

# NUScience

Northeastern University's First Science Magazine

## BIOMEDICAL ENGINEERING AND THE BIONIC AGE

How scientific advances have brought modern medicine into the realm of science fiction

ALSO INSIDE:  
ENGINEERS WITHOUT  
BORDERS AT NEU

STORING DATA WITH  
GOLD NANORODS

NANOMATERIALS AND  
OUR ENVIRONMENT

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Are you looking for a creative way to showcase your work on campus? Do you want to boost your resume in a way that's creative, intellectual and fun? Become a part of NU Science! We publish two issues per semester on a variety of themes in science and technology and welcome our writers to explore any appropriate topic they find interesting.

You can always email us at [nusciencemag@gmail.com](mailto:nusciencemag@gmail.com), check out past issues on our website at <http://nusci.wordpress.com>, or follow us on **Facebook** ([Facebook.com/NUScienceMagazine](http://Facebook.com/NUScienceMagazine)).

We meet every **Monday** at **7:30pm** in room **154 Ryder Hall**. Come collaborate with us!

## LETTER FROM THE EDITOR

We at NU Science are delighted to present you with our tenth issue, our first of 2012. On a personal note, Issue Ten is also my first as Editor-In-Chief. I'm very excited for this new role; I've loved every minute of my time in NU Science. It's always great to work with our fantastic team and discuss some pretty cool science. I plan on doing everything I can to help this magazine keep moving forward. In the past couple issues, we've really found our footing as a magazine. We've learned quite a bit over the last few years about how to bring Northeastern the best science magazine we can, and I'm thrilled by how visible the improvement has been.

On that note, I believe it's entirely fitting that our feature this issue is biomedical engineering and health care technology. Few other fields have shown such notable progress as medical technology has over the last several years (or over almost any time frame you like, really). In this issue, we aim to show you a nice assortment of some of the most cutting-edge advances in medical technology. Developments such as iPS cells astound us with science's ever-increasing control over the components of the human body. Others, such as artificial tracheae or bionic prosthetics, hint at our growing ability to seamlessly replace elements of the human body. Of course, as the scope of biomedical engineering expands, it presents new and challenging ethical dilemmas, handled by the increasingly significant field of bioethics.

Perhaps the most exciting part about these discoveries is that they're happening all around us, even on our own campus. There are so many ways for you to get involved, too. There are numerous research assistant positions at Northeastern and almost certainly a professor studying a field that interests you. If that doesn't appeal to you, numerous clubs and groups exist on campus that can help you star up to date on exciting new developments as they take place.

We've done our best to give you a nice sampling of some pretty awesome innovations and we hope you enjoy learning about them over the coming pages. We're rather proud of this issue, and we couldn't be more excited to bring you another ten.

Michael Murray  
Editor-in-Chief  
NU Science Magazine

## EVENT CALENDAR OF SCIENTIFIC HAPPENINGS

### MARCH/APRIL 2012

at Northeastern and in the Boston Area

#### March 15

**"Channeling in the Development of Cognitive Ability: Environment and Genes Both Matter But Probably Not the Way You Thought."**  
4:00pm in 320 Behrakis

This talk, by Dr William Dickens, a Northeastern University Distinguished Professor in the Department of Economics, will take place in 320 Behrakis. It is open to the public, with refreshments offered fifteen minutes prior to the presentation.

#### March 29

**RISE:2012 Expo**  
10:00am in the Cabot cage

This year's Research, Innovation, and Scholarship Expo will take place in the Cabot cage from 10:00am until 2:00pm, with an awards ceremony at 3:00pm. Come check out all the innovative research taking place at Northeastern!

#### April 25

**Dangerous Encounters: The Hunt for Asteroids**  
7:00pm at the Museum of Science

The Museum of Science will host this free lecture by MIT professor Dr. Richard Binzel and Dr. Timothy Spahr, director of the Minor Planet Center at the Harvard-Smithsonian Center for Astrophysics. They will discuss the actual threat posed by asteroids impacts.

## LETTER FROM THE FOUNDER

It is with great pleasure and pride that I welcome you to the tenth issue of NU Science Magazine. At the time of its conception, I never could have imagined the level of success this publication would have achieved, the number of people it would have involved, and the number of incredible things I would learn because of it. It is astounding how far we've come in four years, and it has been a wonderful journey.

The idea for NU Science arose while I was sitting in Dr. Davies' General Chemistry course in Fall 2008. After a recent switch into the Biochemistry major, I was quickly realizing how much there was to discover about the world of science. My required coursework was supplying the tools to navigate scientific language and concepts, but I wanted to find a way to merge my interests in writing and leadership into a creative pursuit that would help me navigate the field further. Simple as that, the inspiration for the magazine struck.

Why not start an undergraduate publication where students could write about what interested them outside of the classroom? Why not create a place where stressed out academics could let loose and let their creative juices fly, all while indulging their intellectually curious sides? Too often, especially in the taxing fields of biology, chemistry, physics, and engineering, students can get overburdened with classwork and co-op and not have enough time to explore topics that truly interest and inspire them. With this in mind, I envisioned the magazine as a platform for the spreading and publishing of independent student work in a way that would be accessible to both majors and non-majors alike.

I recruited a few friends, and we began brainstorming and working on a prototype right away. By Fall 2009, we had received recognition from the university, recruited a ton of new members to the club, and published our very first issue! It was a tremendous feeling and a great success after a year of diligent planning, but, looking back, our exponential growth from that point onward has been even more impressive and humbling.

Now, flipping through the proof of our tenth issue, I could not be more proud of what we have achieved. It has been a tremendous amount of work to reach this level of success, including many a late-night editing spree, endless email threads, and ever so many missed deadlines. But thanks to the dedicated and ambitious staff, the magazine is better than ever, and I am completely confident that it will continue to expand and improve.

I have to extend a heartfelt 'Thank You!' to a few special people who have worked with me on this project since the very beginning. First, Brad West, who has performed just about every role possible in the past four years as different Eboard members came and left. He has excelled at everything he's done and I could not ask for a more reliable person to serve as President. Second, Lizzy Gilbert, editor extraordinaire, with a heart of pure gold. I can't thank her enough for always having her articles in on time (or early!) and perfectly proofread. She has been a real life-saver over the years, especially at times when everything else seemed to be going wrong. I also have to thank Taarika George for always stepping up when something needed doing. She has served as a graphic designer, treasurer, and editor, and has been invaluable every step of the way. And, of course, Dr. Davies. He has been a wonderful advisor and an even better personal mentor throughout the years. Dr. D has always been a pillar of support, and his ideas and encouragement have significantly shaped the magazine.

Finally, I have to thank all of the writers, editors, and the faculty and staff at Northeastern University who have made this dream a possibility. It has been an absolute pleasure getting to know you all over the years, and I appreciate the innumerable ways you've contributed to the magazine. Whether it was providing suggestions for articles, conducting an interview, or letting us speak to your classes, your involvement made this magazine's success possible.

As I am graduating in May, this will be the last NU Science issue with which I am actively involved, and I am excited to leave the Editor-in-Chief title to Michael Murray. Mike is a talented writer and diligent editor. I am sure that he will be just the person to take NU Science to the next level, and this first issue under his leadership is an indication of great things to come. I look forward to seeing what the future brings for NU Science Magazine. To the staff and writers of NU Science: We'll make it to the top of the NU trophic cascade soon... or, to put it simply, just keep swimming!

Yours in Science,  
Kristina Deak  
Biochemistry, 2012

# NuSci Explains: Touch Screens

BY MICHAEL MURRAY, COMPUTER SCIENCE AND ENGLISH, 2014

**T**ouch screens are all around us. We use them daily on phones, tablets, and, more and more, on smart appliances such as refrigerators. For many people, touch screens are their primary medium for communication, entertainment, and even working. Few of these users, however, know how their devices work.

Touch screens are older than most people suppose. The earliest iterations date back to 1965, when it was created as an experimental technology in the Royal Radar Establishment in the UK. Over the next years, various advances brought touch screens to people in new mediums, such as ATMs, music production, and a few PDAs, eventually leading to the more advanced devices we enjoy today.

These devices focus on determining the X-Y coordinate that a user had touched. Early screens could only detect input at one point at a time. The most common devices back then would use either

infrared or capacitive sensing to pinpoint where the user touched. For infrared, beams of light would be projected from the edges, along the plane of the screen. When something makes contact, interrupting some of the beams, the device is able to understand where on each axis the break occurred. For capacitive screens, a layer just below the touch surface possesses an electrostatic field. When someone touches the screen, they disrupt the field's energy, which the device is able to use to calculate the coordinates the user touched.

The most popular form today is the resistive touch screen. Two sheets of electrodes are placed behind the screen. A touch presses them together, interrupting unidirectional currents running along each axis. The second sheet is able to measure the distance along each axis as a function of voltage. Resistive screens can also be made to read touches at more than one point.

Recently, even more possible constructions of touch screens have become available. One twist on the infrared design uses a number of image sensors in conjunction with black lights behind the screen. Pressing the screen creates a shadow, which the sensors capture and use to interpret where contact happened. Other devices use an even more inventive medium: sound waves, which can be used in one of two ways. Microphones behind the screen are able to pick up the sound of a touch and precisely match it to where on the display it happened. Another sound-based technique constantly sends ultrasonic waves across the surface of the screen. A finger absorbs some of these waves, disrupting the others in a way that computers can use to recognize the coordinates.

Touch screens, in all of their forms, have become an unavoidable part of modern life. Next time you see one, though, you'll understand what's at work a little better. n



# One Second

BY TEH DEVAKUL, PHYSICS, 2015

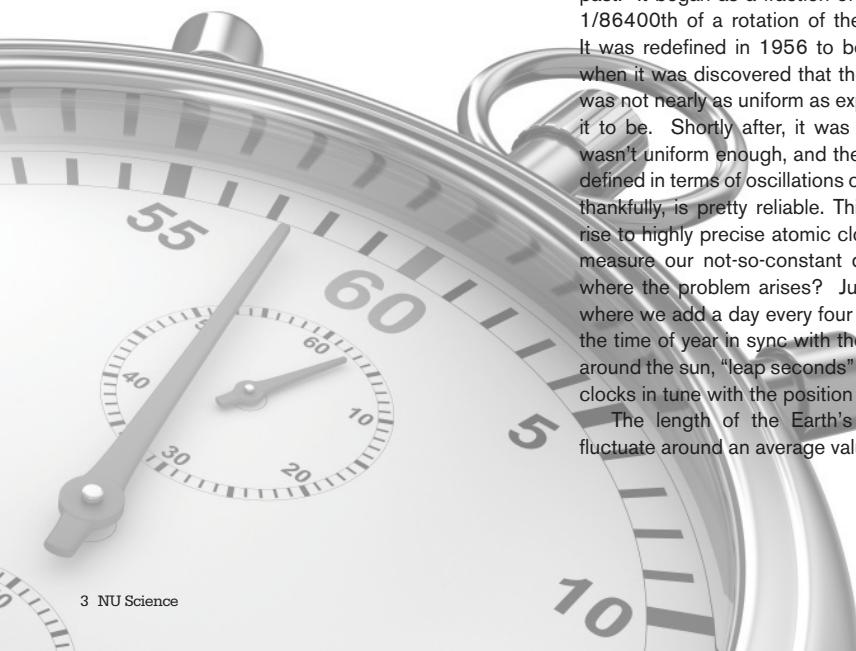
**T**hat's how long it took you to read the title. And one second less of doing whatever else you had planned... or is it? Every year or so, a second or two is added to the year to keep it in line with the sun! Why not spend a few more seconds and learn about our ever-so-important leap second?

The second has undergone many changes in its past. It began as a fraction of a day, or to be exact, 1/86400th of a rotation of the Earth about its axis. It was redefined in 1956 to be a fraction of a year, when it was discovered that the rotation of the Earth was not nearly as uniform as experts would have liked it to be. Shortly after, it was decided that this still wasn't uniform enough, and the second was officially defined in terms of oscillations of caesium-133, which, thankfully, is pretty reliable. This new standard gave rise to highly precise atomic clocks, which we use to measure our not-so-constant days and years. See where the problem arises? Just as with leap years, where we add a day every four years in order to keep the time of year in sync with the position of the Earth around the sun, "leap seconds" are added to keep our clocks in tune with the position of the sun in the sky.

