



# NUScience

Northeastern University's First Science Magazine

## HEALTH AND MEDICINE:

NU Science Magazine collaborates with the Bouvé College of Health Sciences to explore current research and developments in the medical field.

### Also Inside:

- The Effects of Ultramarathons on the Human Body
- Interview with Dr. Terry Fulmer, Dean of Bouve College
- NUSci covers MIT's EmTech 2012 Conference

# Letter from the Editor

Dear Readers,

We are very pleased to present this issue of NU Science Magazine to the Northeastern campus. In collaboration with the Bouvé College of Health Sciences, our thirteenth issue focuses on one of the most essential branches of science to mankind, Health and Medicine.

The overwhelming desire to improve the health and wellbeing of others has prompted scientists to accomplish groundbreaking medical discoveries for centuries. Some of the greatest scientific minds of all time, from Hippocrates to Leonardo da Vinci to Louis Pasteur, have dedicated their lives to the pursuit of advancements in this field.

As you read through this issue, we encourage you to take a look at the diverse nature of health, encompassing topics such as preventative vaccines, human muscle tissue regeneration, and sleep patterns. Health and medicine are closely tied to numerous aspects of the human experience. Issue Thirteen of NU Science Magazine seeks to explore these ties

more closely. I am so grateful to the talented writers and dedicated editors/e-board members that have made this issue such an incredible success.

On a personal note, I am incredibly honored to serve as Co-Editor-in-Chief alongside Michael Murray for this special issue in collaboration with the Bouvé College of Health Sciences. For the past five years, I have had the privilege of studying in the Bouvé College as a health science major. This experience has opened my eyes to the incredible field of public health.

Through Bouvé, I have received the mentorship of dedicated and inspiring professors, the guidance of caring advisors, lasting supportive friendships with a number of my classmates, and the opportunity for life-changing travel experiences learning about health care around the world in areas including Southeast Asia and East Africa. I could never fully express how much my life and future plans have been shaped by my time as an undergraduate student in Bouvé. I

know that I would not be the person I am today without this College or its dedicated staff and faculty.

NU Science Magazine wishes to thank Dean Terry Fulmer, Assistant Dean for Administrative Affairs Anne M. Sullivan, and all of the faculty and staff in the Bouvé College of Health Sciences that have helped to make this issue possible.

As always, we encourage you to submit any suggestions you might have on ways we can improve and we invite you to get involved with the group if you would like to contribute to the magazine. Happy Reading!

## Elizabeth Gilbert

Health Science and International Affairs, 2013  
Co-Editor-in-Chief  
NU Science Magazine

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## GET INVOLVED!

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.

We meet every **Monday** at  
**7:30pm** in room **408 Eli Hall**.  
Come collaborate with us!

# Letter from the Dean

Dear Students,

As Dean of the Bouvé College of Health Science, I am reminded daily of the remarkable energy and spirit of discovery felt throughout the Bouvé community and our university.

We hear much in the news about STEM and the importance of our science programs that are so vital to the future of discovery in all areas. Whether you are a biology major, nursing major or health science entrepreneur club member, the daily media reminders underscore the point that a strong base in science is essential to becoming a well-informed, productive citizen.

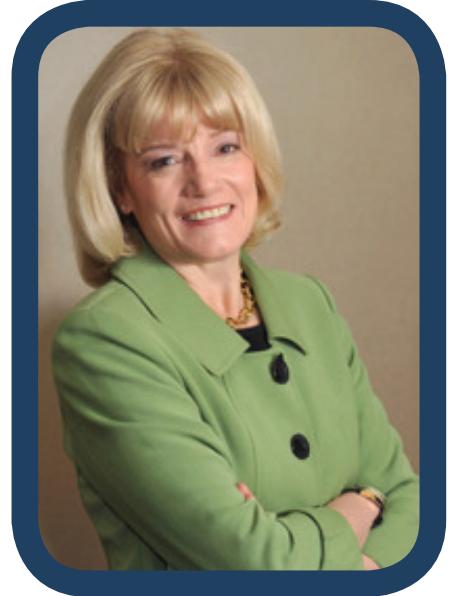
In this age of health care reform, the application of that science is evident every day as we learn about how human genomes help unlock new applications for drug discovery and delivery. The interprofessional and experiential cooperative education we provide at Northeastern are essential in preparing students to be successful in their careers. Today, graduates are likely to have at least 4-5 careers

in their lifetime and the education and practice they received at Northeastern will be vital to their success. Students in Bouvé and the College of Science have a particularly unique relationship with opportunities to collaborate through, for example, the Center for Drug Discovery and the Biotechnology program.

I am inspired by the tireless effort and unbridled enthusiasm of our students. As the semester comes to a close I commend you on your dedication and hard work.

I hope you have a wonderful holiday and I wish you the very best for the New Year and all of your academic and personal endeavors!

Sincerely,  
**Dean Fulmer**



## Interview with Dean Fulmer

BY TAARIKA GEORGE, HEALTH SCIENCE, 2013

Almost one year ago to the day, Northeastern's Bouvé College of Health Sciences gained one of its most renowned members to date. Dr. Terry Fulmer, most recently the Dean of the New York University College of Nursing, joins the university at a time of great momentum. I had the opportunity to speak with Dean Fulmer, and learn more about her impressive journey and new position at Northeastern.

Dean Fulmer earned her bachelor's degree from Skidmore College and her master's and Ph.D from Boston College. She attributes her passion for nursing to her mother. "I was incredibly proud of her in her professional role and the way she brought that role into our family life. She was a World War II cadet nurse, graduated from Syracuse University and always spoke of her education with great pride."

In addition to her career as a nurse, the Dean has held numerous academic positions in institutions including Boston College, Harvard

University, Yale University and Columbia University.

After completing her first year at Northeastern, Dean Fulmer stated that the best part about her new role is meeting the people who comprise the Northeastern community. Dean Fulmer characterizes the community as one of bright, energetic and welcoming people. She is happy to be a part of this dynamic enterprise. The Dean is a strong advocate for the co-op program and it was a major feature that intrigued her when contemplating joining Northeastern. She believes in the idea of experiential learning and its importance for future health professionals. Co-op provides many advantages and opportunities for students and Dean Fulmer enjoys watching as students engage in such meaningful and integral experiences.

In addition to her numerous responsibilities as Dean, she continues her own research on elder abuse and the relationship between elders and caregivers. Specifically, she studies the dyadic

interface between them during stressful situations. On average, she states, older adults have between three and five chronic diseases and are on five to ten medications. The magnitude of the combination of complexity and stress is not only overwhelming but often leads to abuse and neglect.

When asked about her perspective on the future of Bouvé, Dean Fulmer says she is completely energized by the momentum in the college. She hopes to take this opportunity to use that momentum to work with the faculty to continuously improve academic excellence, student experiences, and research trajectories during this time of health care reform.

In closing, the Dean leaves the readers of NU Science with this message: "Consider a career in the health professions! The future promises to hold many new opportunities and I encourage you to think entrepreneurially." n

# Calendar of Events

# January 2013

## FRIDAY, JANUARY 11

**Gene-Environment and Disparities Research Workshop Series: "Measuring Behavior in Gene-Environment Studies: Placing 'Choice' in a Social Context"**

3–4:30pm | Minot Room, 5th floor Countway Library, Harvard Medical School

*This event is part of a year-long series focused on understanding the origin of health disparities. RSVP required.*

## TUESDAY, JANUARY 22

**Timekeeping with a Three-Protein Circadian Clock**

10:30–11:30am | Whitehead Auditorium, MIT

*A public lecture by Erin O'Shea, HHMI and Department of Molecular and Cellular Biology at Harvard.*

## THURSDAY, JANUARY 24

**Malaria Seminar Series: "The Sporozoite's Journey from Mosquito to Mammalian Host"**

5–6pm | Cannon Room, Harvard Medical School

*Photini Sinnis, of John Hopkins University, will present on one form in the life cycle of the parasite responsible for malaria.*

# NUSci Explains

## ...Allergies

BY BILL FLEMING, CHEMICAL ENGINEERING, 2016

Many people have allergies, most of which are not life threatening. An allergy is essentially an overreaction of the immune system to a non-harmful substance. Most allergies are due to a combination of environmental and genetic factors. Some common allergens include pollen, food, insect stings, medications, dust mites, mold spores, and pet dander.

Our bodies contain mast cells, which normally help the immune system defend against pathogens. These cells have antibodies for specific substances. When that substance – the allergen – binds to its antibody, the cell releases a chemical called histamine, which triggers the symptoms associated with allergies: runny nose, watery or itchy eyes, and sneezing. Most anti-allergy medications are anti-histamines, meaning they block histamine from binding to its receptor.

While most allergies are inconvenient rather than dangerous, there exists a population of individuals who have a more acute sensitivity. For them, allergens trigger a life-threatening reaction known as anaphylaxis. During anaphylaxis the allergy sufferer will experience swelling of the face and throat, low blood pressure, and labored breathing. A common treatment for this is injection of epinephrine via an Epi-Pen. Each Epi-Pen comes preloaded with the correct amount of epinephrine for the individual based on their weight. The epinephrine causes the blood vessels to tighten, increasing the blood pressure. This helps the lung muscles to relax, returning breathing to normal and diminishing swelling of the face and throat. n



# The Rise of Food Borne Illness

BY KRISTEN TATSUNO, ENVIRONMENTAL SCIENCE, 2016



In the 21st century, it seems as though problems of food safety, first exposed by Upton Sinclair in *The Jungle*, should be a thing of the past. Unfortunately, the past two years have seen a 44% increase in foodborne illnesses. It seems that every few weeks there is a recall on everything from peanut butter to smoked salmon, citing diseases such as Salmonella or Listeria contamination. Yet supermarket aisles are lined with more food than ever. Packages tout miracle health foods from the Amazon and hermetically sealed fresh frozen shrimps cite their origin in the Far East. Our year-round access to such a diverse array of fruits, vegetables and meats should be keeping us healthier, right? Not according to the latest reports released by the CDC. In fact, our appetite for foreign-grown food might just be what is making us sick.

Foodborne diseases are not uncommon. They affect nearly 48 million Americans with symptoms ranging from fever to diarrhea and vomiting. In extreme cases, foodborne illnesses have been the cause of over 3,000 deaths. There are over 250 different bacteria, viruses and parasites that can cause foodborne illness. This leaves the FDA (Food and Drug Administration) inspectors with their work cut out for them. The average American consumes around 400 pounds of vegetables, 200 pounds of fruit and 175 pounds of meat each year, which leaves a lot of room for a contaminated bite. By the FDA's own admittance, only about 6% of the food grown in the U.S.

