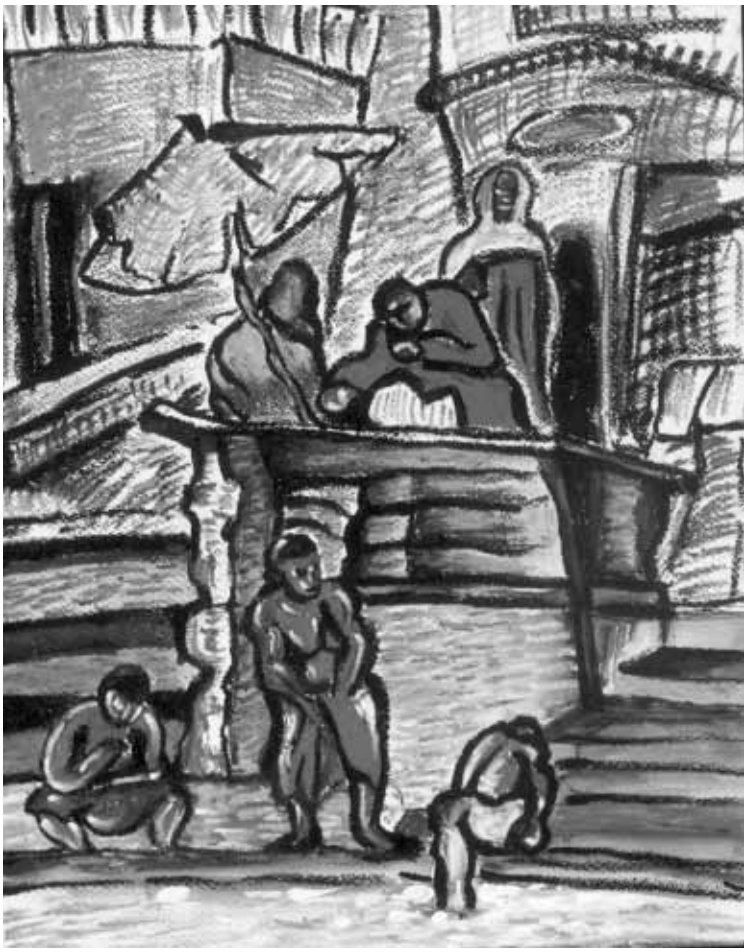
To produce a drug that did not detonate in healthy cells as well as cancerous cells, the Gottingen researchers designed a prodrug, an inactive precursor of the drug that would be activated in the body by an enzyme. The prodrug contained a sugar safety-catch; once the sugar was clipped off by the enzyme, the molecule rearranged into a three-atom carbon ring, which was highly strained and likely to burst open. Once open, it was a reactive molecule that destroyed nucleic acid molecules necessary for normal cell function.

The enzyme that cut away the sugar safety-catch used an antibody to specifically attach to tumors. The researchers think that the same principle could be used in humans. However, although the pharmaceutical use of antibodies linked to toxic molecules has long been explored, no clinical use has yet been found. The effectiveness of such a drug would depend on the ability of the antibody to attach to the correct cells and the absence of enzymes in the body that could also activate the prodrug.

Saving the Earth:
Dealing with Global Warming

Aadel Chaudhuri

Envision a future full of erratic storms, frequent floods, and wars over food and fresh water. Although such a scenario seems extreme, it is a possibility if mankind continues to abuse the delicate environment. Historically, many human societies have mistakenly considered the earth to be a limitless resource here solely for their convenience. This selfishness has led humans to often blatantly disregard the well-being of other organisms with which we share this planet as well as that of future generations who will inherit it.



The situation, however, is not hopeless. Major environmental damage has only been occurring for the last 150 years or so; thus efforts at improving our attitudes and treatment of the environment could reverse much of it. Additionally, governments and people everywhere have become more environmentally aware over the last 25 years and have become more willing to reconcile the situation.

Still, the task of restoring the environment is daunting. Environmentalists and politicians have had to clearly define their goals; not doing so in the past made it difficult to achieve any observable progress. The world's objective, as it was recently discussed at the World Summit on Sustainable Development in Johannesburg, was stated clearly by Mark Malloch Brown, administrator of the United Nations Development Program (UNDP): "The key now is to put people first and the environment second, but also remember that when you exhaust resources, you destroy people."[1] Bearing this in mind, summiteers discussed a number of current environmental issues including global warming and the underlying energy problems that are leading to it. The following explores possible technological solutions to this specific issue.

Global Warming — The Problem

The major problem of global warming is characterized by worldwide climate change beyond normal levels, thus eventually melting ice caps and changing weather patterns. The long-term implications of global warming are enormous: If it continues at its current rate, earth's average temperature will rise between 4 and 9 degrees Fahrenheit. Already, global warming has decreased the Arctic Sea ice thickness from an average of 9.8 feet (3 meters) between 1958 and 1976 to 5.6 feet (1.7 meters) between 1993 and 1997.[2] The melting of the ice caps could eventually (within the next 100 years) lead to major flooding of coastal areas such as New York City and Los Angeles. Other possible adverse effects include the extinction of entire ecosystems that are not accustomed to the new climate and a resulting "ice age effect." Although the consequences are dire, there are a number of things we can do to combat the problem.

Mechanism of Global Warming

Global warming stems from high levels of greenhouse gases in the atmosphere, primarily carbon dioxide, which is responsible for about half of the rise in worldwide temperatures in recent years. Warming occurs when greenhouse gases absorb infrared heat reflected by the earth and keep it trapped within the atmosphere. Normally, radiation from the sun hitting the earth is reflected back in the form of light and heat, and some of that heat is naturally trapped by greenhouse gases; however, the percentage of such gases is low, so a major increase in concentration can easily disrupt the reflection-absorbance balance.[3] 1.83 billion tons of carbon dioxide was emitted in the United States in 2000, up 400 million tons from 1980. The level of greenhouse gases far exceeds normal amounts, causing the temperature to also increase slowly but steadily (1.3 degrees Fahrenheit since 1900).[2]

Sources of Greenhouse Gases

Carbon dioxide is produced readily in every developed and developing country. Automobile admissions and industry produce enormous amounts each year. Plants absorb carbon dioxide and use it in their metabolism. However, such high amounts as are emitted by the world overwhelm these natural diffusive mechanisms. Additionally, deforestation, another environmental issue, only compounds the problem.

Renewable Energy

Our reliance on fossil fuels (such as oil), the burning of which yield carbon dioxide, is the reason behind global warming. Tackling global warming requires first finding methods to curtail the use of fossil fuels, and then finding inexpensive, nonpolluting, and renewable replacement sources.

Reducing Emissions

Many countries have been requiring greenhouse gas emission standards since the 1970s. Power plants in industrialized countries are required to have scrubbers that limit the output of carbon dioxide and sulfur dioxide (a smog and acid rain culprit). Cars in most industrialized but not many developing countries are required to have emissions tests.

Alternative Energy Sources

The ultimate solution to global warming (and air pollution) lies in non–fossil fuels, as such fuels produce no greenhouse gases and are for the most part environmentally safe. Forms of alternative energy include nuclear, wind, hydroelectric, geothermal, hydrogen fuel cells, and solar. These forms are renewable and clean, but often difficult to harness.

Nuclear Energy

Nuclear energy is the most controversial of the listed sources of alternative energy, but also has the greatest energy potential, carrying more energy per ounce than conventional fossil fuels. Although harmless if functional, power plants risk meltdowns such as those in Chernobyl and Three Mile Island, which pose very serious health hazards to people in the surrounding area. Thus many countries such as Germany consider nuclear energy to be unsafe and are unwilling to harness it. In the United States, however, 20 percent of all energy is produced by nuclear power.[4]

Wind and Solar Energy

The other forms of renewable energy, while

tougher to implement because they are less established, hold the key to our future: They are truly renewable, environmentally safe, and carry no health hazards. Wind energy is the fastest growing and most common of these. Experts say that in two decades wind could provide up to 12 percent of the earth's electricity. A decade ago, Denmark required utilities to purchase any available renewable energy at a premium price. Today, 18 percent of its energy is provided by wind. The European Union, led by Germany and Spain, accounts for 70 percent of today's wind energy.[5]

A major challenge faced by environmentalists and proponents of renewable energies is integration with the current system. Many governments subsidize fossil fuel plants, and thus give them an advantage over other energy sources. Other countries, however, such as Germany, have reversed this trend by offering major cost incentives to renewable energy plants. As a result, Germany is the leading generator of alternative power. Wind and solar energy are used there extensively.[5]

Geothermal Energy and Hydrogen Fuel Cells

Iceland is another major center for renewable energies, thanks to the extensive geothermal activity there. Geothermal energy accounts for 90 percent of the energy consumption. This clean form of energy harnesses the heat deep in Iceland's volatile crust. The country plans to use geothermal and hydroelectric power to produce hydrogen in the near future for use in fuel cells.[5] Hydrogen fuel cells utilize the energy released from the reaction of pure hydrogen with oxygen to produce water. Thus, their only by-product is pure (drinkable) water. A number of automobile prototypes have been designed to be powered by fuel cells. Some experts suspect that portable hydrogen fuel cells, due to their compact size but high energy potential, may replace power plants altogether. Currently, scientists are excited by the prospects of storing extra energy (solar, wind, geothermal, etc.) in fuel cells for later use.[5] Therefore, energy would be available during low wind or cloudy days, for example.

Conclusion

Although global warming is a grave environmental issue, the vigilance of environmental groups, scientists, and governments will most likely lead to a revolution akin to the Industrial Revolution of the nineteenth century. This energy revolution will lead to the replacement of fossil fuels, an artifact of the Industrial Revolution, with clean, environmentally friendly, and renewable fuels. Recent history shows that the price of this new technology is sometimes cheaper than the old technology. Oil prices are generally very high, and the scrubbers required in power plants are expensive. Thus, some private groups and governments are currently trying to exploit the economic advantages of using renewable sources of energy.[5] As the technology improves, these economic advantages will become more substantial.

Nonetheless, the current environmental issue is grave enough so that steps must be taken now. There are simply some things such as nature and life, both of which are intricately connected to the global warming issue, that should not be left to exploitation.

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The Role of Online News in Mass Media

Izzat Jarudi

Is the spread of Internet use helping to "democratize" mass media and the world in general? Like any technological development, whether or not the relatively new medium of the Internet ultimately contributes to human progress depends on how we use it. In that sense, it is no different from radio and television. As one media historian put it: "The age of 'radio' was not only the age of Roosevelt and Churchill but that of Hitler, Mussolini and Stalin."[1] Similarly, today television delivers to the living rooms of so many American households a lopsided mix of shows like *American Idol* and *The NewsHour* with Jim Lehrer.

Nevertheless, the nature of Internet technology gives online news the *potential* to be more progressive than other media. Now, almost 10 years after its development, we can begin to answer whether that potential is being realized. The Internet gives individuals greater access to information and more power to receive and deliver news. There are almost 5,000 daily newspapers available online from around the globe that any one of the over 350 million people with access to a modem can read.[2] Most of these newspapers, especially in the United States, are free of charge to view.