The length of the Earth's rotation doesn't just fluctuate around an average value; it's actually getting

slightly longer. This results in a slight positive deviation in the length of a year. It's a small amount, so it's nothing to worry about – unless you're a timekeeper. The Coordinated Universal Time (UTC) has been adding these leap seconds to our years for the past 40 years, typically at the end of June or December, totaling about +25s so far. While not a big difference, the fact that we even have these leap seconds means we are attempting to keep our "universal" time corresponding with solar time.

There have been proposals to remove the leap second, arguments for which include the difficulty of accurate measurement of time intervals – particular for astronomers (not to mention difficult New Year countdowns for those obsessed with accuracy). What's more important, though, is that it will signify the end of our dependence on something like the irregular orbit of Earth for time. In today's technological age, is a constant measure of time more important than corresponding with the sun? What do you think? The next scheduled leap second is announced to make an appearance on June 30th, so watch out for it! n



# Solar Panels in Your Phone?

BY BILL FLEMING, CHEMICAL ENGINEERING, 2016

**W**yships, a French company, has developed an interesting new product that should be on shelves by the end of this year: a new solar film for electronics. This film goes under the screen to capture excess light, which then charges the device. Wysips currently has cell phone prototypes and says the technology will be excellent for tablets and e-readers. The company says that the technology will not impact the brightness of the screens since it is only 100 microns (0.1mm) thick, and that it can fully charge a cell phone in six hours. The screen is capable of generating 250 mW of power, which will charge the battery of the device in addition to both ambient light and sunlight.

Wysips has a very unique product. They are currently boasting a 9 percent solar efficiency. Wysips' design places the solar film underneath the touch screen, so the touch screen is completely unaffected by the solar film technology. If the film is cheap enough, it may make sense to try and implement the same technology for larger devices such as laptops and televisions. An important question to ask when looking into buying a new device is cost. Wysips says that the film they manufacture and plan on using for their devices will raise the price of these devices by only \$1. The question then becomes whether or not it would still be cheap to do on a larger scale for larger devices. n

# Portable Lab Testing: There's An App for That

BY REBECCA MILLER, BEHAVIORAL NEUROSCIENCE AND PHILOSOPHY, 2013

**I**t is not uncommon to hear a young adult proclaim, "My phone is my life!" However, with technology racing towards smaller devices that maintain great accuracy, we may instead be hearing exclamations closer to, "My phone saved my life!" Research groups and companies are currently developing and producing digital dermascopes, patient record trackers, and so called lab-on-a-chip, all of which have a smart phone application for efficient and effective mobile analysis.

Current technologies such as the lab-on-a-chip allow for clients to place blood, urine, or saliva samples on a small chip that may then be mailed into a lab for analysis. Sending in the sample on the microchip device is relatively cheap and may provide greater access in more rural areas, although it does still require processing time.

Even more immediate medical applications are on the horizon. For only \$1,592, doctors can attach their new Handyscope, a digital dermascope, to their iPhone and assess their patients' skin at a magnification of 20 times the original size, allowing for more accurate and sure diagnoses.

In addition, doctors could one day be informing their patients of cancer cells in as few as 60 minutes. This is possible all thanks to a team located at

Boston's very own Massachusetts General Hospital (MGH). The MGH team was able to develop a nuclear magnetic resonance (NMR) machine no larger than your Dunkin Donuts coffee, and has made the device send the result directly to a smart phone. Such technology would allow doctors to take a sample labeled with the appropriate magnetic nanoparticles and have the results in about an hour that are 96-100% accurate.

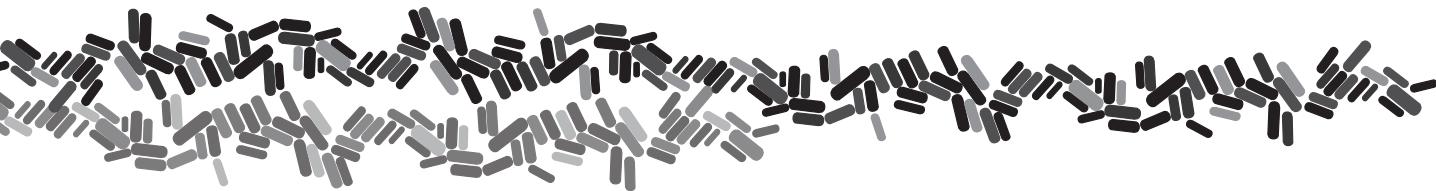
If 60 minutes is still too long for you, researchers at the Korea Advanced Institute for Science and Technology are working on using a smart phone's capacitance capabilities to instantly provide diagnoses. Their research detects biomarkers in a drop of spit on the phone's touch screen. There are high hopes for such an application to offer great relief to those who suffer from chronic conditions with the idea that regular tests can be conducted within the comfort of their own home or on the go. It also has potential as a major new tool in promoting the importance (and, in theory, the ease) of getting tested for sexually transmitted infections.

It looks like the smart phone has a bright future ahead of it, beyond the scope of "Words With Friends" and Facebook updates. Suddenly, "My phone is my life," takes on an entirely new meaning. n



# Storing Data in the Fifth Dimension: Increasing Storage Density with Gold Nanorods

BY BILL FLEMING, CHEMICAL ENGINEERING, 2016



Thanks to the research of an Australian Professor, storage capacity has greatly surpassed what was once possible. Min Gu, director of the Centre for Micro-Photonics at the Swinburne University of Technology in Victoria, Australia, has been researching a new way of storing data. Gu has been conducting research since attaining his Ph.D. in optics at the Chinese Academy of Sciences.

Gu and his team are developing a new form of readable disc using gold nanorods. This disc will be about the size of a modern DVD or CD, but can hold much more information. This is because traditional DVDs and CDs store data on their surfaces in two dimensions. What Gu and his team have developed is a "five-dimensional optical material" is capable of recording data in the traditional three dimensions; the material would be responsive to different wavelengths and polarizations of laser light.

What this means is Gu's team is able to greatly increase the amount of information stored in any given space. They have increased the storage density of these discs to 1.1 terabytes per cubic centimeter. Another statistic that Gu's team is boasting is a recording speed of 1 gigabyte per second. This technology could be immensely helpful and influential.

Data is recorded to these nanorods with laser pulses. The rods are less than 100 nanometers long, and the laser is used to melt and reshape them. This changes how the nanorods interact with light, allowing data to be read. Similarly, by using rods of different sizes and thicknesses, different wavelengths will react with each of these types of rods differently, and the machine will recognize the information.

As time goes on, technology keeps advancing at faster and faster rates. The first computer ever built was developed in 1942 by Iowa State University Professor John Atanasoff and graduate student Clifford Berry. The machine weighed over 700 pounds and could calculate one instruction every 15 seconds.

Today's computers' capacities are far beyond that of the first computer. Even the laptop I typed this article on contains a processor that weighs mere ounces and can process billions of operations per second.

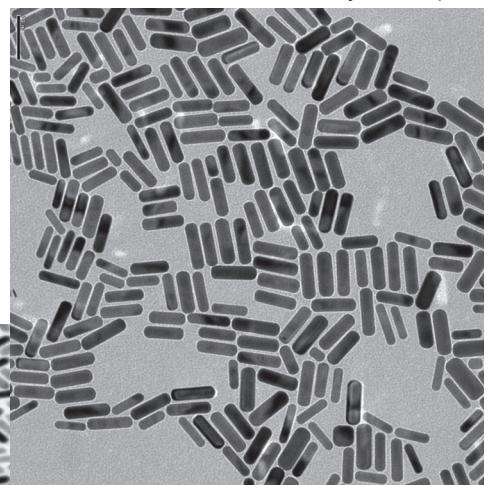
There is only really one main drawback to this new technology. The gold nanorods are distributed

randomly through a clear plastic, which is spun on a glass substrate. This is a problem because of the angle of propagation of the light. The rods absorb the light most strongly when the polarization of the light is aligned with the rods' long axis. Because of this, the patterns can't be erased or rewritten. But Gu and his team claim that these things should become stable as time goes on.

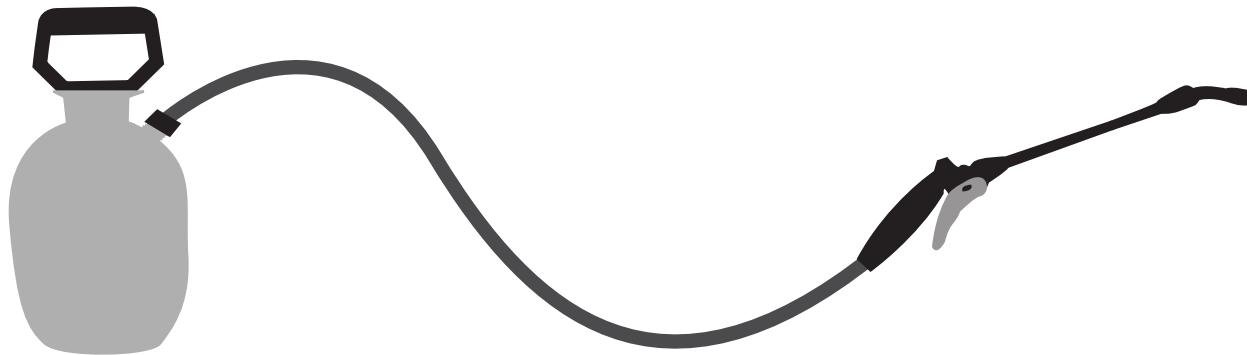
Gu also addressed similar previous work that he had done on multi-faceted optical storage that relied on light responsive polymers. Gu pointed out that the absorption spectrum of these polymers are very broad. The gold nanotubes are much more responsive to much narrower spectrums of light, making them more precise than when using the light receptive polymers.

The most remarkable thing about technology is the way in which two people can make similar advancement using different strategies, such as the technology Gu's team is currently developing and the previous work done with the polymers. One of these two is superior to the other; however just the notion that similar results can be obtained different ways explains how technology is able to advance the way it does. There is no one absolute answer for anything; the same results can be achieved a number of ways and work can be done to improve and optimize the results. □

*Photo courtesy of Nanopartz*



*Photo courtesy of Murphy Research Group, University of Illinois at Urbana Champaign*



## What Effects Will the Environmentally Ubiquitous Nature of Nanomaterials Have on Our Biosphere?

BY KRISTINA DEAK, BIOCHEMISTRY, 2012

From the 1940's to the 1950's, the United States was heavily involved in the production of potent pesticides, which were made available for public consumption with little knowledge about their effects on humans and the environment. Scientists had discovered chemicals, such as DDT, which could simultaneously help the troops combat malaria abroad and protect crops and food production at home, and their immediate need in the marketplace overshadowed the task of pragmatic toxicological evaluation. Largely due to public outcry after the publication of the seminal book, "Silent Spring" by Rachel Carson in 1962, strict regulations have since been put in place and information on how the various toxins used in insect repellants could alter human physiology has been made available. But is history repeating itself, this time with particles produced in an infinitely smaller scale?

Nanomaterials have been taking the science world by storm over the past few decades and have immense applicability in a wide range of industries and research fields. Perhaps the most well known example are carbon nanotubes (CNTs), discovered in 1985, which are superb electrical and thermal conductors, and have a strength-to-weight ratio 460 times that of steel. They are used in plastics, electronics, adhesives, batteries, and even water purification systems; global production of CNTs is estimated to be over 1,000 tons per year. Other classes of nanomaterials include semi-conductor nano-crystalline particles, known as Quantum Dots, that can be used to identify the location of cancer cells in the body and dendrimers, a class that has been optimized for cell-specific drug delivery due to their intricate surface topology and intricacy.

While their utility is indisputable, their production and incorporation into manufacturing has far-outstripped scientists' ability to monitor their effects on ecological and physiological systems. Thus, nanomaterials have become environmentally

ubiquitous at a time when little is known about how they will impact species health and biodiversity. The complication in determining toxicological information about the materials is derived from a variety of factors, including the very properties that make nanoparticles so advantageous.