**“Our year-round access to such a diverse array of fruits, vegetables and meats should be keeping us healthier, right?...In fact, our appetite for foreign grown food might just be what is making us sick.”**

can be inspected. That amount is even lower for imported food. 15% of all U.S. food is imported and only 1% is ever thoroughly inspected by the FDA. In either case, the amount of food that goes past testing and straight to America's dinner plates is disturbingly high. While more stringent laws can improve the sanitation of food producers in the U.S., the problem with foreign imports is the lack of knowledge concerning how that food was produced. The CDC is concerned that as our appetite for cheap, foreign produced food increases, so will the number of outbreaks of foodborne illness.

To help illustrate the problem, let's look at one of the most commonly imported and commonly

contaminated products: seafood. According to the CDC, as much as 85% of the seafood eaten in the United States is imported and of the 39 foodborne disease outbreaks documented between 2005 and 2010, 17 were caused by contaminated seafood. Certain types of fish and shrimp, both once thought of as luxury items, are now seen at all-you-can-eat buffets and are widely available in the frozen section of the supermarket. Fish is seen as a healthy alternative to red meat and shrimp has now surpassed tuna as America's favorite seafood. The way this change occurred is through the same process that brought you the Dollar Menu at McDonalds, the industrialization of food production.

Dubbed aquaculture, the methods used to produce large quantities of fish or shrimp in a confined space are similar to what you would see on a Midwest factory farm. The animals are herded into underwater pens made of netting and over the course of several months they are fed a mixture of antibiotics and feed in order to quickly grow to market size. This process is much the same whether you are looking at a U.S. fish farm or an Asian one; the difference is in the details. In the U.S., regulations to insure the sustainability of marine habitats are beginning to be put into place. The FDA also strictly prohibits the use of some antibiotics and is able to more closely monitor fisheries domestically. Foreign fisheries are never inspected firsthand by the FDA, which only sees the final product. Shrimp from Thailand and China have been found with traces of banned drugs in their system. In addition, the reason farmed seafood needs the antibiotics is because the animals are often left to swim in their own waste and carcasses of other dead animals because the pens are in lakes or shallow water. The problems don't end with unregulated production; improper labeling is also prevalent in foreign markets. Because of differences in taxes and tariffs on food imported from some countries, producers will deliberately change the place of origin on shipments. This not only makes it hard to monitor the fisheries, it also doesn't allow officials to trace the source of the outbreak once it occurs.

The lack of transparency in foreign food production is causing major problems for the budget stricken FDA. President Obama recently signed the Food Safety Modernization Act, which would give the FDA more power to enforce laws and inspect food. But with foreign imports only continuing to increase, we can only hope the administration can maintain even its 1% inspection rate. n

# Think Before You Eat

BY KRISTIN MINISH, COMMUNICATIONS, 2013

What is the worst consequence of a bad diet? A fat joke? Maybe diabetes when you're older? What about Alzheimer's disease? Researchers have been debating the connection between diabetes and Alzheimer's since 2005, but the link between these diseases and a bad diet has only recently drawn attention.

In March 2012, researchers at the University of Pennsylvania published the first study to show existence of insulin resistance in the brains of people with Alzheimer's disease. Researchers located protein deposits known as amyloid beta in the brain tissue of Alzheimer's patients. These deposits are similar to those found in the brains of Type 2 diabetics. These proteins can damage the ability of insulin to signal, impeding the flow of blood sugar throughout the body. This creates a build up of sugar in the blood called hyperglycemia. Cells need this insulin in order to keep the blood vessels in the brain healthy; low insulin levels can lead to reduced brain function. While researchers do not believe that diabetes causes Alzheimer's disease, there is firm evidence supporting a shared root between the diseases.

In September of 2012, *New Scientist* published an article titled *Food For Thought: Eat your way to dementia*. This sparked a new interest among media in the connection between diet, diabetes and Alzheimer's disease. Many journalists agree that the United States' continuing struggle with rising obesity rates will lead to an increase in the number of individuals diagnosed with Type 2 diabetes. However, the implications of a bad diet on the development of Alzheimer's disease are just now being explored. Obesity alone increases the risk of cognitive impairment; however, Type 2 diabetics are twice as likely to develop Alzheimer's disease as non-diabetics.

These implications could be devastating. According to the Centers for Disease Control and Prevention (CDC), over one-third of the American population is obese and nearly 26 million are affected by diabetes. Type 2 diabetes accounts for 90 percent of these cases, and in 2010 alone doctors nationwide diagnosed an astonishing 1.9 million cases in Americans. In addition, there are an estimated 79 million individuals with prediabetes, the grey area between normal and diabetic blood sugar levels.

According to PubMed, bad diet, excess body weight and low activity levels are all risk factors of Type 2 diabetes. Although these causes have been long established and are widely known, a disturbing problem has recently emerged. Between 2002 and 2005, there were about 3,600 new cases diagnosed a year of people under the age of 20 with Type 2 diabetes. Researchers worry that individuals who develop



Type 2 diabetes in their youth will suffer its complications much earlier in life than those who become diabetic as adults. This could ultimately lead to a decline in the onset age of Alzheimer's disease for these individuals.

Dr. Mark Hyman, author of the New York Times Bestseller *The Blood Sugar Solution*, has even coined a name for this epidemic: "diabesity." The term "diabesity" was created on the prevalence of obese individuals being diagnosed with Type 2 diabetes. There is an evidential link between these epidemics; more than half of adults diagnosed with diabetes are also obese, and more than 30 percent are overweight. This is not to say, however, that Type 2 diabetes and obesity are perpetually connected. In fact, one-third of obese people will never develop diabetes. However, as the obesity epidemic surges, it is hard to ignore the simultaneous rise in people diagnosed with Type 2 diabetes. According to the CDC's most recent data from 2009, diabetes is seventh leading cause of death. Many other factors on this list, including the number one leading cause - heart failure, are linked to obesity. This shows that the effects of Hyman's so-called "diabesity," are far-reaching.

The newly discovered relationship between diabetes and Alzheimer's has led many to wonder whether diet and exercise could also help prevent Alzheimer's disease. Should people make an effort to eat a low glycemic diet; eliminating the processed foods, sugars and carbs that can lead to high blood sugar? Will this protect the brain from developing the amyloid beta proteins associated with Alzheimer's disease? The benefit of a low glycemic diet is still being examined because

insulin resistance has been found in the brains of Alzheimer's patients regardless of whether they have diabetes. At the University of Pennsylvania, researchers believe that treating this brain insulin resistance with currently available diabetes drugs has the potential to slow or prevent cognitive decline. However, further trials are needed to determine whether these medicines would be effective in non-diabetic patients with Alzheimer's disease. With slow progress towards a solution from pharmaceutical companies, preventative measures like diet and exercise may be key in reducing the number of people suffering from these diseases.

So is Alzheimer's disease really a third type of diabetes? That is still up for debate, but a connection between the causes of Alzheimer's disease and diabetes based on insulin resistance seems probable. Diabetes creates insulin resistance in the brain, which damages brain cells. This loss of brain function in turn leads to memory loss and disorientation – in essence, Alzheimer's disease. Many researchers, including Dr. Susan DeLaMonte, a neuropathologist from Brown Medical School who has studied this possible link, agree that diet and exercise could help. In a *Boston Globe* article, DeLaMonte encourages individuals to be mindful of their diet and exercise patterns. She cautions that excess fat can increase insulin resistance, while exercise can make cells more responsive. Although taking preventive measures against diabetes through diet and exercise does not guarantee safeguarding against Alzheimer's disease, many doctors agree that it is a good idea in itself as diabetes is linked to many other health problems. n

# Eye Drops as Neurodiagnostic Tools

BY MATTHEW COTTLE, BEHAVIORAL NEUROSCIENCE, 2013

Questions about neurodegenerative disorders such as Alzheimer's, Parkinson's, and prion diseases, though highly researched, still remain mostly unanswered overall when it comes to treatment and diagnosis. The August 2012 edition of *The Journal of the American Chemical Society* published an article by a team of researchers led by Jerry Yang and Emmanuel Theodorakis at the University of California San Diego entitled "Aminonaphthalene 2-Cyanoacrylate (ANCA) Probes Fluorescently Discriminate between Amyloid- and Prion Plaques in Brain." This article explained that recently developed technology, relevant to amyloids, could be turned into a new way of early diagnosing these diseases.

The amyloids that are observed in these diseases are misfolded protein fragments derived from amyloid precursor proteins that gather among the nerve cells in the brain. Prions, present in diseases such as Gerstmann-Straussler-Scheinker Syndrome and Creutzfeldt-Jakob Disease, are proteins that produce an "infectious" signal that leads to errors in protein production. This causes them to misfold without being corrected or broken down, causing the formation

of amyloids. Healthy brains remove these amyloids, whereas in some neurodegenerative diseases, they gather and form plaques in the brain. Though the direct role that amyloids play in neurodegeneration remains unclear, scientists are confident that they are a critical factor due to the abundance and location of plaques.

For years, much of the therapeutic research being conducted on these diseases has focused on targeting amyloids and the prevention of accumulation. Likewise, diagnostic research has focused on amyloids, contributing to the scientific community's growing understanding of the protein mutants. Existing diagnostic techniques, derived from years of research, include introducing radioactive molecules into the brain that make the amyloids visible in positron emission tomography (PET scans). Because these neurodegenerative diseases are all characterized by the formation of amyloids, it can be difficult to form a certain diagnosis. At this time, there is no way of differentiating between the amyloids that associate with different diseases, limiting the ability to tell the diseases apart. Such distinctions are frequently derived from the outward symptoms

of the disease as it progresses.

Cao et al. worked in their lab to create fluorescent markers that interact with the amyloids, recognizing the small differences that are associated with the various neurodegenerative diseases. The fluorescent probes change the color of the amyloid plaques according to the disease they associate with. As was discovered in the lab, the amyloids associated with a prion disease, like Creutzfeldt-Jakob Disease, emanate yellow, whereas with Alzheimer's disease, they show green. The amyloid buildups characteristic of neurodegenerative diseases occur not only in the brain but in the eye as well. Because of this, Yang and his team are looking to develop an eye drop that utilizes this technology as a means of diagnosing these diseases.

Diagnostic tools, like the eye drop, could not only provide more definitive diagnostics, but also provide earlier identification of disorders, which in turn can leave time for more effective and targeted treatments. The license has been issued for the commercial development of this eye drop (or ointment) and human trials will begin upon its completion. n

# When It's Broken, Fix It: A Lecture on the Importance of DNA Repair Genes in Preventing Cancer.

BY HANNAH BIALIC, BIOCHEMISTRY, 2016

On September 19th, Science in the News, a graduate group supported by Harvard Medical School, hosted their first of nine engaging scientific lectures. A group of Northeastern students, along with Professor Rifat Sipahi, were in attendance. Dr. Sipahi wanted to expose students to a different campus by walking around Boston and conversing on the topic being discussed. The lecture, entitled "Broken Genes: The Role of DNA Repair in Preventing Cancer" was led by PhD students Jacob Sargent, Ben Morris, and Thomas Graham. The seminar began with the basics of cancer and the impact genetic mutations have on its development. It was within

the genome, specifically the portion that codes for DNA repair proteins, that the lecture gained its focus.