Moreover, the Internet eliminates the need for middlemen, and with them, any filters through which traditional media passes its primary sources. For example, the articles of wire services like The Associated Press and Reuters — which were recently only available to newsrooms, universities, and libraries — are now readily viewable at any time through their Web sites.[3] The low physical costs of the manufacturing and distribution of online news translate into low barriers for entry into the industry.[4] Instead of printing presses and delivery trucks, all a person needs to push the number of dailies past 5,000 is some time and Microsoft Front Page. Of course, these aspects of the Internet also create potential problems such as the questionable credibility of some online news sources. Because some online publishers have invested so little into their product, they do not have much to lose by trading off expediency for accuracy. On the whole, however, Internet users have quickly learned to recognize such dubious sites, and more and more people are using the medium's unique advantages to take control of the news they gather, whether for themselves or for others.

The Internet's Unique Advantages

The Internet combines all of the defining features and attractions of the three traditional media—the audio of radio, the images and text of newspapers and magazines, and the animations, simulations, and video of television—all connected and accessible through the enormous network of sites and hyperlinks that constitute the World Wide Web. But the Internet is more interactive

than television, its biggest competitor, because users are not passive consumers of the richness of its multimedia. The medium demands that they do more than change the channel or Web site by choosing how and when they experiences the news. This audience control over presentation gives online reporting a "nonlinear" quality.[2] Instead of having to sit through the sequence of sensationalistic drivel of local news broadcasts until the weather portion toward the end of the half-hour, you can simply go to weather.com, type in your zip code, and check the five-day forecast. This does not mean that traditional media will become obsolete. People will still turn on the car radio during their morning and afternoon commutes. Just like the advent of television did not bankrupt the radio industry, the Internet will not replace but rather supplement the other ways people get their news.

This supplementary role that online news plays is best exemplified by the standard way today's journalists punctuate their "in-depth" reports in traditional media: "For more on [topic of report], visit our web site at www…." With its unlimited space and time for presentation, the Internet has become an interactive, on-demand, and vast news library. For example, the *Mercury Center*, the web site for the San Jose *Mercury News*, enhanced its 1999 coverage of the Microsoft antitrust trial online by designing an interactive virtual courtroom, an electronic version of courtroom no. 2 in the United States District Court for the District of Columbia. Among other features, users could tour the virtual courtroom, receive an introduction to the U.S. federal court system, read a professional biography of Federal District Judge Thomas Penfield Jackson, and view the evidence in the trial against Microsoft.[2] Providing such depth and context for a story is exceptional in a newspaper or magazine but commonplace on quality online news sites, which go beyond simply reproducing the content of their traditional media counterparts for more efficient transmission. Other illustrations of the Internet's unique advantages include the MSNBC.com Web site for a 1997 *Dateline* report on dangerous roads in America. The television program naturally focused on a few dramatically threatening roads but still encouraged viewers to check out their own community streets through a fast online search of federal data — just type in your zip code to find out how many fatal accidents had occurred in your area between 1992 and 1995. In less than half a day, that particular feature received nearly 70,000 hits.[2]

Online News Users

Being relatively young, I find it natural to use the Web for many things, including getting news, even though the Web itself is barely 10 years old. For younger people, life must seem unimaginable without it. On the other hand, some members of older generations, who understandably have not adjusted to the technology as quickly, see Internet use (and computer use in general) as harmful and antisocial. They point to it as a source of civic apathy among many young Americans today, who appear uncaring about what is happening in the nation or the world in general. At the same time, others across generations view the technology of the Internet as an indisputable blessing to the world for its facilitating the realization of a "global village."

So is the Internet good or bad for society? The answer is not as simple as either side of the debate might lead you to think. It is true that some young people spend too much time on their computers and sacrifice developing richer social relationships with members of their own community and learning about the world outside their town or city. And yet, if you stop to compare this to other laudable pursuits, excessive reading is no less antisocial. Furthermore, more young people are turning to the Internet *for news* rather than to traditional media. From 1996 to 2000, the fraction of Americans in their 20s and 30s who regularly used online news sources increased from 10 to 25 percent.[2] More recent studies have shown a slight shift upward in the demographic base for online news to people in their 30s, but clearly the audience is still dominated by younger Americans.[5]

A Global Village

Although the Internet brings people together, it is not always for the better. For example, it has helped racists find and recruit other racists by giving them a forum for presenting and spreading their hate online. While a public domain for the masses always risks being used for wrongdoing, the Web seems to have had more of a positive effect by promoting the growth of good communities for people with similar interests and concerns, particularly when it comes to their objections to the state of the mainstream media today.

According to a 2001 report by the Annenberg Public Policy Center at the University of Pennsylvania, only 13 percent of top executives of media, telecommunications, and e-companies are female.[6] As a result, Internet news services like Women's Enews have have been launched to focus on stories particularly relevant to women, which are often neglected by a media increasingly dominated by corporate news outlets run by men. At the same time, Women's Enews tries to influence the media from the bottom up by making its reports available to them for free and listing female experts on more than 150 topics as a resource for their journalists.[6]

Similar alternative press sources exist online for political interest groups on the Left and the Right, such as AlterNet.org, TomPaine.com, NewsMax.com, and WorldNetDaily.com.[7] Particularly popular among conservatives are sites that attack the alleged liberal bias of the media. Former president of the *Harvard Crimson*, Ira Stoll has created a site called SmarterTimes.com that is devoted to criticizing the *New York Times* for what he often considers to be slanted news articles.[8] On the other hand, the news sites of nationally known conservative papers like the *New York Post* and *Washington Times* have attracted more readers to their online versions.[5]

In this particular case, the Internet seems only to be limiting people's exposure to alternative perspectives by providing them with news that is not necessarily objective yet conforms to their ideology. (The problem of selective reading will be addressed later in this essay.) There is additional evidence, however, that suggests the Internet really is inching us closer to something resembling a "global village." Access to international newspapers online has exposed some Americans to multiple perspectives on current events outside the United States that are often not covered in the same depth or at all in the mainstream American media. The desired information, analysis, and commentary can range from less serious topics like European soccer (unless you are a true fan) to the most serious like the Palestinian-Israeli conflict. Internet users have also been able to tap into the news of communities that are not their own. For example, Good

Morning Silicon Valley, a special section of the local online news site Mercury Center based in San Jose, covers the valley's high-tech industry but attracts 70 percent of its visitors from areas outside Silicon Valley.[2]

The Internet and Democracy

Aside from the state of online journalism today in America or from an American perspective, what about the rest of the world? The sad fact is that dwarfing the millions of Internet users in the United States are billions of people in the developing world on the other side of the "digital divide" who do not even have access to a computer. Obviously, their poverty undermines the feasibility of a true global village for years, if not decades to come. Nevertheless, we can still compare ourselves to other large and relatively prosperous countries like Russia to see if their growing Internet use might have a similar positive impact, particularly in terms of supporting democracy.

Only 7 percent of the Russian population use the Internet compared to 60 percent in the United States and 39 percent in Europe.[9] This clearly limits the extent to which the new medium affects the average Russian. Given President Putin's recent war on the private press that has claimed the voice of major independent television stations like TV-6 and the Internet's rapidly expanding audience, it may have an increasingly important role to play in sustaining freedom of the press in the country. Meanwhile, the Kremlin is doing its best to undermine this potential source of government opposition by seeking greater access to Internet communication like e-mail for the FSB, Russia's security service, and even recently sponsoring a privately

owned, proadministration news site called Strana.ru.[10] Unfortunately, Strana.ru's semipropaganda has been reasonably successful: The site is visited significantly less than other private online news sites but is vastly more popular than the official government site, Gov.ru.[9]

Correcting the Media

The media in the United States is not under attack from the government as in Russia, but it is not immune to criticism, particularly from members of its audience. After lawyers, journalists are perhaps the most detested professionals in America, because it seems so many of them favor sensationalism over substance in their stories. But until recently, those with complaints about inaccurate or biased reporting could only try to end the industry's lurid streak by resorting to questionably effective tactics like writing a letter to the editor or ombudsman. The Internet has helped to change all that by allowing individuals to spread their objections more easily and cheaply to certain traditional media coverage. The amount of media criticism on the Web recently motivated the creation of a gateway site called Mediachannel.org with links to the vast majority of that commentary.[8] Often, this online forum is ignored by corporate news outlets, but sometimes a well-organized online campaign against an inaccurate story can succeed in correcting the media. In 1998, a group of outraged veterans with little funds relied on the Internet to publicly protest what they showed to be a blatantly false CNN report about American Green Berets nerve-gassing traitors in Laos in 1970. Directed by its parent company Time Warner, CNN eventually retracted the story and fired some of the producers of the program.[8]

Selective Exposure

Online news itself has been far from immune to criticism. In particular, detractors—usually traditional journalists—have claimed that the personalized filter that users develop in getting their news from the Internet is not much better for society than any filter that is imposed on the content of mass media.[11] If a user only confirms his own bias when he sees his preferred version of the news online, is he really more informed as a citizen? The problem with this argument is that it already happens with traditional media—every time you pick up a newspaper or magazine or even when you watch a television news show. You probably do not approach them "objectively," making sure that you play the role of an informed citizen by paying attention to all of their content and commentary. You look for the stories that interest you and ignore the rest because you do not have the time or inclination. Sometimes a report will catch your eye that normally would not, but this could also happen on the Internet. There are very few people in the world savvy enough to restrict their exposure to the news only to content that conforms to their ideology.

Moreover, the selective-exposure argument misses the point that online news is not replacing but rather supplementing other sources of news for the vast majority of its users. These people will still read the headlines on the front page of their daily or watch the eleven o'clock news every night. In contrast, most still only go online for news once a week. Even among the young, only 17 to 18 percent of those under the age of 49 check sites daily.[5] Ultimately, the Internet has the potential to engage more people by allowing them to adapt the news they get to their needs so that they do not give up on the mainstream media altogether.

Credibility

A more powerful argument that critics lob at online news sites focuses on their credibility. It is so much quicker, easier, and cheaper to publish a story on the Web that in the race to be the first to break the story online, many journalists, with little to lose by way of reputation, have loosened their requirements for verification and reliable sources. The classic example is an erroneous report by the online edition of the *Dallas Morning News* during the 1998 Clinton-Lewinsky scandal that a secret service agent had seen Monica Lewinsky and President Clinton alone together. In response, ABC quickly broadcast the story to millions of people before the news site retracted it later that day.[4]

Nevertheless, such sloppy reporting is unusual on the more prestigious online new sites. The online edition of the *San Jose Mercury News* once erred in presenting a series called "Dark Alliance" by Gary Webb about his discredited investigative report linking the CIA to the cocaine epidemic in the United States;[2] however, this was the same site that created the virtual courtroom for the Microsoft trial and that has made numerous other positive contributions to online journal-

ism. The Internet is a breeding ground for rumor and conspiracy theories that only rarely infect reputable news sites.

Users are usually smart enough to separate the sensationalism from the substance. Gossip sites like the Drudge Report are popular, but most people accept that they are as accurate as supermarket tabloids.[12] The evidence for this user intelligence lies in the unparalleled success of large and well-known news sites like CNN.com and MSNBC.com. A recent study by the Online News Association found that users felt such sites were as reliable as traditional media. For example, more than 78 percent of those polled called cable–television operated Web sites credible compared to 82 percent for cable news.[11] These major sites' superior credibility and resources, particularly when it comes to their coverage of national and international events, have made them by far the most popular sources for online news in general.[7] Uusers seem to be coping quite well with the credibility problem by turning to recognizable and trusted brands for the bulk of their news online while looking to smaller international or local sites for alternative perspectives or coverage on issues that tend to be neglected in the mainstream media.