### Small sizes can lead to large complications

Nanomaterials are defined as having at least one dimension below 100 nm, or one billionth of a meter. This size alone can be problematic for three main reasons. First, characteristics such as conductivity, strength, and reactivity of such tiny particles differ from those at the macro or even micro scales, which means that ordinary chemical and physical constraints may no longer apply to them. Second, they are at a sufficiently small size to interact or be incorporated into critical biomolecules, which could lead to alterations in cell membrane transfer, interactions with metabolites, and even alterations in nucleotide sequences. Finally, they have a very high surface area-to-volume ration, which encourages their interaction with substrates.

While scientists currently lack the analytical methodology to determine how these particles affect species, preliminary data with model organisms have suggested possible routes for biological uptake and toxic potential. Uptake of nanomaterials from the environment is guaranteed, primarily through the gut, with possible subsequent movement to other parts of the body. The molecules can enter different cells by simple diffusion through membranes, as well as by endocytosis and adhesion, as seen in Daphnia models.

Once inside the cells, toxicity may be incurred by various mechanisms. For example, nanomaterials can increase the fluidity and permeability of cell membranes through the production of reactive oxygen species (ROS), which would change the natural ability of the cells to interact with receptors

and participate in nutrient uptake. ROS could also affect protein stability by interrupting the iron-sulfide clusters that form enzyme cofactors, or by forming disruptive disulfide bonds between amino acids, thereby altering the protein's function-dependent tertiary structure. Nanoparticle incorporation could also lead to genotoxicity and interruption in energy transduction processes.

### Considerations for the environment

70% of our earth's surface is covered by ocean and the majority of industrial discharges are linked to estuarine or marine environments. Couple this with improper wastewater treatment and agricultural run-off and it's easy to see how the world's oceans may be the final sink for man-made nanomaterials. Preliminary research has indicated a tendency for the materials to conglomerate with natural organic matter, disperse, and eventually sink to sediments. Thus, they may impact a variety of organisms on their path to the seabed, from plankton at the surface, to pelagic species at the thermocline, where organic matter tends to accumulate, to bivalves and other bottom-dwelling species at the sea floor. Unfortunately, working in the chemical soup of the marine environment makes research even more difficult, as the natural salt-based ionic character of the water further alters the behavior of the ever-susceptible nanoparticles. As salinity and temperature varies with depth, it is possible that the characteristics of the nanoparticle will be different for each depth-associated taxa it encounters.

It is apparent that a great deal of work needs to be done to elucidate the effects ubiquitous nanomaterial exposure can have on our biosphere. While the positive impact nanomaterials are having in industry, medicine, and technology cannot be ignored, it is important to understand how they will ultimately impact the biodiversity and ecological network of our planet. n

# Scientists Develop Meningitis B Vaccine

BY JULIETTE KASSAS, BIOCHEMISTRY, 2015



**P**ut yourself in the early 20th century. Right smack dab in the middle of the industrial revolution.

The economy is booming. There are new things being invented all around the world that you couldn't ever imagine existing – cars, telephones, televisions. Now jump forward in time about 75 years, computers and cellular phones are starting to come out. Keep going, twenty more years and you have iPods, laptops, the Internet. Who would have known that technology was going to evolve so quickly? Technology hasn't been the only area of major development over the last century, but it is definitely the first thing we think of when we hear the word "advancement." Another major area of progress in the last hundred years has been the increase in our knowledge of the human body and medical treatment. The life expectancy for people in third world countries is significantly less than for developed countries, undoubtedly due to superior medical treatment and increased investment in treatments and cures for certain viruses, diseases, and infections. Recently, a revolutionary treatment for meningitis type B has been discovered. This illness has been considered incurable and barely treatable until now, but sources state that there will

be a vaccine hitting the market this spring through the company Novartis.

Meningitis occurs when the protective membranes covering the brain and spinal cord, called meninges, become inflamed. The cause for this inflammation is generally due to a viral or bacterial infection. The symptoms of this illness can range from mild to extremely severe, and it can progress very quickly. Some of the general warning signs include a headache with stiffness of the neck, which is accompanied by a fever, confusion, and vomiting. These may not seem all that severe, but if left untreated, these symptoms may evolve into deafness, cognitive deficits, or epilepsy. These apply to most cases of the infection, but what we will mainly focus on is type B meningitis.

Meningitis type B has undoubtedly been the most difficult type of the infection to deal with and treat, primarily because there are so many different strains of the virus. It is most prevalent in Europe, especially in Britain, and the age groups most commonly affected are infants, children, and young adults. The younger the patient, the harder it is to diagnose the illness and therefore harder to treat. However, recent research has shown that there is hope for a vaccine to prevent

the onset of meningitis type B. Until now, this strain has been incurable and more than 170,000 people each year have lost their lives to it. Researchers at University of Chile, located in Santiago, have made significant progress in finding a preventative measure for this horrific illness. The new vaccine they have brought to the table is called 4CMenB, and findings suggest that the vaccine will be made available for the open market in just a few months.

The vaccine, 4CMenB, was first tested on a group of 1,631 adolescents (aged 11 to 17) – each person was given three doses over six months. Nearly all of the people in the group, ninety-nine percent, were able to create antibodies to repel against meningitis type B. This finding is groundbreaking, although it took quite a bit of time to plan out the trials and research studies. It has been confirmed that this course of action would be appropriate to use in regions where the disease is most common, because it encompasses protection from several strains of the bacteria. A second study confirmed this: 3,600 European children (aged 2 to 4) and also children in preschool displayed similar reactions to those of the adolescents.

Chilean researchers came to finding the vaccine 4CMenB through a method known as "reverse vaccinology." This is a genetic technique that is frequently used to first synthesize all of the proteins that make up particular bacteria cells and subsequently determine the ones that are best most likely to produce an antibody response. This proved to be very effective, considering the fact that there have been many previous attempts at fighting against this disease. Typically, cells are surrounded by polysaccharide sugars. Scientists discovered that the sugars that surround the meningitis B bacterial cells have a very similar structure to the sugars that surround normal human body cells. For this reason, normal body cells are easily able to integrate and accept these otherwise foreign cells. Consequently, the body would project a negative response to the cells once they were in the system. Fortunately, after surpassing this obstacle, scientists were able to come up with an effective vaccine.

Overall, these findings will help to eliminate nearly all meningitis B cases, which make up 40 percent, 80 percent, and 60 percent of the meningitis cases in the North Americas, Europe and Chile, respectively. With increasing technology and innovation, many of the diseases, viruses, and other illnesses will eventually be terminated... Just think what the world will be like in 100 more years!

# Bioethics

The Study of Right, Wrong, Both, and Neither in the Biological Sciences

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE, 2013

Throughout history, advances in biological knowledge and technology have frequently brought a wave of public anxiety. Dissections were largely illegal in Europe until the mid-1800s. Before that, the subjects of anatomy studies came either from grave robbery or the hangman's noose. Cutting up a body was considered sacrilege, a desecration that would affect the soul. But dissections are an invaluable part of modern science; without them, medical practice would be unrecognizable.

Darwin's contention that all life descends from other life caused rifts throughout society, both academic and private. It laid much of the foundation for modern genetics. It also seemed to give scientific support to the ugliness of eugenics - something that Winston Churchill, Alexander Graham Bell, and Darwin's own son all believed in.

As humanity unfolds the mysteries of genetic code, it has become possible to manipulate DNA more specifically than can be done via interbreeding, directly inserting genes into organisms that are sold as food and medicine. Modified bacteria produces commercial insulin that saves the lives of diabetics consistently and safely, and has since first introduced to the market in 1982. However, in 1988, a company called Showa Denko, which sold amino acid supplements, engineered a strain of bacteria to produce more of an amino acid called tryptophan. The FDA allowed the product to be sold without further testing. 37 people were killed and 1500 permanently disabled from a contaminant thought to be a byproduct of the cells' overproduction of tryptophan.

It is no surprise that a movement has risen to specifically address the ethical issues brought by modern biology. Appropriately called bioethics, it is a cross-disciplinary study of every ethical concern in biology, from GMOs to neural enhancement in soldiers. The first bioethics institute was the Hastings Center, founded in 1969.

Initially, bioethicists took on issues involving extension of life, including respirators, brain death, and organ transplants. The focus has since expanded; the Hastings Center has dozens of ongoing research projects, including wide-ranging subjects such as health care reform, synthetic biology, and the genetics of drug addiction.

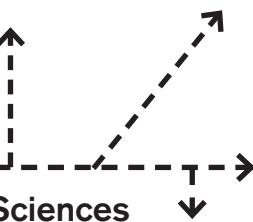
Bioethics have featured prominently in many recent national debates: Terry Schiavo's life and death, embryonic stem cell research, labeling of genetically modified foods, and the admission of brain scans into criminal trials. These are all incredibly important conversations in an age when technology's exponential growth changes human knowledge with neck-breaking speed.

It is not just flashy new technologies that require ethical discussion. Basic standards of informed consent and research ethics have developed through trial and error - and the errors can harm gravely, or even kill. Between 1932 and 1972, the US Public Health Service prevented 400 black men from gaining access to treatment for their syphilis, in order to study the progression of the illness. 128 died of syphilis and related complications, 40 wives were infected, and 19 of their children were born with the disease. This is now infamously known as the Tuskegee Experiment.

Between 1974 and 1983, several commissions and panels released reports that helped define federal regulations in medicine and research. The most famous of these, the Belmont Report, was a direct result of public outcry over the Tuskegee experiment. It helped define legal and ethical guidelines for human research, including requiring informed consent and reporting accurate test results to patients.

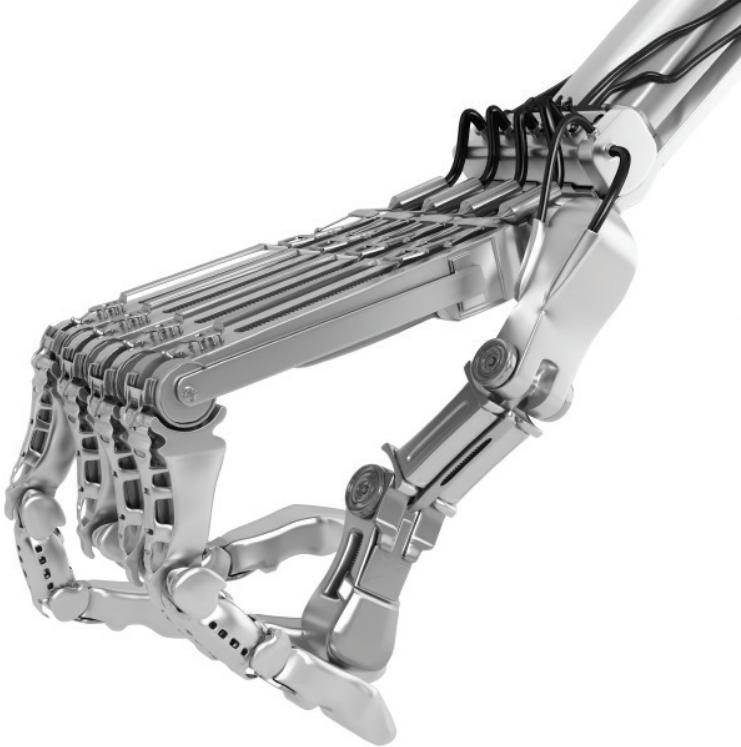
In 1996, the Clinton government founded the National Bioethics Advisory Commission, which advised policies on human cloning, stem cell research, and clinical trials studying the mentally disabled, among other subjects. It was dissolved in November of 2001, and replaced by Bush's President's Council on Bioethics. After wide criticisms of that council, including accusations by ex-councilmember and Nobel Prize-winner Elizabeth Blackburn that the council existed entirely to support the president's views on abortion and stem cell research, the Obama administration disbanded it and replaced it with the Presidential Commission for the Study of Bioethical Issues.

