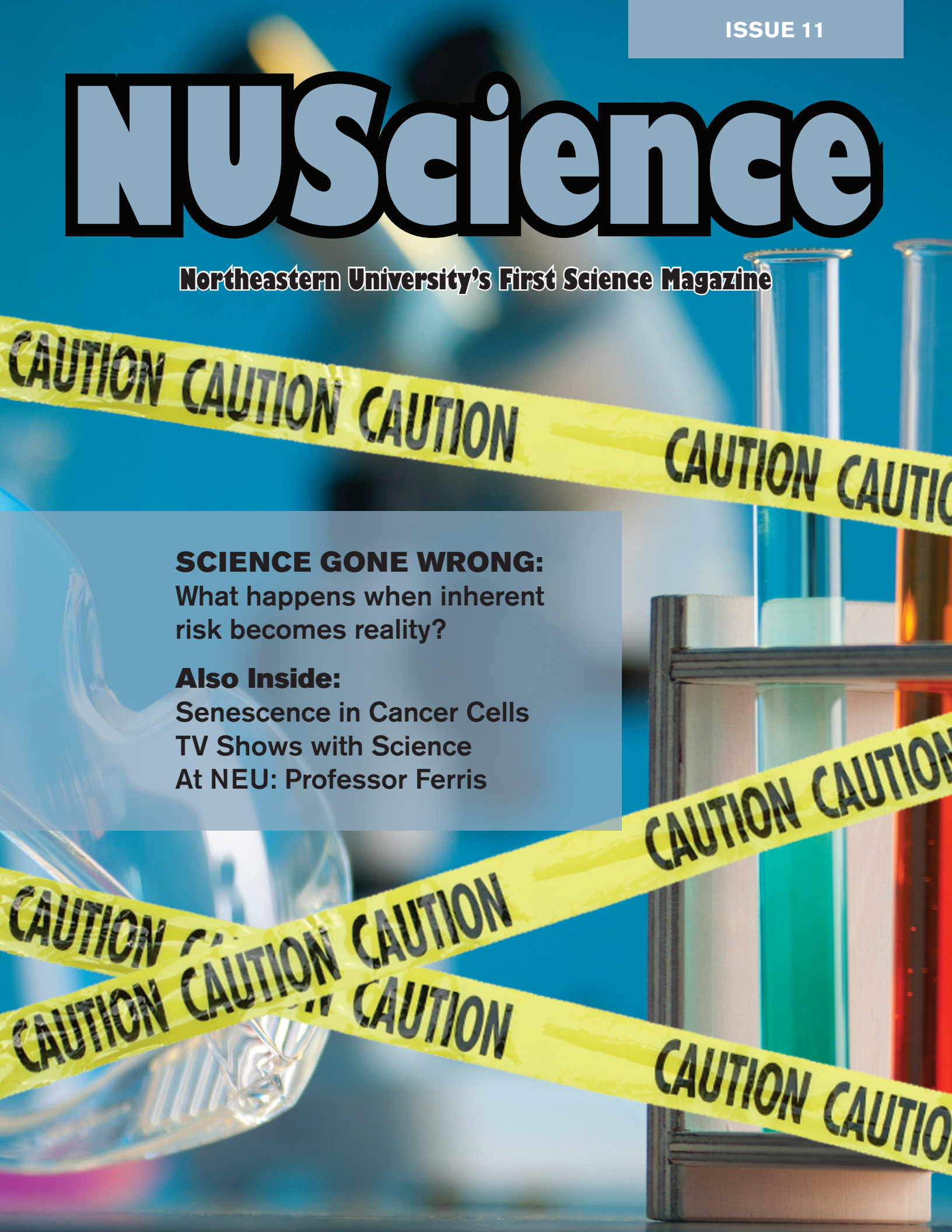
ISSUE 11

NUScience

Northeastern University's First Science Magazine



SCIENCE GONE WRONG:
What happens when inherent risk becomes reality?

Also Inside:
Senescence in Cancer Cells
TV Shows with Science
At NEU: Professor Ferris

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We really appreciate their dedication and hard work for our magazine. We would also like to extend a special thanks to **Tara Dhingra**. She has been with our group since Issue 1 and has contributed to every issue. It has been a pleasure working for her and we wish her the best of luck for after graduation.

CONTRIBUTING DESIGNERS

Ellen Biewald, Graphic Design, 2014
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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 **159 Ryder Hall**. Come collaborate with us!

LETTER FROM THE EDITOR

Science is fascinating, profound, and generally pretty amazing, particularly when things work as expected. Sadly, we aren't always so fortunate. Whether in the form of retrospectively hilarious accidents in Chem lab or large-scale disasters, something going wrong is an inescapable part of the scientific process. Often, however, these incidents offer a silver lining by presenting an unexpected opportunity to learn for those who are paying attention. The most famous example is that of the Scottish biologist who entered his lab one morning in 1928 to find that the Penicillium mold that had contaminated his samples was quite effective at killing bacteria. The biologist, of course, was Alexander Fleming, and his fundamental contribution to the development of antibiotics would completely revolutionize pharmacology, earning him the Nobel Prize in Physiology or Medicine in 1945.

In Issue Eleven, we've chosen to focus on "Science Gone Wrong," bringing you a wide assortment of occasions when things didn't quite go as planned, from chemical disasters to embarrassing stories from Northeastern students in lab and on co-op. The story of Alexander Fleming reminds us that mistakes are a chance to learn something you may not have anticipated, as long as you look for it. It might not make up for whatever went wrong, but that also doesn't invalidate the knowledge that you gained.

As the semester draws to a close, I'd like to thank all of our members for their hard work this year. We can't wait to bring you more science news in the fall!