September 11: A Case in Point

The use of online news sites in the aftermath of the September 11 terrorist attacks illustrates the important role they have come to play in the way Americans get their news. On the day of September 11, major news sites were flooded with visitors, some receiving over ten times the usual number of page views: CNN.com had 162.4 million hits in 24 hours compared to its average 14 million. In the 48 hours after the attacks, the percentage of Internet users who visited news sites increased from 22 to 33 percent.[3] In the month after, the fraction further rose to more than half, the highest ever in the Internet's history. Throughout that month, the most visited sites were major national ones like CNN.com with percentage changes in hits for the top five ranging from 66 percent (MSNBC.com) to 315 percent (Time.com).[13] A few months later, traffic to these sites was still at a level two to three times as high as it was before September 11.[7]

Beyond the statistics, people seemed to have used the Internet for what traditional media could not adequately supply. Some people relied on it as a source for breaking news, particularly when they did not have access to television;[14] however, according to the Pew Internet and American Life Project, only 3 percent of users polled considered the Internet to be their primary news source soon after the attacks compared to 81 percent for television.[3] Yet nearly a third of them said it was still helpful in providing information about the attacks.[15]

It follows that online news served mostly as a supplement to traditional media, more like a resource than a source. People turned to the Internet for on-demand lists—lists of passengers, companies, closures, donation centers, community events, and of course, of people missing or dead.[16] In addition, major news sites like MSNBC.com served millions of video feeds in the days following the attacks.[17] The Internet also provided direct access to the world's reaction to the events. Through online versions of international newspapers, Americans could read about the different perspectives of people everywhere from Europe to the Middle East.[17]

The Future of Online News

The coverage of the September 11 attacks was obviously a defining moment in the history of online journalism; however, it has only been one among several turning points for the industry in the past five years. Other events of national significance like the release of the Starr Report during the Clinton-Lewinsky scandal in 1998 and the voting problems during the presidential election of 2000 have led to a peak in Internet use during the crisis, followed by an overall higher plateau of traffic to the news sites.[7] This trend of audience growth and response clearly suggests that online news has a secure future as a legitimate and important new part of mainstream media in America and other parts of the world with growing Internet access. After Internet users recognize the unlimited resources of the medium, few decide not to take advantage of that information to enrich their understanding of the news.

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Women and Their Impact on Global Population

Martin Kurtev

"A passing century is sometimes remembered in terms of a single event of lasting importance. For ours — the 20th — that singular happening may well be the sudden and unprecedented expansion of the world's population."[1]

—Carl Haub, a demographer and director of information and education at the Population Resource Bureau, Washington, D.C.

The words of Carl Haub seem greatly justified considering the impact that population growth has had on the past century and the impact that it will have on the current one. The world population numbers are truly astounding. In the year 1900 the earth was home to 1.6 billion people. The total had grown by 600 million in the 100 years since 1800, the year the first billion was reached; but the change in the 19th century gave no hint of things to come. By the middle of the 20th century another billion had been added in only 50 years. Moreover, 80 percent of the growth had taken place in the world's poorer or developing nations. In 1995, but 45 years later, world population had risen by an additional 3 billion, with most of the increase, as before, in Asia, Africa, and Latin America. In October 1999, world population hit 6 billion, an increase of a billion people in just 12 years.[2]

Population: We know it is a problem. In fact, most of the problems facing individuals, families, communities, and nations are affected by the quantity of humans sharing the planet. So what can we do to solve the problem? In 1994 more than 180 nations from all parts of the globe gathered in Cairo for the International Conference on Population and Development (ICPD) and signed the Program of Action.[3] The goal of the conference was to move women's health beyond the narrow focus on population control and reproductive health and instead empower women of the world to take control of all spheres of their lives —

academically, economically, socially, and politically. Cairo challenged the world to live up to the affirmation that women's rights are human rights. Cairo supported the view that a woman's value exists far beyond her reproductive organs, that her fate does not exist in a vacuum. In July 1999, the United Nations General Assembly's ICPD+5 review of the Cairo conference reaffirmed that better education for women, accessibility to contraceptives and improved healthcare, and elimination of social and cultural abuses are all ways to limit world population and save the planet.[2]

In order to determine whether the new programs implemented have any affect on limiting population growth, there needs to be a measurable feature to provide feedback on their effectiveness. One key measure of a country's population growth is the total fertility rate (TFR), defined as the average number of children women will bear in their lifetime, based on current age-specific rates for a give country or region. In matters of population, the TFR is the key to the future. Today, women in developing countries bear an average of about 3.6 children, or 4.2 when numbers for the much-lower fertility of giant China (with over a billion people and more than 21 percent of the world's population) are removed. Either figure is well down from the 6.1 of the early 1950s. This change, however, does not remove concerns about a population explosion. If the TFR remained constant in all countries at its present level, world population would rise from 6 billion today to 22 billion by 2050 and to 694 billion by 2150. At that point, it would still be growing at over 4 percent per year. This purely illustrative projection ignores the likely possibility of associated calamities such as famine, but it suffices to show the purely mathematical consequences of sustained high fertility.[1] TFR, though a necessary measure, looks at the problem in terms of numbers, and humans are more than just numbers. Otherwise the stories about famine, infant death, and abuse of women would not have the power to touch us.

Better Education for Women

The delegates at the Cairo conference in 1994 recognized that education programs for women — particularly adolescent girls — play a crucial role in slowing down the pace of population growth and improving the quality of life for future generations. Women with a basic education are about half as likely as those with less schooling to begin

Martin Kurtev

a family before age 18, yet in developing countries girls are two-thirds of the 130 million children not attending school.[2] Helping girls stay in school and giving them the opportunity to have employment and legal rights are critical areas for stabilizing population. Inadequate education is a powerful determinant of high fertility and unquestionably ensures that individuals do not live up to their potential.

Today's adolescents are the next generation of parents, workers, and leaders. To fill these roles to the best of their ability, they need the guidance and support of their family and their community, and the attention of a government committed to their development. The U.S. government took the early lead in this direction when the Department of Health and Human Services (DHHS)[4] implemented numerous programs to support women throughout all phases of their lives. The *Girl Power!* program focuses on girls aged 9 to 14 when they begin their often complex and confusing transformation into women. Studies show that girls encounter different social, cultural, physiological, and psychological challenges than boys. For example, the National Longitudinal Study on Adolescent Health reported that 1 in 20 girls has attempted suicide, double the rate for boys, and girls today are 15 times more likely than their mothers to have begun using illegal drugs by age 15. *Girl Power!* is designed to help girls through the critical period of preadolescence by building their self-confidence in academics, sports, art, and other activities and developing their interpersonal and social skills. In addition, they also receive health messages about drug use, sexual activity, nutrition, and mental health.

The National Strategy to Prevent Teen Pregnancy[4] helps young girls with the transition into womanhood. This program promotes education to encourage abstinence, conducts evaluations, and funds pilot projects. Teen pregnancy rates and births have declined in the United States in recent years, but the teen birth rate is still two to seven times higher than that of other industrialized countries. Teenage mothers are only a small portion of the 14 million young women aged 15 to 19 who give birth every year. These pregnancies can interrupt and even stop a woman's education, which can affect her economic independence for the rest of her life. Of women who give birth during high school, 62 percent drop out of school, and they are less likely to go to college as compared to women who delay their pregnancy. These grim statistics speak resoundingly about the need to prevent unwanted pregnancies among teenagers.

The importance of family planning is also emphasized as part of the comprehensive approach to slow down the pace of population growth. The provision of family planning services reduces unintended pregnancies and makes abortions unnecessary. The International Planned Parenthood Federation (IPPF)[5] is the world's largest voluntary family planning organization, working in 134 different countries. Set up in 1952, it is made up of autonomous associations in each country, run by local people for local people, implementing programs of their own making. One of the best-known member associations is Pro Familia in Colombia, which won a special award from the United Nations in 1998. With little direct support from the government, Pro Familia operates 43 family planning centers and, over the course of 23 years, has seen the population growth rate reduced from 3 to 1.7 percent. The key to its success has been the recruitment of local women to run community workshops and to make house-to-house visits, dealing not just with family planning but with health care of all kinds. The main education tool is a health guide with diagrams and a calendar, directed principally at women with small children, to remind them of the dates for vaccinations, dental checkups, and other medical appointments. The instructors and health teams often have to operate in areas ravaged by guerrilla war, drug trafficking, and extreme poverty. In spite of this, the services they offer are wide reaching and highly efficient: Two in every three couples now plan their families responsibly, using contraceptive methods recommended by Pro Familia.

Contraception and Better Health Care for Women

Far too many women in the world are still denied contraception and decent health care as they continue to suffer needlessly from unwanted

pregnancies, unsafe abortions, and ill health. Many countries are working to improve reproductive health services and are training staff to provide better information, wider choices, and client-centered care.

Although contraceptive use has increased, there are still 350 million women in developing countries who do not have access to a range of safe and effective family planning methods. Up to half of the nearly 175 million pregnancies each year are unwanted or ill-timed. Furthermore, there are no trained childbirth specialists present at almost half of all births in developing countries, putting the lives of mothers and babies in jeopardy.

Every minute at least one woman dies from problems related to childbirth and pregnancy. Less than 1 percent of the deaths occur in developed nations. Of the estimated 585,000 women who die each year, the majority could have been saved. One study found that where mothers' death rates were very high, the risk could have been reduced by as much as 80 percent by providing care during pregnancy, information about warning signs, and services to provide emergency obstetric care during childbirth. In addition to deaths, complications arising in pregnancy and childbirth can have long-lasting effects. It is estimated that at least 7 million women suffer serious health problems during pregnancy, and as many as 50 million suffer some health consequences after childbirth each year.

Another significant factor is unsafe abortion, which claims the lives of some 70,000 women annually. The delegates at the International Conference on Population and Development (ICPD) agreed that unsafe abortion should be addressed as a major public health concern. At the United Nations General Assembly's 1999 fifth-year review of the Cairo Conference, governments agreed that where abortion is legal, countries should train and equip health service providers and take other measures to insure that abortion is safe and accessible. Studies and experience show that the best way to reduce levels of abortion is to prevent unwanted pregnancy by making family planning services more accessible. In the Central Asian countries of Kazakhstan, Uzbekistan, and the Kyrgyz Republic, better availability of services and information has increased the use of modern contraception by 30 to 50 percent since 1990, and abortion rates have declined by half.

