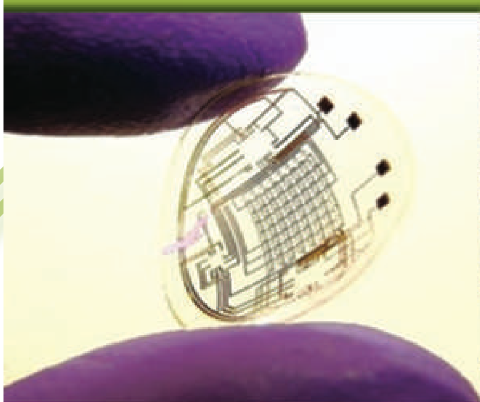
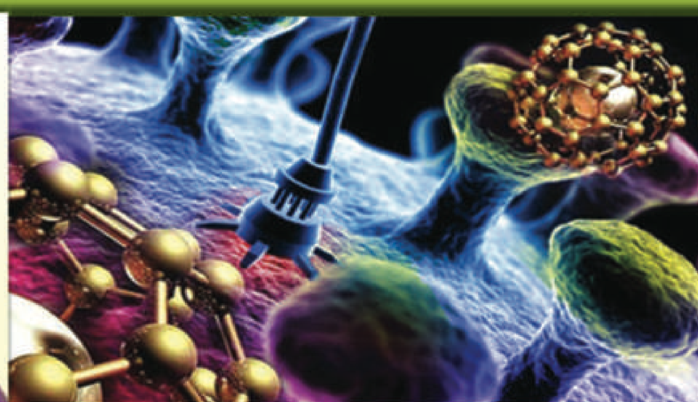
TECHNOLOGY OBSERVER™

The science and technology magazine created and published by students of Albert Dorman Honors College of New Jersey Institute of Technology.

TECHNOLOGY OBSERVER

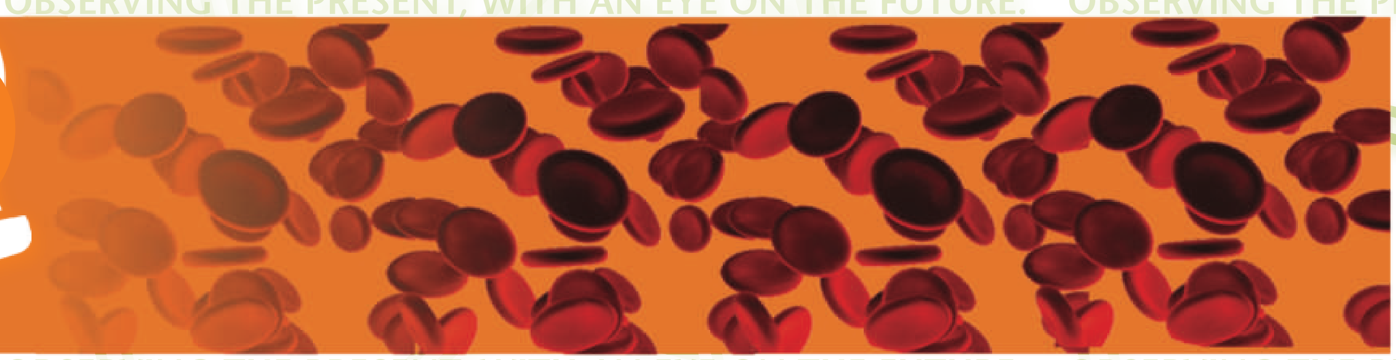
Issue 2009-2010 Volume 01





NJIT
New Jersey's Science & Technology University

CELEBRATING OBSERVING THE PRESENT, WITH AN EYE ON THE FUTURE. OBSERVING THE PRI



10 YEARS
1999-2009 OBSERVING THE PRESENT, WITH AN EYE ON THE FUTURE. OBSERVING THE PRI

TECHNOLOGY OBSERVER

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Visit Us at **honors.njit.edu/news/technologyobserver**

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expertise application progress insight

nanotechnology drive

"Without change there is no **innovation, creativity, incentive** for improvement."
-William Pollard, Physicist and Priest

medicine

edge

"To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science."
-Albert Einstein, Physicist

agriculture res motivation

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"The great thing in the world is not so much where we stand, as in what **direction** we are moving."
-Oliver Wendell Holmes, Physician and Poet

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"The most exciting **breakthroughs** of the 21st century will not occur because of technology but because of an expanding concept of what it means to be **human**."
-John Naisbitt, Author

skill foresight capacity wisdom imagination advancement knowledge dis

"When eating a fruit, think of the person who planted the tree." -Vietnamese Proverb

Dr. Janet Bodner from Humanities, for helping the students bring out the best in their writing; Dr. Rajiv Mehta from the School of Management, Dr. Mesut Sahin from Biomedical Engineering, Dr. Horacio Rotstein from Mathematical Sciences, Dr. Gareth Russell from Biological Sciences, and Dr. Haimin Wang from Physics for their time and insight into their illustrious work.

Extended thanks to Dr. Paul Dine, for his guidance on this project; Dr. Joel Bloom and the administrators and staff of the Honors College for their support; Romer Jed Medina for lending his time and photographing skills; Babette Hoyle, Jean Llewellyn, Johanna Moroch, and Carol Pilla from University Communications, for ensuring that we best represent the school; and Dr. Fadi P. Deek and Sylvana Brito-Rodriguez from the College of Science and Liberal Arts for their valued input and suggestions.

Of course, the greatest thanks are for the students who worked long hours and with much effort, without whom this magazine would not exist.

Message from the Editor

"We are building the bridge to the future while standing on it."

– U.S. Army Colonel
from Wired for War: The Robotics Revolution and Conflict in the 21st Century *by P. W. Singer*

The mission of the *Technology Observer* has been to report on current developments in science and technology as students see it; students, whose curious minds are fertile for planting questions. Nourished by the motivation to learn, they search for the most relevant and inspiring projects to report on. This tenth-year anniversary issue is no exception.

The articles of this volume all deal with a specific aspect of nanotechnology's expanding sphere of application. Innovations in areas such as drug delivery, disease control, and food nourishment have guided nanotechnology into sustaining and even augmenting our health. At the same time, nanotechnology has enhanced the sophistication of the military's tools and defense. With so much to offer, it is no wonder that this time may be the Age of Nanotechnology, as termed by Michael Laine, co-founder and President of LiftPort Group, the company responsible for envisioning and engineering an elevator to space.

To appreciate how far technology has trekked, we thought it appropriate to take a step back and observe how far along we have come: to, somehow, recognize the scientists who had the courage to ask "why" and "what if," the explorers who braved uncharted territory, and the inventors who strove to engineer methods and contraptions to enhance the quality of life. Hence, our tenth year anniversary special feature is a timeline delineating major milestones, inventions, or discoveries that have influenced each of the following four areas: agriculture, astronomy, medicine, and military.

There was no lack of devoted students on this issue, and those who endured the strenuous and demanding hours deserve the utmost commendation. The magazine was forged in 1999 by the dedication of self-driven students, and it thrives in their persistence to share what they learn in their experience of working on the magazine.

Jeff Admon, the first editor-in-chief of the *Technology Observer*, and one of its main proponents, ended the first editor's message stating, "We aspire to be the best, most innovative magazine in our field – and with time and assistance of our fellow students we will surely grow and improve to make this a reality." We aim to one day attain that aspiration as we continue to observe the present, with an eye on the future.

Fatima Elgammal
Editor-in-Chief

Kupfrian, Faculty Memorial and Tiernan Halls at New Jersey Institute of Technology

About New Jersey Institute of Technology

THE EDGE IN KNOWLEDGE

New Jersey Institute of Technology is a public research university enrolling more than 8,800 bachelor's, master's, and doctoral students in 120 degree programs through its six colleges: Newark College of Engineering, the College of Architecture and Design, the College of Science and Liberal Arts, School of Management, the College of Computing Sciences, and Albert Dorman Honors College. A top-tier research university, NJIT houses laboratories in 48 key areas and 20 state-of-the-art multidisciplinary centers. Research initiatives include manufacturing, microelectronics, multimedia, mathematical sciences, transportation, computer science, solar astrophysics, environmental engineering and science, and architecture and building science.

About Albert Dorman Honors College

ENGAGING THE FUTURE

The vision of Albert Dorman Honors College is the engagement of the brightest students with the best faculty, original research, and practice-oriented projects. The context of this engagement is inquiry-based learning, a computer-intense campus, an urban setting, diverse population, global relationships, and an environment that is erudite and transformational.

Albert Dorman Honors College currently enrolls over 680 students, with average SAT scores above 1300. Students are enrolled in honors courses, participate in leadership colloquia, partake in professional projects, and conduct research with faculty at various NJIT research centers. These scholars work closely with national and international businesses and industries, and participate locally in community activities. They are leaders on the NJIT campus, and future leaders in the science, engineering, mathematics, and technology professions.

For more information :: **honors.njit.edu**

PHOTOGRAPHER: BABAJIDE AKEREDOLU

Message from the Dean

This year we are celebrating the 10th anniversary of *Technology Observer* and the 15th anniversary of Albert Dorman Honors College, two significant milestones on the behalf of gifted students, some of whom you will meet within the pages of the issue. These are milestones for our university as it consistently attracts these students, and for the faculty who engage them in the classroom and in their research. These are milestones for our state, national and global communities, the ultimate beneficiaries of the science and technology being researched and presented in this edition.

The presentation of this edition has been adroitly led by our editor-in-chief, Fatima Elgammal. Fatima is currently completing her dual baccalaureate degrees in mathematical sciences and biology.

Fatima and her colleagues chose to focus on technology "at the edge," nanotechnology. They share with us fascinating concepts and developments of this nascent science and its technological applications that are becoming life changing. Matthew Deek discusses medical applications of carbon nanotubes that can deliver nanoparticle drugs to specific cells in the human body. Wasseem Abugosh explores the application of carbon nanotubes in improving the ability of the infantry soldier to survive in combat. Bushra Hossain researched "nano-foods" that could help solve the world's shortage of food and water. Fatima Elgammal presents to us "nanorobots" designed to prevent the worldwide spread of diseases. David Thompson observes the athletic and recreational use of the technology that will result in greater competitiveness and change the future of sports. Mohammad Nawaz fascinates us with a "space elevator" using a tether of nanotubes to "reach outer space."

Donald Sebastian, senior vice president for research and development, an early advocate for NJIT's involvement in the science of nanotechnology, comments that *Technology Observer* writers have done a wonderful job of capturing the different dimensions of this field of study that will ultimately bridge the classical scientific disciplines. "We are fortunate to have such students enriching the university's scientific community. Imagine the possibilities now that we can not only see individual atoms but actively invent new molecular structures without the constraint of natural process. That is the dream of nanotechnology. The dream is rapidly becoming the reality of nanotechnology, and many faculty members are engaged in pioneering research that will make practical use of the scientific discovery now emerging," he said.

Our student writers build upon the "New Jersey Institute of Technology in Action" feature, which originated in the 2008-2009 issue of the *Technology Observer*. This section briefly introduces us to the broad array of research being conducted by some of the faculty at NJIT ranging from studying the transferability of marketing channel management practices across international markets, the oscillations in the brain at the cellular, molecular, and network level, to the application of The FLAMES device that is implanted into the spinal cord to help those unable to walk to do so again.