Gradschools.com, "the #1 graduate school directory," lists 53 bioethics graduate school programs in a number of countries. At NYU's Center for Bioethics, the graduate program combines both environmental and medical ethics. The program's website explains,



*"The two fields have advanced moral principles and concepts similar enough to invite close comparison—for example, 'Above all do no harm' with the Precautionary Principle; the 'sanctity' of human life with the 'intrinsic value' of non-human life; just distribution of healthcare with just distribution of environmental burdens; personal responsibility for individual health with collective responsibility for environmental health."*

Knowledge is power: the more known about life, the more it can be manipulated, whether advantageously, dangerously, or both. Bioethics does not live in an ivory tower. It is the necessary, concerted effort from all fields of science, medicine, policy, and philosophy to catalogue the moral implications of biological science and technologies – and to define the right and wrong ways to use them. n



# Merging Man and Machine: The Bionic Age of Prostheses

BY KATE BARRAL, HEALTH SCIENCES, 2015

**"**I felt a responsibility and knew I could not give up," Pierpaolo Petruzzielo said to Discovery News of his extraordinary feat. Petruzzielo is a 27-year-old Italian man who lost his arm three years ago in a car accident. With the help of his father and engineers at Pisa's Scuola Superiore Sant' Anna, Petruzzielo became the first person in the world to move a biomechanical hand using only his brain. Funded by the European Union, the project took five years to complete.

Electrodes placed on the remaining nerves in Petruzzielo's arm send signals to the robotic limb for movement. This type of cutting-edge technology is what researchers and scientists have been hard at work planning for the past decade. Robotic limb control is also called "Targeted Muscle Reinnervation" (TMR) and was developed at the Rehabilitation Institute of Chicago by Dr. Todd Kuiken, the project's director.

But how exactly can someone move a robotic arm with his or her brain when it doesn't exist anymore? Essentially, the nerves throughout a person's body operate as an information highway, constantly sending and receiving messages.

When an amputation occurs and the peripheral nerves in the muscle are no longer there, a dead-end is created. The motor command signals the brain sends have nowhere to go. In Petruzzielo's case, electrodes surgically implanted along the ends of these nerves act as a bridge connecting the command signals from the brain and relay the message to the biomechatronic hand.

This kind of technology is advanced and extremely expensive. There are other, simpler forms of prosthesis on the market, from the basic limb components doctors are molding around the world today. What is so unique about the way inventors and scientists operate is that they are always looking for an improvement and always looking for the next technological advancement. Thought-controlled limbs are still a ways off from being accessible and affordable, but looking back to earlier days, it's easy to see exactly how far technology has come. The notion of peg-leg wielding pirates isn't just folklore. Wooden attachments and metal hooks fashioned into hands have actually been the standard prosthesis throughout much of history.

Prostheses has evolved along with mankind

throughout history, going through a design rebirth during the Renaissance and adapting to needs of wounded soldiers during war times. Prosthetics are changing and adjusting as scientists add to and improve on the prosthetic model.

## EVOLUTION OF THE ARTIFICIAL LIMB

Unearthed in 1858, the first artificial limb was thought to have been a leg rescued from a Roman burial sight in Santa Maria di Capua Vetere, today known as Capua, Italy. The prosthetic limb, used as a below-the-knee device, dates back to around 300 B.C. and is made of bronze and iron with a hollowed out wooden core used for attachment to the amputation site. It since stayed in London, England, at the Royal College of Surgeons, but was destroyed in a bombing raid during World War II.

Thought to be the first artificial limb, an artificial foot discovered in a burial tomb in Egypt astounded scientists of the day. In 2000, archaeologists discovered a carved foot made of wood and leather attached to the nearly 3,000-year-old mummified remains of an Egyptian noblewoman. To this day

clear signs of wear are visible corresponding to the strapping and position of a typical Egyptian sandal.

A foot from ancient Egypt, a leg from the Roman Empire – the ancient world certainly had an answer to the challenges that being an amputee heralded. Many more prosthetics emerged from then on: a Roman army general who fashioned an iron hand that could hold his shield so he could return to battle; a Persian prisoner who wielded an artificial foot after escaping death by amputating his own foot. The structure and materials for prosthetics were simple and uncomplicated, usually items that could be assembled by either the amputees themselves or a tradesman.

The Renaissance is well known for its rebirth of art, culture and music, but a change in prosthetic design formed as well. By mid-1500, French barber and surgeon Ambroise Paré, a man considered the father of modern amputation, surgery, and prosthetic design, created a functioning above-the-knee device.

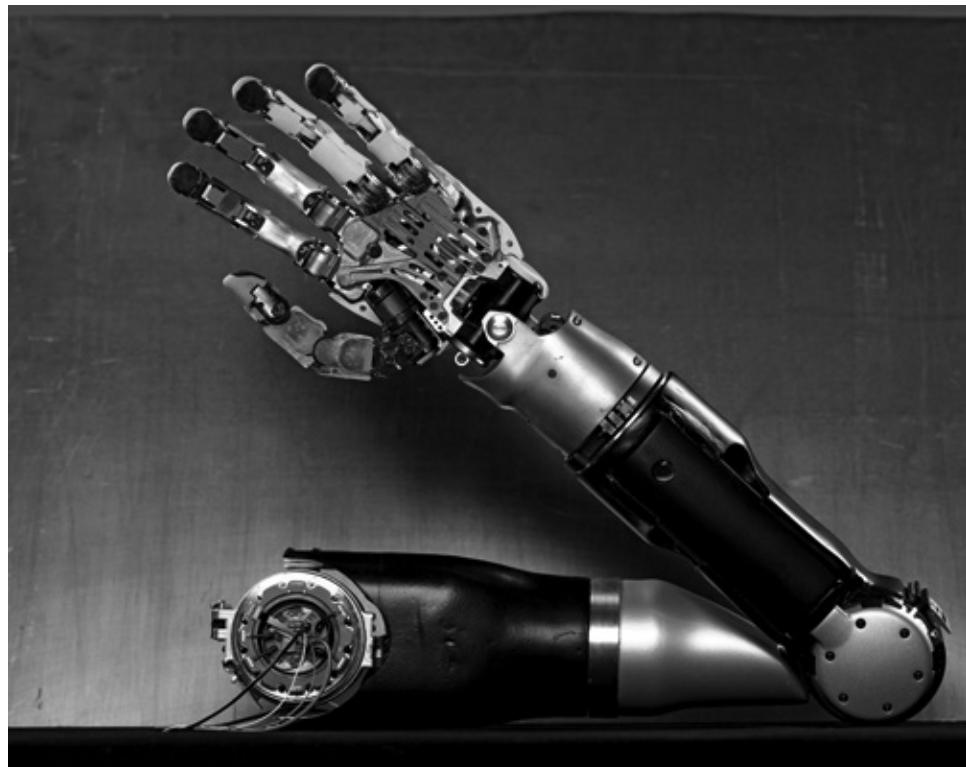
Soon after that time, materials such as leather, paper and glue replaced heavy iron in making prostheses. In 1839 the first artificial leg with an articulated foot was brought to the United States. In 1868, limbs were made more functional and lighter by replacing steel with aluminum. But nothing pushed the advancement of prosthesis quite like the demands of war. Great strides were made in the field after the Civil War. Wounded veterans found a need for a more comfortable prosthetic attachment. After World War II, thousands of amputee veterans demanded improvement from the U.S. government after dissatisfaction boiled over from the lack of enhanced technology in their prosthetic devices. The government took funding that would've gone to weapons technology and redirected it to the advancement of prosthetic devices.

By the end of the 20th century, new and vastly superior technology emerged. There were now microprocessors, computer chips, cell phones and the Internet. A new dawn of technology had risen, and this technology was about to make its way over to the human body.

#### THE GOVERNMENT SECTOR

Deep within the Pentagon's Defense Advanced Research Projects Agency (DARPA), scientists are working hard on their "Revolutionizing Prosthetics Program." Similar to Petruzzello's bionic arm, project researchers are testing the Modular Prosthetic Limb (MPL) on a human, which can control the arm with just thought. However, electrodes are a thing of the past. This is the first time scientists will open up a human brain and implant a neural interface to operate the artificial limb.

"The prosthetic will rely on micro-arrays, implanted into the brain, that record signals and



*Photo courtesy of National Geographic*

transmit them to the device," Michael McLoughlin, the project program's manager, said of the tool to Wired magazine. Making prosthetics more lifelike and able to perform everyday tasks is the program's goal. The project team is already preparing patients to test this cutting-edge device. Their next step is to incorporate a sense of touch and pressure into the device's system. This is vastly improved from the days of plastic and steel used so frequently just 100 years ago.

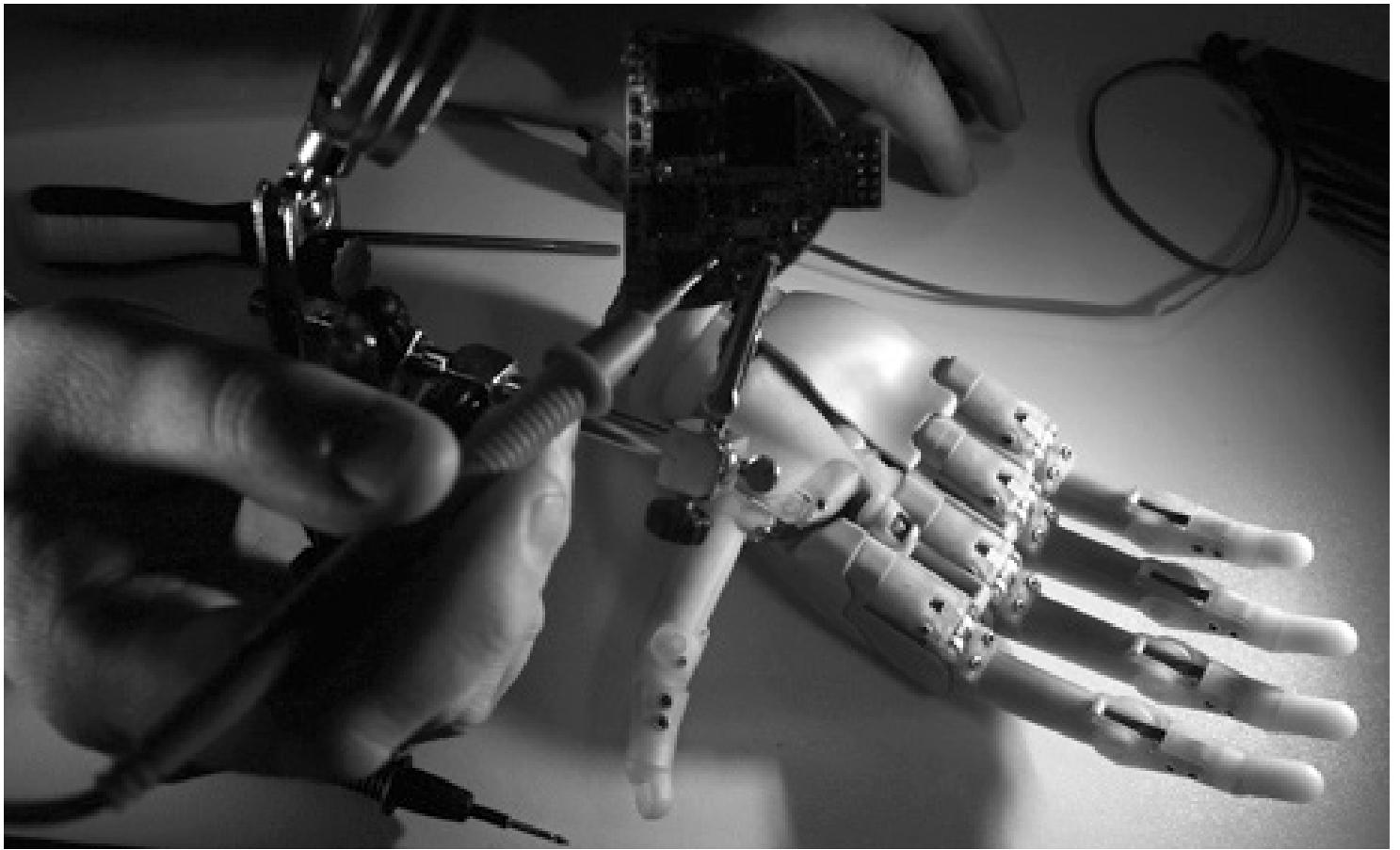
In 2005, researchers at Vanderbilt University discovered a nerve that could be triggered using infrared light. DARPA, the Pentagon's highly advanced team of military researchers, dove right in, supplying \$5.6 million for the creation of the Neurophotonics Research Center, which is currently working on the development of prosthetic devices powered by infrared lasers. The use of infrared lasers differs vastly from the use of electrodes or signals. A cuff loaded with optical cables was attached to a prosthetic at one end, and on the other, connected to the severed nerves. The biggest challenge of the project was to create a sensor able to detect and trigger the infinitesimally small signals of a single nerve. Comparing electrical signals to the speed of fiber optic laser cables is like comparing the speed of a tortoise to the speed of a hare. Dr. Marc

Christensen, the program's leader, admitted the project is still in its early stages but said to Wired magazine, "Right now [our] prosthetic can pick up or transmit maybe two signals. We think we can turn that into thousands."