When outside agents such as UV-B rays or X-Rays interact and damage a cell's DNA, repair proteins spring into action. If such proteins are impaired and fail to rectify the damage, then serious mutations can arise. It is within those errors that cancer finds its foothold in a cell. Yet, to diversify the issue, there are times when DNA damage is used to actually treat cancer. Cancer cells divide rapidly, so if a chemical were introduced into the body that inhibits cell division, then that chemical would directly inhibit cancer

growth. For example, if a cancerous cell is targeted with mustine, that mustine will form an interstrand crosslink across a strand of DNA. This can cause the DNA to break apart then attempt to repair itself. If those repair proteins make a mistake or are damaged, the DNA will fail to replicate and the cancerous cells will cease their growth. This discovery is the foundation of all chemotherapy and radiation treatments. The lecture was both easy to understand and extremely insightful, delivering home a strong message: the key to cancer lies within our genes. n

# Ultramarathons and the Human Body: A Scientific Look beyond the Blood, Sweat, and Tears

BY KRIS WEBER, BEHAVIORAL NEUROSCIENCE, 2017

After a full day of classes, lunch dates, and club meetings, it can be quite tempting to proclaim, "I feel like I've been running around all day!" Of course, the majority of our waking hours are usually spent sitting down, whether studying or on Facebook, and the majority of our exercise comes from madly dashing across campus. To say we've been running around "all day" is certainly an overstatement for most of us—but not for all.

Enter a small group of elite athletes known as 'ultrarunners.' Ultrarunners push themselves to their physical and mental limits by competing in footraces (aptly named 'ultramarathons') that exceed the 26.2 miles of a typical marathon. Ultramarathons often involve extreme conditions and terrain, and can span over 24 hours. While many people shake their heads at the notion of running 26.2 miles through city streets, ultrarunners regularly tackle 100 miles through the Sierra Nevada Mountains (Western States Endurance Run); 135 miles through the scorching desert hills of Death Valley (Badwater Ultramarathon); and 153 miles from Athens to Sparta (Spartathlon). To say these athletes are dedicated to their sport would be an understatement. Yet, what exactly is the cost of this dedication for their bodies?

First of all, an average runner lands on each foot approximately 5,000 times per hour throughout the duration of a race, though this varies significantly for ultramarathons when taking into account course difficulty from the extreme terrain. With the athlete's feet absorbing up to three times their body weight with each step forward, over one million pounds of pure force can be exerted during any given hour. Over 24 hours, such an amount of strain on the lower extremities becomes tremendous; feet can swell up to three sizes, while injuries related to the soft tissues of the lower extremities become commonplace (and are incidentally the most commonly cited reason for dropping out of an ultramarathon).

Rhabdomyolysis—dissolution of skeletal muscle—is especially prevalent among ultrarunners. Rhabdomyolysis results from buildup of creatine phosphokinase (also known as CPK, an enzyme found inside muscle cells) after strenuous exercise. High CPK levels also indicate the release of myoglobin, a protein capable of crystallizing within the kidney tubules. Thus, in extreme cases (such as when the individual is dehydrated, taking Ibuprofen, or under severe

heat stress, as during ultramarathons), excessive buildup of myoglobin can result in renal failure.

Violent spasms of hiccups, seizures from inadequate blood flow to brain, gastrointestinal bleeding—all are relatively expected physical side effects of participating in an ultra. Ultimately, however, one of the greatest physical challenges remains to be sustaining a sufficient energy balance to allow satisfactory performance.

It is not uncommon for ultrarunners to burn over 10,000 calories during a race, especially when the race spans multiple days. Prolonged endurance-based activity is known to significantly suppress an athlete's hunger drive, as do high temperatures and chronic dehydration; in short, the very nature of ultramarathons makes eating solid food a nearly impossible task. The diverting of blood flow from the digestive system to the outer extremities in order to cool the body down and maintain motion can cause runners to feel nauseous and unable to consume any form of calories, possibly leading them to vomit mid-race (which results in even greater dehydration). Yet, it is during these events of extreme athletic endurance when solid foods, as opposed to more digestible specialty products like 'GU' and energy drinks, are ultimately required to keep up an adequate balance of calories.

Running for such extended periods of time with a continuous caloric deficit—a common occurrence for these runners—is only one factor contributing to the enormous psychological impact incurred during an ultramarathon. With athletes running in extreme temperatures and conditions while consistently maintaining a negative energy balance, losing 4-6 liters of water per hour, depriving themselves of sleep to meet a time goal, and moving for extended lengths of time, it should not be shocking that many experience some sort of hallucination during their race. A 2003 study done on Death Valley's Badwater Ultramarathon (which is particularly notorious for its incidence of hallucinations) found that at least 30% of its runners hallucinated at some point. Out of these reported cases, the majority occurred during the second night when sleep deprivation was high, physical exhaustion was near its peak, and the silent darkness of the desert was so absolute. These conditions send the brain into 'survival mode' and weaken its abilities to discern what is real. One participant reported seeing rotting corpses cluttering the road in front of her; another



"Tarahumara runner Arnulfo Quimare runs alongside ultra-runner Scott Jurek in Mexico's Copper Canyons." Photo and caption courtesy of [www.bushwalking.org.au](http://www.bushwalking.org.au).

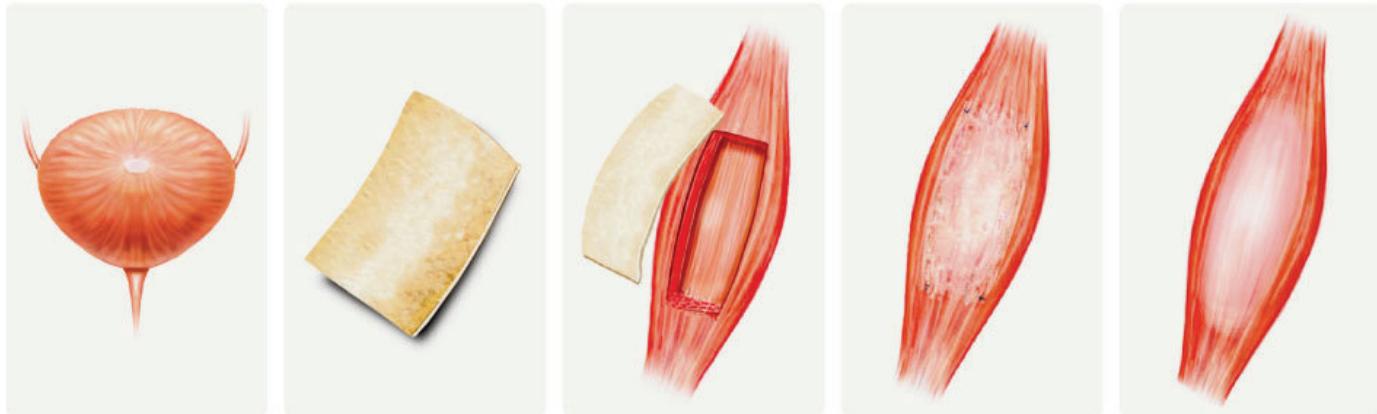
gave an account of feeling a bat constantly flapping its wings against his shoulder. Marshall Ulrich, a ten-time Badwater participant, once experienced an auditory hallucination so intense he believed an airplane was landing right next to him.

Foot injures. Renal failure. Seizures. Hallucinations. Is the satisfaction of completing an ultra truly worth the tremendous physical and psychological traumas incurred? Why do these athletes subject themselves to such suffering? What do they possibly stand to gain, apart from the knowledge that they completed a race of almost obscene proportions? Scott Jurek, two-time winner of the Badwater Ultramarathon and seven-time winner of the Western States Endurance Run, said it best in his memoir, Eat and Run, "The longer and further I ran, the more I realized that what I was often chasing was a state of mind...where worries that seemed monumental melted away, where the beauty and timelessness of the universe, of the present moment, came into sharp focus."

A moment of serenity, a state of near-transcendence, a time in which only your mind, body, and the road beneath your feet seem to exist... a runner's high of epic proportions. n

# Regrowth of Skeletal Muscle Tissue

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2017



**BLADDER** The process begins by removing a thin sheet of tissue from a pig's bladder. The tissue is treated to remove living cells.

Source: Dr. Stephen Badylak, University of Pittsburgh

**SHEET** The resulting web of collagen and protein is called extracellular matrix, and can look like a thick piece of parchment paper.

**IMPLANTATION** Scar tissue on the damaged muscle is cut out, and the matrix is stitched directly to the remaining healthy tissue.

**GROWTH** The matrix immediately begins to break down, which signals the body to recruit stem cells to the site and grow muscle.

**MUSCLE** Intensive physical therapy begins the day after surgery. Even a partial regrowth of muscle can improve movement.

THE NEW YORK TIMES; ILLUSTRATIONS BY RANDAL MCKENZIE

In the last few years, scientists have been conducting research in preparation for the regenerative science boom to come. One new technology uses extracellular matrix (ECM), the thin sheet of material produced by cells and underlying all tissues and organs, to regenerate damaged tissue. It has been shown that ECM taken from mammalian tissues can signal the human body to grow and repair injured muscle tissue at the cellular level. At the University of Pittsburgh Medical Center, extracellular matrix (ECM) was taken from the bladder of a pig to rebuild the severely damaged thigh muscle of an injured soldier. After stitching the matrix to

the damaged tissues, the matrix degenerated and signaled the body to recruit stem cells that developed into new muscle.

The loss of skeletal muscle is a unique challenge for doctors and patients, as the body cannot fully heal this kind of injury by itself. The US Military financially supports regenerative research and medicine, due to the fact that severe skeletal muscle injury is among the most common type of wound received by US military personnel. Currently, the standard treatment for muscle injuries is muscle flap procedures, in which doctors move a portion of muscle and its blood supply to another part of the body. However, this method is not applicable to large muscle defects, as the gap between separated muscle segments must be bridged to allow regenerating muscle fibers. New research suggests that the ECM is an important structural component for the development of these fibers. They provide a more suitable chemical and mechanical environment for the differentiation of cells, while releasing chemical signals to the surrounding environment and encouraging repair processes.

In a study published in the online scientific journal *Tissue Engineering Part A*, a team of researchers at University of Texas evaluated whether a graft of the ECM from skeletal muscle could be implanted into a large muscle defect in

rats and provide the proper environment for the growth and differentiation of regenerating muscle tissues. Four different degrees of injury were created in the lateral gastrocnemius (LGAS) of healthy Sprague-Dawley (S-D) rats. The LGAS is a calf muscle important for walking and standing. Each of the rats had a control surgery, a mild laceration, or a small or large chunk of muscle removed. Another group of rats, this time from the inbred Lewis strain (bred to easily accept transplanted tissue), was subjected to the most severe injury given to the S-D rats. In the inbred group, decellularized muscle ECM from other Lewis rats was implanted into the wound.