An area of increasing concern is the need for reproductive health care for refugee women. Around the world, there are more than 22 million people who have been displaced by war or natural disaster, the vast majority of them women and children. It has become increasingly clear that these women need services to protect them from violence, ensure safe pregnancy and delivery, prevent unwanted pregnancies and STDs, and deal with rape and the complications of unsafe abortions. Since 1995, an initiative by the Office of the United Nations High Commissioner and UNFPA has addressed the reproductive health needs of refugee women in Africa's Great Lakes region. The program trains staff and provides equipment and supplies to address needs in family planning, assisted childbirth, complications of unsafe abortions, sexual violence and rape, and prevention of STDs including HIV/AIDS. In April 1999, UNFPA provided reproductive health packages of drugs, supplies, and basic surgical equipment for the hundreds of thousands of refugees fleeing Kosovo to camps in Albania. The fund also undertook an investigation of sexual violence against Kosovar women.[2]

There have been many important advances in reproductive health as a result of the growing strength of women's organizations and their increasing ability to forge alliances with governments as well as other civic groups. Working together, these alliances have been able to secure legislative change and action to improve reproductive health and to begin to change underlying attitudes toward gender issues. Since the Cairo Conference, two-thirds of all countries have introduced policy or legal measures to promote gender equality and the empowerment of women; many have strengthened laws and policies to combat gender-based violence; and many have acted to improve the quality of health services.

Societal Pressures on Women to Bear Children

Through the ages women have been subjected to various social and cultural constraints on their

ability to control their reproductive lives. Issues such as domestic violence, unsafe abortion, unfair employment, unequal pay and land rights, and inequality in law and marriage need to be resolved in order for women to feel like fully empowered members of society with full control over all aspects of their lives.

Although population growth has complex sources in the industrial revolution and in improvements in medical technology, which have reduced the infant mortality rate in underdeveloped countries that traditionally seek large families to compensate for early death and to provide labor-sharing, the ultimate source of the population explosion is gender-based. It is the desire by men to secure their fertility rights over women, to ensure they can control a fertility process in which they are less secure than the female according to the adage: "Momma's baby, Poppa's maybe."

Indeed, reproductive insecurity appears to be at the root of a major social shift, which accompanied the social epoch of urban culture and the rise of patriarchal religious monotheism across the world. This "spermatogenic imperative" is manifest not only in population but also in the exponential growth principle, which drives utopian vistas of endless economic growth. The idea of holding dominion over nature and woman, which are the founding principles of the Judeo-Christina-Islamic belief and aspects of Indian philosophy, can only be corrected by the patriarchal religions coming to terms with their own errors. Some of their principles have been adopted haphazardly by world political leaders in their pursuit of economic growth at the expense of the environment and our natural resources.

The religious leaders of the world have fed mankind with the dangerous myth that humanity is somehow above nature and that it is our God-given right to hold dominion over the earth and subdue it. In many cases they have actively encouraged overpopulation and have gone out of their way to prevent family planning. This conflict of views is illustrated by the criticism of Nafis Sadik, executive director of the United Nations Population Fund, at Pope John Paul's statement that hunger is not linked to overpopulation, saying the world's future food needs would be inextricably linked to demographic changes. The pope has also been widely criticized over his stance on contraception. Considering the significant influence that religious and political leaders have over millions of people, a change in their attitude regarding reproduction would certainly slow down the unbridled population growth in certain parts of the world.[6]

A Success Story

Even though we face many difficulties in trying to slow down the earth's population growth and despite the fact that it will be many years before the many reforms implemented will bring any changes, there have been success stories. Bangladesh is the ninth most populous country in the world and also one of the poorest. In 1990 its birthrate was an unbridled 4.9 children per woman. The rate is now 3.3, a fact that has astonished those who believed that the country's population would drop only after chronic poverty and illiteracy were overcome.

Much of the credit goes to two of the many organizations that help the poor: the Dhaka-based Grameen Bank, with its innovative program of "microcredit" (or small loans), and the Bangladesh Rural Advancement Committee (BRAC), with its nationwide network of village clinics. The work of BRAC and Grameen has made it possible for millions of women and children who once could hope only for survival to begin to dream of progress.

Since its launching in 1976, the Grameen program has loaned more than 2 billion dollars, averaging $180 for each of the 2.1 million destitute women. The reason for the success of loaning money to women is that it benefits the whole family; a recent study found that income controlled by the mother had a benefit to her children's health that was almost 20 times greater than income controlled by the father. When people can start making decisions about their lives, they also start making decisions about the size of their families, and vice versa; family planning within Grameen families is twice as common as the national average. Surveys have also found a strong link between education and family planning.[7]

Bangladesh still has a high death rate of babies

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and mothers. Here females die earlier than males (the opposite of the biological norm), due in part to severe malnutrition and risky pregnancies, often too close together. To help improve health care, BRAC has founded the Shushastho, a community-based fixed-point provider of health facilities located in rural Bangladesh. This has evolved as a result of BRAC's commitment to ensure comprehensive health care services to rural people, especially women, children, and the poor. The goal of the Shushastho initiative is to improve the health status of rural people through delivery of need-based essential services from a sustainable model of static health facilities.[8]

The Crucial Role of Women

The status of women is crucial to solving the population problem. Women's bodies are the gateway to each new birth. It is essential that the women of the world be given the ethical freedom to make basic decisions about their own fertility. Improving the status of women worldwide by providing them with better education and readily available, quality health care and contraception will allow them to plan their pregnancies better and have fewer but healthier children. Overcoming societal and cultural pressures on women to bear more children is another way of giving them the control over their life that they deserve. The future rests heavily on the welfare of adolescent women — on how well they fulfill their roles as mothers, as contributors to the economy, as teachers of the next generation, and as sources of strength for their communities and nations. As they work toward claiming their full and legitimate place in the world, young women face hardship and challenge. But the challenge for communities and nations — to give young women the helping hand they need and deserve — is even greater.

Production and Reproduction; Architecture and Music

David Foxe

"The task of architectural education is somewhat similar to preparing for a career in musical composition for one who does not play a musical instrument…."

—N. Michael McKinnell, "Notes from the Profession," *Thresholds* **12**[1]

Architecture and music share a perilous heritage of each being compared to the other, with varying degrees of literalism. Architects supposedly orchestrate tectonics, while musicians show structure, line, and space. As a student of both architectural design and music composition, I am often confronted with reevaluating the extent to which they share similarities, so I may remain focused artistically and because their combinations of creativity and technicality invite the comparison. I believe it is dangerous to delineate equivalencies between art forms, to say that a piece of music is *about* a piece of art or architecture. Similarly, Goethe's idea relating architecture to "frozen music" seems to do a disservice to both disciplines; taken literally, architecture can often be quite flowing and dynamic, while music doesn't always feel thawed through. Analyses such as those in *Pamphlet Architecture* 16 that search for *translations* between architecture and music are fascinating but ultimately as unrewarding as transliterated poetry that lacks an original synthesis of syntax, meter, and connotation.[2]

This quest for equivalency or translation between architecture and music even populates student works, particularly theses. For example, Chih-Jen Yeh's MIT M.Arch. Thesis, printed in *Thresholds* 12, states that "architecture and music share the same vocabularies: rhythm, proportion, harmony, repetition, contrast, etc."[3] Searching for such "parallels" between architecture and music shows that it is the descriptive, semantic language that is shared rather than any actual content.

Instead of analyzing the final product or the disciplines in the abstract, it is far more meaningful to discuss the creative and educational processes involved in the reproduction and production of music composition and architectural design. Both help create documents to instruct in the production of a reproducible entity (scores, construction documents) rather than create the actual entity. Furthermore, the actual music or architecture will come into being by a further process of reproduction, rarely with more than a supervising role by the composer or architect. In my own experience, each can be modeled as a *design* process, where one places designed elements in a context of time (music) or space (architecture).

It is not a novel notion for architectural education to focus on design (rather than on exclusively technical skills), but musical education is rarely treated as a design process. This descriptive discrepancy may at first appear to be one of semiotics, but it gives a glimpse of how the education processes of architecture and music have different adaptations of production and reproduction.

Throughout history, both architecture and music have occurred without its creators being formally schooled, and the disciplines were once taught primarily through individual tutorship and apprenticeship. The foundation of studying with an established master is to reproduce the masterworks and develop a facility in that manner. Change and development thus occur either through gradual development or punctuated moments of genius. Even Mozart and Bach, however prodigious their talents, had elder family members who facilitated an environment rife with the musical language of their time. These incredibly original creators frequently took up active study and transcription of their predecessors' masterworks, painstakingly reproducing them for new instrumentations or settings so that they might internalize some of the musical devices.

Just as many musical geniuses have learned primarily through self-directed study, Charles Correa is particularly insightful in asserting that "we do not know if architecture can be taught, but we know it can be learned."[4] He extends this by detailing the educational relationship of the student to a teacher as "guru," for whose wisdom the student has an unquestioning trust.[5] Correa applies this guru model both in formal learning situations, in which the student and teacher meet in person, and to Bach, who learned through self-study. Architecture was treated as a building trade one learned through apprenticeship in professional practice and experience. Prior to MIT founding the first school of architecture in the United States (1865), American-born architects who did not study abroad were necessarily self-taught; Thomas Jefferson is a prime example. As architectural education was brought into the formal academic realm, combined with its apprenticeship heritage, Correa describes how the educational environment (from the Beaux-Arts to the present) is periodically inhabited by gurulike instructors.

Because universities and conservatories have codified curricula and largely institutionalized the education process, the disciplines of architecture and music have changed drastically. In music, select examples from the Renaissance polyphony of Palestrina to the classical-era forms of Haydn and Mozart became a sequence of compositional exercises. Students often learn through individually created but highly structured assignments, taught in groups by a professor/composer. The chorales of Bach and the minuets of Mozart are among those studied and emulated for their structure and content. Building on the tradition of Rameau's treatises on theory and harmony, later textbooks for harmony and counterpoint presented a highly clarified, systematic approach to analyzation. The works to be analyzed, however, were not created in this manner; Mozart wasn't following a textbook but rather the accepted conventions of his time. Each student in such classical models creates his own solution, subject to myriad rules, and gradually develops fluency of creation.

Just as conservatory education codified the reproduction of classical harmony, the foundation of a Beaux-Arts education in architecture was that of faithful reproduction, both of the human form and of principled classicism. Like many universities, MIT houses archived collections of student work from 100-plus years ago, including the visually stunning perspective renderings of existing and proposed classical and neoclassical buildings. Even the prefix *neo-* implies the built-in heritage ascribed to such new

adaptations of classical languages. Whether relating to works of Alberti, Wren, or Calatrava, the classical models of proportion and the study of human form are a leitmotif of architectural study. Such education returns each student to a reevaluation of first principles and design strategies disembodied from specific applications, reproducing the basic in order to step beyond and hopefully produce a supposed original.

As a contrasting example, the first experiences with architectural design in MIT's undergraduate studio program emphatically emphasize production over reproduction. A variety of historical precedents, structural languages, and context tidbits are presented, but "first principles" of structure and organization are worked into a more experiment-oriented, model-focused introductory studio. With guidance and wide-ranging examples from Katsura to LeCorbusier to Wright to MDRDV, students "produce" column grids and manage load-bearing, sculptural concrete forms with relation to light wood construction. Just as it would be foolish to assess Beaux-Arts student works from MIT in the 1890s as completely original products, studio works from the 1990s are linked inextricably to the heritage of modernism and organic design that are presented as frameworks for their creative process. Are the best results of both educational processes highly creative? Absolutely, but Mies may be right: Architecture is not reinvented every day.