#### IMAGINE ALL THE PEOPLE

Today the vast majority of amputees have prosthetics with a normal frame, suspension system and socket that ensures the limb will adhere to the base of the amputation. But think about the few out there that walk around with thousands of dollars of technology attached to their body; usually recipients of research or fortune, these amputees carry the future of modern medicine with them wherever they go.

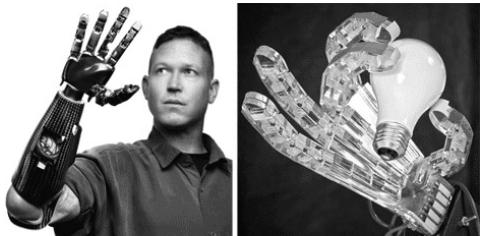
In 2005, Craig Hutto lost his leg in a brutal shark attack off the coast of Florida. Today he works as a lab assistant to Michael Goldfarb, a professor of mechanical engineering at the Vanderbilt Center for Intelligent Mechatronics. Hutton sports a leg similar to a computer that's equipped with a processor and motors that operate with sensors. The sensors on Hutton's robotic leg detect his motion and move in unison with him. The sophisticated software checks for stability, and if Hutton happens to stumble, the software causes the leg to plant itself in a stable spot. As a lab



*Photo courtesy of National Geographic*

assistant, Hutton aids Dr. Goldfarb with invaluable input about the leg's functions, giving information on what works and doesn't work, thus making the leg workable in a real-world environment.

Rob Spence, a Canadian filmmaker, redefined the view of prosthetics. His prosthesis is much different than that of an arm or leg. Housed in Spence's right eye socket is the world's first bionic eye.



*Photo courtesy of weburbanist.com*

After a shooting accident rendered him only one usable eye, Rob Spence looked to his camera to find a solution. Named in Time magazine as one of the "best inventions of 2009," Spence's bionic

eye includes a battery-powered video camera that produces a low-resolution image but still creates the genuine experience of looking through the eyes of someone else. His eye contains 1.5mm-square, low-res video camera, a small round-printed circuit board, a video transmitter, and a 3-volt rechargeable battery that he can charge off his USB port on his laptop.

"Unlike you humans, I can continue to upgrade," Spence joked to IEEE Spectrum, calling himself "Eyesborg."

Upgrading is something everyone is capable of, and it's what science continues to do everyday. Matthew James just happens to be one of the lucky recipients of such an upgrade.

Ross Braun, current head of Mercedes Benz GP, received a letter one day from a 14-year-old boy from England. Matthew James, who was born without his left arm, wrote a touching letter to Braun asking for a state-of-the-art bionic arm and offered to sport the Mercedes Benz logo on his arm.

"I really didn't think it would go anywhere. I mean, I was just thinking I'll send a letter off and they might send me a t-shirt or something," James admitted to The Telegraph, a United Kingdom newspaper. However Mercedes used their connections with Scottish firm Touch Bionics to get James a new i-Limb Pulse bionic hand, which uses Formula 1 car-inspired technology. The arm's price tag is a whopping \$58,000 and includes motorized control of each finger. The arm, much like Hutton's leg and Spence's eye, are all innovations on the forefront of prosthetic technology.

Through extraordinary and astounding advances in technology, the field of prosthetics



*Photo courtesy of weburbanist.com*

has been revolutionized. Today people with little to no limbs can swim, ride bicycles, run marathons, and even compete in the Olympics. People who were once confined to beds and wheelchairs can live completely active lifestyles. Modern prosthetic limbs are lighter, stronger, and cosmetically more appealing than ever before. They are getting extremely close the real thing. The goal of prosthetics has been to restore, to give back what is missing. While the age of bionic invention continues, people like Pierpaolo Petruzzello, Craig Hutton, and Rob Spence pave the way for more improvement to come, for the field of prosthetics to become accessible to all. n

# Artificial Neural Networks

BY SHRUTI PRATAPA, BIOTECHNOLOGY, 2013



**S**cientific research has revolutionized the way medicine is practiced. It has amassed a huge quantity of data, making practice difficult for the physicians who must process all of it to treat their patients. Neural networks have emerged as a powerful tool for data analysis. There has been an explosion of interest in the technology within the last decade.

An artificial neural network consists of a set of connected cells: the neurons (mathematical systems). Data is entered into the system, and the neurons communicate with each other to solve problems. Neurons are connected by synapses through which signals pass. Each signal has a weight. A switch receives input from other neurons and depending on the total weighted input (coefficient of connectivity), is either activated or remains inactive. The weight, by which an input from another cell is multiplied, corresponds to the strength of a synapse—the neural contacts between nerve cells. These weights can be both positive (excitatory) and negative (inhibitory).

The most important advantages using artificial neural networks is that this kind of system solves

problems that are too complex for conventional technologies, do not have an algorithmic solution, or the solution is too complex to be used. This is often the case in medicine.

Artificial neural networks have been successfully applied to various areas of medicine, such as diagnostic systems, biomedical analysis, image analysis, and drug development. For example, neural networks can compare a patient's real-time heart rate, blood pressures and breathing rate at different physical activity levels to a standard model specific to that patient and mimics the interactions so that it can help diagnose heart problems. The simulator will have to be able to adapt to the features of any individual without the supervision of an expert. This would take into account all aspects of the patient's condition without the need for an expert. Similar uses might involve the monitoring of patients with high-risk diseases, allowing data to be collected and processed in less time.

Artificial neural networks may also be useful in telemedicine. Telemedicine is the practice of medicine over long distances via a communication

link. The networks have been experimentally used to create artificial "noses." The electronic nose would detect odors in the remote surgical environment using sensors that perceive change in electrical properties. These detected odors would then be electronically transmitted to another site where a generation system would recreate them using digital signals that are computed on the other end based on statistical methods.

To date, the application of artificial neural networks seems to be most powerful in image processing, as looking at the images makes most of decision-making. The important and exciting progress in biotechnology, nano-medicine and new innovative therapies is exceedingly dependent on integration with medical imaging for successful application into standard clinical practice. Images are split up into segments, each representing an anatomical feature. Poli and Valli (1995) employed the Hopfield neural network for optimum segmentation of 2-D and 3-D medical images. Hopfield neural network includes one or more sets of 2-D layers of neurons with local connections. This architecture can be focused to perform the segmentation of 2-D and 3-D images by simply changing the number of such sets and the size of the component layers. By changing synaptic weights, the design can adapt to the differences existing between tomographic and radiographic images. The networks have been tested on synthetic images and on real tomographic images, including X-rays.

An application called the "instant physician" trained an auto associative memory (that retrieves a previously stored pattern that closely resembles the one we desire) neural network to store medical information such as symptoms, diagnosis, and treatment for a particular case. After training, the network can be presented with input consisting of a set of symptoms; it will then find the right pattern that represents the "best" diagnosis and treatment.

As of today, neural networks have not broken all the barriers to applied sciences. Neural networks may have their disadvantages. For example, the neural network needs proper training to operate. The architecture of a neural network is different from the structural design of microprocessors and therefore needs to be emulated. It may also require high processing time for larger networks. But they can perform any task that a linear program cannot and can be implemented in any application. It learns very fast and need not be re-programmed. Thus, neural networks can ultimately succeed in being the most faithful models of biological "neurons" and help improve scientific research in general.

# Leaps and Bounds in Bioinformatics:

## How this interdisciplinary field is changing the way we look at life

BY SUMAYAH RAHMAN, BIOLOGY, 2015

We are in the middle of a genomics revolution. Right now, laboratories around the world are using gene sequences to uncover information about a variety of organisms, including humans. The completion of the Human Genome Project in 2003 is often touted as the biggest biological accomplishment of our time. But even though the genome has been sequenced, there is still much to learn about the way the body works and how it is controlled by genes. In recent years, we have made important discoveries about the exome (the coding portions of genes), the proteome (the set of expressed proteins), and a number of other entities. These discoveries have the potential to illuminate the processes by which biological structures develop and interact with each other.

What we have now is an incredibly vast array of data, the base of which is written in a code of Cs, As, Ts, and Gs. We are slowly deciphering this code through careful analysis, but when the amount of data escalates to a point this high (there are over 20,000 coding genes in the human genome alone), it becomes impossible to analyze without some additional help.

This is where bioinformatics comes in. With the help of computers, we can take the raw data that we obtain in the sequencing lab and convert it to concrete knowledge that will be useful to mankind. There are many ways in which computers can be utilized to do this, including the creation of searchable databases that store genetic information. For example, the National Center for Biotechnology operates a database known as GenBank, which

contains all published nucleotide (and amino acid) sequences. Anyone with an internet connection can search for a particular gene within this database and obtain results in under fifteen seconds.

Scientists have built upon simple databases such as these and gone even further. One software development project with far-reaching applications in the field of medicine was conducted by a group at Stanford University led by Atul J. Butte, PhD. They designed a computer program that searched through a data repository called the Gene Expression Omnibus, which contains data from genomics studies around the world. In these studies, researchers recorded whether or not specific genes were expressed, and the extent to which they were expressed, in various experimental conditions. The computer program then used this data to determine which drugs would be effective against which diseases. It did this by matching a disease that increased a certain gene's activity with a drug that decreased the gene's activity, or vice-versa. Of course, this program recognized many matches that are already well-known and in clinical use. However, some matches were previously unknown. One of the matches in particular was something that nobody would ever expect: cimetidine (a medication used to treat ulcers) appeared to be potentially effective against lung cancer. After the computer program revealed this match, Butte's team tested the theory in the wet lab, and cimetidine did indeed slow the growth of cancer cells.

Another rapidly-emerging field within bioinformatics is the usage of computer programs

to model biological processes. A wide range of simulation software exists; for example, ENteric Immunity Simulator (ENISI), developed by a group at the Virginia Bioinformatics Institute, models inflammatory bowel disease, and allows investigators to set 87 different parameters and then observe the outcome of the simulated disease. However, one drawback to this software is that the disease progression cannot be observed in real time. A real-time simulation is a very complex undertaking, due to the large amount of computational power required, the intricacy of the interatomic reactions, and the fact that steps within processes can occur on completely different time scales (i.e. picoseconds vs. seconds). But in the past few years, much progress has been made in this area, and plans are in the making for an upgrade to ENISI in which the real-time interactions can be observed.

The methods described above only comprise a tiny proportion of the wealth of bioinformatics software that exists today. Likewise, the expanse of software that is in use today is a mere fraction of what will exist in the future. Biological research, like a number of other fields, is becoming more and more data-driven, and if it were not for the development of computer programs that analyze this data, research potential would be severely limited. Fortunately, biologists and computer scientists have joined forces and this union will enable us to learn more about the world around us than we would have ever thought possible.