The resulting data supported the theory that ECM can aid muscle and blood vessel regeneration. Full functional recovery did not occur until after 42 days in the Lewis rats, while in the Sprague-Dawley rats, no functional recovery occurred in either of the groups with removed muscle tissue. Now, 2 years after the University of Texas study, this technique is being successfully used in humans. These advances in regenerative medicine tremendously affect stem cell and regeneration research, and can potentially change the lives of millions of people. n

**“**It has been shown that ECM taken from mammalian tissues can signal the human body to grow and repair injured muscle tissue at the cellular level.**”**

# Nanoparticles: A Promising Endeavor

BY HANNAH BIALIC, BIOCHEMISTRY, 2016

Science is always growing to adapt to a changing world. But as its scope seems to grow, its scale conversely seems to shrink. A promising avenue in drug targeting, the direct delivery of a medication to a patient in a manner that maximizes concentration of the drug, is the use of nanoparticles. A nanoparticle is a particle that is 100 nanometers or fewer in size and can become quite reactive when paired with other molecules, including chemotherapies and agents that target delivery to certain areas in the body. This flexibility gives nanoparticles great potential in the field of drug development, especially involving cancer treatments.

Nanoparticles of a substance tend to behave differently than that substance in larger quantities, often giving them unique and diverse properties. There are numerous types of nanoparticles, all with widely diverse applications in the field of direct drug delivery. These classes are very general and the borders of our understanding are constantly expanding due to the rapid growth of the field. The applications that nanotechnology

and nanoparticles present are currently under extensive research, even under our roof by a current Northeastern student.

Sean Burns, a fifth-year Chemical Engineering student, who worked at the Dana-Farber Cancer Institute, has some experience dealing with nanoparticles in association with cancer treatment. He spent his summer working along with the professionals at Dana-Farber on improved nanoparticle screening methods for potential cancer drugs. Using this new technology, they search through thousands of different drug molecules to find specific ones that can disrupt proteins crucial to the cancer's survival. The use of nanoparticles makes screening faster and more accurate, allowing scientists to survey a larger collection of promising drug molecules. The more diversity we can explore in the field of drug discovery, the more likely we will be able to find a way to specifically target the illness in the body and not the entire body itself.

Currently, polymer nanoparticles are being studied as a way to deliver a chemotherapy

drug called Docetaxel directly to cancerous tumors merely by targeting a protein present in such tumors. Gold nanoparticles are also being considered as a way to fight skin cancer by delivering a translation-halting RNA molecule to the cancer cells. The promise behind these endeavors is astonishing! The ability to cure a patient without dire side effects could change cancer therapy all together.

Nanoparticles aid ventures outside of the domain of cancer as well. Aluminosilicate nanoparticles have been found to induce blood clotting, which can reduce bleeding in trauma victims. Even a method to fight aging using porous nanoparticles is being developed. There seems to be countless possibilities for this budding field.

Though many applications of nanoparticles are still in the research phase, they present many amazing opportunities. As long as the research continues, treatments will improve and medicine will evolve. n

# The Nanoparticle Nicotine Vaccine

BY LAUREN HITCHINGS, BIOLOGY, 2015

According to the Centers for Disease Control and Prevention, cigarette addiction is the leading cause of preventable death in the United States and causes more deaths than HIV, illegal drug and alcohol use, motor vehicle accidents, suicides, and murders combined. When a person breathes in the smoke from a cigarette, nicotine travels through the lungs, into the bloodstream, and up to the brain where it triggers the release of dopamine, creating a feeling of happiness and reward. Withdrawal from nicotine is a biological condition that can lead to symptoms including anxiety, inability to concentrate, shaking, dizziness and more. Add that to extreme and persistent cravings for something that is so tempting and readily available, and it is easy to see why smoking is such a difficult habit to break.

There are currently many products available to aid smokers in their efforts to quit, including nicotine patches, chewing gum, inhalers and more. These products work to interfere with cravings by delivering small amounts of nicotine to the body, allowing the user to feel a reduced

portion of the nicotine buzz, slowly weaning the body off of it. Even with a variety of ways to quit, still upwards of 90 percent of people who attempt to give up smoking relapse at some point. Once smokers feel that first full buzz from even just one drag of a cigarette, the addiction is refueled.

Scientists at the Boston-based startup company, Selecta Biosciences, have been looking into an entirely new way to help people quit smoking. They aim to create a highly specific vaccine that may be able to reduce the addictive effect of nicotine and aid smokers in their efforts to quit. Unlike most current methods of smoking cessation, which allow the user to feel small amounts of pleasure from nicotine and gradually wean themselves off, the nicotine vaccine would hinder the pleasurable effects of nicotine altogether.

The novel vaccine uses synthetic nanoparticles to prompt the immune system to produce antibodies specific to nicotine. Much like how antibodies would attack a virus or foreign bacteria, these antibodies will bind to nicotine if

it enters the bloodstream. When the nicotine has an antibody bound to it, the complex is too large to pass through the blood brain barrier, and so the nicotine never makes it to the brain. This way, if a former smoker relapses and smokes a cigarette, he or she will not feel the effects of the nicotine and will not get a sense of a buzz. The hope is that even if a smoker gives in to a craving, a cigarette will no longer produce the desired reward, and it will be easier to quit for good.

Selecta's nicotine vaccine showed impressive results in pre-clinical trials and is now the first synthetically engineered nanoparticle vaccine, distinct from biological conventional vaccines, to be tested in humans. The vaccine is currently being tested in phase 1 clinical trials where it is being evaluated in healthy smoking and non-smoking volunteers for safety and potency. If it is well tolerated in humans and the results are good, further testing will follow, and there may soon be encouraging news for those who want to kick the nicotine habit and change their lives for good. n

# The Changing MCAT of 2015

BY JOSHUA TIMMONS, MAJOR, YEAR

**D**o you consider yourself pre-med? Would you take the Medical College Admissions Test (MCAT) in or after 2015? Well there's something you should know... But don't panic!

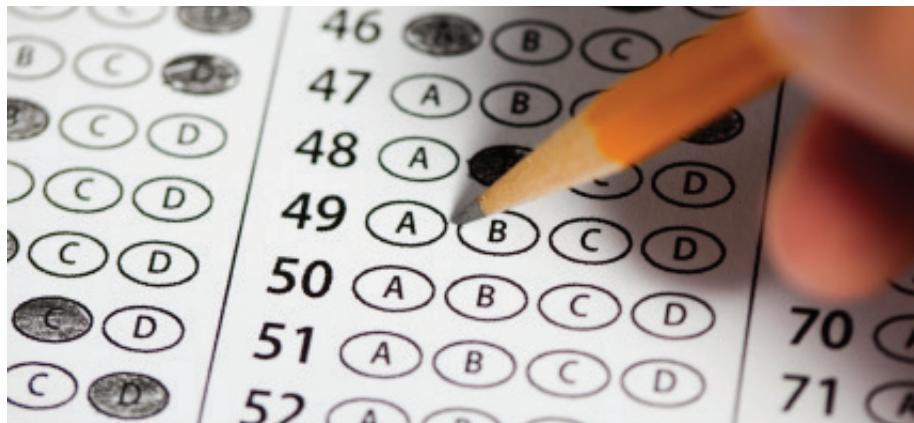
Yes, the MCAT of 2015 may be new and different. It may include some changed material and seem ominous for pre-meds who fear what they don't know. It may also, however, be comforting to remember that in the end the MCAT is just a test. With the right class selection, background knowledge, and study habits, the new MCAT will serve as an invaluable preparatory guide for the years of medical school ahead.

Why is the MCAT changing? For over three years, a committee of 21 people reviewed near 3,000 surveys from medical schools and medical professionals of all levels. Their goal, and consequently the goal of the Association of American Medical Colleges, was to improve upon the existing test and create one that more accurately reflects the needs of future doctors: "Our nation is growing, aging, and becoming increasingly diverse, so physicians of the future must be more culturally competent"<sup>1</sup>

**“At the end of the day, the most crucial message to take away is that the MCAT is still conquerable.”**

What does all this mean for you? It means the addition of new sections, the removal of old ones, and an overall change in focus for what is often considered the single largest determinant of medical school acceptance. The MCAT will soon incorporate an additional emphasis on the sociocultural and behavioral determinants of health. It will not however, starting in 2013, include a writing portion. According to medical school acceptance officers, the writing score was rarely used for acceptance and has therefore been scraped in favor of other sections.

Social and behavioral sciences are the backbone for the new section "Psychological, Social and Biological Foundations of Behavior." This makes introductory psychology and sociology two strongly recommended classes for pre-meds: an estimated 60% of the section will be psychology questions, 30% sociology, and 10% introductory biology. Comparative optimism,



implicit bias, and symbolic interactionism are just a few examples of new concepts for the MCAT of 2015.

The current verbal section will be revamped to become the "Critical Analysis and Reasoning Skills", designed to determine whether the test taker has the analytical skills necessary to identify and solve problems analogous to those seen in a clinical environment. The reading passages of this section will feature topics from social sciences to humanities and, while background knowledge is not required, the subject matter will largely focus on philosophy, ethics, and population health. This section will be largely skill based, so the best form of preparation may be to simply familiarize oneself with extrapolating information and reading scientific material.

The two natural science portions, "Biological and Biochemical Foundations of Living Systems" and "Chemical and Physical Foundations of Biological Systems", aren't new to the MCAT but will now include additional biology and an emphasis on biochemistry. With this in mind, the AAMC is recommending students take an intro level course of biochemistry. While there has always been biochemistry on the MCAT, they're making its presence official.

The new additions to the MCAT of 2015 will require some additional course selections and long-term planning for pre-med students. If you've been keeping score, you'll realize the newly recommended classes are intro-psychology, intro-sociology, genetics, and biochemistry. No longer will the basic "pre-med track" of sciences suffice; students will need exposure to social and cognitive sciences in conjunction with natural sciences. This could clearly have implications

for non-science majors wishing to go to medical school. While it is definitely still attainable, the key to success will be long-term planning. "For those students [non-science majors], they have to be super, super organized," explains Dr. Gail Begley, Director of the University Pre-Health Program here at Northeastern. "They have to plan, not next semester, but the next four or five years. We don't want to scare people, but we want them to understand that they have to plan. Sit down with major advisors and pre-health advisors. Everyone has to work together to make sure that the schedule makes sense."

At the end of the day, the most crucial message to take away is that the MCAT is still conquerable. In Dr. Begley's words, "the key to success in the new MCAT is the same as for the old MCAT: take a program of rigorous courses; learn, retain, and apply knowledge and skills from one course to another and between courses and experiential learning; study for around six months after completing prerequisites; and don't take the test until you are achieving consistently high practice test scores."