Michael Murray
Editor-in-Chief
NU Science Magazine

EVENT CALENDAR OF SCIENTIFIC HAPPENINGS APRIL 2012

at Northeastern and in the Boston Area

April 23

Sound and Semiocapitalism: Affective Labor and the Metaphysics of the Real
7:00 - 9:00pm at MIT, Wiesner Bldg. (E15-001), Lower Level, 20 Ames Street, Cambridge MA

April 24

Haute Culture: Tailoring stem cells to make us well
6:00 - 7:30pm at at Joseph B. Martin Conference Center at Harvard Medical School

April 24

The Urban Coastal Sustainability Initiative at Northeastern University
1:00 - 3:00pm in Curry Ballroom

April 25-30

Maurice Auslander Distinguished Lectures and International Conference

April 26

ASI Presents speaker Adam Anderson: Part of the Monthly Speaker Series
8:00 - 9:00am

April 27

Annual Riser Lecture, Murphy Bunker
4:00 - 5:30pm at the Marine Science Center

MUST-WATCH SCIENCE TV SHOWS

BY JOHN JAMIESON, CHEMICAL ENGINEERING, 2015

FOR THE PHYSICIST:
***Through the Wormhole*, The Science Channel**

Do you ever wonder about the beginning of the Universe? String Theory? Extraterrestrial life? Time travel? These are just some of the topics explored in *Through the Wormhole*. Narrated by none other than Morgan Freeman, this science channel program delves into the deepest mysteries of existence, discussing questions that have yet to be answered by humans.

Though the Wormhole has tracked down researchers conducting fascinating experiments in the areas of Astrophysics, Astrobiology, Quantum Mechanics, String Theory, and more. It provides the viewer with a general background of the subjects and makes strong use of visualizations and metaphors to help the viewer wrap their head around the concepts being discussed.

Through the Wormhole brings together the brightest minds and best ideas from the very edges of known science to reveal extraordinary truths about our Universe. So be sure to check it out if you see it in the channel guide, and prepare for an hour that will send your mind spinning with possibilities that are out of this world.

FOR THE ENGINEER:
***How it's Made*, The Science Channel**

Based on a brilliantly simple premise, *How it's Made* is a documentary-style program that demonstrates the production process of various everyday items, anything from watches to tower cranes to baseballs to tapioca pudding. The segments are fairly quick, so in a 30-minute episode they will usually cover 3-4 items.

Each process is shown from beginning to end, often following a single item's journey through production. Every step is described in detail by the narrator. The machinery used to manufacture some of these items is really ingenious, and watching a raw material turn into a familiar finished product before your eyes is fascinating.

FOR THE BIOLOGIST:
***Planet Earth and Life*, The Discovery Channel**

Anyone who has not seen an episode of *Planet Earth* should do so immediately. It was the first nature documentary filmed entirely in high definition, and was hailed as "the definitive look at the diversity of our planet" by the BBC.

The shots they captured are absolutely incredible. Animals in their natural habitats, predator-prey interaction in the wild, and even competition within a single species. It's like if Darwin had high definition film equipment and a team of hundreds of unbelievably patient cameramen at his disposal. It is both astonishing and highly educational when it comes to ecology and wildlife.

Life, also aired on Discovery, was a ten episode nature documentary based on the same premise–finding rare footage of the wildlife on our planet and bringing it to the living room. *Life* was narrated by Oprah Winfrey, while *Planet Earth* was narrated by Sigourney Weaver in the US version, and David Attenborough when shown in the UK.

Although these two series were difficult to produce, don't air all too frequently, and the DVD sets are somewhat expensive, they were absolutely amazing to watch, and certainly worth checking out if you haven't yet seen either.

Also, be sure to check out the websites of all of these shows, as they post additional video clips online. n

Photosynthetic Animals?

BY SUMAYAH RAHMAN, BIOLOGY, 2015

The first recorded attempt to classify life occurred around 300 B.C. when Aristotle sought to separate organisms into groups using characteristics such as the presumed presence of blood. Today, organisms are often classified based on the biological processes that take place within them. One such process is photosynthesis, the conversion of sunlight to useful energetic compounds. Photosynthesis is known to occur in plants, algae and some types of bacteria. However, certain groups of animals, such as sponges and corals, have the ability to form symbiotic relationships with algae where they can make use of the algae's energy. Some mollusks can even break open the algal cells and discard everything except for the chloroplasts, which they keep in their bodies and use to capture light energy.

Elysia chlorotica, a green sea slug, takes it much further. Genes involved in the production of chlorophyll (a light-capturing pigment in chloroplasts) have been incorporated into the slug's genome through horizontal gene transfer with the algae that it digests. These genes encode for enzymes in a chlorophyll-synthesizing pathway, and when the slug has these genes, it can create chlorophyll to power the chloroplasts that it "stole" from the algae even after the original chlorophyll reserves of the algae have been depleted. Remarkably, evidence indicates that this is a heritable trait: unhatched sea slugs that have never been exposed to any algae have been found to contain these photosynthetic genes. In what appears to be an oxymoron, *Elysia chlorotica* can be called a photosynthetic animal.

It is important to note, however, that although *Elysia chlorotica* can manufacture chlorophyll, it still needs chloroplasts from algae for the energy conversion process. An interesting variation on this discovery would be an animal that contains the necessary machinery from the start–and scientists at Tel Aviv University seem to have found just that.

It all began when entomologists noticed that the Oriental hornet was most active when the sun was most intense. Upon further investigation, the Tel Aviv team discovered that the hornet's brown and yellow stripes absorb sunlight. Evidence suggests that the yellow pigment xanthopterin converts the absorbed sunlight to electric power by creating a voltage gradient across the hornet's exoskeleton (which has a layered structure much like that of chloroplasts) that can be tapped into for energy.