Meanwhile, music pedagogy at MIT and many other institutions with highly respected composition faculty has retained several strong elements of classical reproduction in contemporary education. Even after a century in which many of the rules of classical harmony have been routinely shattered, the traditional forms and models for harmony are still taught precisely so that students know how to break them. Whereas architecture studios now begin with essentially twentieth-century principles, music from the same period is reserved for advanced study. Experimental trends in extended harmony, aleatoric and improvisatory techniques, and minimalist repetition that are commonplace in contemporary composition are treated as a realm only reached after mastery of the accepted conventions of the nineteenth century. Even professors like John Harbison, whose Pulitzer Prize–winning composition work has its own rigorous and highly personal style, teach tonal harmony within historical rules and models so that students can learn techniques to apply to their own style.

These generalized trends in music and architecture are certainly not without exception. Dissent about education has a long history, often centered around young emerging radicals protesting the banality of work emerging from institutions. Beginning with Wright's oft-exaggerated legend about abandoning his studies, architects in the heyday of twentieth-century architecture espoused ideas intended to shatter traditional academia and its self-reproduction. Their alternative: original forms of (often guru-centered) education for new types of production. These came full circle as Bauhaus leaders like Mies and Gropius became heads of American architecture schools, and Taliesin recently became a nationally accredited program.

Similar cycles have occurred in twentieth-century music as emerging musical languages lost their ability to incite riots (such as Stravinsky's *Rite of Spring* in 1913) and became staples of most advanced composition studies. However, the underlying motivations for dissent differ. French Impressionist composer Claude Debussy criticized the conservatory education process for its uniformity. In the first issue of the journal *Musica* in 1902, he writes:

The best thing one could wish for French music would be to see the study of harmony abolished as it is practiced in the conservatories. It is the most ridiculous way of arranging notes. Furthermore, it has the severe disadvantage of standardizing composition to such a degree that every composer, except for a few, harmonizes in the same way. We can be sure the old Bach, the essence of all music, scorned harmonic formulae.[6]

The example of Bach is crucial because his concise, aphoristic chorales and keyboard inventions are primary formal examples imitated during introductory composition courses, yet the complexity and surprising turns in many Bach examples defy explanation in an introductory academic setting. Whether in Bach and Britten or in Aalto and Moneo, the most brilliant solutions are remarkably often those that create a clear and focused logic for structure and content, and then are bold enough to break that logic for a specific requirement or moment of uniqueness. Debussy's assertion is thus critical, but not in the

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sense of a creator of the "modern" objecting to the "historic" tradition: Studying past examples and writing music that uses the logic of a precedent as a point of departure is highly valuable. About the same time he wrote the *Musica*, Debussy composed his *Pour le Piano* suite. It makes extensive allusions to Baroque forms and techniques, but with new harmonic and phrasing twists and turns. The practice Debussy warns against is to narrowly use examples from the past as a pattern-book of strategies to be applied uniformly or with a rigid grammar.

Half a century later, architect Alfred Caldwell was a frequent voice of dissent in education. He criticized academic initiatives that focused on "research" in architecture prior to mastery of design fundamentals. He described how the Latin origin of research means "to go round again. Now if you don't know anything about these things, how can you do research in it? You haven't gone round it once?"[7] Caldwell recognized the need for reproduction and practice in student work before actual productive research or the creation of a viable new entity can occur. Even though he did not have a thoroughly formal university education, his landscape architecture work led Mies to ask him to teach at IIT. He later taught at Virginia Polytechnic and USC with a highly individual style that often antagonized administrators but drew great respect from many students who admired such an iconic individuality in education. By reverting to the "guru" model in his teaching, he reconnects back to the era of individual masters from which architecture and music both emerged.

Amid such dissent, there is some common ground between architecture and music occurs with respect to their experiential aspects. To be actually produced, designs depend on their reproduction in real space, and compositions need to be played. Whereas architecture can be experienced and revisited as an object without necessarily being inhabited (a sad proposition), music requires people as performers for mere existence, to reproduce it live. The exception is that one can instead listen to a recording, adding yet another layer of reproduction. In truth, however, this occurs in architecture: One experiences examples of the built environment most often through reproduced drawings and photographs rather than physical visits. The architectural "Grand Tour" is often mediated by digital media or someone else's predetermined view, and the resulting comprehension of space is just as incomplete as a recording compared to a live performance.

In the design processes of music composition and architecture, the key is to develop a sense for visualizing and feeling the characteristics of the final product through a series of reproductive, predictive exercises. In other words, an aspect of the education process is learning to predict the experiential nature of the project in its fullness through the management of reproductive simulation. Dissecting a preexisting design analytically and documenting existing built conditions are among the ways to reproduce an original in order to learn how to translate the drawings and documentation into real space. Likewise, perspectives and models enter into educational situations to reproduce the orthogonal projections and give a sense for the proposed design. In music, the use of computer-simulated sound can be just as magical or misleading as visual simulation. Especially with ensemble works that cannot be transcribed for piano or another single instrument, analysis and mastery of each of the parts is necessarily matched by a mental conception of the whole. One will not always have a batch of fresh concrete or a string orchestra to try out new materials and ideas, but through experiential learning of how concrete or strings behave, the product can be a more faithful reproduction of the ideal.

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The Mobil Speedpass and Mobile Commerce

Cari Rottenberg and Sisi Liu

I. Introduction

Mobil Corporation has been an industry leader in the innovation and development of payment technologies for its retail gasoline distributors. In a competitive market in which a customer must decide between a couple of nearly identical stations at several intersections, technology advancements in payment systems have become one of Mobil's strategies to get ahead of its competitors. The company, marching toward a mobile and cashless commerce, has successively employed prepaid cash cards, branded credit cards, and now its current Speedpass system to serve as its loyalty payment system.

Earlier examples of Mobil's customer-oriented electronic payment systems include bank debit cards and pump-located Customer Activated Terminals. In 1986, four years ahead of its competitors, Mobil created a fuel credit card payment. Mobil became the first petroleum retailer to introduce a prepaid cash card to the market, the Mobil GO Card, and it also introduced pay-at-the-pump services where customers can pay with credit cards at the pumps. In 1997, Mobil launched the Speedpass payment system as a further innovation on pay-at-the pump technology.[1]

Mobil teamed with Texas Instruments and the leading dispenser manufacturers, Gilbarco and Wayne Dresser Division of Dresser Industries, to develop the Speedpass system. Mobil Speedpass is actually an electronic trinket, radio frequency energized, usually in the form of a 1.5-inch-long tag attached to a key ring or a car tag adhering to a vehicle's rear windshield. When the customer waves the transponder near a reader unit housed within the gas dispenser, the tag is powered by radio frequency interrogation signals radiating from the reader and transmits its unique ID code. The reader then interfaces with a central host computer for authorization of the ID code via a local point-of-sale terminal. The Speedpass system verifies the individual customer and activates the pump, and the customer is then free to select the grade of gasoline and fill-up, and in turn, the central computer will charge the customer's designated credit card. The entire process takes simply a fraction of a second. Incorporating the innovative Texas Instrument's RFID technology, Mobil Speedpass was the industry's first RFID-based automated payment system as well as the industry's largest adoption of radio frequency identification technology.

As a successful example of mobile commerce, Mobil Speedpass is one of the case studies we carried out in Professor Jim Short's research project on wireless communications technology and the mobile commerce market. Our goal was to study the business drive of Mobil's Speedpass launch, to evaluate the success of this RFID system in the market, to discover the business opportunity posed to Mobil with the expansion of Speedpass, and to explore Speedpass's future and its role in the mobile commerce environment.

II. Literature Review

The Speedpass research and case studies represent a component of a larger research project aiming to investigate several aspects of wireless data and mobile commerce. The whole project involves researching new ventures in core wireless technologies and adopting consumer products and services in mobile commerce. Speedpass falls into the research focus of leading adopter markets, market structure, and standards for mobile commerce systems in the United States, Asia, and Europe.

Mobile commerce, which is commonly referred to as m-commerce, has become an important concept in today's business environment. In a 2001 case study written by Accenture, m-commerce is defined as "the ability to interact and transact with your customers, employees and suppliers at the point of need — anytime, anyplace" (mCommerce: Exploring the Opportunities). Many retailers have been experimenting with the innovative technologies and processes in order to enhance their businesses. The consulting firm highlights the use of Mobil Speedpass to pay at McDonald's as one of the lead adopters of wireless trials.

In her book *Going Wireless,* Jaclyn Easton discusses the impact of mobile commerce, Internet cell phones, and other devices on both the workforce and consumers. In Chapter Seven she introduces the concept of cashless payment and uses the Mobil Speedpass as the initiator of these systems:

> *While technologically 1997 may be remembered most for the landing of Pathfinder on Mars, 20 years from now the most enduring event may be the debut of a little device that in a nanosecond wirelessly paid for goods. It was not issued by a bank or credit card company. It was distributed by an oil company.*[2]

Thus, Speedpass is an important part of efforts toward a cashless society and a more technologically advanced way to pay for goods. Other devices and technologies have followed the Speedpass, including competing systems that use the same technology. This high-speed evolution combined with the growing popularity, availability, and reliance of these devices make a cashless society possible in the future.

Credit cards, debit cards, and other newer cashless systems have been growing in popularity and usage, especially at food service locations nationwide. The cashless technologies induce shorter lines at checkout, no need to dig for cash or loose coins, and often higher revenues at these operations. Donna Farmer, president and chief executive of the Smart Card Alliance, recognizes that the food service industry is a considerable market for these new payment technologies. As technology continues to grow and develop, it is becoming more convenient and cost-effective for these companies to install new payment systems.[3]

Across the world, the drive to adopt cashless payment systems is coming mostly from companies and the government, not banks. Singapore represents the world's first country to announce a move away from paper money to development and promotion of a large range of electronic and card-based instruments. A cashless economy is actually cheaper because it eliminates the costs of paper and metal at printing presses or armored cars transporting cash, for example.

In Hong Kong, travelers on the mass transit system use their Octopus smart card to pay for travels. The system has eliminated 25 tons of coins per day from the transit system, and transactions take less than a third of a second. Further, the cards can be read from up to 10 centimeters from the reader, meaning that travelers do not even have to remove the cards from their wallets. The cards are accepted throughout Hong Kong at phone booths, drink machines, snack bars, and even McDonald's.

In Japan, Sony has completed a trial of a new contactless payment card called Edy, based on Sony's Felicia system. This contactless payment will function as an electronic "purse" that customers can fill with electronic money at ATMs or convenience stores to use at a variety of locations. Sony even plans to launch a PC interface, which would enable consumers to spend cash over the Internet by merely sitting next to their computers.[4]

III. Research Approach

In an attempt to learn as much as possible about the Speedpass, ExxonMobil Corporation, and other wireless technologies, we conducted in-depth research to obtain most of the necessary data. Through content analysis of firm disclosure data, historical data analysis, company case studies, and sector reports, we gained much valuable

information pertaining to our research. A further element of research involved a trip to Chicago to visit a number of McDonald's sites that accepted the Mobil Speedpass. There we conducted several consumer surveys and interviewed staff members to gain more insight into the use of Speedpass. The results of our extensive research were three case studies involving mobile commerce and radio frequency identification.