The new MCAT will be more application focused, says Dr. Begley. "It's more about real world applications, understanding research, understanding clinical applications, and I think that Northeastern students are already ahead of the curve on that" Dr. Begley goes on to share, "I think that Northeastern students are going to rock the new MCAT." With a well-planned class selection and dedicated focus, NU pre-med students should have a positive outlook on the coming MCAT of 2015. n

# #IAMBOUVE:

A student pursuing the Bachelors in Health Science and Masters in Public Health program speaks about her experiences in the Bouv  College of Health Sciences

BY BINJA BASIMIKE, HEALTH SCIENCE/PUBLIC HEALTH, 2013



To sum up close to five years in the Bouv  College of Health Sciences is quite the task, but I hope to provide a glimpse as to what I experienced as both an undergraduate and a graduate student. These include: the title of *People's Choice* at the Annual Northeastern African Student Organization (NASO) Pageant, Panelist at the 2012 Fall 5 Under 25 Series, Bouv  Fellow and Bouv  Fellows Executive Board Member, three international internships (one in South Africa and two in Zimbabwe), a co-op at Dana – Farber Cancer Institute, Bouv  Service Medal Recipient, Resident Assistant, Mentor, Teaching Assistant and Entrepreneur.

Please, do not read this and throw in the towel. No! This list is to show you what an African girl miles away from home was able to achieve. What more of you? We have the best faculty on campus. From award winning researchers to internationally recognized health providers, the Bouv  College of Health Sciences offers a high caliber of health professionals serving as mentors shaping your

future as a health care leader.

The advising team at Bouv  is truly unparalleled. As a student who is part of the four + one BS MPH program, the advising team ensured that all my undergraduate requirements were fulfilled and continuously checked in with me to confirm that I was not overwhelmed with the transition to the MPH graduate program. The MPH advising team seamlessly picked up from where the undergraduate advising had left off. I can certainly say that the faculty and advising team have become part of my family: a home away from home. It is in this environment that I felt confident enough to venture out beyond the realms of Bouv  and experience all that Northeastern has to offer.

One such undertaking involved my desire to see more innovation in health care leadership and management; thus, I joined NUIDEA, Northeastern University's 'entrepreneurship lab'. There I learned how to create a business plan and what it takes to be a successful leader. These

“I firmly believe that Bouv  paves the way for many students to succeed.”

transferable skills are what I will carry into the workforce when I graduate in May 2013. Bouv  provides a platform for growth and an avenue where young leaders are prepared for the realities of the health care field in today's world.

I firmly believe that Bouv  paves the way for many students to succeed. From co-op advising to international opportunities created through dialogues in both Spain and South Africa, Bouv  truly encourages students to not only excel in their academics but also as global citizens, specifically culturally competent future health workers. To further the need for a competent workforce, Bouv  is merging with the law school and college of computer science, just to name a few, to create joint degrees which provide students insight into health law and health informatics – areas of great importance in the health field today. This interdisciplinary approach benefits the students at the Bouv  College of Health Sciences as it mimics actual work environments, further preparing students for better integration into the health care workforce.

Finally, despite the progress the college is making, it is up to the students to stand on the shoulders of those that have gone before them and excel. The college offers a platform; a step of determination and faith is what it takes to succeed in Bouv . In the words of Dr. Cornel West, "faith is stepping out on nothing and landing on something" – so go on, have a little faith and be great! n

# Plants, Pills and the Power of Belief in Alternative Medicine

BY CLAUDIA GEIB, JOURNALISM/ENVIRONMENTAL SCIENCE, 2015

All over the world, people are turning away from traditional pharmaceuticals in favor of "alternative" medicines, a range of treatments based on nature rather than science, to find that they work just as well as any drug to heal their medical woes.

Or do they? Many researchers have begun to investigate whether the successes that come from natural remedies come not from the medicine itself, but from the minds of those who use them.

Alternative medicine can refer to a number of different therapies, from acupuncture to herbal remedies to kinesiology. Few could be found in a medical textbook, and almost none are approved or regulated by the FDA. Some homeopathic medicines entirely lack the active ingredients that science would dictate necessary to have any effect on the human body at all. Yet somehow, many people testify to their belief that natural therapies are extremely beneficial.

So, how is this possible? Some researchers theorize that successful alternative medicine practices may fall under the umbrella of the placebo effect. The placebo effect is a well-documented phenomenon in which a patient's belief that they are taking something curative is enough to convince their bodies to heal, regardless of the treatment's actual value.

Research has shown that when patients use a placebo believing that it is a real drug—either because it looks like one or because they have been told it is—their brains produce opioids, chemicals that relieve pain, as well as dopamine, the brain chemical associated with pleasure. As a result, the patient genuinely feels the effects they have been conditioned to believe they should feel from the mock medicine. The same results come from sham procedures that appear to be real, such as when patients in research trials are told that they have undergone surgery to fix an issue and the patient finds the issue resolved, even when no actual surgery occurred.

Homeopathic medicine, with its connection to nature and the practices of ancient Eastern cultures, is so surrounded by mysticism that patients' belief in its power may play a larger role in the success of natural treatment than any other. Many natural therapies, in fact, focus on summoning the body's power to heal itself, placing the responsibility of recovery in the patients' hands.

A 2010 study published in the Oxford Journal *Rheumatology* found that homeopathic remedies used to treat rheumatoid arthritis pain made no significant difference in patient pain as compared to a placebo sugar pill. The Disease Activity Scores (DAS), a measure that gives the level of disease activity in the joints due to rheumatoid arthritis, of patients who received placebos were an average of 4.87 out of 10, while patients who received homeopathic treatment had an average DAS of 4.23 out of 10. The simple act of receiving the "medicine," regardless of what it truly was, produced the same results in both groups of patients.

Yet at the same time, anecdotes and research projects support the opposite—that certain holistic healing has medical value outside of placebo.

Cindy Shankman, a mother living in Greenlawn, New York, does not get colds. She does not suffer from headaches or upset stomach. Her 19-year-old son, Bryan, no longer has any signs of acne on his face, and her own skin is clear and smooth.

Yet Shankman does not use any of the medication or cream that might be found in the average mom's medicine cabinet. Her secret is essential oils, extracted directly from herbs and plants, which only contain materials that are found in nature. According to Shankman, they can be used to treat anything from burns to bad moods.

"The body recognizes nature because we are nature," Shankman said. "It's interesting, because many people come into these oils not believing in them at all... and all of a sudden, the aches and pains go away, they get up easier in the morning, their anxiety is lessened. The fact that people don't believe in them and still get results proves to me that this is not something they create in their minds."

Other alternative medicines have been scientifically proven to have a result outside of the placebo effect. A 2004 cooperative study by the National Center for Complementary and Alternative Medicine and the National Institute of Arthritis and Musculoskeletal and Skin Diseases found that acupuncture reduced the pain of patients with osteoarthritis of the knee by 40 percent and improved function by nearly 40 percent. While the sham acupuncture group did experience a similar decrease in pain, which can be contributed to the placebo effect, this group did not experience the increase in function that resulted from group that received true acupuncture. This suggests that

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"All medicine, even Western medicine, has this placebo aspect to it."

acupuncture therapy may have significant medical value in treating osteoarthritis as well as other afflictions.

What's more, even those successes in alternative therapies that can be attributed to the placebo effect are not limited to this field. In fact, the power of belief plays a part in all aspects of medicine.

"All medicine, even Western medicine, has this placebo aspect to it," says Lisa Conboy, Clinical Instructor at the Beth Israel Deaconess Medical Center and Director of Research and Chair of Biomedicine at the New England School of Acupuncture. "When you go to your regular doctor they say, take this medicine and it will make you feel better, and you believe it. Just believing helps you get better. Some part of healing is always going to be a placebo."

In all, the truth about alternative medicine's effectiveness cannot be boiled down to a single answer—the field is too varied, too complicated. The hundreds of methods of alternative healing make it impossible to label all forms of this medicine as a placebo science simply because a few practices have been proven as such. To do so would be like characterizing all sports as dangerous, simply by looking at football and wrestling.

Rather, more research is needed to investigate this field further. Relatively few scientific studies have been performed on alternative medicine, and those that have been completed often yield inconclusive results or contradict each other. With additional research and thorough testing, those alternative practices that have medical value can be differentiated from those which do not—and perhaps someday, doctors will be able to confidently prescribe plants in the same way that they prescribe pills. n

# Are We Ready for Personalized Medicine?

BY ANDREW BLOY, BIOLOGY, 2016

Now that the age of jetpacks, vacations to the moon and chrome spandex jumpsuits seems right around the corner, the good people of the world are waiting for the scientific community to discover a cure for all that ails them. When the complete human genome was published in 2003, most people thought that medicine tailor-made for their genetics was just around the corner. It has been almost ten years since the human genome was published, but still there's no personalized medicine based on individual genomes.

One of the primary reasons personalized medicine has not become widespread has been the slow speed and high cost of sequencing individual genomes. Initially, sequencing human genomes was a colossal undertaking, involving large teams of highly trained scientists and state of the art equipment. Whole genome sequencing was also a long and arduous process. The first human genome took 13 years to complete. The sheer amount of resources needed to sequence drove the cost of whole genome sequencing up. But now that the technology has been on the market for some time, and the process has sped up and become far less costly, developments on personalized medicine can truly begin.

Genomic medicine may be on the horizon, but is society ready for the implications that personalized medicine will bring? Sure, it will make a significant impact in the race to cure genetic diseases such as Huntington's disease and Sickle Cell Anemia, but there are a few important questions that must first be raised: Is our current health insurance system going to be viable when doctors can forecast major illnesses based on genetics? Are there enough genetic counselors and bioinformaticists to meet the demand from personalized medicine? Are healthcare providers and patients ready for what this will radically change the healthcare system?

While the main aim of the healthcare industry is to treat patients, it is still a business.

And businesses need to turn a profit to please their shareholders. One of the biggest parts of healthcare is insurance. An insurance company's business model depends upon the likelihood of people staying healthy and paying their bills. But how will this model adapt when diseases that involve a great deal of expensive medical interventions can be detected by a routine test, years before they occur? Inevitably, this will lead to insurance companies denying claims of people with major genetic defects, thereby denying coverage to people who need it the most. How will the system change? Will



**“Personalized medicine is the next great leap in medical technology. Exciting patients are ready to make that leap, but society as a whole is unable.”**

socialized medicine be the answer?

Before this becomes a problem, the question has to be asked: Can the current genetics industry handle the demand generated by routine genomic tests? Currently there are 2,307 genetic counselors in the United States. That makes one genetic counselor for about every 135,000 people. Assuming that most people would schedule routine visits with a genetic counselor, the patient load would be far too high. There would need to be up to 100 times more genetic counselors, or general practitioners would need to be trained in genetic counseling, according to a recent study published by the American Academy of Family Physicians. The problem with both of these solutions is that they take a significant amount of time to

educate hundreds of thousands of busy medical professionals.