As we celebrate this double anniversary, it is my pleasure to acknowledge those who had the vision to establish an Honors College at NJIT: President Emeritus Saul K. Fenster, Board of Trustees Chairman (1988-2000), Victor A. Pelson '59, and the college's namesake, Albert Dorman '45.

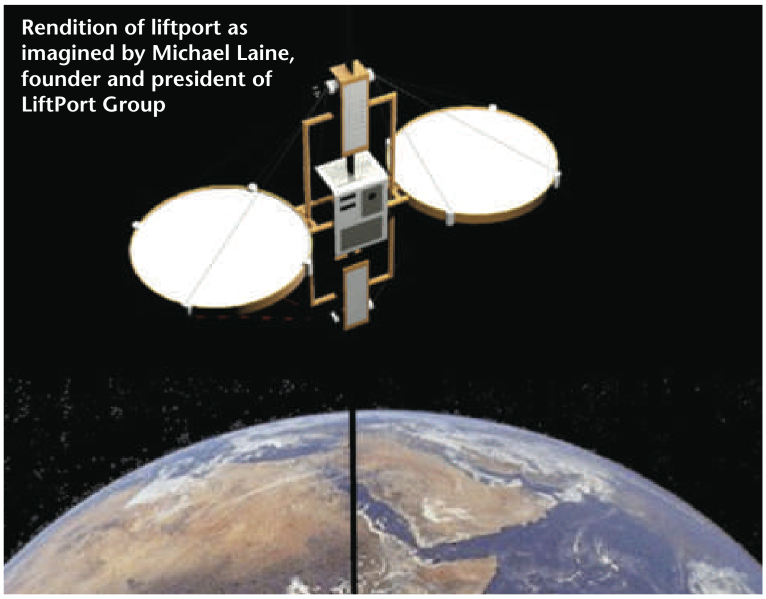
Thank you.

Joel Bloom, EdD
Dean of Albert Dorman Honors College
Vice President of Academic and Student Services

Climbing to the Stars

Exploration of space has continued to be a lucrative trove of knowledge and in the near future, we will not need rockets to get to space

:: BY MOHAMMAD NAWAZ ::



Rendition of liftport as imagined by Michael Laine, founder and president of LiftPort Group

As the barrier between reality and science fiction becomes increasingly blurred, technologies that were once thought to be figments of imagination are now making their way into reality. The space elevator is one of the prime examples of this. The space elevator is a transportation vehicle similar to any other elevator that will form a bridge between Earth and a point in space.

The concept of a space elevator was first conceived of by Konstantin Tsiolkovsky, a Russian rocket scientist, who was inspired by the construction of the Eiffel Tower in 1895. Later, it was Arthur C. Clarke, a science-fiction writer, who introduced this idea to a broader audience in his 1978 book, *The Fountains of Paradise.* Clarke argues for the feasibility of building such a device throughout his book by suggesting that "if the laws of celestial mechanics make it possible for an object to stay fixed in the sky, might it not be possible to lower a cable down to the surface – and so to establish an elevator system linking Earth to space?" [1].

This link between Earth and space is being vigorously investigated by Michael Laine, founder and president of LiftPort Group, a research and development company that is working on the mechanics of the space elevator. Laine brings more than fifteen years of business management and development experience for the technology, financial services, and military markets. Prior to LiftPort, Laine was co-founder and president of HighLift Systems, a Seattle-based company that received funds from NASA's Institute for Advanced Concepts (NIAC) to research building an elevator to space. The group's goal is to create the first working space elevator near the year 2030. From the plans that have been developed thus far, the space elevator will be composed of a track from Earth to space that will allow climbers to run on it, similar to a train on a railroad track. The track will be held in place by an anchor on Earth and a counterweight in geosynchronous orbit in space. An object that is in geosynchronous orbit with Earth is an object that stays in one place in the sky, relative to the Earth. The space elevator setup can be made analogous to a person spinning himself while holding a string attached to a ball. As the person spins, because of centripetal force acting on the ball, the string becomes taut and rigid. The spinning person is analogous to the rotating Earth, and his hand clutching the thread is comparable to the anchor, or liftport. The string is akin to the track that will be used by the climbers, and lastly, the ball at the end represents the counterweight spinning in geosynchronous orbit about the person.

The liftport, as conceived by LiftPort Group, will be located on the Pacific Ocean near the equator. The exact area was chosen for its lack of use as a path for airlines as well as its calm waters and weather. The liftport station will serve as the anchor that will connect the Earth to the counterweight and will be the location from where the elevator ascends and descends. The counterweight will be composed of satellites and construction bots after serving their purpose of building the elevator. This is what will keep the tether taut. There will be a variety of different climbers that will be used for transport on this system. Each will be built for a specific purpose, such as transporting cargo, people, or even inspecting the track upon which the other climbers will depend. The climber will receive its power from a laser beamed from the liftport to panels on the climber that will convert laser light into mechanical energy. The most challenging part in developing the space elevator is creating a 60,000-mile long tether that is both durable and flexible.

Carbon Nanotubes and the Tether

Besides being one of the foundations of life and its great versatility, carbon is known for forming one of the hardest natural materials on earth: diamond. Not only that, but one of the most potentially versatile materials can also be made with carbon. It could possibly replace steel as the most common building material once a process for synthesizing it has become more refined. These materials, called carbon nanotubes (CNT), have many attractive properties such as a density that is three to six times less than steel, and are perhaps the only materials that will be employed by LiftPort Group to create the tether of the space elevator [2].

Carbon nanotubes have [a] density that is three to six times less than steel.

CNTs are structurally similar to graphite. Each carbon is bonded to three other carbons in one plane, creating a stable sheet of graphite.

Once each sheet of graphite is rolled up to form a seamless cylinder, a carbon nanotube is formed. The nanotubes can be single-walled, meaning there is only one cylinder, or multi-walled in which more than one carbon nanotube exists concentrically within others. The advantage of a multi-walled nanotube is that there is a dramatic increase of strength, similar to intertwining two or more strings together.

One of the most attractive properties of a single-walled CNT is its tensile strength. Tensile strength is measured in pascals, the unit of pressure, or force per unit area. The greater the tensile strength, the greater the force needed to break the object. Bone, a common material used many millennia ago, has a tensile strength of about 0.1 gigapascals (1 gigapascal = 1 billion pascals), whereas steel, one of the most common building materials of today, has a tensile strength of 0.4 gigapascals. A single-walled CNT has a tensile strength of 75GPa, and a multi-walled CNT has one of approximately 150GPa – almost double [2].

Another striking property of CNT is its stiffness. The stiffness of an object is its resistance to deformation. Its measure is the modulus of elasticity, which is defined as ratio of stress applied to the strain that results in response, also measured in pascals. This is a measure of how much pressure is required to change the shape of the object. For example, a very light and thin rubber band only requires a little bit of force to be stretched or deformed, whereas a heavy and very thick rubber band requires a greater force in order to be warped. Steel has an elastic modulus of just over 200 GPa, whereas those of single and double CNTs both are over 1,000 GPa [2]. This means that CNTs can withstand at least five times more pressure than steel before they bend.

"We only need [the tether] to be 30 times stronger than steel for this system to work," says Laine, and a multi-walled CNT is well beyond that. One obstacle that remains is synthesizing CNTs that are 60,000 miles long. The longest ones that have been synthesized are only a few centimeters long, and to achieve the required length for the project to be successful needs much effort in research ahead [3].

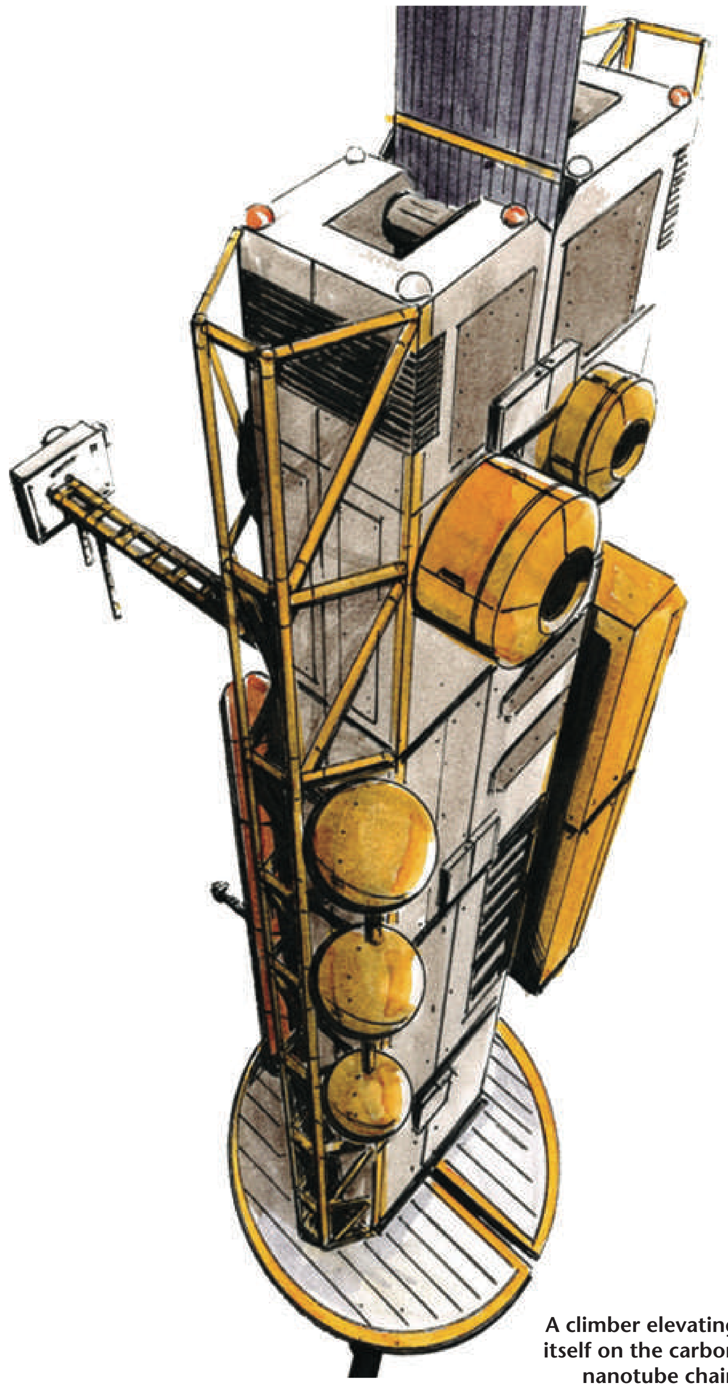
Space elevator and advantages

Laine gives a very rough estimate that building the space elevator will cost around $14 billion. Even though a space shuttle is a lot less expensive – the Space Shuttle *Endeavour* cost about $1.7 billion – the cost of operation for a space elevator is cheaper. According to NASA, it costs $450 million to launch a space shuttle into space; however, Laine estimates the cost to be closer to $1 billion [4, 5]. As of yet, an estimate for the cost of operation of the space elevator doesn't exist. Nevertheless, Laine claims that the cost will be significantly less than launching a space shuttle.

In addition to being a cheaper way to launch projects, the space elevator will allow more frequent visits to space. "A space shuttle that on its best configuration in its best year had only seven trips with 60 tons of cargo. That's the most optimistic system NASA has been able to develop. [With the space elevator,] we're looking at 50 trips per year, at 100 tons [of cargo] per trip," approximates Laine. This will be a significant improvement from approximately 420 tons for a NASA space shuttle to approximately 5,000 tons for the space elevator.