*Northeastern University offers a Professional Master of Science in Bioinformatics.*

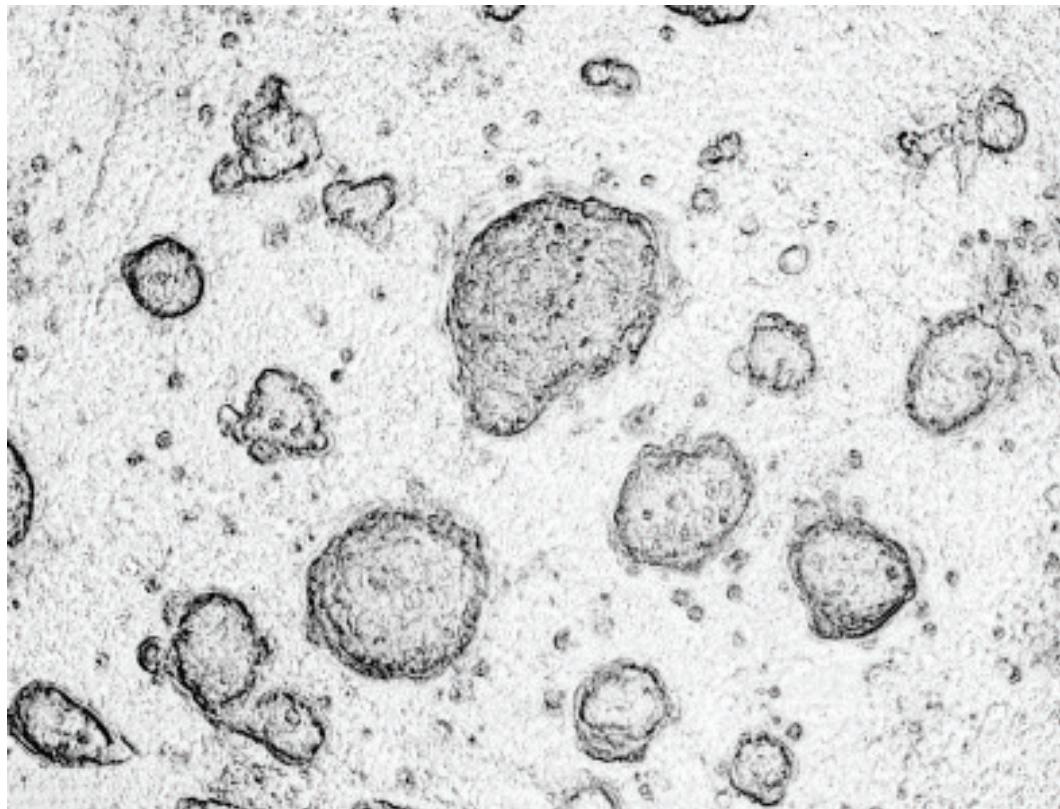
# IPSSay WHAT?

BY SHANNON JONES, MARINE BIOLOGY, 2017

There is new hope for ways to manufacture stem cells while avoiding the procedures that have been found repugnant by some. The use of induced pluripotent stem cells, or iPS cells, holds great possibility. Basically, the idea is that skin cells are taken from an adult and cultured in a dish, and then they are altered in order to reset the cells to an embryonic state. These cells can, theoretically, then be applied back onto the body of the patient that they were taken from, because they express stem cell markers. Their undifferentiated state means that they will fulfill whatever purpose needed in order to heal the patient, becoming skin cells, liver cells, red blood cells... anything that the body needs.

Stem cells are useful in medicine because they can express qualities characteristic of any of the three germ layers of blastocoels, which are one of the earliest stages of embryonic development. They can be used in drug development and testing or disease modeling, such as studies of cardiac arrest or genetic diseases. Even when not used directly in a human body, they can improve lives. However, when used in medicine on patients, they can be used as a part of organ transplants, blindness reversal, and other techniques which can save or better lives.

iPS cells were first produced in 2006 from mice, and in 2007 the first human cells were made. However, they have been put through many rigorous tests since then, as the public is wary of them, because they may differ from true stem cells in unknown ways. Early tests found that some iPS cells could cause cancers and uncontrolled cell growth if not made properly, as at the time the cells were made by introducing a retrovirus which would force the cells to express the four gene markers that were thought to be characteristic of embryonic cells. The virus used could remain in the cells, or alter them in other ways, and this method did not always work. This was a great shortcoming to the method, and research continued. Since then, it has been found that many different gene marker groups can be altered in order to make a cell act as if it was embryonic, and most advances have led to a simplification in the process.



Research is currently being done to make stem cells safer for use in humans, and advances have already been made. John Hopkins researchers have made iPS cells by inserting circular strands of DNA made from blood cells made from human cord or adult blood, which completely changes how we look at ways to make stem cells. As stated in their press release by Linzhao Cheng, Ph.D., the new cells "are much safer than ones made with previous technologies because they don't involve integrating foreign viruses that can potentially lead to uncontrolled, cancerous cell growth." The cells created at John Hopkins are ready for use in

about fourteen days, instead of the month needed previously. The circular strands of DNA have been proven to dissipate and are lost, instead of remaining in the cells the way the retrovirus would. Cheng says, "This easy method of generating integration-free human iPS cells from blood cells will accelerate their use in both research and future clinical applications," which means that stem cells may be on their way to being integrated fully into medicine sometime soon. Once proven entirely safe, they will make a conflict-free alternative to embryonic stem cells, while being applicable to any branch of medicinal testing or treatment. □

# Smart Tattoo Simplifies Blood Sugar Monitoring

BY TARA DHINGRA, BIOCHEMISTRY, 2012

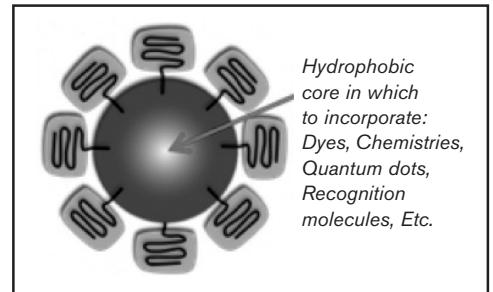
**I**magine a tattoo that detects sugar levels in blood. Heather Clark, one of the leading analytical chemists developing this new and exciting tool, loves the idea that a dangerous disease could not only be managed, but could be managed with such little effort and pain for each patient. Nanosensors are a breakthrough technological tool that are being developed right here on campus to fight major biological problems such as the diabetes epidemic. On January 17, 2012 I met with Dr. Clark and she described her research, its developing momentum and potential effects for diabetes patients.

A nanosensor is a small particle -100nm diameter – made of polymers with a core that can hold substance of interest like dyes. In the case for glucose detection, organic dyes are incorporated that fluoresce in the presence of glucose theoretically correlating to blood glucose levels. There are some obstacles to overcome such as the immune response and application. In vivo studies show no major problems with immune reaction upon insertion of the tattoo. However, studies are in early stages and therefore Clark insists that this question has no answer yet and that more research must be done before FDA approval is within reach.

Though no immune response seems to be elicited upon insertion of the particles, does initial inset affect the glucose reading in the area? This may pose a bigger problem since inflammation at the site which is normally associated with a tattoo indicates the usage of glucose which can skew results.

This tattoo is not permanent like the artwork displayed on many people. However, permanent in this case is not practical since nanosensors do not last forever. Dr. Clark described two ways to apply nanosensor technology as a temporary sugar detection tattoo. One is to have a tattoo that is applied weekly via an epi-pen apparatus that doesn't go deep into the skin layer and sloughs off naturally. This option is less painful to apply and ideally would be able to be applied by patients. Another option lasts longer by going deeper into the skin layer and is naturally biodegradable. This option would take longer to develop, but would be more accurate reading of glucose levels since it's closer to the blood vessels.

Another technique being perfected in the Clark lab is utilizing the ion selective quantum dot (ISQD) to monitor cell signaling. As professor Clark described, ISQDs are nanoparticles made of

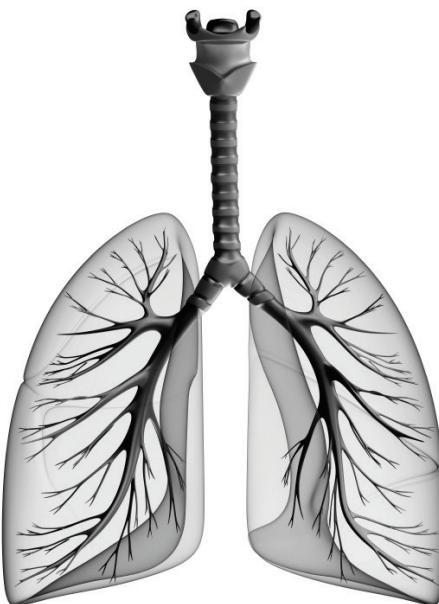


the semi-conductor material with a more stable fluorescent property. This device is incorporated with the polymer nanosensors to detect ion channels in signal cells. However, these particles will most likely not be incorporated into the glucose detecting tattoos because they are toxic, but they prove useful for observing cells in culture. This technique can be used to compare ion channel activity in healthy versus unhealthy cells which could have big implications for many diseases especially cardiac diseases.

Overall, Clark is on the cusp of an amazing breakthrough that could change the lives of millions. n

# Scientists Implant First Artificial Trachea

BY MICHAEL MURRAY, COMPUTER SCIENCE AND ENGLISH, 2014



**S**cientific advances constantly expand the range of what modern medicine can treat. One such new and innovative procedure is the use of an artificial trachea to replace a cancerous one. The transplant, which has now been performed multiple times, offers new hope to those suffering from previously-inoperable tracheal cancer.

This procedure first took place in 2011, on a patient from Iceland at the Karolinska University Hospital in Stockholm, Sweden. A frame for the new trachea was uniquely crafted for him using three dimensional imaging. Then, his own stem cells were used to complete the airway, guaranteeing that his body would accept the transplant. The artificial windpipe also freed him from having to wait on the donor list, a lengthy process complicated by the difficulty of precisely matching tracheae.

Growing the recipient's tissue on the transplant was a difficult process, lasting days. Once the stem cells were introduced to the frame, they slowly began to divide and grow. Compounds known as "transcription factors" were used to coax the cells into becoming specialized trachea cells. After time in a bioreactor, the trachea was ready to be

introduced to the patient's body, after which the stem cells began to assimilate into the surrounding tissue.

While the new procedure has been successful so far, several major issues must be resolved before it can become more widespread. First is the issue of cost; at present, the entire treatment totals roughly \$450,000. More importantly, the long-term success of the treatment is currently unknown. While all recipients have been recovering well so far, many experts have doubts about the longevity of the implant. Dr Alan Trounson, the president of the California Institute for Regenerative Medicine, praises the work of those involved, but predicts that the host bodies will eventually react adversely to the pieces.

While this treatment is currently imperfect, it offers insights into the potential future of medicine. Custom-made organs that would have otherwise seemed like science fiction only a few years ago are now carried by people today. With other organs becoming available, such as the bladder, it seems reasonable to expect great strides to come from the field of tissue engineering. n

# At NEU: Professor Niedre

BY TUSHAR SWAMY, ELECTRICAL ENGINEERING AND PHYSICS, 2015

**P**rofessor Mark Niedre is a researcher at Northeastern University who is at the forefront of biomedical imaging. Obtaining substantial grants from organizations such as the National Institute of Health and the Massachusetts Life Sciences Center, Professor Niedre has made some significant advances to biomedical engineering.

Professor Niedre works on a variety of projects related to imaging technologies. Though he has several projects running simultaneously, one in particular has come to fruition in recent months. Professor Niedre and Master's student Eric Zettergren have been building a device that would allow scientists and doctors to track and monitor the movement of individual cancer cells in an organism's blood stream, also known as metastasis. The way they do this is by tagging the cancerous cells with fluorescent proteins. The organism is then subjected to two lasers (~640 nm) that, while not harming the organism, will cause the fluorescently tagged cells to excite. When excited, the cells emit light at specific wavelengths. An array of specialized sensors set up around the organism pick up the light and feed it through fiber optic cables to an instrument known as a Photomultiplier Tube (PMT). When the photons from the cells arrive at the PMT, they excite electrons via the photoelectric effect. These electrons then excite more electrons through secondary emission. The electrons are then picked up as a current, which the PMT, along with accompanying software, uses to indicate whenever a fluorescently tagged cell (a cancerous cell) crosses the field of view of the sensors. In this way, the system can effectively count the number of cancerous cells in an organism's blood stream, thereby monitoring the progress of the metastasis. The set up also has the benefit of being "in vivo" ("within the living" in Latin). Conventional devices take small blood samples from an organism and analyze them at a later date through a host of

various techniques. This makes detecting rare cells difficult because the rare cell may not occur in the blood sample. Professor Niedre's setup examines the organism's bloodstream without ever taking a sample or disrupting the blood flow. In this way, he can accurately observe the entirety of the blood in an organism in a short time. Part way through the development of the system, Professor Niedre and Eric ran into a complication. Multiple tagged cells were moving through the field of view of the sensors at the same time, and the PMT was picking them up as only one cell. To this end, they put together a program using MATLAB that would use the information gathered from the sensors to create a reconstruction of the arteries and veins. This would allow them to see when tagged cells moved through specific arteries and veins. In this way, one would know if cells were double counted because the reconstruction would show cells going through specific arteries and veins simultaneously.