The negative implications of technological advances are rarely taken into account when a major innovation is at stake. Just as the inventors of the automobile didn't consider pollution and urban sprawl, people haven't considered the emotional and social implications of knowing their entire health future. Imagine the emotional strain created by knowing that you or a close family member will develop a debilitating genetic disease in the near future. Imagine problems with prospective employers ordering genetic tests to determine the true and future health of prospective employees. The social implications are enormous; it will change the way society functions.

Personalized medicine is the next great leap in medical technology. Exciting patients are ready to make that leap, but society as a whole is unable. Between the current state of the health insurance industry, shortage of genetic professionals and overall lack psychological readiness, those sick patients may have to wait a number of years for their personalized medicine revolution. n

# NU Science Interview with Medical Anthropologist

## Dr. Inez Adams, Ph.D.

BY ELIZABETH GILBERT, HEALTH SCIENCE AND INTERNATIONAL AFFAIRS, 2013

Medical Anthropologist Inez Adams, Ph. D., began her first semester as a professor this fall at Northeastern. In teaching a course entitled *Race and Ethnicity in Health Care*, Professor Adams instructs undergraduate students on existing racial barriers in the US Health Care System. In her career as a Medical Anthropologist, Dr. Adams has examined a number of challenges relevant to how people acquire and receive medical care. NU Science Magazine had the opportunity to meet with Dr. Adams to learn more about her work and experiences in the field.

Dr. Adams earned her Bachelor's Degree in Physical Anthropology from the University of Pennsylvania. As an undergraduate student, she decided to take a medical anthropology course because it worked well in her schedule. After taking this course, she realized her passion for the subject and chose to pursue it at the graduate level. Professor Adams went on to earn her Ph. D. from Michigan State University in Anthropology with a focus in Medical Anthropology.

As an anthropologist, Dr. Adams has had numerous experiences in the field. This includes her time spent working at Georgetown with an epidemiologist, focusing on African American women and breast cancer in the DC area. She then began consulting work in Baltimore, involving anthropological ethnographic research on the corporate level for pharmaceutical companies. Professor Adams explains this work as "rapid ethnography," meaning that she engaged in a very intensive study of different participants, examining their behaviors, challenges, and experiences.

Professor Adams has most recently begun a post-doc fellowship position at Harvard University School of Public Health with the Lung Cancer Disparities Center. She feels that this position is an excellent opportunity because it incorporates both her skills as a medical anthropologist and her previous experience in social marketing as an anthropological consultant. As Dr. Adams explains, this center works through NIH grant funds to pursue five main projects relevant to lung cancer. According to the Lung Cancer Disparities Center website, this center focuses on, "innovative, interdisciplinary research to address the determinants of racial/ethnic and socioeconomic status in lung cancer disparities." Dr. Adams focuses on the ethnography of the

"participants are the experts, not the anthropologists. I find that to be true because no matter what the topic is, I always hear something [from the participants] that I'd never thought about before."

ban on smoking in Boston Public housing and its implications.

Professor Adams has long been interested in research and academia. She recently became interested in teaching and has found her experience at Northeastern to be very positive. After spending time pursuing her Ph. D. in the Midwest, she is very happy to be in the urban Boston environment. Dr. Adams enjoys the intellectual nature of the area. She finds her students to be very engaged and intelligent. Dr. Adams believes that the co-operative learning experience is an extremely beneficial aspect of Northeastern. These experiences act as vital components in providing students with necessary practical experience, particularly prior to engaging in graduate programs.

In terms of career opportunities for those interested in the medical anthropology field, Professor Adams explains that the academic arena is very competitive. Often, academic positions have very specific geographical requirements related to the applicant's research region. Other career paths for people interested in this field include government positions, such as with the National Institutes of Health (NIH). These positions can provide significant job security, however it is important to note that in governmental positions, there are restrictions on what nature of research the anthropologist can pursue. In the private sector, companies



such as IBM, Ford, GM, and Motorola look for anthropologists to examine the population and engage in market research.

Professor Adams considers the opportunity to conduct interviews and speak with people to be her favorite aspect of working as a medical anthropologist. She believes, "participants are the experts, not the anthropologists. I find that to be true because no matter what the topic is, I always hear something [from the participants] that I'd never thought about before."

More information about the work of the Lung Cancer Disparities Center can be found at the Lung Cancer Disparities Center Website, <http://lcdr.sph.harvard.edu>. n

# Polio Eradication in Pakistan: The Challenges that Endure and Why We Should Care

BY HEESU KIM, PHARMACY, 2018

In response to deeply rooted inequities that obstruct vaccination programs in Pakistan, the WHO's Global Polio Eradication Initiative (GPEI) was adjusted in a definitive new effort to eliminate poliovirus from the population.

Poliovirus, or polio, mainly affects children and is transmitted through fecal-oral conduits. One in 200 infections results in irreversible paralysis, frequently of the legs. Conversely, 95% of infections will cause no symptoms. All infected individuals, both asymptomatic and symptomatic, may transmit the virus to others. It is estimated that for every one reported case of paralysis, another 100 to 200 people are asymptotically spreading the disease.

Statistics of our human history with polio illustrate the troubling reach the virus previously extended on global populations: according to the WHO, an estimated 350,000 cases of polio were reported in over 125 endemic countries in 1988, including the United States. GPEI, a partnership of organizations including UNICEF and the WHO, has since reduced this number from over 125 countries with endemic polio presence to three countries by 2012. Its programs, which include vaccinations, door-to-door visits, and community outreach, have generally produced highly positive results on the global stage. Yet, the GPEI has failed to accountably provide effective programs to certain areas with extensive social disparities and economic strife. Today, Pakistan, Afghanistan, and Nigeria stand as the last places on Earth in which endemic polio continues to exist.

In recent years, global scrutiny has shifted to Pakistan, previously the world's number one source of endemic polio, only recently surpassed by Nigeria. Once believed to have had infections on the decline, Pakistan showed a stunning spike in polio cases in 2011 that revealed a widespread failure of vaccination programs in the country. Since then, hot spots in Pakistan consistently report cases of polio in the midst of unsuccessful outreach by GPEI: from January to November 7, 2012, 48 cases were recorded in Pakistan, the second highest incidence in the world.

Reasons for the failure of programs in Pakistan are complex and varied. A distrust of unfamiliar humanitarian programs pervades and colors the Pakistani community's receptiveness to outreach by GPEI. Past errors, including a botched CIA

operation that posed agents as vaccine workers to locate Osama Bin Laden's family, have propagated a wide culture of suspicion against workers seeking to vaccinate children in problem areas. In extreme cases, hostility to international workers has incited violence: in July 2012, a drive-by shooting in Gadap, Pakistan killed a doctor and his driver, agitating the already high tensions plaguing GPEI presence in the area.

Furthermore, GPEI workers in some areas of Pakistan have demonstrated corruption and irresponsibility in their administration of vaccines. Records of vaccination have previously been falsified or exaggerated, and vaccination events have been late to begin or early to end. In many cases, the responsibility of administering vaccines is shuffled from individual to individual to the effect that no vaccine is ultimately given. Inconsistencies in holding GPEI workers accountable for existing programs have therefore perpetuated the Pakistani misconception of GPEI efforts in the area.

The community's misunderstanding of GPEI intentions has led to the dissemination of rumors that deter mothers from allowing their children to receive vaccination. Rumors involving the poliovirus vaccine include the belief that it is actually a virulent strain of AIDS sent to sabotage Pakistan, or that it will sterilize a child. These false rumors are perpetuated and cemented through community discussion, making them highly difficult to reverse or disprove.

The various problems surrounding GPEI point to a slew of deeper social disparities at work. In the direst areas, poverty and illiteracy combine with violence and anti-Western views to impede international vaccination attempts. Extremely low-income regions foster unsanitary living conditions that form a breeding ground for disease. Government provisions for health care are dysfunctional and limited, blocking easy access to medical help. Moreover, particular areas experience high levels of population movement into and out of cities, causing a wider and less contained spread of polio. These overarching social conditions promote a disease-harboring environment and complicate already frayed efforts to eradicate poliovirus.

In October 2011, oversight agency Independent Monitoring Board (IMB) published

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“Today, Pakistan, Afghanistan, and Nigeria stand as the last places on Earth in which endemic polio continues to exist.”

a report that included a candid criticism of failed GPEI programs in Pakistan. Following its release, GPEI modified its approach to vaccinating Pakistani children, including an adjustment that allocated more resources to 33 high-risk districts. New leadership was also put into motion that held employees accountable for timely and responsible work. Additionally, GPEI reached out to various influential members of the Pakistani community who could rectify false rumors and persuade constituents to allow vaccination. Reflecting the significant progress made in addressing Pakistan's various inequities, IMB officially took the country off its critical list in June 2012.

In the end, the situation in Pakistan bears valuable lessons for healthcare providers around the world. Pakistan overwhelmingly demonstrates the profound influence social disparities exert over the health of vulnerable populations. Importantly, GPEI's treatment of Pakistan demonstrates that to ignore these disparities is to perpetuate unhealthful and ineffectual medical practices. Next, as long polio still stands in Pakistan, global eradication will have failed. To date, there is no cure for polio. It is therefore an impetus of universal concern that vaccine regimens succeed in all areas still endemic for the virus. To be unsuccessful will constitute a grave failure to wipe out a deadly and prolific disease; to succeed will constitute a pioneering triumph achieved through the decades-long action of a historic global partnership. n

# Fungal Meningitis: A Rare Danger

BY KATHERINE HUDSON, MARINE BIOLOGY, 2017

In 2002, the Center for Disease Control and Prevention discovered that five cases of fungal meningitis were the result of unsterilized methylprednisolone acetate steroid injections that were contaminated with *Exaphiala dermatitidis*. Ten years later, a batch of 14,000 injections of the same steroid, used to treat back and joint pain, were found to be contaminated with a black fungus, leading to meningitis. The outbreak of the extremely rare disease has caused 29 deaths in nearly four hundred cases across nineteen states as of November 1, 2012.

Meningitis, whether bacterial, viral or fungal, is an inflammation of the membranes around the brain and spinal cord caused by infection. The inflammation of these membranes (meninges) causes excess pressure on the brain, which can lead to the compression of areas in charge of vital functions such as sight and coordination. Symptoms of meningitis include stiff neck, photosensitivity (light sensitivity), severe headache, fever, chills, and changes in mental state. Many of these symptoms lead meningitis to be misdiagnosed as the flu, resulting in inadequate treatments. Due to the swelling of the meninges and the added pressure on the brain, meningitis has the potential to cause permanent damage to the brain and spinal cord, which can result in hearing or sight loss, joint stiffness, epilepsy, behavioral and concentration problems, memory and coordination loss, and learning disabilities.

The batch of infected injections originated from the Framingham, Massachusetts-based pharmaceutical plant New England Compounding Center (NECC). The NECC has had a poor history of complying with health and safety regulations in the past with dirty floor mats and leaky boilers among many other complaints. An investigation of the plant soon after the outbreak found more than fifty vials of unopened steroid injections that were contaminated with the same fungal strain that caused the outbreak. This led to the closing of the plant and the recall of all products.