IV. Results and Conclusions

Business Drive and Decision

Faced with decreasing profits and an out-of-date business plan, Mobil decided to re-create itself in 1993 by taking a new approach to retail gas distribution. Until this time Mobil had participated in price wars with its competitors trying to secure the business of the many price-conscious consumers. Research revealed, however, that those price-conscious consumers comprised only 20 percent of the market, whereas 80 percent of the market valued attention.[5]

Mobil has been conducting consumer research for many years. In studies dating to the early 1990s, it appears that "service" is highly important to consumers. Surveys, research, and other studies by Mobil have resulted in many driver-centered and service-oriented changes. One such change was the pay-at-the-pump credit card readers introduced in 1994.[6] While consumers readily accepted this new device, they still desired an even faster, more convenient gas experience. John McCalla, Fuel Marketing's U.S. brand manager, claims that "if we were to differentiate ourselves from the competition…delivering outstanding customer service was the way to go. Service, as defined by the customer included getting in and out of the station quickly…."[7] Mobil's mission, therefore, centers on identifying what consumers want and finding a way to deliver that. Essential to Mobil's success at meeting the needs of its customers is its surveys and consumer studies.

With the new focus on customer service, the company learned that its customers highly valued time and convenience. Mobil then set to tackle that issue; Speedpass resulted as a convenient payment method to reduce refueling times. Its popularity and rapid expansion illustrate Mobil's success in meeting the goals of speed and usability.

Speedpass development began as early as 1994, when Mobil started to think of even better ways to get customers in and out of the station as quickly as possible. This was just after the company pioneered pay-at-the-pump technology. Customers liked it, but wanted even more convenience. Mobil's continued to study how it could improve customer satisfaction, emphasizing the necessity of speed. In 1996 the company began to develop the new transaction system using TI-RFID technology with the ultimate goal of getting customers in and out of the gas station as quickly as possible. According to Rick Ellison, marketing pricing and technology manager for Mobil Corporation, "Our research indicates there's an opportunity to make the purchase transaction easier, faster, and magical to the consumer. RFID technology really gives us the opportunity to do that."[8] With a technology that met Mobil's needs and was readily available, creation of the Speedpass was accomplished (Fig. 1).

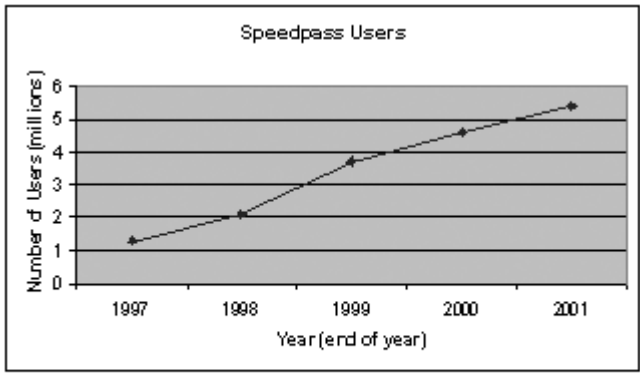
Figure 1

Speedpass Success and Market Reaction

Speedpass has been a great success story for Mobil, beyond any initial expectations for the company.[9] Other gas retailers have taken Mobil's lead to develop RFID or innovative payment technologies, but Mobil is still several years ahead of the pack. The fast growth of Speedpass confirmed the great success of this pioneering payment system. By June 2000, nearly 4 million customers in the United States were using the Mobil Speedpass transponders. Continuing the extensive marketing campaign and expansion, by year's end, there were over 4.5 million Speedpass customers with over 4,000 Mobil sites accepting Speedpass payments at the pump. With the Exxon merger (Exxon Corporation and Mobil Corporation became ExxonMobil at the end of 1998), the company expanded the Speedpass program to include over 1,800 Exxon sites beginning in 2001. Its success in the United States offered great prospects for a Singapore launch of the Speedpass, and it was indeed received very well. ExxonMobil created plans to expand the Speedpass to other markets worldwide, including Esso stations in Canada. Today, Speedpass is in use at more than 7,000 Exxon and Mobil service stations and convenience stores from coast to coast, claiming over 5 million users.

Speedpass Expansion

The rapid success of Speedpass and its network of millions of customers thrust the Speedpass into the media spotlight.[13] With the advancement of technology and continual development of new payment methods such as Smart Cards, the



(Mobil Corp. Press Release)

Figure 2

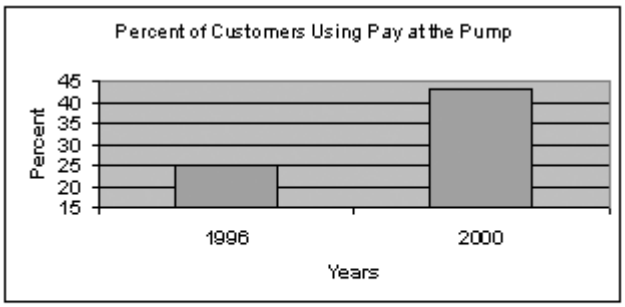


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Figure 3

Speedpass stands as a candidate for a future cashless payment system in the United States. Mobil is now in the position to enhance a new business opportunity with the expansion of the Speedpass. Other cashless options exist, and the Speedpass technology is not difficult to replicate; however, an established customer base and the easy-to-use, convenient Speedpass device provide evidence for the estimated success of expansion. The question remains as to whether a petroleum company can successfully market and implement a universal payment system.

Mike Goldberg, president of Speedpass networks, wants to expand the Speedpass beyond service stations in order to give the now 5 million customers more avenues with which to use the Speedpass. He states: "This is a natural evolution of an innovative system. Both customers and retailers will benefit as Speedpass is introduced into more retail establishments."[14] Expansion of a successful payment application with an existing customer base promises to be an issue further explored in the coming years.

Mobil hopes to profit from the popularity and success of the Speedpass by creating a new business, Speedpass Network. The idea involves expanding the network, allowing other retail outlets to use the Speedpass payment system. McDonald's is doing a test at its Chicago restaurants and other tests are underway in the Chicago area using RFID chips imbedded in Timex watches.[15] According to ExxonMobil Speedpass Network President Mike Goldberg, the great success of the Speedpass prompted other retailers to call the company about getting involved with the system. Additionally, customers were interested in using the Speedpass at other locations. According to a company press release, Mobil "wanted to take it to other places where customers wanted speed and convenience in a very simple process." Mr. Goldberg continues, "Soon we'll be at many other retailers: major drug store chains, video stores, grocery chains. The same kind of multiple transaction per month where customers want speed and convenience."[16] With 90 percent of users highly satisfied with the Speedpass system, expansion to other retailers makes a lot of sense for the company.

Loyal customer Richard Glantz has been using his Speedpass for several years and likes it for its convenience and speed. This Hillside, Illinois, consumer now uses his Speedpass daily to get breakfast at McDonald's and at Mobil stations for every fill-up. When asked what he dislikes about the Speedpass, Mr. Glantz has no response. He has no complaints and even wishes that he could use it at more places like McDonald's. Richard Glantz is not the only happy customer. ExxonMobil research found that more than 92 percent of the 5 million Speedpass users are highly satisfied with the technology. Speedpass is now accepted at over 400 Chicago-area McDonald's[17] (Fig. 4). Moreover, Mobil plans to target drug, grocery, and video chains anywhere consumers value speed and convenience.

The latest expansion effort of the Speedpass Network involves the Stop & Shop grocery chain in Massachusetts. The trial began at three Stop & Shop supermarkets in October 2002, with a planned rollout to the more than 300 other stores in Massachusetts.[18] Stop & Shop represents the first retailer to test the newest Speedpass feature, enabling a retailer to operate its own loyalty program within the Speedpass system. This provides the answer to some of Mobil's competitors for RFID payment systems such as FreedomPay and 2scoot, which currently incorporate loyalty

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schemes for retailers. The Speedpass loyalty function allows customers to make purchases instantly using Speedpass technology, while getting Stop & Shop discounts and rewards without necessitating a separate Stop & Shop loyalty card.

Other expansion opportunities for the Speedpass lie in Mobil's affinity markets. As a gas and service station, Mobil is heavily connected to the automobile industry as well as the travel industry. Possible markets could open in terms of hotels, motels, car rentals, and other tourist affinities. In terms of Mobil's convenience stores, the biggest partners are with snack food and soft drink companies. Coca-Cola, vending machine companies, and Mars candies represent a few options of Speedpass adoption in the convenience store affinity markets. By utilizing consumer affinities as they relate to the gas station or convenience store, the Mobil Network gains great potential for widespread adoption.

The Future of RFID transponder in Mobile Commerce

RFID transponders offer a great potential to collect data about users and function as sophisticated customer-relationship management tools. This enables retailers to offer their most loyal customers special rewards while collecting information on buying patterns. Moreover, tags can be used at service locations like a hotel or restaurant to indicate consumer preferences like smoking rooms or meat preparation. The Mobil Speedpass offers a simplistic version of this by allowing customers to set the preference of whether or not they would like a receipt with their purchases. The application possibilities of these devices in the retail front are endless, including planning product placement based on regional sales.

Transponders offer a great value proposition that will continue to make them successful because they:

- save time for consumers and retailers.
- utilize established and understood payment systems by linking to a credit card or prepaid account.
- work with cheap, secure, and durable technology.
- allow for loyalty programs ranging from extremely simple to quite complex.

With over 15 million transponders from different manufactures in use, more retailers will begin to accept existing or new transponder technologies.[19] Compatibility between technologies may be necessary as vendors will move toward use of these systems like they did to Visa and MasterCard when they first hit the scene. Other technologies exist, but the convenience, ease of use, simplicity, and growing acceptance of RFID transponders make them viable for future success in the retail space.

Figure 4

Despite the promising future predicted for the RFID market, it is still a new industry with many players and has not yet reached maturity. High cost and technology glitches have somewhat slowed the market growth to less than what was previously projected. Aside from these, privacy and security issues have also been raised. Average citizens are likely to be unaware of the amount of information that could potentially be gleaned by monitoring the devices they carry. The control of information is going to be the challenge. However, corporations are concerned about the levels of security required to run RFID devices. They are now recognizing security expenses as part of the overall cost of doing business in a widely distributed, increasingly wireless environment.

Undoubtedly, the RFID market will grow and continue to work through its issues — issues typical of any immature technology. RFID will make further progress in the next five years, how rapidly depends on the actions and efforts of all players in the RFID market. Global demand for RFID equipment and systems will be driven by various factors ranging from continued reductions in transponder unit costs, increased viability of RFID solutions, technological developments toward RFID interoperability, and advancements made in the development of technical and application standards.

RFID technology enables retailers with high volumes of customers who do not want to slow down sales times with adoption of credit cards but who would like to enjoy the benefits of a cashless system. RFID technology also helps retailers build the extremely important affinity programs. Michael Liard, an analyst specializing in RFID at the Natick, Massachusett–based consultant Venture Development Corporation, highlights the importance of collecting data on consumers' spending habits.[20] This enables the businesses to send coupons to customers and create targeted incentives with relatively no effort.

The Mobil Speedpass, which was aimed at customer satisfaction and customer loyalty, now

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accounts for a 3 percent increase in gas sales over the past four years at Mobil stations. As Mobil expands its Speedpass network and high credit card rates continue to leave retailers with little incentive to stick primarily to that technology, ExxonMobil is in the position to control and develop the future of cashless payment in the United States.[21] Despite the lack of RFID standards and the plethora of alternative payment technologies, the convenience of a smart key chain for the predominately driving population of this country is quite important. Moreover, imbedding the chips in other devices such as watches from Timex creates an even larger opportunity for growth.