The space elevator can expand the exploration of space tremendously. Transporting cargo and people up into space without the use of rockets decreases the risks of space travel. Furthermore, space exploration vehicles can be elevated and lowered into and out of space without having the need to spend extra resources on fuel for launching or requiring the vehicles to carry energy for landing.

The space elevator can expand the exploration of space tremendously. Transporting cargo and people up into space without the use of rockets decreases the risks of space travel.



A climber elevating itself on the carbon nanotube chain

Conclusion

The space elevator will allow for many changes in our world. Other than for science and research, there have been many proposed imaginative uses for space elevator, ranging from space tourism, hotels, and restaurants in space, to the production of certain products in space. The forefront to what will allow the space elevator to exist is how far nanotechnology and the knowledge of carbon nanotubes come. "Civilizations rose and fell because of material science," comments Laine, "As a race, we've gone from just bones to the Copper Age, to the Bronze Age, and then to the Iron Age. Soon, we will be entering the Carbon Nanotube Age."

"Change the world, or go home," is the motto of the company LiftPort Group, and it seems like the space elevator will not accomplish anything less than changing everything.

Mohammad Nawaz is a third year undergraduate student studying biology at NJIT.

Current surgical tools are too large to be capable of the precision needed for modern surgical practices

Nanotechnology in Medicine: The Next Big Thing is Small

How medicine is using nanoscale tools to improve surgical procedures and drug delivery, and the ethical implications of these emerging technologies

:: BY MATTHEW P. DEEK ::

Trying to predict the future is like playing a game that we may win or lose. This is so because we tend to base our forecasts on past experiences or other probable scenarios, which may be completely irrelevant. With technology, however, visualizing the future, given the developments of the past and present is predictable. It is known and even expected, for example, that computers will be smaller, faster, and more efficient. In medicine, what was impossible then has become a reality now, from suppressing cancer to supplanting damaged organs. Similarly, materials are becoming lighter, stronger, and more sophisticated, whether it is bigger and lighter aircraft, paper that is stronger than iron, or clothes that do not stain. Indeed, in 1971, computer science researcher and inventor Alan C. Kay expressively suggested in a business meeting: "The best way to predict the future is to invent it. This is the century in which you can be proactive about the future; you don't have to be reactive. The whole idea of having scientists and technology is that those things you can envision and describe can actually be built" [7]. It takes a very long time, a decade or more, and high resource investments, to translate the results of laboratory research into products and services for everyday life. Nevertheless, one can easily trace back great human accomplishments to their earlier points in time of vision.

In medicine, what was impossible then has become a reality now, from suppressing cancer to supplanting damaged organs.

Nanotechnology in Medicine

Building on the advances of the last few decades in physics, microelectronics and communications technologies, scientists are now working at nanoscale, or at the levels of atoms and molecules, using new techniques and tools to create sophisticated products and technologies that will have significant impact on every aspect of our lives, with promising, upbeat consequences for our health. K. Eric Drexler first introduced the term "nanotechnology" in the *Engines of Creation: The Coming Era of Nanotechnology*, in 1986. He envisioned the manipulation of individual atoms and molecules as the basis for building systems from the bottom up, atom by atom, and declared "our ability to arrange atoms lies at the foundation of technology" [3]. Drexler's work was inspired by physicist Richard P. Feynman who gave a speech at a meeting in 1959 of the American Physical Society at the California Institute of Technology. Feynman told the audience: "What I want to talk about is the problem of manipulating and controlling things on a small scale," and he told the gathered scientists that he was confident it must be possible to build machines smaller than the head of a pin which should be able to store massive amounts of information [5]. Professor Feynman went on to win the Nobel Prize in Physics in 1965 for his fundamental work in quantum electrodynamics and its consequences for elementary particles.

Drexler's 1992 follow-up book, *Nanosystems: Molecular Machinery, Manufacturing and Computation*, discussed the issues around the development of nanoscale machinery and proposed the building of atomically precise products under digital control [4]. His work, in essence, defined the field of molecular nanotechnology and demonstrated the feasibility of scaling down concepts of macroscopic systems to the level of molecules. In the two decades since Drexler first offered his imaginative and carefully laid out roadmap for a new science, progress toward the applications of molecular assembly has become evident in many domains. However, the most promising forecast of *Engines of Creation* is that nanotechnology will allow for significant improvements for human life far beyond its span, "not only to heal ourselves, but to heal Earth of the wounds we have inflicted" [3]. This was a very bold prediction, but perhaps there is already a glimpse of what it might actually take to realize this vision of Drexler.

Nanotools for Minimally-Invasive Surgery

Much progress has been made in terms of understanding the human body, its various organs and their functions. However, when it comes to medical surgery, it appears that there remains a mismatch between the task and the tool. "Disease and ill health are caused largely by damage at the molecular and cellular level. Today's surgical tools are huge and imprecise in comparison" [10]. In addition, depending on the type of procedure, degree of invasiveness, and the instrumentation required, the repetitive insertion, maneuvering and removal of these tools during surgery could pose risks to the involved body system and tissues. Thus, smaller, multi-purpose tools can result in safer and less invasive surgeries through the use of small incisions, which reduce trauma to the body and shorten recovery time. For example, integrated nanoscale machines, or nanorobots, controlled by surgeons and pre-programmed to carry out specific tasks, could be used to perform surgery deep inside the human body through the vascular system or in conjunction with a catheter through the cavities of the body [2]. The use of robotic instruments in surgery, along with image-guidance systems and biosensors, allows for better navigation during procedures and results in greater precision.

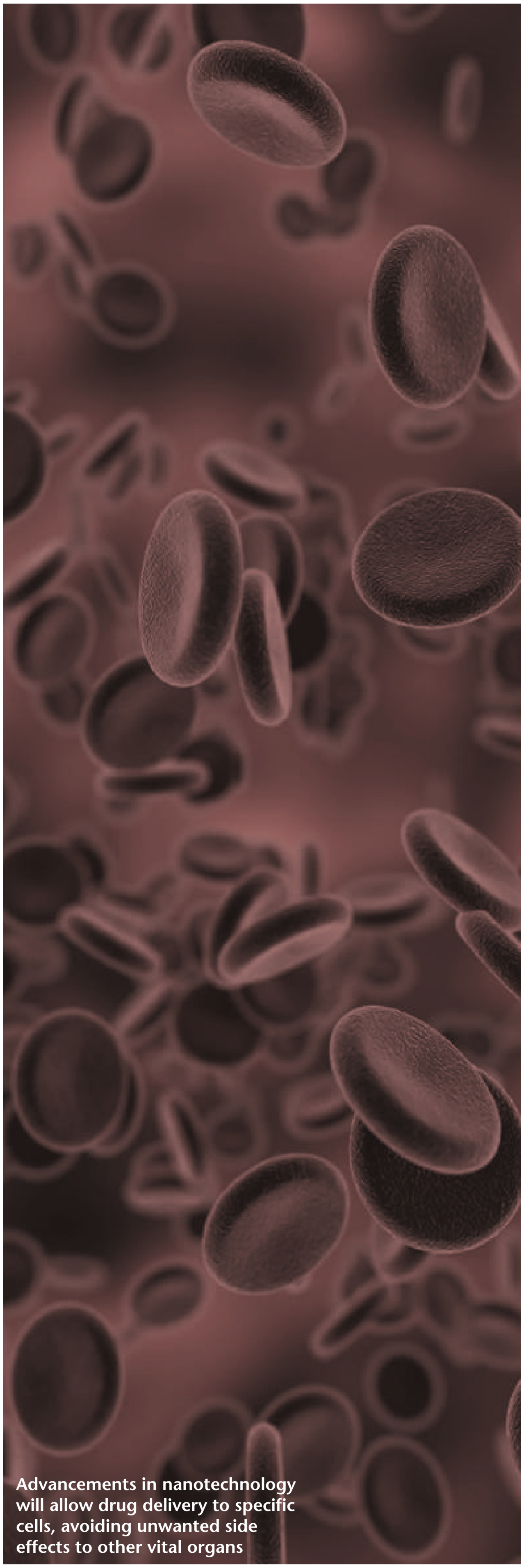
Much progress has been made in terms of understanding the human body... However, when it comes to medical surgery, it appears that there remains a mismatch between the task and the tool.

Nanoparticles for Targeted Drug Delivery

Recent advances in medicinal chemistry have led to the development of drugs that are effective in curing many diseases. However, scientists continue to be challenged to produce new generations of viable drugs that are more effective or can cure ailments that, up until now, are still unresponsive to existing drugs. Another challenge is dealing with side effects resulting from the use of some of these drugs, which sometimes can be serious. The severity of side effects depends on the illness, the type of prescribed drug, the dose, and overall medical profile of the individual receiving the treatment. For example, anticancer drugs are designed to attack tumor cells growing in the patient's body, often within vital organs. While some side effects are minor with short-term consequences, others can have prolonged effects and become life-threatening. In order to deal with this significant medical problem, scientists have developed tools, like carbon nanotubes, that bring needed medical therapies to the cellular level by utilizing nanoparticles that selectively deliver drugs to specific cells in the human body[12].

...[S]cientists have developed tools, like carbon nanotubes, that bring needed medical therapies to the cellular level by utilizing nanoparticles that selectively deliver drugs to specific cells in the human body.

Carbon nanotubes, discovered in 1991 by Sumio Iijima, are long,



Advancements in nanotechnology will allow drug delivery to specific cells, avoiding unwanted side effects to other vital organs