As animals that obtain energy from the sun, the Oriental hornet and *Elysia chlorotica* are two creatures that blur the lines that we instituted when classifying forms of life. Unexpected exceptions such as these show us how confusing, bizarre, and downright fascinating biology can be. n

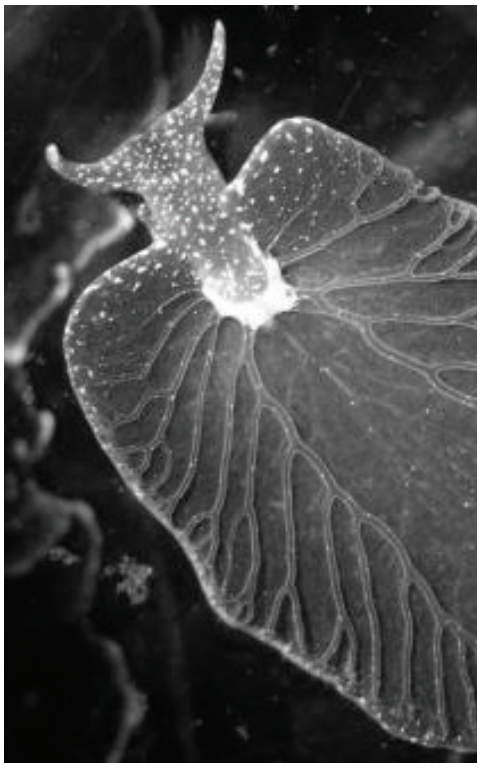


Photo courtesy of Patrick Krug, Flickr

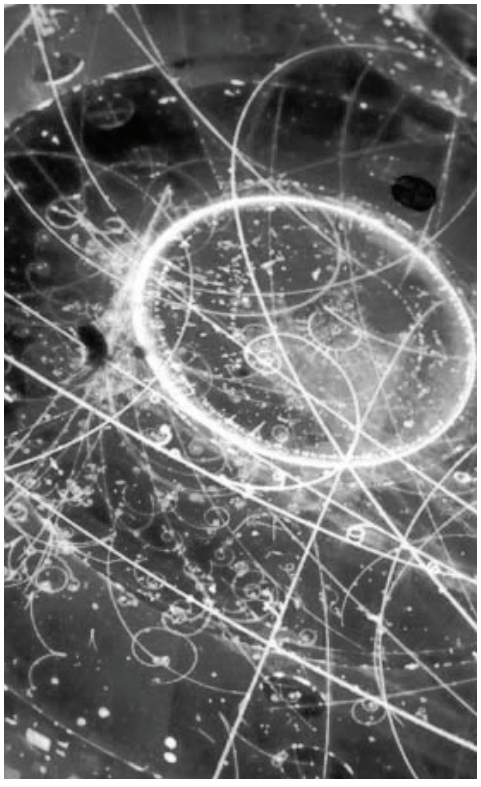


Photo courtesy of The Guardian

Neutrinos: Still Faster Than Light?

BY JOHN JAMIESON, CHEMICAL ENGINEERING, 2015

Last year the physics community was shocked and divided when experimental findings were released that indicated neutrinos could travel faster than light. If confirmed, this discovery would shatter one of Einstein's main theoretical achievements, his special theory of relativity.

The original results claimed that neutrinos sent from the CERN particle physics laboratory in Switzerland to the detector located in central Italy arrived about 60 nanoseconds earlier than light would have.

The OPERA collaboration, the group behind the report, has been working tirelessly to verify their results. Repeated trials in the past months had been consistent with their original findings.

However, in late February, news broke that two potential issues had been discovered. One, there was a loose fiber optic cable that was causing one of the atomic clocks to produce false results. When this cable was fixed and checked, the change in time observed was almost exactly 60ns, which would account for the neutrino's early arrival.

The second issue concerns an oscillator used to provide the time stamps for GPS synchronizations. It would also cause a difference in apparent neutrino travel time, however, this error would be in the opposite direction of the first, actually increasing the measured effect.

More tests from OPERA are forthcoming to evaluate the net impact of these issues, and more data will be gathered in the coming months–by independent particle research groups as well as OPERA–to help determine the true speed of neutrinos. n

Drilling to Lake Vostok

BY TUSHAR SWAMY, ELECTRICAL ENGINEERING AND PHYSICS, 2015

On February 5th, a Russian team of scientists completed a two decade-long mission to drill through a two-mile-thick sheet of ice in Antarctica. They hoped to reach a lake buried beneath the large glacial sheets. Though it is covered in ice, the lake (dubbed Lake Vostok after the research station above it) has remained in liquid form due to a combination of the pressure from the glacial sheets and geothermal heat. The sub-glacial lake has been trapped underneath ice for around 20 million years without contact to wind or even light. Recent discoveries have shown micro-organisms living beneath icy regions like Lake Vostok. This gave scientists hope that organisms may be able to live in Lake Vostok. These organisms would have an entirely different gene pool and may give scientists an insight into early life. They would essentially be a living time capsule. Potentially even more important, the conditions in Lake Vostok mirror those on Jupiter's moon Europa. Similar to Europa, Lake Vostok has sulfur deposits. In addition, most of the water on Europa is trapped underneath sheets of ice that have blocked any sort of light, similar to Lake Vostok. Scientists hope that in addition to revealing secrets about early life on Earth, it will also give hints about the existence of extraterrestrial life on Jupiter's moons.