These black specks were identified as *Exserohilum rostratum*, a species of fungus that is common in soils. Other species of fungus were discovered in patients, but *Exserohilum* was the primary cause. This species of fungus was not known for causing fungal meningitis before the outbreak. Dr. Kirsten Nielsen of the University of Minnesota speculates that since most pathogens cannot, "cross the blood-brain barrier, the immune cells of the central nervous system (CNS) have



never seen *Exserohilum*, and so it takes a while to recognize the fungus and begin mounting an immune response." According to Nielsen, this fact, combined with the abundance of nutrients in the cerebrospinal fluid allowing for rapid growth, is why the fungus has been so prolific.

Another reason for the severity of these cases is that the fungus gained direct access to the spinal fluid. Steroid injections for back pain are meant to be epidural, meaning that they are injected into the space outside the covering that coats the brain and spinal cord, or the dura mater. It is believed that the fungus infected the dura to the point where it began to seep into the spinal fluid. Once there, the fungus was given direct access to the blood vessels of the brain and the membranes surrounding the brain. The infection of these vital systems led to the meningitis.

One of the issues surrounding the outbreak is treatment. The antifungal drug Voriconazole is being considered to treat those infected. However, when taken in the quantities necessary to combat meningitis, this drug can possibly produce dangerous side effects including hallucinations, photosensitivity, visual distortion, nausea and liver damage. Voriconazole also has a bad history of strong, dangerous interactions with other drugs

when taken simultaneously. The brown-black coloration indicates to scientists that the fungus will fend off antifungal drugs and other immune responses, making it harder to treat. Since this strain of fungus has never been known to cause fungal meningitis before, scientists are also unsure of how long to treat those affected.

With this outbreak, there are many unknowns in areas other than treatment. Meningitis symptoms do not begin to appear for months after infection so thousands are still at risk. The brown-black coloration of the fungus indicates that it produces melanin, a common skin pigment in the human body, making the fungus near impossible to identify once it has entered the system. n

# Interview with Sleep Researcher Patrick Fuller

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE 2013

Patrick Fuller, a sleep researcher in the Department of Neurology at Beth Israel, is boyish and immensely likable, with a mop of curly blonde hair and a broad, easy smile. He wears sandals to our interview. This nonchalance, along with his willingness to discuss his current research in detail, makes him a pleasure to interview.

After a PhD in neuroscience and molecular physiology, Fuller landed a post-doc at Harvard working alongside renowned neuroanatomist Clifford Saper. Fuller is currently an assistant professor at Harvard Medical School. His area of interest is how the brain controls behavioral states, from coma to extreme arousal. "Not so much the content of this conversation," he tells me, flashing an apologetic smile, "but the actual ability of the circuitry to keep the cortex at this aroused level that allows us to engage in this sort of activity."

Specifically, Fuller is looking for what he calls the "holy grail of neuroscience." Various techniques allow scientists to identify neurons that are active during certain behavioral states. The British paper, *The Daily Mail*, is especially fond of these studies - a recent headline proclaimed, "Paedophiles could be 'spotted and cured' through MRI scans to detect brain abnormalities and low IQs". But none of that tells us what those neurons do. As Fuller explains, "We can say a neuron is 'x-active' - sleep active, wake active. But is the neuron actually sleep- or wake-promoting?"

One of the Fuller Lab's current projects involves a new pharmacogenetic technology called DREADD. Pharmacogenetics is the study of how genetics affect reactions to drugs. Fuller and his colleagues insert a gene for an ion channel into mice brains using a non-pathological adeno-associated viral (AAV) vector. The ion channels are coupled to a membrane receptor that is only activated by an otherwise pharmacologically inert drug - that is, the drug has no other effects in the rat other than to open these new ion channels. Substances that bind to a particular receptor are called its ligand.

The mice are genetically engineered to make a specific protein called cre-recombinase in certain populations of neurons; the receptors are only expressed in neurons where cre is present. This allows for a great deal of specificity in terms of what neurons end up with the ion channel, which in turn makes the technology an excellent way to study the sleep or wake-promoting activity of small areas of the brain.

Recent work at the Fuller lab upholds a long-standing theory that there must be a cluster of sleep-promoting neurons in the medulla, a part of the brainstem. Using mice, one of Fuller's post-



docs, Christelle Anaclet, inserted an excitatory (activating) receptor into certain neurons that excrete GABA, an inhibitory neurotransmitter, in a part of the medulla called the parafacial zone. When the mice were given the activating ligand, they curled up and went to sleep. In litter-mates who did not express cre in those GABA neurons, the channel was not present and the drug had no effect.

Fuller believes that DREADD is at least as ground-breaking as optogenetics, a technique that has revolutionized neuroscience. Optogenetics is actually quite similar to DREADD in theory. Receptors are added to the cluster of neurons, but they activate in the presence of light instead of a pharmacological ligand. A fiber-optic cable is then inserted near the cells. When the light is turned on, depending on if the receptors are excitatory or inhibitory, the cells can be turned 'off' or 'on.'

As Fuller points out, "Obviously you can see the drawbacks [of optogenetics], particularly when you start talking about human genetics... at least in its current conception, people walking around with big fiberoptic bundles coming out of their heads...and the cable has to run to the light source." He pauses and holds up his hand in a 'stop' gesture. "Now, I don't want to in any way underestimate how impactful optogenetics has been - it's been revolutionary - but we feel if we want to

take this to the next step, i.e. out of the research zone into the biomedicine realm, we probably should emphasize the pharmacogenetics."

Medicine is exactly where all of this technology is going: in collaboration with the Saper lab, the Fuller lab has initiated their first work using AAVs in non-human primates. The scientists hope to start clinical trials in humans within a decade. Applications are nearly endless: Parkinson's patients who suffer from tremors might have the neurons responsible silenced, oncologists might have new ways to treat tumors, and even victims of trauma might have new ways to prevent or treat PTSD. A paper published recently showed that DREADDs can be used to turn memories 'on' and 'off' in rats, moving humanity closer than ever to worlds imagined by science fiction writers.

So will scientists ever be able to fully understand the brain? "That's what's great about this research, at least from a job-security perspective," says Fuller with a grin. "Every time you answer a question, there's a dozen more." n

# MDMA for PTSD

BY KEVIN FRANCIOTTI, BEHAVIORAL NEUROSCIENCE, 2013



Over the past few years, groundbreaking research into a new experimental treatment for post traumatic stress disorder (PTSD) has produced impressive results. In July, 2010, a study published in the *Journal of Psychopharmacology* showed an 83% effectiveness rate in treating the most debilitating symptoms of PTSD. A long-term follow up on the subjects in the initial study also showed that these benefits persisted over time, with data collection averaging 3½ years following initial treatment. The study's principal investigator, Michael Mithoefer, MD, along with his wife and co-therapist Ann Mithoefer, BSN, recruited twenty-one subjects and conducted the experimental treatment out of the University of South Carolina.

What is this exciting breakthrough in PTSD research? Popularly known by its street name, "Ecstasy," 3,4-Methylenedioxymethamphetamine, or MDMA, was administered to the subjects in a tightly controlled environment, in conjunction with treatment similar to traditional talk therapy. The study was funded primarily by an organization called the Multidisciplinary Association for Psychedelic Studies, or MAPS. The Executive Director of MAPS, Rick Doblin, PhD, believes that MDMA is the key component in the success of this treatment. Some of the barriers to conventional treatment are inherent in the symptomatology of PTSD, but when under the influence of MDMA, there is an enhancement of a trusting, positive relationship with the therapist, allowing the patient to be more comfortable reliving the trauma while exposing their symptomatic vulnerabilities. On a video posted to the organization's website, ([www.maps.org](http://www.maps.org)) Doblin states, "In a psychotherapeutic situation, the

drug (MDMA) helps people to go deep into their feelings...and people work through the pain, rather than avoid it." Doblin is hopeful that if MDMA-assisted psychotherapy becomes an approved treatment for PTSD, it could prove extremely useful for veterans of the wars in Afghanistan and Iraq that the Veterans Administration may not have the resources to handle.

In 2011, Dr. Mithoefer was invited to present the results of his pilot study at Northeastern as part of a panel on the use of psychedelic drugs in medicine. This past November, the research received widespread media attention following the publication of the long-term follow up paper, including a feature article in *The New York Times*. Proponents of MDMA's potential for use in psychotherapy highlight the scientific rigor with which the studies are designed, but critics have argued that the objective data may be biased, since the research is funded by an organization aimed at establishing the drug as a prescription medicine. In an email to the magazine, Rebecca Shansky, PhD, Assistant Professor in the Department of Psychology at Northeastern wrote, "I think there's nothing inherently wrong with trying new avenues for pharmacological therapies, provided the trials are carefully controlled and side effects (both short and long-term) are assessed." Professor Shansky conducts animal research to assess the effects of stress on neural circuitry, including the role of the fear response in potentiating neural circuitry, with a particular focus on brain regions involved in PTSD.

One advantage of using MDMA in therapy may be the acute effects of the drug, which could provide symptom relief faster than traditional

**"In a psychotherapeutic situation, the drug (MDMA) helps people to go deep into their feelings...and people work through the pain, rather than avoid it."**

antidepressants. Shansky pointed to another drug with known psychedelic effects currently being used in research, "One promising potential treatment for depression that's come out recently is ketamine... It seems to be solving the problem with SSRIs [antidepressants], which is that they can take several weeks to have any kind of efficacy – not a desirable feature when someone's a suicide risk."

For a drug to be developed into a prescription medication, making it available for doctors to prescribe for treatment, the Food and Drug Administration (FDA) requires a rigorous approval process. MDMA is currently in the Phase II category and has been approved for experimental protocols involving human subjects. These protocols are specifically designed to produce results aligned with the highest standard of drug research, meaning they are compared against a placebo. The studies are double-blind, so neither the subject nor the experimenter knows in advance whether a patient is receiving MDMA or a placebo. The sessions are recorded, and the therapist's skills are assessed by an independent group of raters. During a segment on CNN, Dr. Mithoefer said, "I'm excited that we got this kind of result, but it is only a first step."

Only a handful of studies using MDMA to treat PTSD have been approved, and many of them are being conducted abroad, such as a study in Switzerland published in the October issue of the *Journal of Psychopharmacology*. Other studies are being conducted in Australia, Canada, Israel, and Jordan. Dr. Mithoefer's team has a new protocol aimed at treating PTSD in veterans of war. The FDA has agreed to allow the data compiled from these studies to be used in a proposal of Phase III studies, which is the final experimental stage in the drug approval process before a medication can be legally prescribed. n

# Conference Review: EmTech 2012

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE 2013

Between October 24th and 26th, MIT Technology Review invited some of the finest minds in tech to the MIT Media Lab to brag, swap stories, and hear about the latest and greatest technological advances across a wide spectrum of applications, from medical devices to oil refining. Introduced by game show music and standing against a futuristic backdrop of back-lit blue tiles, speakers presented new ideas and innovations to a well-paying, mostly male audience (a ticket to the two-day event topped out at a little under \$2,000). A camera whose pictures could be refocused after the fact received gasps and applause, while jokes about start-up crash and burns drew knowing chuckles from the attendees.