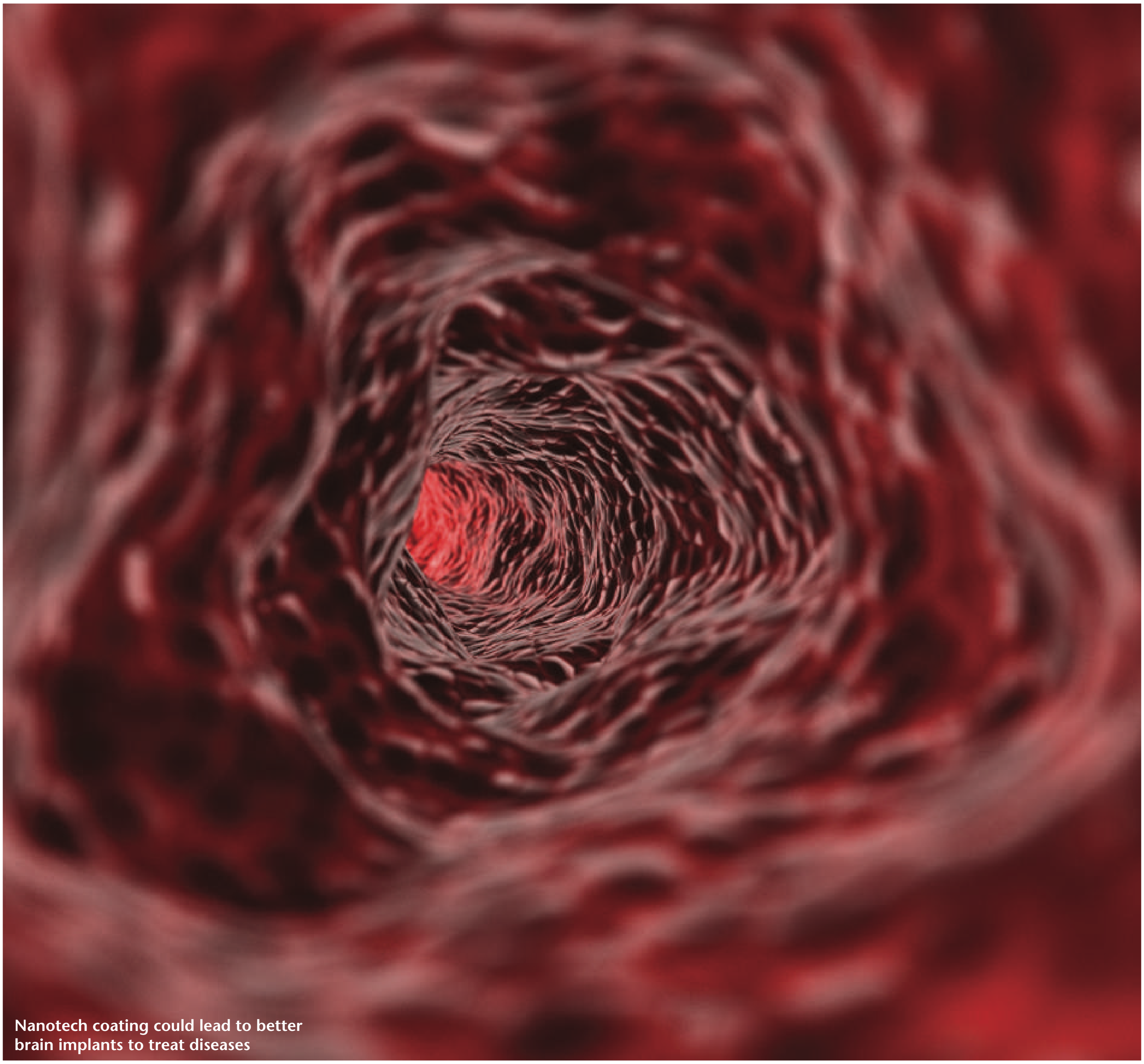
thin cylinders of carbon, unique for their size, shape, and remarkable physical properties [6]. Such use of nanoparticles for targeted drug-delivery has resulted in distinct improvements compared to traditional methods [9]. One reason for this is that the use of fine particles, which have more surface area per unit mass, will improve drug solubility and dissolution rate [11]. The effective carrying and dispensing of drugs deep into the body requires the development of a means, in this case a carbon nanotube, which is capable of encapsulating the drug molecule and, once it reaches a targeted tissue or cell, releasing it without causing toxicity to other healthy organs. In addition to drugs, carbon nanotubes have the ability to carry a variety of molecules including proteins, antibodies, and enzymes. The physicochemical features of carbon nanotubes, including their ultra lightweight composition, superior properties in electric current carrying capacity, thermal conductivity, and thermal stability explains their popularity as potential systems of drug carrying and dispensing.

The effective carrying and dispensing of drugs deep into the body requires the development of a means, in this case a carbon nanotube, which is capable of encapsulating the drug molecule and, once it reaches a targeted tissue or cell, releasing it without causing toxicity to other healthy organs.

Ethical Issues for the Use of Nanotechnology in Medicine

There is a wide belief, and indeed evidence, that nanotechnology promises many potentially positive developments for the future, especially in medicine and health. Understanding the toxicity of nanomedicines is an important factor in ensuring its promise for viable and effective therapies [8]. The question is how to accelerate the benefits of nanotechnology while diminishing its risks [1]. The medical profession has long been subject to its own code of ethics developed primarily for the benefit of the patient, but also of society, other health professionals, and itself. Until recently, such concerns rested principally with the physicians, presumably because the subject was considered to be complex and mainly of a scientific nature pertaining only to the domain experts. This has evolved over the last few decades as advances in medicine, such as the application of nanotechnology, engendered uncharacteristic attention to medical ethics on the part of society in general and ardent interest on the part of philosophers, theologians, and lawyers specifically. Changes ensued in how hospitals approach issues of life and death as evident in the presence of powerful ethics boards and in the incorporation of ethics as a subject of study into medical education. Bioethics, emerging as a result of these transformations, is viewed as an extension of medical ethics that concerns questions of basic human values [13]. Bioethics encompasses medicine, life sciences, technology, policy, philosophy, and religion. Clearly, bioethics is applicable to nanomedicine where scientific developments must progress in parallel with the careful consideration of ethical, legal and social implications. Current issues involving ethical consideration in the use of nanomedicine include regulating its use in therapeutic means versus life enhancements, assessing its known risks compared to desired benefits, ensuring the privacy and confidentiality of patient information, and weighing the environmental risks of nanowaste disposal.

Understanding the toxicity of nanomedicines is an important factor in ensuring its promise for viable and effective therapies. The question is how to accelerate the benefits of nanotechnology while diminishing its risks.



Nanotech coating could lead to better brain implants to treat diseases

Conclusion

Across the ages, the requisite ingredients to create the systems of value that have advanced our society on all fronts have always been thoughts, creativity, tools, and raw materials. This has been true in the stone tool, agricultural, industrial, and information societies. Presently, nanotechnology is a type of this human inventiveness that is emerging out of research and development efforts. Historically, and over the long run, societal progress appears to have occurred uniformly in all areas that matter to humanity. In reality, advances have tended to occur more in a focused fashion like industrialization in the 19th century or automation in the 20th century. If the first decade of the 21st century is going to be an indication of such focused advancements, it is likely that progress will be in healthcare, and in nanotechnology applications to medicine specifically, with innovations that will improve the welfare of many people and will enhance their quality of life dramatically. At the same time, and as with all new technologies, there are concerns regarding the tools and products of nanotechnology and their impact on the environment and, ironically, on public health. To realize the full benefits of nanotechnology and minimize its drawbacks, these concerns require considerations in parallel to the development and deployment of new technological inventions.

If the first decade of the 21st century is going to be an indication of such focused advancements, it is likely that progress will be in health care… with innovations that will improve the welfare of many people and will enhance their quality of life dramatically.

Matthew P. Deek is a second year undergraduate student studying biology at NJIT.

The safety of soldiers on the battlefield will be increased through technological advances in nanotechnology

Improving the Next Generation of Soldiers

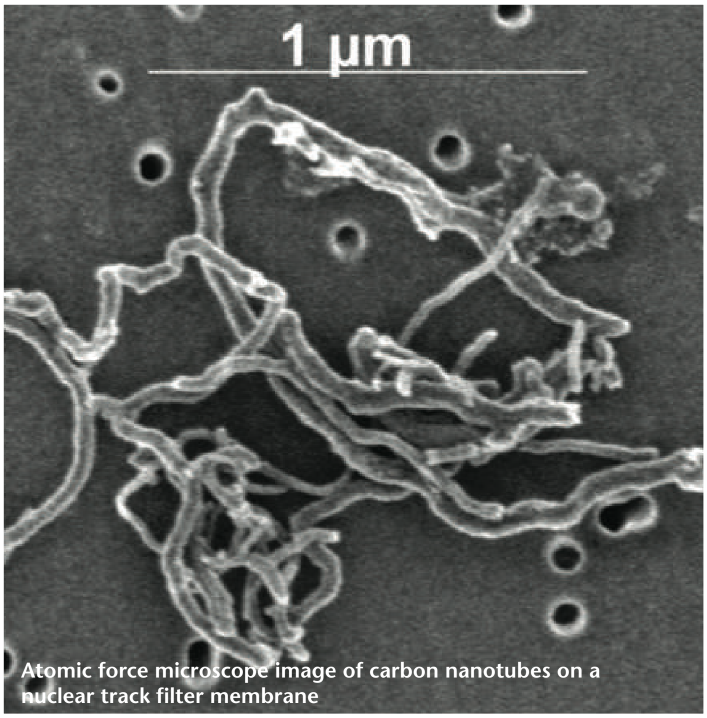
With advances in nanotechnology, today's soldiers are better equipped to face enemy bullets, chemical and biologial warfare, and sustain severe combat conditions

:: BY WASSEEM ABUGOSH ::

The growth of modern-day technology coupled with high demands for advances in battlefield equipment often accelerates the development of more efficient combat gear. On the battlefield, a typical soldier has much to worry about: bullets firing, detonation of nearby explosives, and the hazards of chemical and biological weaponry, just to name a few. In addition, a typical infantry soldier has to carry gear, which could weigh up to 150 pounds [1]. Fortunately, nanotechnology has given glad tidings of a day when the average infantry soldier can survive any type of chemical or biological pestilence. An array of bullets being shot at the chest of a soldier, for example, may no longer be considered a definite kill; the shards of shrapnel that have landed will merely be wiped off without inflicting any pain.

Nanotechnology has given glad tidings of a day when the average infantry soldier can survive any type of chemical or biological pestilence.

Today's soldiers are equipped with bullet-proof battle suits that are strong enough to repel bullets and knives. Researchers like associate professor of Industrial and Manufacturing Engineering at Florida State University, Okenwa Okoli, are always looking to improve the material of military apparel, to make uniform stronger and lighter. Okoli is working with carbon nanotubes to accomplish this mission. Smaller than human hair, carbon nanotubes are the strongest material known. They are delivered by buckminsterfullerene, a 60-carbon molecule formed by a network of carbon bonds. The structure looks like a spherical cage and is comparable in strength and stability to diamonds [3]. Okoli is working with the United States Air Force to perfect this composite material for parajumpers. Okoli explains that "the weight of the current body armor



Atomic force microscope image of carbon nanotubes on a nuclear track filter membrane

system they have… smacks them on the back… and the momentum of jumping from such a great height and the weight of the plates will throw them off target" [2]. Thus, a thinner and lighter protective material would be vital for such situations.

ApNano, an Israeli company, is working on a nano-based lubricant. Results from recent studies on this advanced lubricant in body armor have been impressive. The material withstood the shock pressures generated by the impacts of up to 250 tons per square centimeter from bullets traveling 1.5 kilometers per second. A similar study done by Professor J.M. Martin from Ecole Central de Lyon in France showed that under isostatic pressure, the material withstood 350 tons per square centimeter [2]. The carbon nanotubes from these experiments carry inorganic compounds such as titanium disulfide or tungsten disulfide. The network of covalently bonded carbon atoms encompassing these inorganic compounds make an extraordinarily strong shock absorbing material known as fullerene. This fullerene material is five times stronger than steel and twice as strong as any of today's protective armor material such as boron carbide or silicon carbide. Inorganic fullerenes are cheaper, easier to manufacture, and safer to use compared to organic fullerenes [2].

Paula Hammond, an associate professor at the Institute for Soldier Nanotechnologies at MIT, is working on materials that can detect and degrade such threats. She has created a multilayer polymer containing reactive agents. Each layer has alternating positive and negative charges so that each polymer layer binds to the one above it to form a nano-thin polymer chain.

Advances in nanotechnology for the military are not confined only to bulletproof protective armor, especially with the growing threat of chemical and biological warfare. Paula Hammond, an associate professor at the Institute for Soldier Nanotechnologies (ISN) at Massachusetts Institute of Technology, is working on materials that can detect and degrade such threats. She has created a multilayer polymer containing reactive agents. Each layer has alternating positive and negative charges so that each polymer layer binds to the one above it to form a nano-thin polymer chain. The reactive agents within the polymer will neutralize the chemical threat once it penetrates the polymer. These agents range from a simple titanium dioxide molecule that can deactivate nerve gas to a complex dendrimer which can consume mustard gas [1]. Also, the coating within the polymer is waterproof, so the soldier is protected from biological threats like E. coli. Hammond is also experimenting with genetically engineered viruses that can be placed on the top of each layer. If any harmful bacteria are placed on this material, the virus would take the initiative by infecting it leading ultimately to the bacteria's death [1].