Though the setup shows great promise, the team is still making changes to the system in the hopes of optimizing performance. One of the projects they are currently working on involves adding lasers that operate in the near infrared range (~750 nm). The reason for this addition lies in the fluorescent proteins used for tagging cells. By adding a second set of lasers with a different wavelength range, one could tag another set of cells with a new protein that responds to the new wavelength. Professor Niedre's setup could then be used to detect two different cell populations. Major changes have already been made to the reconstruction program such as the inclusion of the Monte Carlo method: a simulation of every possible photon pathway from the laser. This is a very powerful simulation, but due to its intensive nature, the simulation had to be done at special GPU clusters.

When asked what plans for the future were, Professor Niedre mentioned that one of the end

goals would be using the device as a way to study drugs that treat cancer during preclinical development. Since the setup can effectively monitor the concentration of cancer cells, one could determine the effectiveness of the drug by monitoring how the concentration of the cancerous cells dropped. A longer term goal would be creating a portable device to the same effect, something that could clip onto someone's ear, for example. There is an emerging collaboration between Professor Niedre, Professor Marvin Onabajo, and Professor NicolMcGruer to take the miniaturization idea even farther. Professor McGruer specializes in nanoscale fabrication while Professor Onabajo's area of expertise lies in analog and mixed signal integrated circuits. They are discussing creating an even smaller version of the device, which could be implanted into person's artery or vein. This would allow the device to monitor circulating cells in the bloodstream continuously. The implantation would use current medical procedures such as the insertion of a stent. The idea would be to put a miniaturized version of the electronics used in the current iteration of the device and have it relay information wirelessly. This idea is still in the conceptual stages and will take some time to refine and implement.

Overall, the research being done right here at Northeastern University in Professor Niedre's lab has the potential to change the way cancer detection is currently implemented as well as the manner in which cancer treatment in preclinical development is evaluated. In addition, plans for the future are promising, especially considering the potential collaboration with Professor Onabajo and Professor McGruer. The plans to implement a blood vessel sized variation of the cancer detection setup are nothing short of exciting and could certainly be a powerful tool in the fight against cancer. n

# Meet Professor Edgar Goluch

## DiPietro Assistant Professor of Chemical Engineering

Research area: Making micro- and nano-fluidic devices for bioanalytical sensing

BY JOHN JAMIESON, CHEMICAL ENGINEERING, 2015

**S**tudying bacteria on the level of the individual cell can be a challenge. It is worthwhile, however, to understand how the individual cell reacts chemically in the presence of certain compounds because this knowledge leads to the development of important new antibiotics, among other goals.

But when hundreds of thousands of bacteria can fit on the head of a pin, how can we isolate just one and contain it long enough for it to be studied?

Professor Edgar Goluch is conducting research on devices that allow us to learn more about important species of bacteria. These devices must include a mechanism by which to trap the bacteria, as well as extremely sensitive sensors which surround the bacteria and detect chemicals emitted by the cell.

A micro-fluidic or nano-fluidic chip can be used to fulfill each of these needs. This kind of device resembles a computer chip at first glance, but instead of electricity, switches, and capacitors, they include picoliters of fluid, channels, and valves.

By etching a system of microchannels and nanochannels into the chip, the smallest of which are approximately the size of the bacteria, the bacteria could become physically wedged into a channel, allowing it to be studied by chemical sensors imbedded in the walls.

Professor Goluch is new to Northeastern, in just his second year as a professor here. He was selected from a pool of hundreds of applicants for the position. Prior to joining Northeastern, he received his PhD in Bioengineering from the University of Illinois at Urbana Champaign in 2007, and completed a postdoc in the Netherlands working with a group of biophysicists. *NU Science* had the opportunity to ask him more about his research in his lab in Snell Engineering.

### **NU SCI: What is the main goal of your research?**

My group creates controlled microenvironments with integrated sensors to study how individual cells interact with each other and react to different chemical compounds. Usually these types of experiments are done with a microscope and only track one variable at a time. We try to take a more global view of the cells surroundings, to automate the process, and obtain more quantitative information.

### **NU SCI: How do you approach this?**

We make the devices using the same technology that people use for making computer chips. The first step is to catch individual bacterial cells. This is not as easy as it sounds. Bacterial cells are 10-100 times smaller than most human cells and swim quite fast. We are still in the process of evaluating different designs. One design is similar to a humane mouse trap, where once the bacterium enters a certain area, the door closes behind it and it can't leave. Another design, involving nanochannels, is similar to a very narrow one way street. Once the bacterium goes in, it has a very difficult time turning around and backing out.

### **NU SCI: Once the bacterium is trapped, what happens next?**

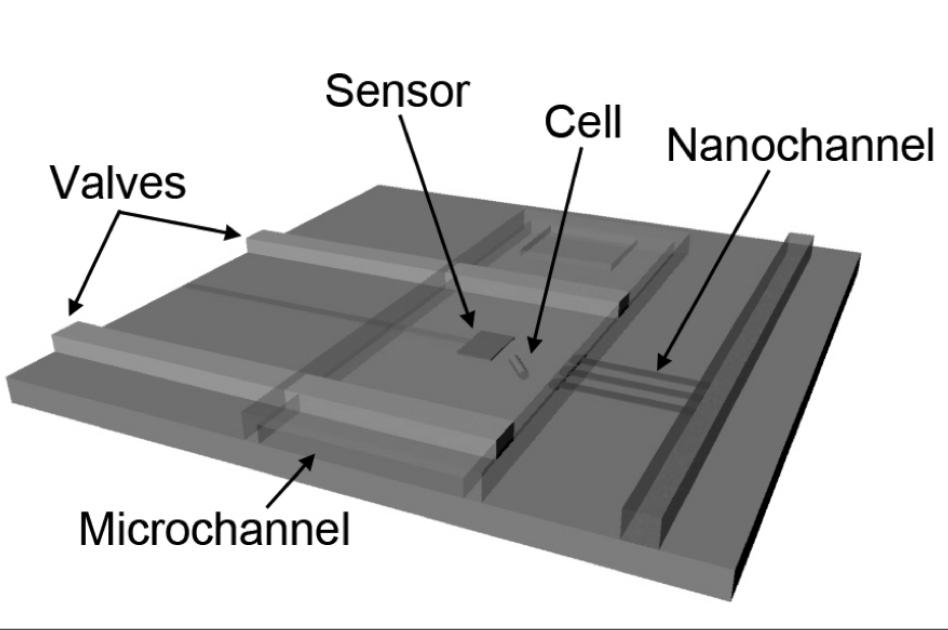
On the walls of these narrow streets, we have chemical sensors that detect the chemicals that the bacterium is making. The first species we are testing is *Pseudomonas aeruginosa* because it is responsible for many hospital infections and a lot of information about it is already known about it. We can compare our results against what others have seen and hope to find out some new information as well. We can also introduce various chemicals to see if they affect the way that the bacteria behaves and use that information to identify new drugs.

### **NU SCI: How did you come to teach at Northeastern?**

Applying for faculty jobs is a very unique process. I had a set of ideas about what type of research I wanted to do and applied to the best schools where I thought I would be successful. The hiring committee at Northeastern liked my research, though it fit well with their vision for the university, and I really liked the environment at Northeastern and in Boston. Northeastern already had the machines that we use to make the devices and some people working in this area. Plus Boston is arguably the best place in the world to do research, so the decision on my end was easy.

### **NU SCI: Which classes do you teach?**

I have been teaching Transport Processes I, a required class for chemical engineers. This is the first course in a series that looks at how different



Example of one of Goluch's devices. Photo courtesy of Edgar Goluch

*P. aeruginosa* is a rugged, gram-negative bacteria that is resistant to many common antibiotics. It is relatively harmless to healthy individuals, but to hospital patients with weakened immune systems or to the elderly, it is very dangerous, and has the ability to cause severe infections in the lungs, urinary tract, or kidneys.

In order to determine a more effective method of fighting this microbe than administering antibiotics, we need to understand the chemistry behind how this bacteria attacks and infects, especially on the level of the individual cell.

things get moved from point A to point B and what equations you use to model this observed behavior. For example we look at how water moves through a pipe and heat escapes from your home. This semester I'm really excited because I'm teaching a senior level chemical engineering elective on bioanalytical sensors which introduces students to my research field.

#### NU SCI: What do you like to do for fun?

I've been bowling in leagues since high school and actually met my wife in college at the bowling alley in the student union. In graduate school, I

started road biking and during the winter, these days, I play squash.

Goluch's research group consists of 3 PhD researchers and 5 undergraduates, each of whom is working on a different part of the problem. Sophomore chemical engineer Jim Berberian is an undergraduate in the Goluch Group, and *NU Science* had the chance to talk to him as well.

#### NU SCI: What have you been working on in the lab?

BERBERIAN: Well, the goal I was helping

with was trying to get liquid to flow into the nanochannel. One of the problems that we have to overcome is that the material used to make the chips polydimethylsiloxane (PDMS) is actually hydrophobic, so we have to show that under the right conditions we can get liquid to flow inside the nanochannel. This is an important step before we can attempt to trap the bacteria there. In November, when we finally succeeded with this problem it was a big step—it meant that the group could work on the real task of incorporating the .

#### NU SCI: What do you enjoy most about working in Goluch's lab? What's the most important thing you've learned so far?

BERBERIAN: I really like working with upper level undergraduates and PhD candidates. They've been there and done that, and that experience is really valuable to me as an undergrad. The biggest thing I've realized is that in research, there are a lot of failures that lead to you ultimately succeeding.

#### NU SCI: What made you decide to do research?

BERBERIAN: It was something that I knew I wanted to do ever since high school. I wanted to get exposed to that kind of environment and add real experience to my resume. It's how I got my co-op. They asked me so many questions about my research.

#### NU SCI: What's your advice for an undergrad that's interested in doing research? How big of a time commitment is it?

BERBERIAN: On a typical week, I spend about 5-10 hours in the lab. As far as getting started, what I did at least, was I looked up a bunch of teachers, emailed them and introduced myself, said a sentence or two about their research to show I was interested in it—that's important—and just kind of put yourself out there and get your name out. I was actually given Goluch's name by another professor that I had emailed who wasn't able to take on any more students at that time. There are really lots of different things you can do to get involved with the chemical engineering department here.

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# Regeneration and Drug Delivery

## Interview with Rebecca Carrier, Ph.D. Chemical Engineering

BY FARAZ ARASTU, BIOCHEMISTRY, 2015



NU Science had the privilege of meeting Dr. Rebecca Carrier, the Director of the Advanced Drug Delivery Research Laboratory (ADDRES) to discuss current projects her lab is working on. Dr. Carrier was recently presented a \$230K grant from the National Institute of Health (NIH) to develop a natural

matrix-based cell delivery system to stimulate retinal regeneration. She also works closely with Dr. Mansoor Amiji of Pharmaceutical Sciences on modeling drug delivery, whose work is newly supported by a \$475K grant from the National Institute of Neurological Diseases. In addition, Dr. Carrier works with Dr. Shashi Murthy, who also just received a \$1.9 million grant to improve intestinal stem cell therapy.

### NU Science: How did you develop interests for tissue regeneration and drug delivery?

Dr. Carrier: In graduate school, I was involved in a project on cardiac tissue engineering, but was drawn to the field of drug delivery for post-graduate work due to the desire to produce a marketable product in the near-term. After graduate school, I worked for a pharmaceutical company which motivated me to increase efficacy in drug delivery. While studying drug delivery, I found that cell culture models used to test drug delivery were not predictive enough. For instance, one drawback to modern gastrointestinal (GI) models is that the cultures are grown on a flat surface. On the microscale, however, there is a convoluted topography that plays a significant role in the function of the GI tract. In the lab, our current approach to intestinal tissue engineering is to generate biomimetic models to assess the factors that influence drug absorption.

### NU Science: What sort of projects are you currently working on?

Dr. Carrier: On the drug delivery side, we are primarily concerned with oral delivery. We are trying to quantitatively assess the effectiveness of emulsion-based drug delivery systems in oral absorption. These delivery systems use emulsified oils to deliver a drug of interest; oils are stabilized in the aqueous phase using a surfactant surface. The goal is to develop better dosing schemes based on oil, surfactant, and drug interactions with the biological environment.