"When we started, we were very inspired by this company Zynga [creator of Facebook games such as Farmville], which now is known mostly for a falling stock price," began Tony Stubblebine, CEO of Lift, a start-up that created an app to help users change and create habits. "But at the time, they were known for very, very addictive games. And there's a whole world of product designers, including ourselves, who wondered, can we use these techniques that Zynga uses in other places?" Stubblebine went on to describe his work at Lift, designing an application that uses social psychology to reinforce good behaviors - taking out the trash, exercising, or, in one notable case, "petting all the animals." Their development process began with a beta that rewarded users with 'points' for doing a specific task. After three months, the last remaining beta user - Stubblebine himself - concluded that 'points' disconnected from any tangible reward were not incentive enough to regularly take out the trash or drink more water.

In the current incarnation, users join groups of others working to create the same habits, receiving positive social reinforcement when they fulfill their goals. For some people, the social incentive comes from viewing this set-up as room for healthy competition; for others, community members giving them 'props' (analogous to the Facebook 'like' button) serves as a motivating force.

EmTech 2012 had a few unveilings, most notably from David Icke, CEO of MC10. The start-up develops thin, high-performance electronics that can bend and move with the human body. Icke announced a new product in development with Reebok, the sporting goods giant: a helmet liner that will be able to detect force and identify traumatic head impacts. The announcement came just a month after the National Institute for Occupational Safety and



Photo courtesy of [www.technologyguide.com](http://www.technologyguide.com).

Health published a study in Neurology, which found NFL players are three to four times more likely to suffer from neurodegenerative diseases such as Alzheimer's, Lou Gehrig's, and chronic traumatic encephalopathy. The wearable impact indicator will be commercially available, allowing professional and non-professional athletes alike access to the technology.

"Human beings are not rigid and boxy [like traditional electronics], we are soft and curvy and flexible, and so we have this mismatch in form factor that is a big problem," Icke explained. He went on to discuss not only the Reebok partnership, but the technology itself. MC10 has developed technology to make silicone extremely thin, thereby making it more flexible than a typical computer chip - Icke compared it to the difference between a 2x4 and a piece of paper. They have also found a way to embed the silicone in stretchable polymers, which offer protection to the fragile semi-conductors. Finally, they 'print' these semi-conductors onto flexible materials and connect them with springy 'bridges.'

These pliable microcomputers can be used as tattoo-like biosensors, which Icke calls biostamps. Because they are made from widely-available materials, they can be produced cheaply and efficiently. This opens new doors for people

outside professional athletics and the military to have access to advanced biometric analysis, such as hydration or temperature monitors for runners and other amateur athletes. MC10 envisions a bandage-like sensor that can be read by a smartphone to measure water-loss or UV exposure. The technology might also be utilized internally: an example Icke gave was inserting a tiny device inside the heart to give doctors real-time information on cardiac functioning.

"Obviously, longer time to market with some of these," Icke reminded the audience, something that was true of many of the technologies presented at EmTech. But if even a small portion of the innovations discussed at the conference ever come to market, the future will be a very exciting time indeed. n

# Dinosaurs: The Recent Discoveries

BY SHANNON JONES, MARINE BIOLOGY, 2016

**D**inosaurs. Who doesn't love dinosaurs? They captivate children and fascinate the inner geek in most adults. Picture them: Gigantic, with bright colored skin, reminiscent of Littlefoot and his friends from the "Land Before Time" movies. Dinosaurs haunt the imaginations of many, but the conception that scientists have of these prehistoric creatures is constantly changing – and what you're imagining may be out of date.

In June, a paper was published that refuted the long-held idea that dinosaurs were cold-blooded. The authors studied lines of arrested growth, or Lags, in the bone tissues of fossils in comparison to other endothermic, or warm-blooded, animals. It was thought that since cold-blooded, or ectothermic, animals have impeded growth and development during the winter, ectothermic animals would show a very specific pattern of bone growth – one with these Lags included. Dinosaurs were thought to be cold-blooded because they had these lines, just as modern reptiles and amphibians do. However, this study showed that endotherms also have these lines – meaning that dinosaurs could have easily been warm-blooded.

Another recent dinosaur finding was the discovery of feathers on a fossil, which led to the new theory that some dinosaurs were feathered. Scientists found 11 separate specimens preserved in amber in Asia displaying feathers in stages of development ranging from proto-feathers to feathers in the same structures fit for flying that appear in modern birds. Evolutionarily, birds have feathers that develop in four stages. During the first stage, a hair-like monofilament develops, which then becomes a tuft of filaments in the second stage. The filaments separate into a central filament, called a rachis, surrounded by secondary branches or barbules, and then start tertiary branching in the third stage. The fourth evolutionary stage of feather development involves the barbules interlocking and becoming a pennaceous, or closed, feather. Anything after this point is referred to as "step five," though there is no standardized fifth step of feather evolution. Since each of these steps can be seen preserved in amber from the age of the dinosaurs, it can be assumed that some dinosaurs were feathered. This theory is supplemented by various fossil finds with feather indentations surrounding the fossilized skeleton, finds such as the skeleton of a *Sciurumimus albersdoerferi* that was found this spring. This megalosaur skeleton, which Luis Chiappe, a paleontologist at the Natural History Museum of Los Angeles County, has called "one of the best meat-eating dinosaurs ever



preserved," has stage one feathers completely covering its body. This fossil was found in eastern Germany, a good sign that feathered dinosaurs existed outside of the Asian continent. Scientists now realize that some, if not all, dinosaurs had feathers.

In addition, discoveries have been made that challenge the way we imagine dinosaurs' bodies to have been. A dinosaur specimen found in 2003, the *Microraptor gui*, has been debated within the paleontology community – it has four wings. How did a dinosaur fly with four wings? What was the purpose of the rear-most pair? These questions were discussed at this year's annual meeting of the Society of Vertebrate Paleontology. One theory put forth by the scientists there posits that all four limbs were used for flying, but that would be mostly useful for gliding and could get very complicated, especially when landing. The dominant theory currently is that the second set of wings was held under the dinosaur's body and was used only when *Microraptor gui* needed extra help in banking and turning, making the area

it needed to turn much smaller. This would make sense considering that the environment it lived in was predominantly forested. That agility would have allowed it to compete with other predators for food; the drag of folded wings is smaller than the drag on extended wings. In fact, scientists theorize that having the second set of wings extended would almost act against *Microraptor gui*, in terms of aerodynamics. These ideas can be applied to all dinosaurs with four winged limbs, and mean that the way flight developed in dinosaurs may not have been the gradual easing from gliding to true flight that has been regarded as the general theory up until the present.

Dinosaurs may be extinct, but our understanding of them is constantly evolving, and will continue to do so as we discover more secrets from the past. So as you're imagining what you would do if raptors attacked you in lecture, remember: They might not look exactly the way you are expecting. n

# Fighting Dengue Fever with GMO Mosquitoes

BY SUMAYAH RAHMAN, BIOLOGY, 2015

You hear a high-pitched buzzing noise and feel a tiny sting. Just a few minutes later, you're itching like crazy.

To many of us, they're a minor annoyance. But to some, they are deadly killers. Mosquitoes spread a variety of diseases, including malaria, West Nile virus, and dengue fever. Dengue fever, which infects over 50 million people each year, is a tropical disease that begins with an extremely high fever and is followed by body pain, nausea, and a rash. In some cases, the disease can result in death.

There is no treatment or vaccine, but scientists at Oxitec, a British biotechnology company, have come up with a possible alternative solution. The mosquito that most commonly spreads dengue fever is the female *Aedes aegypti* (male mosquitoes do not bite). Oxitec has genetically engineered male *Aedes aegypti* mosquitoes by

inserting a gene that will cause their offspring to self-destruct. When the genetically engineered males are released into the wild, they mate with wild-type females, creating offspring that do not survive. This would limit the population growth of *Aedes aegypti* mosquitoes, and thus decrease dengue fever infections.

These genetically modified mosquitoes have been released in the Cayman Islands, Malaysia, and Brazil. So far, all three releases have been successful. In Brazil, the *Aedes aegypti* population decreased by 85% in just one year.

Several months ago, plans were made to release the GM mosquitoes in the Florida Keys, where there was an unexpected outbreak of dengue fever in 2009. However, Floridians responded to this proposal with intense opposition. Some of the reasons they cited were harm to the ecosystem

(i.e. species that depend on mosquitoes for food may go hungry) and the possibility of a female GM offspring (that does not self-destruct as it should) biting a human. Although Oxitec claims that the saliva from the GM mosquitoes is not harmful, people are still wary.

Due to civilian outcry, the plan in Florida was subsequently withdrawn. But do theoretical risks truly outweigh the proven benefits that occurred in the previous releases? It may be a long time before the story of the GM mosquitoes completely unravels and we find the answer to this question, but in this strangely science fiction-like situation, many think we should heed the warning of Dr. Ian Malcolm from *Jurassic Park*: "I'm simply saying that life, uh, finds a way." n

# Monitoring Disasters through Crowdsourcing

BY MICHAEL MURRAY, COMPUTER SCIENCE AND ENGLISH, 2014

When disaster strikes, authorities scramble to gather information that will help them mount an informed response. This critical data can be difficult to come by, especially when the people who need it are extremely far away from the crisis. However, a team at the Columbia College Chicago, led by Steve Millar and Professor David Gerding, has begun proof-of-concept development on an innovative and potentially life-saving solution, utilizing the mobile devices we all carry on a regular basis.

In the event of an emergency, a signal could be sent to the phones or tablets of people who have chosen to install this proposed app. Users would be instructed to activate their devices and point them in a certain direction and, when ready, begin broadcasting. These individuals, already spread at or around the site of the incident, could

quickly transmit audio, video, location, orientation, and accelerometer sensing data to a central location. User responses could be very quickly amalgamated, sorted and updated as they come in, allowing data to stay near-real time. Such an immediate flow of information could allow first responders to have an accurate picture of the situation before they go to the area, allowing them to better prepare for the circumstances they might find.

I was able to see a demo of the technology as it currently stands at a recent conference. I was impressed by the ease with which Millar and Gerding were able to quickly connect and begin uploading sensing data, even in an early prototype version of the system.

Of course, this technology is far from being implemented. At present, nothing exists but a

basic version of the system, with no one but the developers actually using it. However, the potential for this project is incredible: the opportunity for on-scene data collection from multiple perspectives only moments after a crisis takes place could be invaluable for first responders. Footage from multiple cameras could also, at some point, neatly be consolidated into a single model of the situation, allowing those trying to plan a response to know exactly what is happening. It is fantastic to see the ever-increasing potential of technology that works to keep us safe. n

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