Nano-machines would act as artificial muscles…[and] are designed to emulate the function and mechanics of a mammalian muscle.

The large amount of equipment carried by a typical infantry soldier can have a detrimental effect on his or her mobility. Researchers at the ISN are working on a nano-machine that could be constructed within the confines of an already prepared battle suit. These nano-machines would act as artificial muscles. They are designed to emulate the function and mechanics of a mammalian muscle. Ian Hunter, a researcher at the ISN, identified a few characteristics of flesh and blood muscles that the artificial muscle must have in order for it to be successful. First, it must have the ability to contract which is simple for Hunter's nano-machines. Human muscles produce 7310 pounds per square foot of pressure, a mark that Hunter's nano-machines can match. In addition, the nano-machine must be able to produce large forces while retaining its lightness. While the goal is 500 watts per kilogram, Hunter's nano-machines have reached only 50 watts per kilogram. Hunter states, "Our efficiency is somewhat less, but we're slowly bringing it up" [1]. Another characteristic is that it must have the ability to expand with force. The artificial muscle, as opposed to the natural one, is able to accomplish that feat. With this added strength, weapons could be mounted directly to the uniform system, making the soldier a weapons platform. These nano-machines would add 25-35% more power to each of the major lifting muscles which lead to an overall 300% greater load-carrying capability [1]. This would create a distinct edge over the opposing soldiers on the battlefield.

It is no secret that armies are always looking for an advantage over their enemies on the battlefield. The development of nanotechnology has opened a new window for improvement to ease the suffering and reduce the number of casualties of those on the frontline. If the progression of battlefield technology continues to accelerate, the infantry soldier will be more protected and better equipped for combat than before. A soldier will have a less load carry, thus increasing his or her chances of escape from danger and, ultimately, survival on the battlefield. It is evident that nanotechnology will strengthen tomorrow's soldiers as they fight to protect our freedom.

The development of nanotechnology has opened a new window for improvement to ease suffering and reduce the number of casualties of those on the front line.

Wasseem Abugosh is a senior undergraduate student studying chemical engineering at NJIT.

The natural path a golf ball takes after being struck by a golf club could be altered by modifications at the nanoscale

The Edge in Sports Gear

How innovative nanoscale technologies have allowed researchers to improve durability, efficiency and safety of athletic equipment

:: BY DAVID M. THOMPSON ::

What is it that an athlete fears most in a competition? Well, it is probably no longer just those athletes who consistently cheat and seem somehow to get away with it. Surely one of their main concerns nowadays is that their competitors are using better equipment. This is more frequently something an athlete has to worry about now because of the increasing role that nanotechnology is playing in sports so that previously unattainable targets suddenly seem within reach. With the continually developing reality of technological advances like carbon nanotubes, compressible materials, fullerenes, and polymers, it comes as no great surprise that athletes today are very concerned about being outmatched by the astonishing capabilities of nanotechnology in sports.

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If you have ever ridden a bicycle uphill, you know what an effort it takes to reach the top. It is no secret that the ease of riding a bicycle is inversely proportional to its weight. In competitive environments, cyclists need not only the lightest, but also the toughest and most resilient bike. That is why Zyvex Corporation, one of the first nanotechnology-based companies, has introduced carbon nanotube technology in the manufacture of its bicycles.Carbon nanotubes are long strings of carbon chains connected

Nanotechnology is beginning to appear in one of the most essential, yet enjoyable aspects of human life, food. When applied to food, this microscale application allows for the specialization of particles and making nutritional content very precise. It also allows for the enhancement of taste of ordinary ingredients, without additional content. This application lends itself to a brand new field of food engineering. Nanotechnology is already present in many of the foods we sample. For example, canola oil has been modified to reduce cholesterol levels through a technology called nanosized self-assembled structural liquids [3]. The idea is to maximize functionality of oil while minimizing the concentration of fatty acids; there is a reduced health risk without extra consumer effort. Packaging of foods has also been affected by this latest trend, with the use of nanolayers [10]. The layers act as protective barriers for products, preventing the diffusion of gases and moisture across these simulated membranes. Nanotechnology can address problems such as food inequality, nutritional deficiency, spoilage and packaging. It can also enhance flavors and make for a better, healthier population.

When applied to food, [nanotechnology] allows for the specialization of particles and making nutritional content very precise.

With nanotechnology research blooming, there emerge more and more methods of using it in order to augment food. Due to the novice nature of this new technology, its use within the world of food has been minimal up until now. The advantage of microscale material is that it allows for highly accurate results. It becomes possible to allocate specific materials into specific locations, as with nutraceutical delivery. Nutraceutical delivery is concerned with the delivery of foods to have more efficient effects on the human body. Nanotechnology can slow the genetic modification of the common bases of cells and manipulate their differentiation. Lipids, organic water-insoluble compounds present in most foods, can be rendered into hydrophilic molecules, which normally distance themselves from lipids; that is, it can allow for hydrophobic molecules to be water-soluble. Recent nanotech innovation even allows for the stabilization of light and oxygen sensitive beta-carotenes before its addition to foods for coloring. These beta-carotenes can be reformulated to be lipid soluble with the addition of a nano-structured lipid layer which allows the new product to be dispersed in beverages [5]. This could potentially allow for the nanoparticles of functional components to be dispersed well enough for maximum bioavailabilty.

The small nature of nanotechnology allows scientists to have a better understanding of how certain molecules are structured and how they interact. This knowledge allows scientists to manipulate existing materials and apply these results into healthier, more nutritious food. The possible benefits of this groundbreaking field are unprecedented, to say the least. The technology seems to be at the frontier in revolutionizing the world of food, and taking it to a level that is seemingly science fiction. Nanotechnology can potentially lower input costs and increase productivity. Companies globally are starting to accept this new innovation and reap the benefits. The most technologically advanced countries are working on improving the taste and the nutritional value of foods while others are using nanotechnology in agricultural food production. Improving inventory storage helps ensure that enough food can be produced for an entire population. One must also look at the indirect effects of nanotechnology such as improving water resources and allowing for easier purification and desalination [9]. Clean, drinkable water is essential for harvesting, and also for human sustenance. The absence of clean water is a problem that plagues many developing countries and underserved populations today. With the aid of this technology, clean-water deficiency can be a problem of the past.

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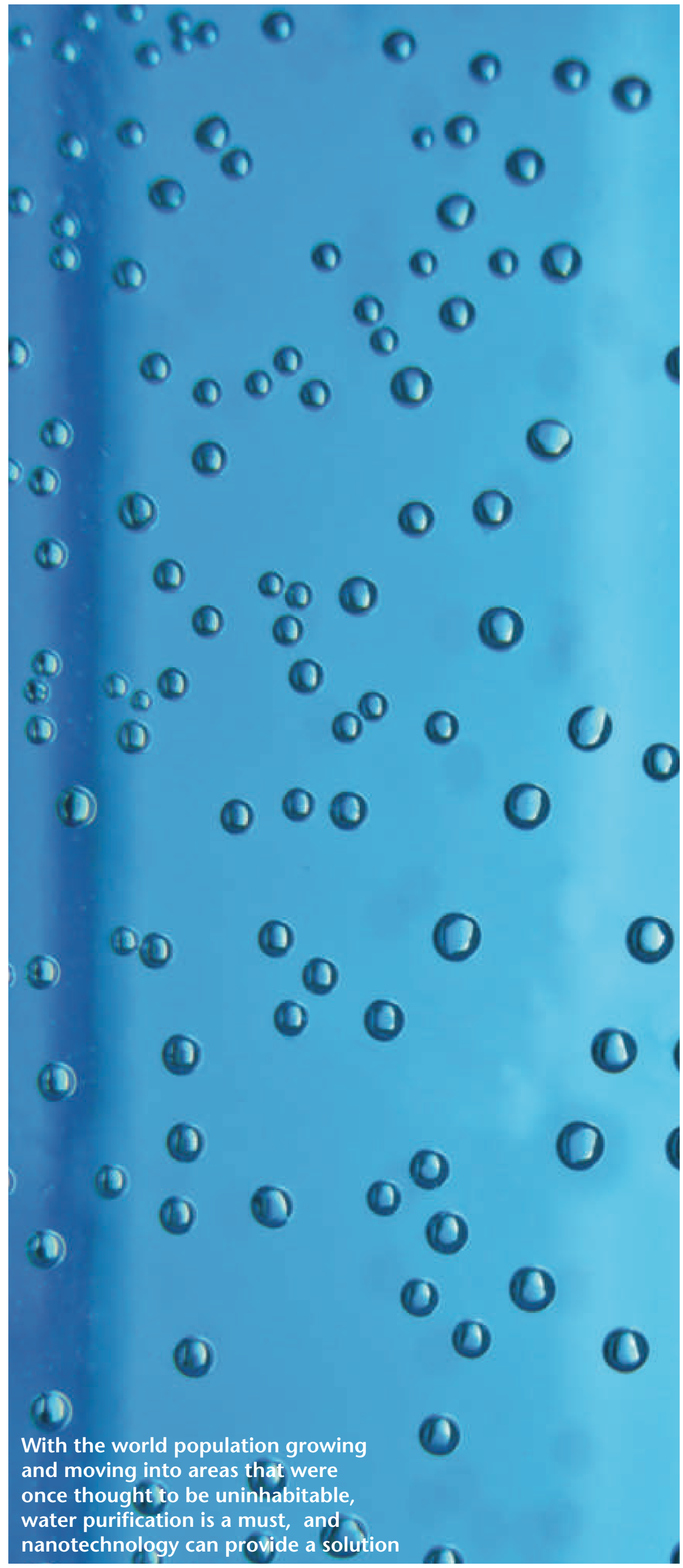


With the world population growing and moving into areas that were once thought to be uninhabitable, water purification is a must, and nanotechnology can provide a solution

Direct injection of vitamins and nutrients could increase health benefits without changing taste

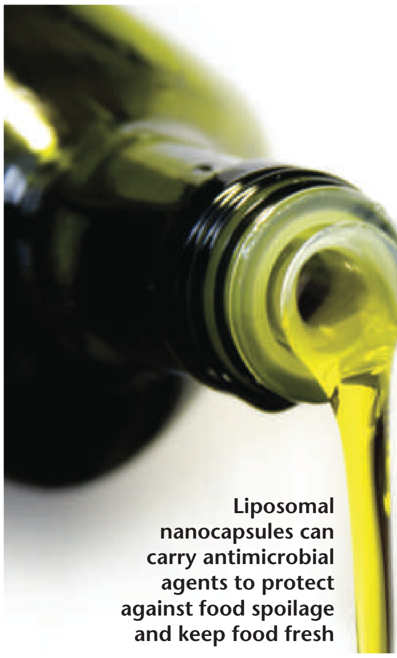
A recent trend is nutritious packaged foods. Nanotechnology can enhance this and create even better, healthier products. Nanocapsules are an important feature making its way into the food industry. Sometimes referred to as minute micelles, these capsules can be injected with substances such as antioxidants, essential vitamins and minerals, antimicrobial compounds and many more compounds which would allow for the direct consumption of these beneficial parts [2]. Once again, lipids have played an important factor in nutritional nanotechnology. Liposomal nanocapsules are the main components that have been used in the food industry. They have been capable of delivering food flavors and nutrients to foods that may have originally lacked high nutrition and flavor value. More recently, these capsules have been found to be adept at injecting important food antimicrobials. This would significantly reduce spoilage and keep foods expected to decay fresh. These capsules can also protect against pathogenic, or disease-causing, microorganisms [13].