Though the Lake Vostok team was able to breach the ice covering the lake, they were unable to acquire any samples from the lake. With the Antarctic winter approaching, the team had to leave at the risk of being stranded. They plan to return in more favorable weather conditions around December to collect and analyze samples. To keep the drilled hole from freezing over, they have used kerosene and freon to fill the hole in their absence. Similar chemicals were used during the drilling for the same purpose. This has caused controversy from several groups that are afraid of possible contamination to the lake from these chemicals. They argue that if there are micro-organisms in the lake, they will not even have been exposed to light in millions of years. There is no way to tell what effect the kerosene and freon will have on them. They suggested postponing breaching of the lake until a hot water drilling set up was available. The Lake Vostok team has countered that they have removed enough of the original kerosene that the pressure from the lake will push water up through the drill hole and freeze, effectively pushing out all contaminants and sealing the hole to any further contaminants as well as giving the team access to water samples. Only time will tell if the samples are indeed pure and if they hold answers to early life, or even extraterrestrial life. n

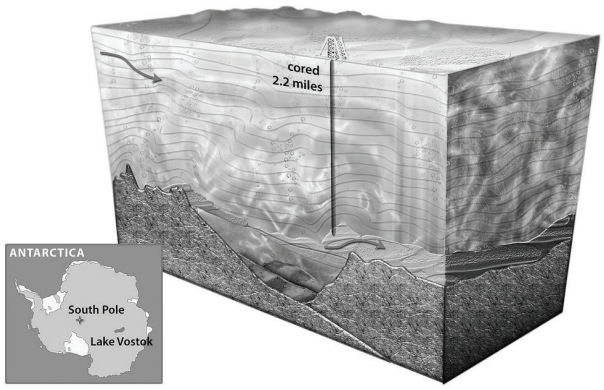


Photo courtesy of Nicolle Rager-Fuller/ National Science Foundation, Flickr

The State of NASA

BY BILL FLEMING, CHEMICAL ENGINEERING, 2016

NASA has been a source of inspiration for many Americans for decades; it was a great moment for everyone who had the chance to see the first moon landing in 1969. This event was very important to many Americans, the culmination of many years work. Ironically, recently they have decided to shut down the shuttle program which has meant so much to many people. The shut down took place in July of 2011. Many people may now find themselves asking, "So, if they're not going into space anymore, what exactly has NASA been doing lately?"

Recently, NASA has announced that they have determined which students they will admit into their Community College Aerospace Scholars program. There will be ninety-two students from twenty four states in the program. These students will go either to Pasadena, California to the Jet Propulsion Laboratory, from May 1 to May 3 or to Houston, Texas to the Johnson Space Center from May 9 to May 11. While at the NASA location, the students will be split up into teams, and each team will have to establish fictional companies seeking to explore Mars. They will then design and build a rover which they will have to use to navigate a course, collect samples and return to a base.

This program was created in an attempt to encourage students to become interested in careers in engineering, technology, mathematics, and science. NASA used an online assignment to evaluate the applicants of the program. The applicants used their online assessment throughout the school year and once they are selected, they will receive an on-site tour of NASA facilities and Briefings from agency scientists and engineers.

Meanwhile, the NASA Scientists operating the Hubble Telescope have noticed what appears to be a clump of black matter. Thought to be a result of galactic collisions, it appears that these galaxies floated away following the encounter. This possibility directly contradicts current ideas, which theorize that galaxies are anchored to dark matter. In fact, when this clump was originally spotted in 2007 the scientists that noticed it didn't believe it to be real.

The specific location where they found the dark matter mass, which is invisible, and can only be seen via its effects, is 2.4 billion light years away. Dark matter is capable of bending light, which is used by scientists to detect its presence. This specific center of dark matter which is exhibiting these characteristics is called Abell 250. When they were examining the core of Abell 250, they noticed that it should contain significantly more galaxies than it actually does.

NASA has seen 6 examples of these mergers, and the two most recent, Abell 250 and one called the Bullet Cluster, are inconsistent with each other. The problem with the evidence that they have is that there simply isn't enough of it to reach an accurate conclusion.

The team has been trying to come up with an explanation for the discrepancies, with no luck. One idea that had been proposed was that Abell 250 was a much more complicated collision than the Bullet Cluster. Another possible explanation is that dark matter is capable of interacting with itself and that through several interactions it could have formed Abell 250. The final possibility discussed was that all necessary galaxies are present within the core, but that some of them were not bright enough to be seen. To test the various hypotheses, they have begun trying to recreate the collisions in simulations.

It is a reasonable question to ask whether or not shutting down the shuttle flights was a good decision, but rest assured that NASA is still certainly hard at work, working on projects which are not quite as expensive as shuttle launches. However, it makes NASA less accessible to the individual citizen. It takes something that was inspiring to many Americans and puts it behind closed doors. The two examples are not are the whole story, only two instances of what they are doing. To see more of their research, log onto *www.nasa.gov.* n

NUScience Explains:
Catenary Arches

BY CAITLIN CANDEE, CIVIL ENGINEERING, 2014

Imagine a piece of string. If you were holding it in your two hands, you could pull the ends apart and feel that the string is strong in tension. However, if you pushed the two ends together, the string would offer no resistance. This is because string has no strength in compression.

So keep imagining that piece of string, hold the two ends and give it some slack, and it forms a shape like a parabola. This shape is actually called a catenary.

Now if you invert that shape, so it looks like a hill instead of a bowl, and you swap out the string for a material that is strong in compression, for example brick, you have created a catenary arch. This premise, with some more complex details, has been used to create some of the coolest arches and vaults in the world.