V. Remaining Questions

Following Mobil's lead, other giants in the retail gasoline industry have looked at innovative new payment systems.[22] Although Mobil does have a huge head start in the technologies and expansion of the market for the payment mechanism, the question arises as to who actually owns the technology or the device itself. Texas Instruments, the same company that manufactures the technology for Mobil, has also marketed its RFID device to Phillips 66.[23] Shell has launched its own system and has focused more on the international market, which stands as a major competitor for ExxonMobil's Esso stations and other retailers. Shell and Phillips 66 are currently the only other major gas stations to offer a similar proximity payment system, and this may create some competition in the future between the stations and in terms of market expansion of the technology.

Standard Building

In the early 1990s, Mobil invested heavily to develop its pay-at-the-pump technology but lost its competitive advantage when others copied the feature. The introduction of the Speedpass represented the same type of challenge for the company. Giordano states, "The risk to keeping it proprietary was that we could lose everything."[24] He does hope, however, that the Speedpass program will have grown to 30 million users by 2006.

The problem of not having national or regional standards for RFID applications is no longer negligible with massive adoption and expansion of RFID technology as a payment solution in several industries.[25] Efforts have been made without satisfactory progress. For example, the Auto-ID center represents a group that works to bring private groups together to establish standards and build smart tags for the supply chain. In the Northeast, toll authorities have come to an agreement on a uniform system, the EZ-Pass, which is likely to spread to other Eastern states. On the other hand, trials of these other RFID devices in the retail scene create standards issues as numerous types of RFID devices could be adapted to the retail space.

The RFID technology of the Mobil Speedpass is not hard to replicate, and therefore gasoline competitors such as Shell and Phillips 66 are launching their own RFID payment devices. None of these tags will be compatible with each other, likely making an enormous key chain if all of these systems expand outside the gas station as well. Obviously having an armful of key chains eliminates the convenience, especially when other companies outside of the gas industry are marketing RFID payment systems.[26] Networks such as the Speedpass one that plan to include multiple retailers or set standards enabling compatibility could solve the possible scenario of too many "smart" keys on one key chain. Texas Instruments has been working with standards committees for RFID since entering the business; however, imposing a set standard for the technology creates many limitations. The technology continues to advance as new developments occur. In order to create some sort of standards one must tackle the issue of which technology meets the business needs and the application requirements.[27]

In the future, biometrics, infrared, and other advanced cashless technologies may permeate society. Privacy, standards, and security are the major issues associated with their advancement. Consumers, especially those in the United States, are extremely reliant on cash, making adoption of a cashless system other than credit and debit cards a difficult process. Thus, while retailers and consumers are curious about these futuristic applications and cashless systems, whether any will actually catch on is still to be seen.

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Potential Well Structure Associated with the Periodically Oscillating Plasma Sphere (POPS)

Michael David Sekora

I. Abstract

This study investigates concepts behind inertial electrostatic confinement (IEC) fusion. Increasing overall fusion output requires sufficient plasma temperature, confinement, and density. Operating an IEC device using a new scheme called the periodically oscillating plasma sphere (POPS) may solve many problems that limit other IEC systems to low gain. Here, the POPS concept is introduced. Measurements pertaining to potential well formation and charge density are taken and analyzed. These measurements confirm that conditions can be created for POPS to exist.

II. Introduction

IEC offers a highly efficient means of producing fusion power. IEC produces fusion by confining plasma with either electrostatic fields or a combination of electrostatic and magnetic fields. These electrostatic fields form a potential well structure that can confine ions. Figure 1 displays an IEC device in operation.[1]

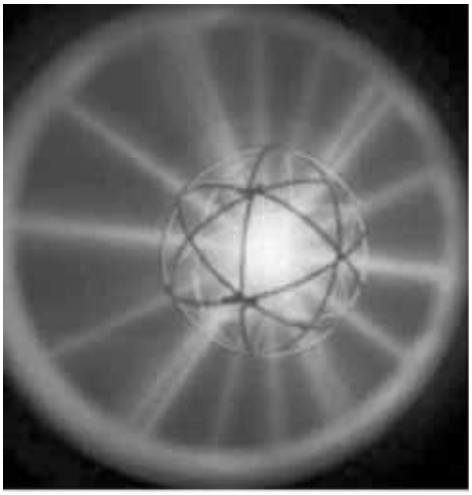

Figure 1: Fusion in an IEC Device

IEC's approach differs from the more mainstream fusion technique, magnetic confinement, which is limited by particle and energy diffusion across a magnetic field.[2] Therefore, IEC devices can be made much smaller (~ 1 centimeter to 1 meter). In magnetic confinement, the average plasma density and subsequently fusion power:

$$P \propto n^2 \qquad (1)$$

where P = fusion power and n = plasma density scale upward in real space.[3] Increasing a magnetic confinement device's size results in higher fusion output power.[1,4] In contrast, one can show using Poisson's equation:

$$\nabla 2\varphi = \varepsilon o \rho \quad (2)$$

where φ = potential (V) and ρ = charge density (C/m^3) that the net fusion power for an IEC device scales as the inverse of the device radius.[5] Decreasing an IEC device's size also results in higher fusion output power.[1,4] However, one problem of making an IEC device small is vacuum breakdown between electrodes. It is very difficult to achieve field strength approximately 50-100 kV/cm without causing arcing. The maximum field strength is governed by the Paschen curve. Because IEC does not require large magnets and has the convenient size of a basketball, an IEC device achieves a high-power fusion density in a lightweight, compact device.

If one wishes to increase fusion output power, one must increase the average plasma density.[3] Typically, IEC devices have a low-average plasma density, which results from the gradient scale length for the electric field not being greatly different from the effective plasma Debye length[2] — a measure of the plasma shielding length.[3] Debye length equals:

$$\lambda = ((KT_e)/(4\pi ne^2))^{1/2} \quad (3)$$

where λ = Debye length, K = Boltzmann's Constant, T_e = electron temperature, n = density, and e = charge of electron. This paper will illustrate the theory behind a new method of operating IEC devices that may enhance IEC performance. Here, an oscillating plasma sphere that periodically compresses the plasma to high densities and temperatures replaces the usual ion beam setup. This new method is POPS. The following pages detail data pertaining to potential well structure to verify that conditions can be created for POPS to operate.

III. Potential Wells

IEC uses strong electric fields to accelerate and confine ions for fusion. It differs from pure electrostatic confinement by overcoming Earnshaw's plasma confinement limit.[6] This limit states that a single charge acted on by electric forces alone cannot rest in stable equilibrium in a static electric field.[6] IEC accomplishes this by having neutrals interact and allowing the inertia of the ions to be propelled into the center of the device.

IEC devices often consist of two hollow, concentric, semi-Gaussian electrodes. The innermost electrode is permeable to charged particle flow, where the flow produces a steady saturated electrostatic potential well capable of confining oppositely charged particles.[3] Electrons injected symmetrically into the hollow, concentric, semi-Gaussian anode produce a negative potential well at its center. This potential well confines positively charged ions.[3]

The IEC device that was used in collecting data for the experiments discussed here consists of two grids, noted as the middle and outer grids with respect to their position from the center of the device. The purpose of these grids is to create a spherical ion source internal to the device by ionizing the background gas.[8] The middle and outer grids are anodes.

To increase electrons into the system, electrons are extracted from six electron guns located at the edge of the device's grounded shell, which acts as a cathode. Inside the grounded shell, an extractor grid acts as an anode. This grid spreads the electrons from the electron guns uniformly over the inside of the grid, which from Poisson's equation forms a harmonic oscillator potential inside the grid.[2] The electrons are farther dispersed as they move toward the outer and middle grids. Likewise, these electrons ionize the background gas that was backfilled into the system.[9]

IV. Periodically Oscillating Plasma Sphere (POPS)

The POPS concept can be derived from a combination of one-dimensional fluid equations for ions and Poisson's equation.[2] As discussed earlier, if the charge density is uniform, meaning the electrons from electron guns are spread uniformly within the extractor grid, then a harmonic oscillator potential forms:

$$\varphi = \varphi_o(1 - (r/r_{grid})^2) \quad (4)$$

where φ = electrostatic potential and r^{grid} = the radius of the extractor grid. The ion dynamics from this harmonic oscillator potential can be calculated from the following equations:

$$\partial n_i/\partial t + (1/r^2)\partial/\partial r(r^2 n_i v_i) = 0 \quad (5)$$

which is the conservation of mass, where n_i = ion density, t = time, and v_r = ion radial velocity;

$$(m_i n_i)\partial v_r/\partial t + (m_i n_i v_r)\partial v_r/\partial r = q_i n_i E r - \partial P_i/\partial r \quad (6)$$

which is the fluid equation of motion, where qi = charge of an ion, E_r = radial electric field, and P_i = ion pressure;

$$P_i/(n_i)^{5/3} = \text{constant} \quad (7)$$

which is the ideal gas law;

$$(1/r^2)\partial/\partial r(r^2 E_r) = 4\pi(q_i n_i - en_e - en_b) \quad (8)$$

which is the Poisson equation, where e = charge of an electron, n_e = thermal electron density, and n_b = background electron density generated by the grid and electron guns;

$$E_r = -\partial\varphi/\partial r. \quad (9)$$

A set of self-similar solutions exists for these equations. However, the calculation of these self-similar solutions is beyond the scope of this paper. These solutions reduce the problem to the following ordinary differential equation for the plasma radius:

$$d^2a/dt^2 + (4\pi q_i^2 n_b/m_i)a = (n_o(a_o/a(t))^3 - n_e)a + (2P_o/m_i a_o n_o)(a_o/a(t)).^3 \quad (10)$$

If one ignores the right-hand side of equation (10), it reduces to a simple harmonic oscillator equation. When the potential on the extractor grid is large compared with T_o, which is the initial temperature, equation (10) reduces to a simple harmonic oscillator equation, except in the region of $a(t)/a_o << 1$:

$$d^2a/dt^2 + (4\pi q_i^2 n_b/m_i)a = 0. \quad (11)$$

Phase locking of all of the ions in the system is achieved by driving the system near one of the resonances.[2] The lowest resonance is:

$$\omega = 2\omega_h = 2(4\pi q_i^2 n_b/m_i)^{1/2}. \quad (12)$$

A harmonic oscillator driven at resonance will phase lock to the driver.[2] In this IEC system, the oscillation in n_b can be provided by oscillating the extractor grid potential.[2] From examining the equations, one notes that because the ions phase lock and motion pertaining to a simple harmonic oscillator is independent of amplitude, all ions with a phase-locked period of oscillation simultaneously arrive at the center as the plasma collapses upon itself.

V. Experimental Setup

The experimental device consisted of a 12-inch-radius stainless steel, spherical, vacuum shell that was grounded. Mounted to six outside ports on the spherical, grounded shell were six electron guns. On the inside wall of the spherical, grounded shell was the stainless steel extractor grid. The extractor grid was made of fine molybdenum mesh and was mounted close to the wall of the spherical, grounded shell near the six ports, where electrons would be emitted from the six electron guns. Inside the extractor grid was the 4-inch radius stainless steel outer grid. The outer grid was a spherical, semi-Gaussian anode biased with respect to the grounded shell. The outer grid had approximately 95 percent transparency. Inside the outer grid was the 2.5-inch-radius stainless steel middle grid. The middle grid was a spherical, semi-Gaussian anode biased with respect to the grounded shell. The middle grid had approximately 90 percent transparency. Separate voltage regulated power supplies maintained well-filtered stable anode potentials between each electron gun, extractor grid, outer grid, and middle grid. The vacuum system consisted of a turbo pump (150 liters/sec) in conjunction with a liquid nitrogen cold trap. This was backed up by a mechanical roughing pump. This vacuum system provided a base pressure less than $1x10^{-8}$ Torr.