Nanocapsules...can be injected with...antioxidants, essential vitamins and minerals, antimicrobial compounds and many more compounds which would allow for the direct consumption of these beneficial parts.

Agricultural advancement does not limit itself to simply production but it is beginning to be used within the breeding of plants. DNA-informed breeding of plants uses nanotechnology to omit unwanted characteristics of plants and mass-produce positive, desired traits. While it is true that this application is still in its infancy, it is expected to be a colossal breakthrough for fresh produce. It can create barriers for harmful substances and provide pathways for better nutrients and can even act as a simple indicator, signaling in different colors when pathogens or dangerous microbes are detected [11]. Following the pattern of metal detection, where semiconductors and magnets are used to detect inorganic matter, nanotechnology uses nanocrystals, microscopic particles which can detect biological matter on a microscopic level. This detection can be achieved with the use of "quantum dots", a three-dimensional grouping of atoms which contain discrete electronic energy levels. What makes these dots even more distinctive is that they are typically the size of a protein, which has led scientists to realize that they could be injected into cells. Quantum dots also have the ability to tune broad wavelength, and their photochemical stability makes them quite useful in biological labeling [1] .

Globally, this technology has sparked interests in scientific, economic, and even national defense arenas. The United States government has begun developing nanotechnology as a possible means of chemically recognizing potential threats to the food supply with nanorobots, also called nanobots. Dutch scientists are working on methods where these nanobots can sense when food is about to spoil, which consequently releases preservatives to extend the shelf life. There are also technologies being developed which involve maintenance of food containers. There are nanocomposites which are molecular barriers that can trap the oxygen within water bottles to ensure that the consumer receives the maximum oxygen, increasing efficiency. Worldwide interest in this technology has increased nine-fold between 1997 and 2005 as observed by the increased investments in the business. It has reached beyond just scientific innovation and has entered into the category of commercial

Dutch scientists are working on methods where...nanobots can sense when food is about to spoil, which consequently releases preservative to extend the shelft life.



Liposomal nanocapsules can carry antimicrobial agents to protect against food spoilage and keep food fresh

business. It is expected that by 2015, there will be over $1 billion of nanotechnology incorporated into products [8]. This specific technology is currently valued at about $410 million and is expected to grow to over $5 billion by 2012 [4]. Scientific discovery is on the verge of creating products that can be comparable to those of Willy Wonka, Roald Dahl's fictional entrepreneur in *Charlie and the Chocolate Factory,* who had the ability to make gum taste like a three-course meal. Although many of these applications are still in their nascent stages, there is little doubt that technological momentum will play its role in advancing these processes to the point where it is feasible for everyone. Perhaps the greatest obstacle lies in the funding for the research of these innovations; the methods of production themselves are not always expensive and in some cases are less expensive than the currently used process.

There are criticisms of this new technology, as with any technology, that these new methods of food production may interfere with what the human body is accustomed to through evolution. Though there is insufficient scientific data to support the claim, that humans should not injest these compounds, there are genuine concerns. There are worries that while nano-functional foods may address one nutritional deficiency, they could omit another. There are also worries of the effects of nano-packaging of foods on the overall health of the population, but as with all new developments, research is proactively conducted [7]. Scientists aim to better human lives with these technologies, to make them more accessible and more feasible to the public. Nanotechnology promises a revolution in the food world because it would allow for the management of the desired and the omission of the unwanted and deadly. Nanotechnology in food involves aims to make human life healthier in a much easier fashion. It could potentially eliminate all toxins and render foods free of pathogens and work towards a healthier society. It has been accepted and welcomed not only by the food industry but also by the public. Social trust by the public has been granted and has in fact been an influential factor in the development of this Willy Wonka technology [12]. These technologies are being put into place in hopes of creating a healthier, more flavorful future, a future where a small meal can have the filling and palatable effect of a three-course dinner.

Nanotechnology promises a revolution in the food world because it would allow for the management of the desired and the omission of the unwanted and deadly.

Bushra Hossain is a third year undergraduate student studying biomedical engineering at NJIT.

In Vivo Disease Diagnosis by Nanorobots

How nanorobots can detect, diagnose and treat diseases *in vivo*

:: BY FATIMA ELGAMMAL ::

What do you get when you merge the diagnostic prowess of Gregory House, M.D. with the technological adeptness of Optimus Prime into a device that can be smaller than the width of a single strand of hair? The answer: medical nanorobots [3]. Nanotechnology made its medical debut through drug-delivery and minimally invasive surgery within the last decade. However, there is a new motivation to utilize this nascent biomedical application: reducing the spread of infectious diseases to prevent the onset of an epidemic. When research into minimizing the spread of infectious diseases expanded into the ecological and evolutionary disciplines, the need to record time series of data continuously has become imperative [7, 13]. Nanorobots provide a much-needed feature of disease control: to record relevant data, such as antibodies that are present during an immune response, in real-time.

By recording data in real-time, nanobots can be used to control diseases from spreading

The Role of Nanorobotics in Nanobiotechnology

Nanorobots were first described in K. Eric Drexler's 1987 *Engines of Creation: The Coming Era for Nanotechnology*. Just as cells contain their own tools and machinery to function and repair cellular damage, Drexler predicted that an artificial system can be programmed to carry out similar basic tasks. Such a system will need the ability to access cells, recognize molecules by specialized sensors, disassemble damaged molecules, rebuild molecules found in the cell, and reassemble every system in the cell [6]. While this may be a tall order for a dwarf-sized device, achieving this goal is closer than it seems.

As nanoengineering fine-tunes the instruments wielded by the professional, tasks can be adjusted to more precise levels. Robots can be programmed to carry out routine tasks. Couple this capability with the miniaturization of sensors and generators, and nanobots can be introduced into the body to perform procedures accurate to the molecular level [10]. The NanoRobotics Laboratory at Carnegie-Mellon University in Pittsburgh, PA is developing microcapsules that can be ingested and positioned in the small intestine to provide clinicians with a way to diagnose endoscopic diseases without patient sedation. Once in the gastrointestinal tract, movement of microcapsules is controlled by the clinician to propel them to the desired site, where they can anchor to the lining and release drugs or chemicals for treatment [11].

A Nanobot in the Making

Volatile microenvironments of biological systems demand that nanobots be sensitive to fluctuating chemical concentrations and mechanics of cellular function while maintaining the integrity of surrounding elements and not triggering the immune response against the nanobot. Adriano Cavalcanti of the Center for Automation in Nanobiotech (CAN) in Melbourne, Australia has been studying the requisite architecture and hardware to enable such a device for biohazard defense. Cavalcanti's "medical nanobots" employ actuators, or mechanical devices that operate a mechanism, that are supplied with electrostatic, electromagnetic, or electrothermal inputs [12]. In addition, scientists at CAN have implemented software, the Nanorobot Control Design (NCD), to simulate the chemotactical response by the nanorobot using real clinical data. These devices are fitted with sensors to monitor chemical parameters and relay signals through a radio frequency identification device located on the same nanobot [3].

Recent developments have made side-stepping the issue of power supply less obtrusive. Zhong Lin Wang, a Regents professor at Georgia Institute of Technology's School of Materials Science and Engineering, along with his research team, demonstrated a self-powered nanogenerator that draws its power from mechanical energy. The nanogenerator consists of wires made of zinc oxide and can produce up to 1.2 volts. Any strain on the wires can produce

electrical charges, and the current generated from the flow of electrical charges can power the devices. The nanogenerators can measure ultraviolet light as well as the pH of the environment since both factors produce a change in voltage amplitude that the nanosensor can detect [15]. Combining the ability to self-power these small devices can allow nanorobots to work sustainably and independently without requiring an external energy source.

The Case for a New Public Health Defender

In 1948, the World Health Organization began a program to centrally profile influenza viruses as a stride towards containing infectious diseases. While there has been much progress in creating vaccines and establishing immunization regimes, not enough has been done to proactively address population-wide outbreaks. To effectively control emerging public health crises like epidemics, health metrics need to include advanced real time data. Nanorobots equipped with biosensors can be modified to detect concentrations of molecules that are secreted by cells when they are invaded by pathogens. The nanorobot can then transmit data of its location and biochemical parameters to an external central database system via RFID [3]. Since the overexpression of certain molecules is signature to a local response, infected individuals can be treated before they display symptoms. In some cases, symptoms are manipulations created by pathogens in order for them to be transmitted to the next host [7]. By cutting short the onset of symptomatic reactions, disease-causing organisms are at a disadvantage for replicating and passing on to more individuals.

Public Perception

Even with the formal retraction of the 1998 paper published by the medical journal *Lancet* that linked vaccinations to increased risk of autism developing in children, there is a significant portion of the general public who remain skeptical about using vaccines or antibiotics to treat illnesses [4]. The advent of nanorobots in detecting and treating disease allow patients with the ability to control their own health become more informed [2]. Nanotechnology allows for health maintenance, observation, and, most importantly, early disease detection. Nevertheless, the idea of hosting small devices inside the body is disconcerting to many because the field is new and problems of such sophisticated machines are unforeseen. These concerns on the social and ethical issues of nanotechnology, and more, were expressed in a 2005 report issued by the Agribusiness and Economics Research Unit in New Zealand. The report detailed the thoughts of focus groups, which admitted the cost-effectiveness of self-diagnoses by nanorobots, but communicated distress that such devices can be harmful or, conversely, augment human abilities [5]. All in all, the discussion of biological pairing of nanorobots is a discourse that will influence their development.

Conclusion

Using nanorobots for in vivo disease detection adds magnitudes of efficiency in health monitoring. Current trends in nanobiotechnology enable nanobots to self-generate power, sense fluctuations in chemical concentrations, and even dispense drugs for treatment, at least in theory. Their implementation can increase the reaction time for public health strategies and target areas for treatment and containment. However, medical nanorobots must trounce the technological and social barriers in order to attain their potential as a biohazard defense technology, and a lead innovation for a healthier tomorrow.

Fatima Elgammal is a senior undergraduate student studying applied math and biology at NJIT.

New Jersey Institute of Technology In Action

PHOTOGRAPHER: BABAJIDE AKEREDOLU

NJIT lives up to its designation as New Jersey's Science and Technology University in the classroom as well as the laboratory. Cutting-edge projects are carried out by NJIT faculty with both passion and dedication. The competitive funding obtained in support of these initiatives is at its highest level ever. In fact, total research expenditures for this fiscal year are expected to top $100 million. The success in the laboratory is translated to the classroom by the faculty to the students in real time, benefiting the entire learning community on campus. NJIT, reports The Princeton Review, "stands today as one of the nation's most prominent research schools, specializing in nanotechnology, solar physics, and polymer science...and retains its reputation as New Jersey's top choice for the hard sciences." NJIT has seen the benefits of its commitment to establishing successful departments in the fields of engineering, management, biological sciences, and mathematics. The fruits of this labor can be seen in the faculty mentioned here.

Studying the Principles of Marketing on a Global Scale

:: BY BISHOY R. HANNA ::

Rajiv Mehta
Associate Professor of Marketing
School of Management

In periods of economic hardship, such as the one we are experiencing today, research in management and marketing sales should be stressed, but few scholars have pursued such research. One Drexel graduate and current New Jersey Institute of Technology professor, Dr. **Rajiv Mehta**, is conducting research in both these fields. Through the use of NJIT's Van Houten Library along with various survey companies, Dr. Mehta is leading his colleagues in conducting current and detailed research in the fields of Marketing Channel Management (MCM), Selling and Sales Management (SSM), and Strategic Alliances in International Distribution Channels (SAIDC).