Application of Catenary Vaults

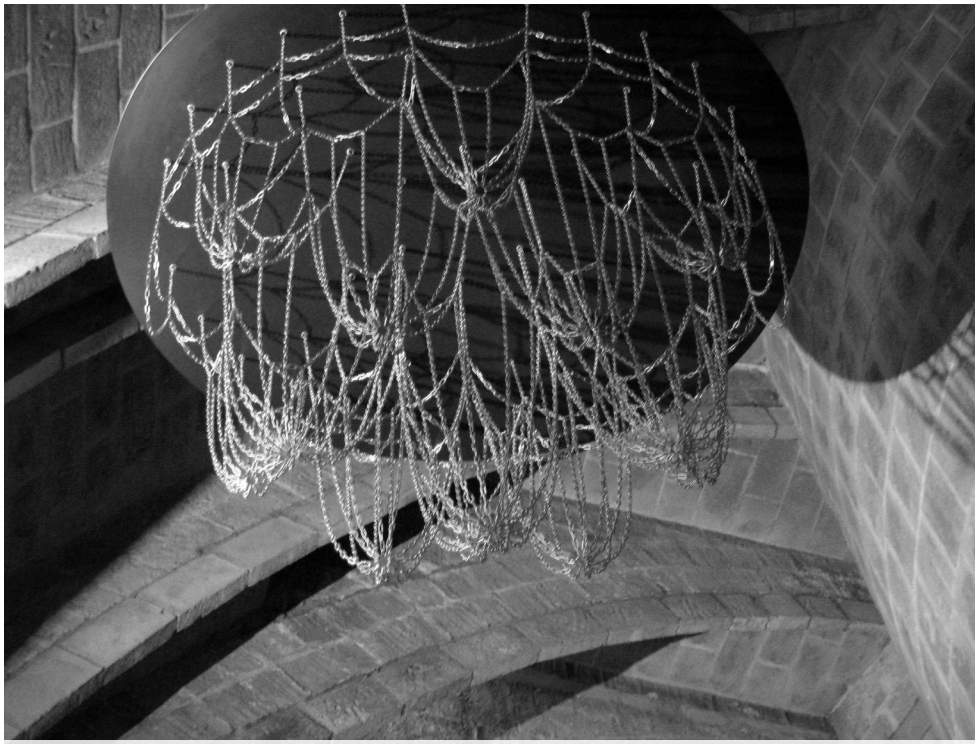
Gaudi, a famous Spanish Catalan architect, used this technique in a few of his works, even before there was modern, advanced structural analysis to explain it. He would start by creating a model entirely out of chain or string with weights then suspend it upside down (see photo), so that it would hang in pure tension. He would photograph the model and turn the photo upside down in order to see how he should design a structure that would act in pure compression (see photo).

The design and construction of these remarkable vaults and arches was based on some bits of string and weights, which can seem a little primitive but is actually ingenious.

Compression

The weighted strings hang down to fully utilize their tensile strength. By inverting the shape, gravity is pushing down on the arch, compressing it. So by replacing string with a compressively strong material, an arch in compression is born.

Nowadays, our structures are designed to require both tensile and compressive strength. Concrete is a very standard building material, and it is very strong in compression, meaning it supports very large loads pushing on it. However, concrete is weak in tension, it fails under a much smaller load pulling on it. This is why we reinforce concrete structures with rebar, steel-reinforcing bars. But catenary arches, by design, only require compressive strength, so they don't need materials like steel for tensile reinforcement, and using a material that is only strong in compression is perfectly sufficient.



One of Gaudi's hanging chain models | Photo courtesy of Laura Padgett, Flickr

One of the cool and unusual things about this design is that it utilizes the full potential of the building material. Concrete and steel construction requires the use of material where it isn't fully utilized. For example, rebar is required where there is tension, but it must be surrounded by concrete for construction purposes. But the strength of that concrete is being wasted, as it isn't being engaged. With these catenary arches, by design the bricks or tiles are completely in compression, and there isn't a surplus of material not being utilized. This results in more efficient structures, and there is some beauty in the simplicity of only using a material to its fullest strength.

In a Local Context

For an example closer to home, just wander down to the Boston Public Library in Copley Square. The vaulted arches in the older portion of the library were designed and constructed by an architect named Rafael Guastavino. This Spanish architect and his son brought this centuries-old catenary arch technology from the Mediterranean to the United States. Guastavino vaults are typically about 4 inches thick, yet hold an astonishing amount of weight, as they are used for both roof and floor systems.

Form and Function

What's amazing about this is that it brings together the beauty and strength of the material during construction–a composition getting lost in today's design process. Today steel and concrete typically make up the structural support for a building, then a façade is draped on the outside. The supports serve no aesthetic purpose, and the façade serves no structural purpose. There is a disconnect between the function and the form of the building.

This separation is obvious when you look at how a building is designed. An architect designs a structure, paying attention to the aesthetics and the abstract. Then the design gets handed to an engineer, who has to figure out how to make the design stand up.

Neither party understands the other's work, and there is little consideration of structure during design or design during structure. As the world has become more specialized, the separation between architect and engineer has allowed both fields to grow, and it has limited their liability. But this was not the system when Gaudi and Guastavino designed their vaults and arches. History calls them architects, but they did the engineering as well.

Building of the Year

Professor Ochsendorf has used what he learned about Guastavino as inspiration for a special project in South Africa. Along with Peter Rich Architects, they have designed and built the Interpretation Center in Mapungubwe Park.

This building uses this arch design for the structure, but it's special for a few more reasons. The tiles used in the construction of the arch were made from the soil that was already on-site, which was environmentally responsible and cost-effective. They also created jobs by training then employing local people living in poverty to make the tiles then build the structure. It won the World Building of the Year at the World Architecture Festival Awards in 2009, for all of the above reasons, as well as for its sustainability and its relation to the landscape around it.

Greater Implications

This Interpretation Center is an example of the larger implications of this technology. Aesthetically, these vaults and the tile work are simply stunning. Environmentally, the design uses simple bricks or tiles, which can be created using local materials and labor. In terms of efficiency, it uses these materials to their full potential, which minimizes waste. Structurally, the tiles that make it beautiful are also what hold it up; it combines the aesthetics and the structure.

Conclusion

Not everything can be an arch, but we should take inspiration from this elegant technology that reduces waste by designing structures that utilize materials more effectively. Architects and engineers need to work more closely and realize how interconnected their work is. Maybe then we can return to structures that are gorgeous for their structural support, rather than hiding it behind facades.