The operating voltages and currents were as follows. The electron guns were consistently operated at 10 V and ~ 5.8 A. Any attempt to take the electron guns to a higher power resulted in melting the electron guns. The extractor grid over each electron gun was consistently biased at 100 V. The current found in each extractor grid varied between which electron gun it covered. These differences can be attributed to how each electron gun was manufactured. Yet the current differences had no affect on creating a uniform electron distribution. The current differences affect only the total current being supplied to the plasma. The current found in each extractor grid varied between ~ 60 mA and ~115 mA. Potential well data was taken by varying the middle grids. Therefore, the outer grid was consistently biased

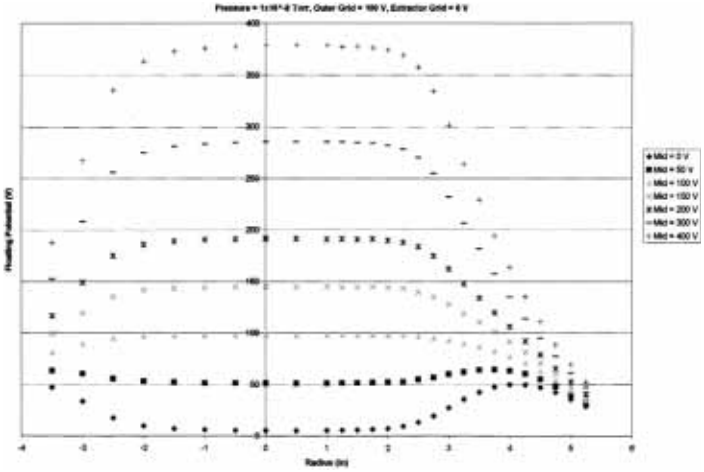

Figure 2: Vacuum Field Potential Versus Radial Position

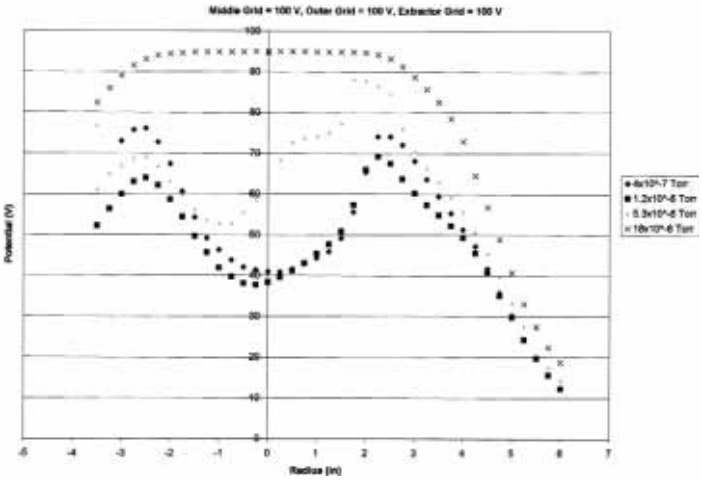

Figure 2: Vacuum Field Potential versus Radial Position

at 100 V, and the middle grid was biased at 0 – 400 V. Never was the extractor grid or any other grid driven at an oscillating potential. These experiments were set up only to verify if the proper conditions for POPS could be created.

Data pertaining to the potential well structures was collected using a hot emissive probe. The hot emissive probe consisted of a tungsten filament spun into braided copper wire that was shielded with nonconducting alumina tubing. The hot emissive probe was consistently heated with a heater current equal to 960 mA. At this current the tungsten filament emitted electrons, and the plasma potential could be measured using the hot emissive probe. The tungsten filament loop extended approximately one-third of an inch outside of the alumina tubing. The entire probe consisting of the tungsten filament and the alumina tubing was ~20 inches. For taking measurements of the potential well profile, the hot emissive probe could be moved to different radial positions across the diameter of the IEC device. From this, one could view how the potential profile changed with radial position. Likewise, one could construct plasma density using the data collected on the potential well profiles and Poisson's equation.

VI. Results

Figure 2 illustrates the vacuum field potential versus radial position for varying middle grid potentials. A vacuum field occurs when there are no electrons being injected into the system via the electron guns and there is no backfilling the system with any gas. Therefore, the operating pressure for this particular experiment was very low ($1x10^{-8}$ Torr). Only the outer grid is biased at 100 V, and the middle grid is biased at varying potential indicated in the graph. For middle grid potentials greater than or equal to the outer grid potential, one notes a consistent filling of the potential well that would exist at the center of the device. This is the result of there being relatively no negative space charge from the emitted electrons existing at the center of the device. Furthermore, for middle grid potentials less than the outer grid potential, one notes a consistent widening of the potential well that would exist at the center of the device. One also notes that in this case the potential decreases as one moves from the radial position of the outer grid (radius = 4 inches) toward the center of the device. This is simply the result of going from 100 V on the outer grid to a lesser potential on the middle grid. Yet, when one gets to the radial position of the middle grid and continues inward toward the center of the device, one notes a consistent potential across the center of the device. This is simply the result arrived at earlier for the middle grid potential greater than or equal to the outer grid potential.

Figure 3 illustrates the plasma potential versus radial position for different pressures. Here, each grid (extractor grid, middle grid, and outer grid) is biased at 100 V. This graph shows the potential well structure's dependence on pressure as one moves a hot emissive probe radially across the diameter of the IEC device. The pressure used for these plots correspond to a low, medium, high, and very high operating pressure. The pressure used in each of these plots was $4x10^{-7}$ Torr, $1.2x10^{-6}$ Torr, $5.3x10^{-6}$ Torr, and $18x10^{-6}$ Torr. At low pressure ($3x10^{-7}$ Torr), one sees a very smooth, parabolic potential well, which is essential for confining ions. This plot demonstrates that there are sufficient electrons being injected into the center of the device to create the potential well structure. If one measures the depth of the potential well, which is defined as the change in plasma potential from the relative minimum near the center of the device to the relative maximum near the middle grid wire (~ 2.5 inches from the center of the device), one finds this depth equal to approximately 35 V. If the pressure is increased to $1.2x10^{-6}$ Torr, the plasma potential starts becoming less smooth. More importantly, the potential well becomes more shallow. Here, the plasma potential has decreased to approximately 30 V. If the number of electrons being injected does not increase while the pressure increases, then the potential well will decrease because there are more ions being created from electrons ionizing an increased amount of background gas. With increased pressure ($5.3x10^{-6}$ Torr), the plasma potential becomes very chaotic. The potential profile in the graph lacks all of the smoothness associated with the potential well profile occurring at $4x10^{-7}$ Torr. Likewise, in this graph it is very difficult to determine the potential well depth. If one measures the potential well depth from the relative minimum near the center to the relative maximum on the left-hand side of the plot, one finds a well depth of approximately 15 V. However, on the right-hand side, it is difficult to discern if a potential well has formed completely due to the large number of ions in the system. One must question the stability of this potential well. Lastly, if one increases pressure to $18x10^{-6}$ Torr, there is no potential well structure. This is what one expects with all of the ions in the system. All of the ions completely fill in the potential well.

The POPS scheme requires a harmonic oscillator potential and a uniform density of electrons

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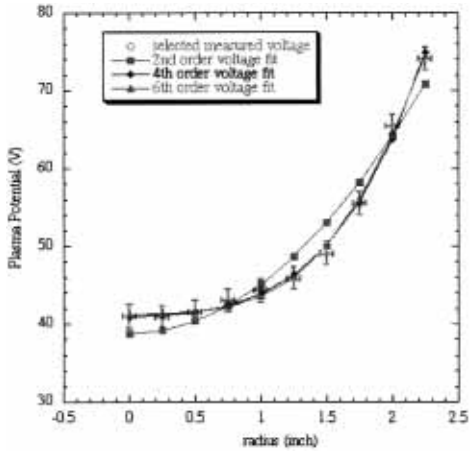

Figure 4: Plasma Potential with Polynomial Fitting

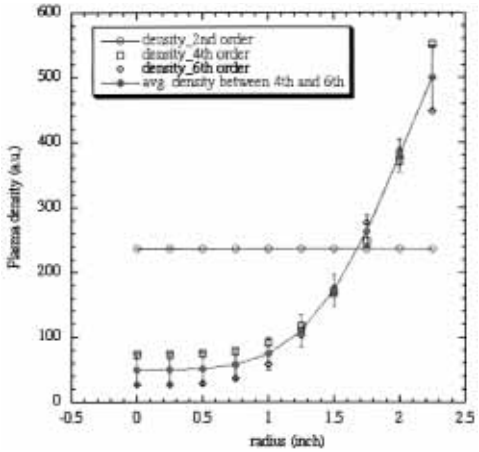

Figure 5: Plasma Density Profile with Polynomial Fitting

to be present in the system. In Figure 3, there was a symmetrical, parabolic, and deep potential well formed, which could satisfy the requirement of a harmonic oscillator potential. To verify if this is a uniform density of electrons existing throughout the system, one would have to utilize the Poisson equation, where one could construct the plasma density from the data collected about the potential well profiles. Using a technique employed by Nebel and Park at Los Alamos National Laboratory, where even order polynomials are used to fit the potential profile, one may subsequently arrive at the density profile. (See Figures 4 and 5.) Figure 4 is the potential profile taken at $4x10^{-7}$ Torr, which was plotted in Figure 3. However, it is fitted with even order polynomials. Figure 5 is the subsequent density profile calculated using the potential profile plotted in Figure 3, but fitted with even order polynomials. Figure 5 illustrates that the electron density is uniform throughout the system. This is necessary for the POPS scheme to be employed.

VII. Conclusion

This paper has described an IEC device and indicated some of the current problems (especially low plasma density) involved with operation of such a device. A possible solution to the low plasma density problem is a new means for operating an IEC device, POPS. We have examined the ion dynamics equations needed for modeling POPS, which allows for a periodical collapse of all of the ions in the system to a point at the center of the IEC device. This collapse is achieved by placing all of the ions in the system within a parabolic potential well that is driven at a resonant ion frequency. Eventually, all of the ions in the system phase lock to the driver because all of the ions in the system have the

same frequency of oscillation, which is independent of their energy.[2]

There are certain conditions necessary for POPS to occur. These include having a harmonic oscillator potential within the IEC device and a uniform density of electrons within the extractor grid. In examining if one can create these required conditions for POPS to occur, it has been experimentally verified that one can create deep parabolic potential wells needed for confining ions, and one can also create a uniform density of electrons within the extractor grid. Although this paper demonstrates that one can create conditions necessary for POPS to occur, this paper does not provide any direct evidence that POPS is actually taking place. Providing direct evidence that POPS is actually taking place by measuring the ion frequency and amount of neutrons produced per second is the subject of current research.

VIII. Acknowledgments

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