Another major focus is to characterize the effects of lipids in the GI tract as a facilitator of nutrient, drug, and toxin absorption. Our results indicate that oils play a large role in modulating mucus barriers, which regulate transportation of nutrients and invasion of pathogens. Because the GI tract is also covered by a diverse microbiome, these studies deal with transportation mechanisms of microorganisms. We use GI mucus from pig intestines to test the integrity of the mucus barrier and couple those tests with *in vitro* assays using fluorescently labeled microbes: mostly *E. coli*. Our research is, of course, clinically directed but we are not at the stage where we can assay in humans.

### NU Science: What collaborations do you have with other professors/organizations?

Dr. Carrier: Our lab is very interdisciplinary, so we have a number of partnerships. Some of the grants are jointly awarded, so that's another factor. One microfabrication technique we use for intestinal tissue engineering was developed in conjunction with Dr. Murthy's lab to mimic the structure of the intestine. We also work closely with Dr. Amiji's group for our drug delivery research. Our work in studying mucus barrier properties and lipid function in the GI tract is being jointly conducted with Dr. David Budil's lab, using electron spin resonance (ESR). Our ongoing lipid drug delivery research is

in collaboration with Merck. More recently, we've partnered with the Schepens Eye Research Institute to develop materials useful for retinal stem cell therapies. But collaboration happens on every level, not only with different labs, but different people. The students in the lab range from biochemistry to engineering. Each specialty has a unique perspective to contribute when we're dealing with complex research questions.

### NU Science: What direction do you see your research taking in the future?

Dr. Carrier: Our project with Schepens is growing, so our lab is shifting focus to include the eye as well as the intestine and oral drug delivery. We want to make progress in developing biomaterials to enable retinal regeneration that can be tested in cell studies and ultimately surgically. Hopefully that research can be applied clinically in the near future.

As far as drug delivery, we want to be able to understand and predict the quantitative impact of lipids on the body's absorption. This will be critical since there is currently no predictive model. Clinically, this could be used for drug delivery, but also to enhance nutrient uptake and help prevent disease. We will also continue to study the significance of mucus in oral absorption. Ideally, we want to learn how to regulate mucus barrier properties to increase nutrient absorption and decrease pathogen invasion.

At the end of the day, our overall goal is to quantitatively understand and predict the interactions between materials and biological systems to enable rational drug delivery design as well as effective tissue engineering.

# Generic drugs: Pills for Less

BY KAVITHA RANGANATHAN, BIOTECHNOLOGY, 2013



**\$** 800,000,000 is the approximate cost of developing an innovative drug. But when this drug becomes a "blockbuster" it brings back billions to the innovator. Lipitor, one such "blockbuster" drug from Pfizer raked in an astounding \$14 billion dollars last year alone! Pfizer has been making big money for many years now and people have been paying hefty co-pays to receive this drug. But for both Pfizer's Lipitor and its patients, this is going to change soon. The prices are expected to plunge by as much as 80%. Why?

The answer lies in "generic drugs".

Innovative companies enjoy monopoly on their invention for 20 years from the time they file a patent for a drug. In this period they recover the money spent on research, development, and marketing of the drug. But once the patent expires, it is up for grabs by generic drug makers who can create "copy cat" versions for far cheaper.

So what are generic drugs and how are they any different from the branded equivalent? Generic drugs are equivalent to innovative drugs in safety, strength, quality, characteristics and route of administration. Simply put, they are bioequivalent of the branded drugs with only one major difference: the price. Since these generic drug companies don't have to spend millions in research and marketing, they can afford to sell their version of the drug at a substantially lower price. In addition, generic drugs get to "piggyback" on expensive clinical trial procedures done by their branded counterpart. Let us compare some prices:

BRAND NAME DRUG	GENERIC NAME DRUG	APPROX BRANDED DRUG COST	APPROX GENERIC DRUG COST
Advil	Ibuprofen	\$12.99	\$4.75
Proza	Fluoxetine	\$126	\$5
Valium	Diazepam	\$157.76	\$1.82

The price difference is significant. But as with anything cheap, there is a negative perception. With the word generic drugs comes many myths:

**Myth:** Generics are not as effective as the branded version.

**Fact:** A generic drug must have the exact same Active Pharmaceutical Ingredient as the branded version. It must be proved as an efficient bioequivalent of the branded version to the FDA before it hits the market.

**Myth:** Generic drugs are not as safe as Branded drugs.

**Fact:** Generic drugs go through stringent quality inspections like branded drugs. Treatment failures can occur in both. Tylenol for example is an extremely popular branded drug that was recalled recently.

**Myth:** Generic drugs are manufactured in sub-standard facilities and are therefore of inferior quality.

**Fact:** Many generic companies are large multinationals and sometimes have more modern facilities than innovative drug manufacturers. Teva, the number one generic manufacturer is as big as Bristol Myers Squibb. In fact, many innovative companies also have their own generic wings.

Generic business is not as easy as it may seem. With many generic companies in the fray, a significant profit can be made only if a generic drug company acquires a "180-day exclusivity" period. During this period only that company gets exclusive rights to sell its generic version. Subsequently, the drug opens to other generic companies as well, dipping the prices even further.

So far we have viewed generics as a mere cost advantage but for many developing and under developed countries generics are the only access to life saving drugs. India and China have well established Generic companies that not only supply drugs to developing countries but also to disease struck under-developed countries like Africa. AIDS kills millions of people worldwide and of the 36 million people affected by HIV, most of them live in Africa. The only affordable access to their essential medications comes in the form of Generic drugs. Further subsidies for these generic HIV drugs are provided by governments of various countries. Similarly, Brazil with the help of generic drugs and flexible patent laws, has reduced the mortality rate of the country by 50%.

Cancer continues to be the leading cause of death worldwide and every year more advanced cancer drugs are introduced. These advanced cancer drugs are made available for cheaper worldwide mainly due to generic drugs.

Generics have made a profound difference to the lives of millions across the globe. With plenty of imminent patent expirations and a highly competitive generics industry, consumers like us only stand to benefit.

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Photo courtesy of Wired.co.uk



Photo courtesy of DailyMail.co.uk

# Monkey Business: Scientists Create Monkey Chimeras

BY LAUREN HITCHINGS, BIOLOGY, 2014

The Oregon National Primate Research Centre is officially the first to introduce three young chimeric monkeys to the world. Chimeras are biological mosaics; they are organisms whose tissues and organs are made up of cells with multiple distinct genomes, which stem from separate embryonic cell lines.

In nature, chimeras are formed only in incredibly rare cases in which two or more embryos fuse together, by chance, in the womb. Research began on creating chimeric animals in the 1960's when researchers discovered that by injecting early stage mouse embryos with stem cells from another, they could get was a single, normalized, healthy mouse containing some cells with the genome of the embryo, and others with the genome of the injected stem cells.

Since their discovery, studies on chimeric mice have proved to be particularly useful in researching embryonic development and stem cell capabilities. They have helped scientists to explain how and why certain cells develop into specific tissues, how specific genes work, how stem cells can best be transferred from laboratory storage to a living organism, and more. Beyond mice, scientists have created a wide variety of chimeric animals including rats, rabbits, sheep, cattle, and now monkeys.

To create chimeric primates, Shoukhrat Mitalipov and his team in Oregon carefully worked to push together four-day-old rhesus monkey embryos in culture dishes. After only a few days, 90% of their cultures had developed into fully formed blastocysts containing more than

twice as many cells as normal. The successfully merged early stage embryos were then implanted into five females, all of which became pregnant. Three of the pregnancies were terminated early; tests on these fetuses confirmed that they were, in fact, chimeric. After a full gestation period, the remaining two expecting mothers gave birth by cesarean section. One had a single offspring, and the other had a set of twins.

The singlet was named Chimero, and the twins, Hex and Roku. All three of the infants were phenotypically male, though blood tests revealed that Roku contained some genetically female cells. Hex proved to be the most diverse of the bunch, containing cells from six separate embryos. As Mitalipov explained in a statement to the press, when the embryos are combined "the cells never fuse, but they stay together and work together to form tissues and organs."

The process of creating chimeric monkeys was not without difficulties for the researchers, and was in fact far more troublesome than it had been for creating chimeras of previous species. The process used in mice, simply injecting stem cells into an early stage embryo, was not enough for successful chimeric growth in primates. Instead, entire four-day-old embryos had to be merged together under very particular circumstances for them to take to one another. The research also showed that, while stem cells residing in actual embryos can develop into any tissue or organ, much of this pluripotency is lost in lines of embryonic stem cells grown in culture.

These difficulties could foreshadow future

troubles for human embryonic stem cell research. The fact that the rhesus monkey embryos were not as flexible as expected may indicate a similar result for human embryonic cells. Most of what scientists know about stem cells now is based only on experiments using mice as the test subjects.

Having a way to study embryonic development in primates will likely lead to research much more relevant to humans. Regenerative medicine and other stem cell therapies are dependent on the capabilities and limitations of human embryonic stem cells, and since it is not likely that human chimeras will be created in the near future, studying other primates is the best way to learn more.

Continuing to create and study monkey chimeras is an incredible opportunity for the medical world. This revolutionary achievement will hopefully make many of the experimental techniques that have been successful in mice, relevant to human healthcare. Animals like Chimero, Roku, and Hex might just be the key to unlocking the link between what can be done in the lab, and what can be applied to living, breathing human beings.



# ENGINEERS WITHOUT BORDERS

## AT NORTHEASTERN UNIVERSITY

BY ELIZABETH CHERCHIA, CIVIL ENGINEERING, 2014

**E**ngineers Without Borders is a national nonprofit organization dedicated to improving the quality of life in developing communities. Groups of students or professionals partner with these communities to assess the communities' needs and design and implement a solution. EWB chapters have developed relationships with communities all over the world. They bring about real change while helping engineering students develop into conscientious, globally-minded engineers.

The Engineers Without Borders chapter at Northeastern University (EWB-NEU) has projects in two countries – Honduras and Uganda. The Honduras program, the older of the two project lines, was begun in 2005. Since then, projects have been completed in several villages in the Yoro District of Honduras; these villages include El Tecuan, Los Planos, and El Chaguite. In El Tecuan, they replaced a 1,200 foot section of old, clogged pipe in the village's water distribution system. After completing the El Tecuan project, EWB-NEU began work in the nearby village of Los Planos, designing and implementing a village-wide water distribution system. In El Chaguite, EWB-NEU redesigned a similar faulty and dilapidated system, constructing a new 6,500 gallon water storage tank and new transmission lines for each tap stand. They are currently working in two villages, El Carrizalito and Los Oreros. A team of students traveled to Honduras in December 2011 to assess the needs El Carrizalito and expand the Los Oreros water distribution system. They will most likely install electricity in El Carrizalito to provide the village with water. Los Oreros is a tiny village of only seven houses; EWB-NEU is working to provide a tap to each one.

In 2009, EWB-NEU began a new project in Bbanda, a village in southwestern Uganda. Working in Uganda brought a new set of challenges to the group – a larger, more disjointed community, a different culture, and a new set of needs. The

village has over 1,200 residents, most of whom are subsistence farmers. Before work began in Bbanda, most residents were drawing water from various open sources. Many were fed by runoff from roads or farms, and some were located close to pit latrines. Since starting work in Uganda, EWB-NEU has drilled two borehole wells and constructed rainwater catchment systems on several schools. A team of students travelled to Bbanda in November 2011 to complete assessment for a village-wide water distribution system, a huge project that will take multiple years and phases of construction to complete.

Engineers Without Borders is where technical design and traditional engineering meet international development. Since they design for real communities and the projects will impact the lives of real people, members cannot afford to focus only on the technical aspects of a design. Instead, they must consider the problems from a cultural perspective, and base the design decisions around the needs, wants, and traditions of the community. A solution that makes sense from an engineering standpoint may not be a system that the village will use. Students learn to understand the health and societal implications of projects – when clean water is provided to people who have never had access to it, their health improves dramatically. Children stay in school for more of the year when they are not sick from waterborne diseases or walking long distances to collect water. In Bbanda, EWB-NEU set up a Waterboard to govern community-wide water-related issues, the only clearly established form of government the village has ever known recently. They also have to consider the sustainability of our project, including how the project will be funded and maintained after the group is gone. All the materials and technology used must be readily available in-country, and all labor must be provided by the community. n



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