[Mehta] is using [SAIDC data] to determine if factors such as trust, relationship closeness, relationship commitment, learning orientation, and strategic integration— all central facets of successful alliances— are statistically significant predictors of cooperation.

With regards to MCM, Dr. Mehta has applied the Path-Goal Theory of Leadership, and the Expectancy Theory of Motivation to channel member (also known as wholesalers, or distributors) behavior. In doing so, he has concluded that participative, supportive, and directive leadership styles heightens cooperation, attenuates conflict among channel participants, as well as encourages channel partners to exert higher levels of motivation. To apply his ideas on a grander scale, like international markets, Dr. Mehta is looking at whether the transferability of marketing channel management practices across international markets is possible. "More specifically, I have investigated if the standardization of international marketing channel management strategies and practices is feasible, or do differences in culture make it contingent for firms to adapt channel management strategies. "

Dr. Mehta has not only been able to conduct research in MCM, but also Selling & Sales Management (SSM) and Strategic Alliances in International Distribution Channels (SAIDC). Using the experience that he gained from working at Usha Martin Industries, Ltd., Dr. Mehta is now attempting to address varying SSM issues such as how to better select, train, and increase performance of sales managers. With the partial help of funding obtained from a Small Business Innovation Research (SBIR) grant, Dr. Mehta has been successful at gathering data from the U.S., Finland, Poland and China that he is using for his research on the topic of SAIDC. He is using this data to determine if factors such as trust, relationship closeness, relationship commitment, learning orientation, and strategic integration—all central facets of successful alliances—are statistically significant predictors of cooperation. In addition, he hopes to investigate if the extent to which distribution channel partners cooperate and coalesce leads to the desirable outcomes of relationship satisfaction, alliance longevity and, in turn, a high level of firm performance.

Dr. Mehta has been the recipient of the Master Teacher Award and the Henry J. Leir for Best Working Paper Award. He instructs graduate and undergraduate courses in marketing at NJIT's School of Management.

Applying Mathematics to the Study of Life

:: BY SHEBA S. KHAN::

Horacio Rotstein
Assistant Professor
Department of Mathematical Sciences

Dr. **Horacio Rotstein** has mastered many sciences, two of which include biology and math. Dr. Rotstein studies oscillations in the brain at the cellular, molecular, and network level. Particularly, he focuses on the dynamics of the brain, how learning occurs, and how memories are stored and retrieved using rhythmic oscillations. These rhythms are found in the hippocampus and entorhinal cortex (EC). Frequency bands of the brain's rhythmic oscillations are recorded using an electroencephalogram (EEG). These rhythms have been found to be connected to many different cognitive and behavioral tasks, including memory, learning, and spatial navigation. Dr. Rotstein uses the reduction of dimensions technique to produce nonlinear, multi-scale biological models that describe the oscillatory patterns found in the brain.

Test animals are induced to have an epileptic attack, and the bioelectrical response produced is compared to the model using various wave analysis methods. In epileptic patients, the cells become hyper-excited just as the person goes into shock. Dr. Rotstein studies why this occurs, and what sort of oscillatory patterns epileptic attacks disrupt. In the models, there is no difference between, or damage, to the individual cells. Though the cells found in this region have the potential to be hyper-excited, conditions are adjusted such that they do not. This rules out a problem at the sub-cellular level; the problem, then, takes place at the level of interactions between cells or between networks of cells. With the use of biophysical, biological and mathematical modeling, the impact of these rhythms is studied at the sub-cellular, cellular, and network levels, and it is here that the impacts of Dr. Rotstein's research becomes readily apparent. By understanding and correctly representing the normal behavior of cells as well as their excited behavior with mathematical models, Dr. Rotstein is able to extract what the variation is at the different previously named levels. By understanding how a healthy brain generates rhythms, the brains that do not function properly can be studied, and ultimately assessed for treatment.

At the cellular level, Dr. Rotstein focuses on the stellate cells (SC), a type of neuron, which exhibits mixed-mode oscillations that produce interspersed spikes. The corresponding model of this phenomenon uses the minimum frequency of the SC, which mimics the mixed-mode oscillatory patterns. By studying the underlying structure of this model, as well as others like it, the patterns at the subcellular, cellular, and network levels allow for the determination of how SCs process and integrate information.

Understanding the natural mixed-mode oscillatory patterns enables researchers to forecast the way the brain can generate other patterns and rhythms. Dr. Rotstein's research of these behaviors can be extended to human navigation issues, as well as the role these waves play on epileptic patients.

Dr. Horacio Rotstein is an assistant professor at NJIT's Department of Mathematical Sciences and researcher at Rutgers University and the University of Medicine and Dentistry of New Jersey.

Looking Towards the Sun to Study Our Earth

:: BY PETER BESADA::

Haiming Wang
Distinguished Professor, Department of Physics
Director, Space Weather Research Lab
Center for Solar-Terrestrial Research

The influence of the sun on the earth environmental conditions is known as space weather, and it is also the subject of Dr. **Haimin Wang**'s research at the Center for Solar-Terrestrial Research at NJIT. Space weather is more sophisticated than normal atmospheric weather because it affects the magnetic fields around the earth, composition of the atmosphere, communications, safety of astronauts, power grids, and even oil pipes. Thus, the need to understand and predict solar activity is important to our society. By measuring the magnetic field of the sun and its orientation, the topology of the Sun's surface can be better understood, allowing for the prediction of solar eruptions. By working alongside the members of NJIT's Department of Computer Science, Dr. Wang and his colleagues developed an algorithm that can detect and classify solar activities such as flares and solar prominences efficiently and automatically. This algorithm works in three stages. In the first stage, images of the surface of the Sun are taken at one minute intervals. Each frame is processed individually and the limb or disk object in each frame forms a vector. In the second stage, the vectors from each frame are piled up in time sequence to form a time map. In the final step, properties of each object, such as brightness, velocity, width, and height are all measured. A machine called the Support Vector Machine Classifier (SVM) differentiates the limb objects.

Dr. Wang's algorithm also has many applications outside of solar physics. He is writing a proposal in conjunction with the University of Medicine and Dentistry of New Jersey to adopt his algorithm to detect and predict aneurysms, which can cause blood vessels to burst. Numerous experiments show that the algorithm works successfully with the exception of only a few insignificant eruptions being misclassified. Despite the near precision of the algorithm, Dr. Wang continues to work closely with Department of Computer Science to constantly improve the software.

In addition to his world-class research, Dr. Wang also takes time to mentor students. At the moment, he has four PhD students working with him as well as several undergraduate students. Due to the large amount of data being collected, more people are needed to analyze the data. By digitizing data collected from 1967-1995, approximately 15 million frames, a more complete set of data is acquired, thus having a greater probability of fitting a more precise algorithm and enhancing the predictions of future solar eruptions. Dr. Wang's research has already had a profound impact on his field and more is undoubtedly to be expected to come in the following years.

Dr. Haimin Wang is the 2009 recipient of the NJIT Excellence in Research Award. For more information on Dr. Wang's space weather research, or to observe solar prominences in real-time, visit http://swrl.njit.edu

Modeling the Movement of Animals at the Speed of Life

:: BY MATTHEW P. DEEK::

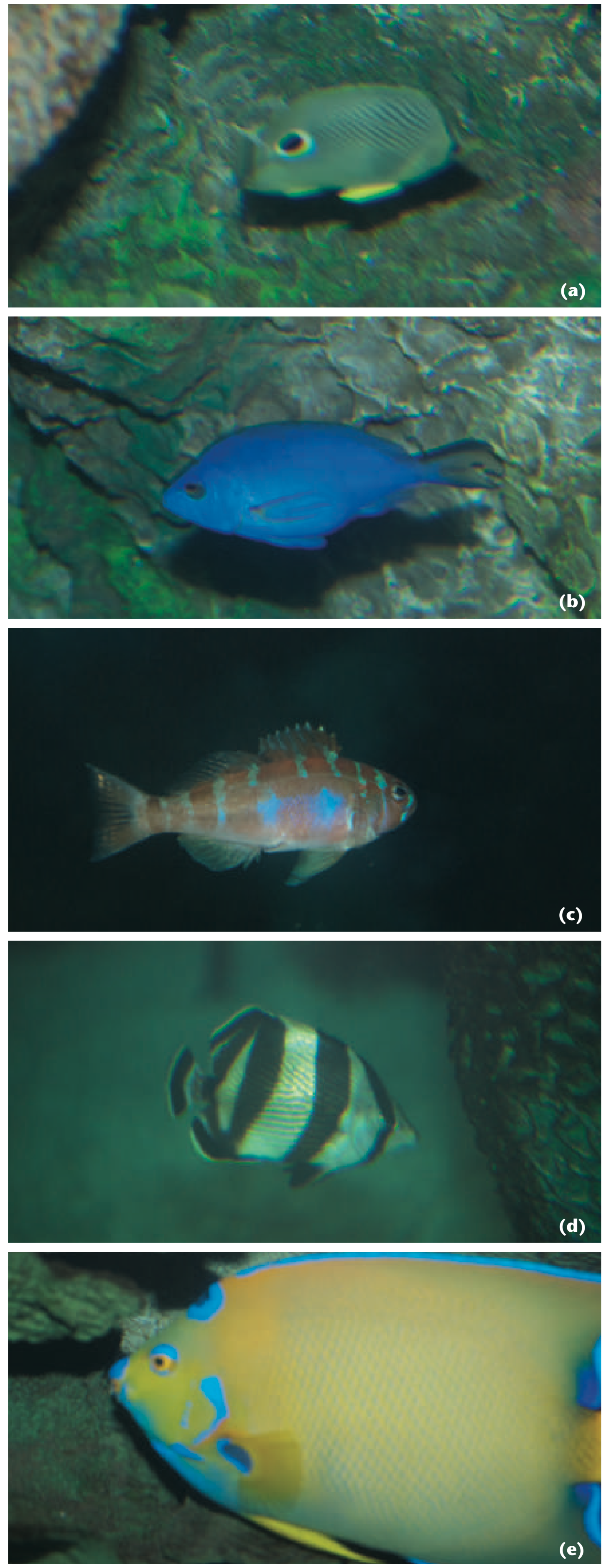
Gareth Russell
Assistant Professor
Federated Department of Biological Sciences

A quick investigation of the academic programs at NJIT shows emphasis in the physical sciences, engineering, and architecture. Ecology might not be a subject that first comes to mind, but Dr. **Gareth Russell** of NJIT and Rutgers's Federated Department of Biological Sciences is thriving in the field. An assistant professor trained in zoology, Dr. Russell employs mathematical ecology in much of his research. One project Dr. Russell is working on is to analyze how organisms move around the landscape in their habitat. Current math models make the simple assumption that movement of animals is random or that there are patches of landscape that organisms either completely avoid or are always drawn to. However, for many organisms like elephants, which have decision-making abilities, this is not true. Currently, many elephants are fenced into areas much too small for their growing numbers. These elephants need more space to live so Dr. Russell creates mathematical models in order to predict which areas in the surroundings would be most beneficial. Data collected from the elephant's movement within their current habitat is used to forecast where an elephant might choose to live based on location of resources, the surrounding environment, and contact with humans.