If you are interested in learning more, check our what Professor John A. Ochsendorf and his team at MIT have done with The Guastavino Project. n

La Sagrada Familia, perhaps Gaudi's most famous work in Barcelona
Photo courtesy of Volkanikz, Flickr

Seeing the Unseen

BY FARAZ ARASTU, BIOCHEMISTRY, 2015

In the immortal words of Ramon y Cajal, "Nature hides its secrets with two veils: making them small and colorless, invisible to the naked eye." In recent years, biomedical experts have taken new initiatives to visualize nature's secrets. BioInteractive at the Howard Hughes Medical Institute, WEHI.TV at the Walter and Eliza Hall Institute of Medical Research, and BioVisions at Harvard University are three active 3-D molecular animation divisions. Their animation teams are raising awareness of advances in biologically directed research.

3-D modeling restructures the perspective on biochemical processes from static to dynamic. Capturing the element of time with space-filling models is an alternative to taking still frames or even motion pictures using microscopy. Pictured in Figure 1 using special microscopy and staining techniques is a cell undergoing cell mitosis in late anaphase. Figure 2 illustrates the S-phase of the cell cycle, when DNA is replicated, using 3-D computer simulation.

The technology used to recreate these phenomena has applications in biomedical education. Medical students are trained using surgical animations. Pictured in Figure 3 is an arthroscopic shoulder surgery performed for subacromial decompression. This patient model shows that shoulder spurs are compressing the rotator cuff tendon, limiting range of motion and causing discomfort. Anatomical recreations are useful in nearly every field of medicine, especially plastic surgery, neurosurgery, cardiology, ophthalmology and orthopedics. Doctors are now using medical animations to inform surgical patients about their procedures. Pictured in Figure 4 is a mitral valve repair simulation provided for patients at the Mayo Clinic in Phoenix, Arizona. The simulation outlines the procedure, its best candidates, and the risk factors involved.

3-D imaging technology has been adapted to magnetic resonance imaging (MRI) and computed tomography (CT) to create digital representations of patients' tissues and organs. Cross sections of the patient on the sagittal, coronal, and axial planes – y-z, x-y, and x-z planes respectively – are consolidated to reconstruct features of interest, including blood vessels and bone structures, which can be viewed in 360° perspective. This can lead to more accurate diagnoses and more effective clinical intervention. Figure 5 shows a patient's skull reconstructed using CT imaging.

Pharmaceutical companies use animation technologies to illustrate drug pathways and efficacy. Informational models attract grant foundations that are interested in funding innovative projects, clinical practitioners, better treatment routes and patients learning to make more informed health choices. Shown in Figure 6 is the mechanism of action of a chemotherapeutic drug delivered via nanoparticles.

Illustrations often follow important discoveries that are abstract or difficult to explain. The polymerase chain reaction (PCR) is one of the most commonly used lab techniques, but it is difficult to understand without visualization. Plots of DNA amplification over time quantify the utility of PCR, but say little about the principle it acts on. The mechanism for PCR, seen in Figure 7, is based on cycles of denaturing by heat and annealing via DNA polymerases.

If the 19th century was the age of physics, and the 20th century was the age of chemistry, then the 21st century is the age of biology. As the biological sciences continue to branch out, there is a higher demand in medical and biological illustration. The Association of Medical Illustrators (AMI) has facilitated communication in the biosciences since its founding in 1945. Its members have extensive background in medicine and the visual arts and are employed in advertising, textbook illustration, patient education, continuing medical education programs , and interactive learning. Some illustrators have even introduced bio-simulation through lifelike patient disease models.

Medical illustration programs are highly competitive with only five Allied Health Education accredited programs in North America, each accepting fewer than 17 students each year. After completing a rigorous graduate program, many pursue an AMI Board Certification to meet the highest standards of medical illustration. Illustrators continue to integrate with new technologies and up-to-date scientific advances throughout their careers. Popularly used programs today include Cinema 4D by Maxon, LightWave by NewTek, and Maya by Autodesk.

Board-certified illustrators are also required to meet continuing education units to maintain their certification. The earning potential for medical illustrators ranges widely based on the field, talent, entrepreneurialism of the individual. However, the competitive nature of the work and high demand in the private and industrial sectors suggests that medical illustration will grow in the age of biology. n

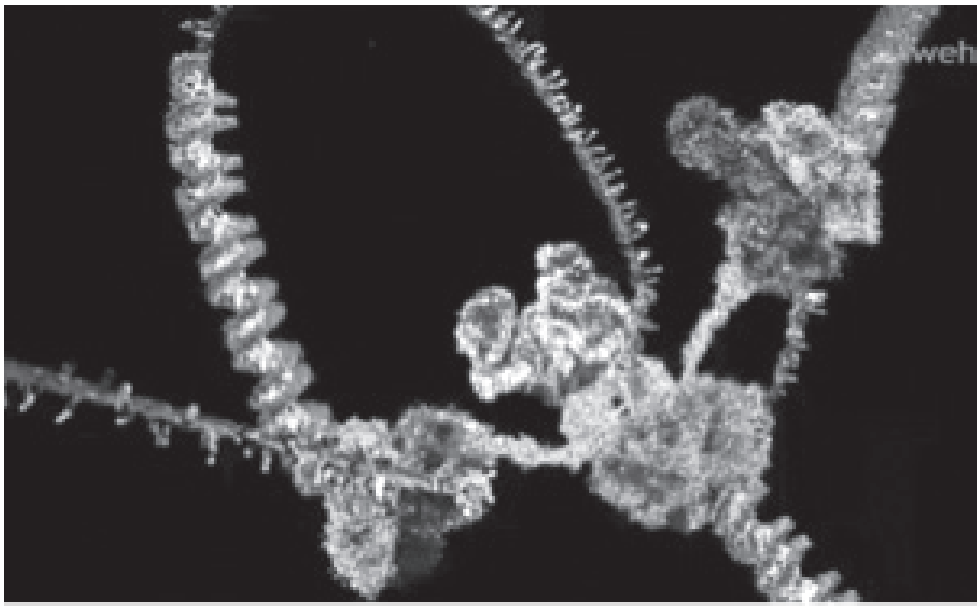


Figure 2 - courtesy of Walter & Eliza Hall Institute of Medical Research, WEHI.TV

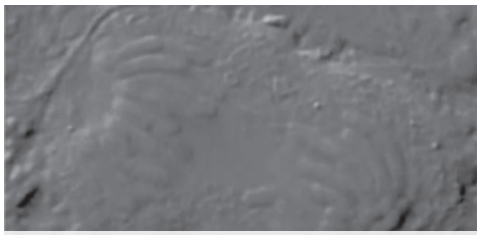


Figure 1 - courtesy of Walter & Eliza Hall Institute of Medical Research, WEHI.TV

Figure 4 - courtesy of Mayo Clinic

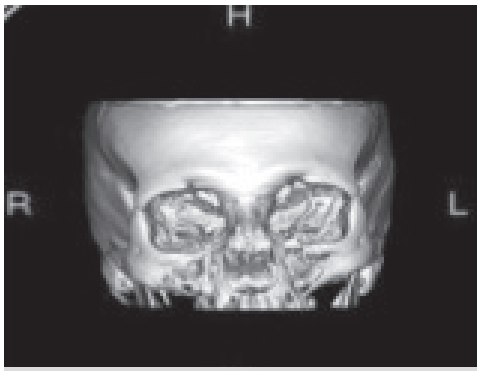


Figure 5 - courtesy of Wikipedia

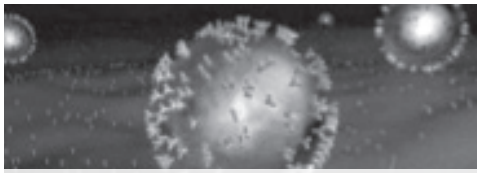


Figure 6 - courtesy of Frank Gu Research Group, University of Waterloo

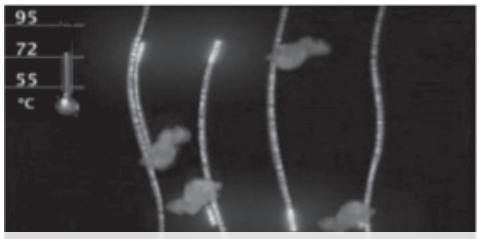


Figure 7 - courtesy of DNA Learning Center

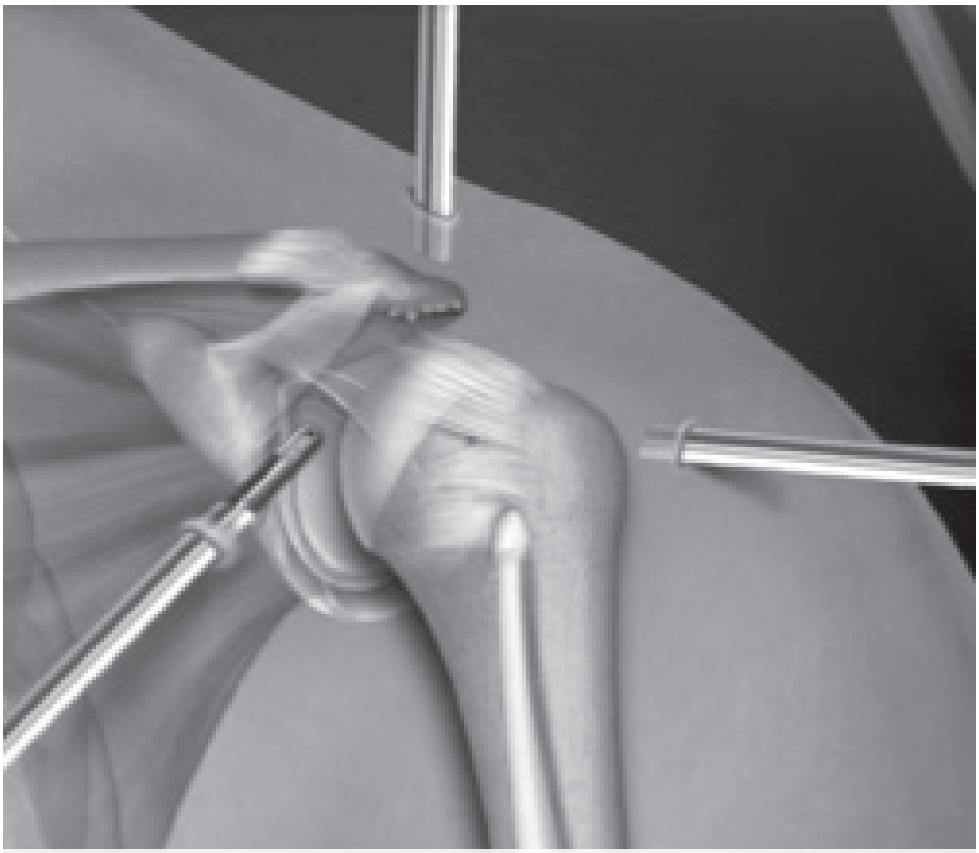


Figure 3 - courtesy of High Impact

Data Visualization:
Making Sense of What You See

BY MICHAEL MURRAY, COMPUTER SCIENCE AND ENGLISH, 2014

Hopefully, just about everyone is familiar with the scientific method: you form a question, make observations, form a hypothesis, test it, pour over the data looking for meaningful results, and repeat as needed. While there are several variations, finding and explaining trends in information forms the basis of scientific research. Finding such a trend, of course, may lead to sharing it with the world, either through publication or presentation, which is where data visualization comes in.