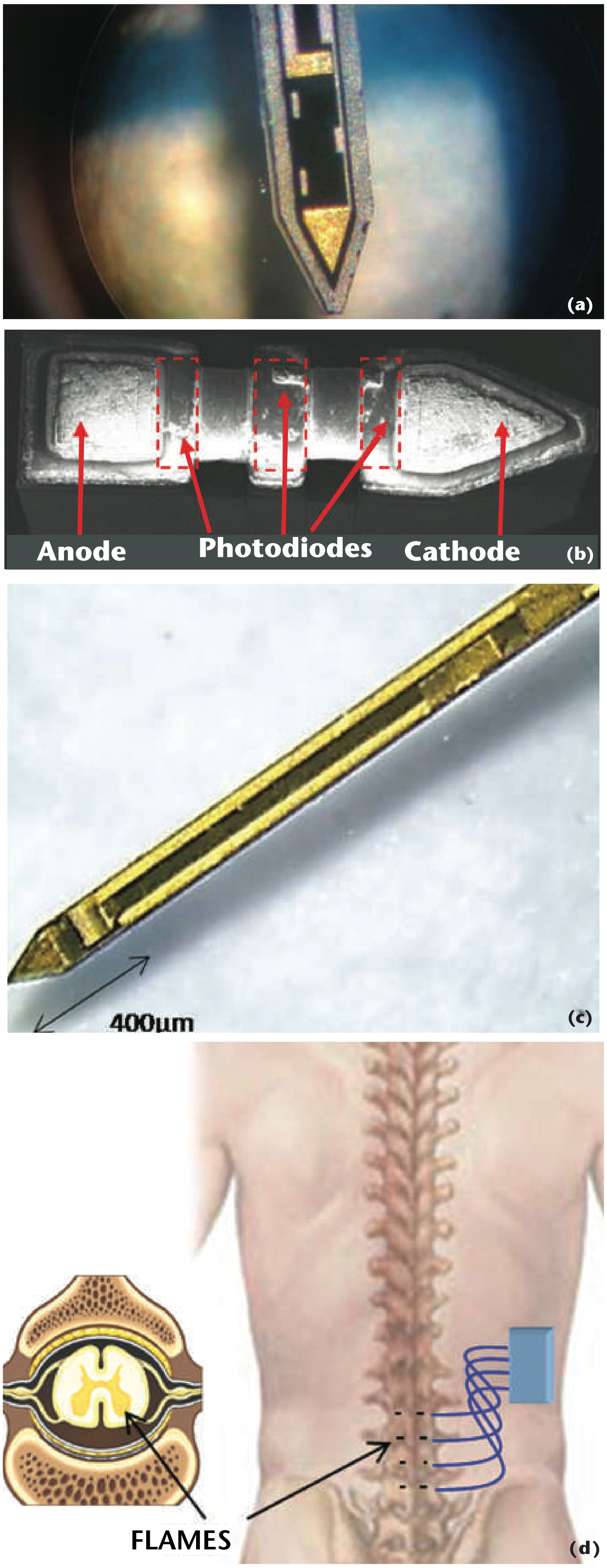
Current math models make the simple assumption that the movement of animals is random...However, for many organisms, like elephants, which have decision-making abilities, this is not true.

Another current project involves an underwater camera to count and identify species of coral reef fish. With the help of Dr. Joseph Wilder from the Center for Advanced Information Processing (CAIP) of Rutgers University-New Brunswick, Dr. Russell has been able to write a computer program that can identify different species of fish from the simultaneous input of two cameras. The camera is presently being tested at the New York Aquarium in Coney Island to work out the kinks. This method of automated data collection allows for rapid detection of changes in species dynamics, which can serve as an early warning system for threats against the coral reef population. The plan is that this summer the camera will be installed on a coral reef off the coast of Belize. Data collected will give valuable information about the population sizes and dynamics for many species of fish.

For more information on Dr. Gareth Russell's research, visit http://web.njit.edu/~russell.



Photos of (a) Foureye Butterflyfish, (b) Blue Chromis, (c) Chalk Bass, (d) Banded Butterflyfish, and (e) Queen Angelfish, taken at the New York Aquarium. An underwater camera is being tested to identify and keep count of species of fish.



(a)-(c) FLAMES device, designed and fabricated in collaboration with Dr. Selim Unlu's lab at BU's Photonics Center
(d) Region of spinal cord where FLAMES would be inserted

Engineering a Way to Walk Again

:: BY BISHOY R. HANNA::

Mesut Sahin
Assistant Professor
Department of Biomedical Engineering

For the past eight years of his academic career, Dr. Mesut Sahin has been researching Floating Light Activated Micro-Electrical Stimulators (FLAMES), a potential treatment for those with varying degrees of paralysis. This project has not only required a great deal of time for Dr. Sahin, an assistant professor of Biomedical Engineering at NJIT, but has also drawn long and extensive hours of work from Dr. Selim Unlu, professor of Electrical and Computer Engineering at Boston University (BU), and undergraduate and graduate student collaborators from both universities. Dr. Sahin and all those who work in his lab are currently studying various aspects of this project, which include computer modeling, microfabrication, and the devices in a chronic rat model, while Dr. Unlu's group has primarily focused on fabrication of the devices. All this work has been funded by the National Institute of Health (NIH)/National Institute of Neurological Disorders and Stroke (NINDS) Neural Prosthesis Program. What has managed to encourage the NIH to support this project is its originality. While previous attempts to activate neurons in the spinal cord included a direct line of contact from an external device to the spinal cord, the FLAMES project is the first to attempt to remotely activate the neuron.

Essentially, FLAMES is a small device that is remotely controlled by an external unit via a near-infrared laser. The FLAMES device is implanted into the spinal cord, and is then allowed to float in the tissue with no wires attached. Possible outcomes of allowing the device to float and not placing it in a stable position have yet to be studied by Dr. Sahin. However, he intends to carry out various experiments in a rat model to fully understand what the outcomes may be. Some parameters of the device are known, such as the upper limit of light power that can be used to activate the device before tissue heating effect becomes a problem. Once this device is completed and made available in the clinics, people who may have been told that "they will never be able to walk again" can potentially use their legs again. The patient would send the command to the external unit to activate the laser, the laser would excite the FLAMES device, which would in turn stimulate the neuron via an electrical current. Although FLAMES is still being tested in animals, Dr. Sahin hopes that one day in the near future humans will be able to enjoy the benefits of his work.

Once this device is completed and made available in the clinics, people who may have been told that "will never be able to walk again" can potentially use their legs again.

More information of Dr. Mesut Sahin's FLAMES research can be found in the 2009 Conference Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

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[Designed by Horane Henry and Fatima Elgammal]
Image of contact lens circuit
<http://www.technovelgy.com/ct/Science-Fiction-News.asp?NewsNum=1409>
Image of nanomotors
<http://www.ecofriend.org/entry/eco-tech-university-of-florida-researchers-develop-photon-powered-nanomotors/>
Image of neurons firing
<http://www.sciencedaily.com/releases/2008/01/080130092102.htm>
Image of red blood cells
<http://www.lifeshare.cc/docs/red%20cells.jpg>

"Celebrating 10 Years"
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Message from the Dean
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Image of molecule sequence
< http://www.somewhereville.com/blognano/dgallis_nanogallery_sdn_dx_large.jpg >
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x 06 Image of the top of the space elevator
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x 07 Image of concept art of the space elevator
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x10 Image of blood cells
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The Edge in Sports Gear : David M. Thompson

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***In Vivo* Disease Diagnosis by Nanorobots : Fatima Elgammal**

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New Jersey Institute of Technology in Action

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x 29 Image of Horacio Rotstein <http://web.njit.edu/~horacio/>
x 29 Image of Haimin Wang, Photographed by Romer Jed Medina
x 30 Image of Gareth Russell, Photographed by Romer Jed Medina
x 30 Images of (a) Foureye Butterflyfish, (b) Blue Chromis, (c) Chalk Bass, (d)Banded Butterflyfish, and (e) Queen Angelfish from <http://gallery.me.com/garethrussell#100032&bgcolor=black&view=grid>
x 31 Image of Mesut Sahin <http://biomedical.njit.edu/people/sahin.php>
x 31 Image of FLAMES devices (a)-(d) provided by Mesut Sahin

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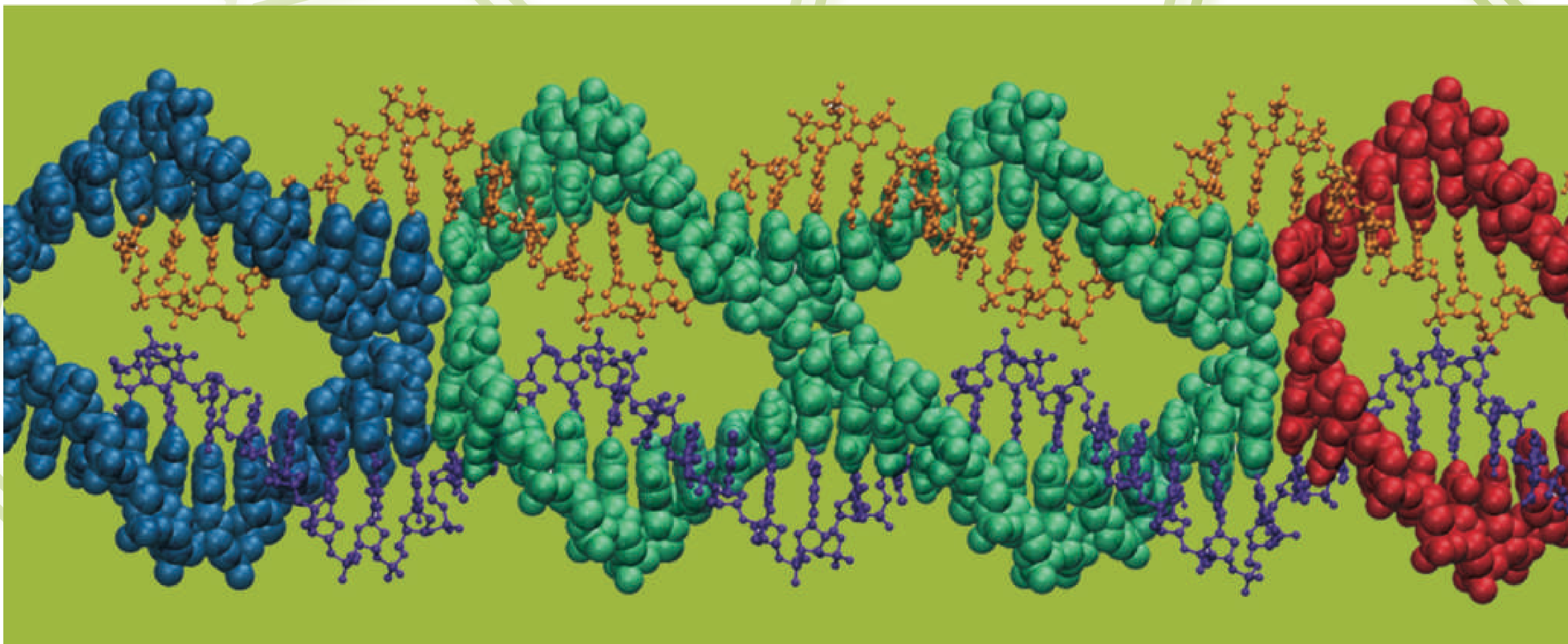

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