Data visualization is a broad term, covering "the graphical display of abstract information," whether for analysis or conveying some idea. That definition covers things as standard as a line graph, as well as including the growing field of infographics, or even techniques more artistic in nature. The advantage of data visualization is clear, since almost any graphical representation of information is more comprehensible to people than a plain list of numbers. Some argue that highlighting a trend in data through graphical means will tend to bias any audience towards the author's conclusion. This argument is valid, making it critical for those working on data visualization to strive for neutral formatting.

Infographics have become very popular in recent years, with publications such as Wired Magazine, Scientific American and many others increasing the number of these designs that they use. They provide a way to present data that is informative, easy to understand and visually appealing to readers. A successful infographic will often display information in more than one form, combining graphs, diagrams, flowcharts and almost anything else to teach the reader. They can cover topics that are serious, like those in scientific publications, or even more humorous subject matters; the popular webcomic XKCD (xkcd.com) often features factually accurate infographics on topics such as gravity wells, radiation dosages, or sizes on a logarithmic scale, with jokes interspersed throughout. The versatility afforded to infographics by the sheer range of subject matter and forms available to them perfectly explains their swelling popularity in recent years.

Data visualization is more than just infographics. It allows for new and creative ways of organizing and sharing information through visually stunning representations. Jer Thorp is an artist and educator with a background in genetics who creates impressive pieces that incorporate elements of both science and art. Described as "an artist whose medium is data," he uses flexible software and algorithms to gather large amounts of information and present it in a visually appealing form. His work is extremely popular, appearing in the New York Times, Popular Science, and Wired, where he is a contributing editor for the UK edition. He views his work as a response to the overwhelming quantities of information that people encounter today. Thorp's vision is to instead present ideas in a coherent and beautiful way, without being any less informative.

One challenge that designers such as Thorp face is balancing the accuracy of their pieces with both their aesthetic quality and their ability to convey the desired information. Unfortunately, nearly all forms of graphic data visualization carry the inherent risk of misrepresentation. Designers have to be extremely precise in deciding what range of information to select, as well as how much data to include and how to group it. While these decisions may seem fairly innocuous, if they are not fully considered (or made from a biased perspective with the intention to deliberately mislead), a single faulty decision can completely reverse the meaning of even simple-seeming bar graphs. Thorp's software is designed to be incredibly fluid, allowing the user to make quick yet drastic changes to the piece while still working with the same underlying data, simultaneously demonstrating the problem and creating his own solution to it.

Data visualization is an essential component of how we share information, scientific or otherwise, and it is becoming even more important as time goes on. Thorp has correctly identified the problem of our internet age: We are subject to "information overload" as a result of constantly having access to enormous amounts of information at any time. His instructive and elegant solution offers us a refreshing change of pace in the way in which we receive our information. n

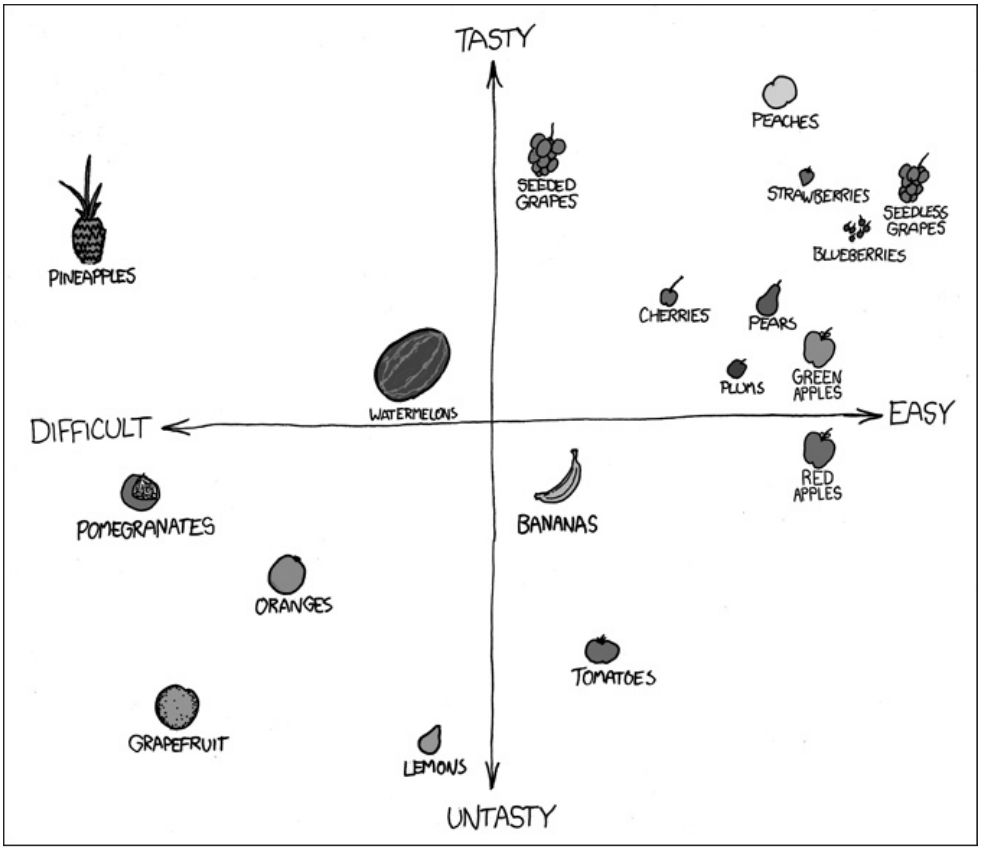


Photo courtesy of Randall Munroe, xkcd.com

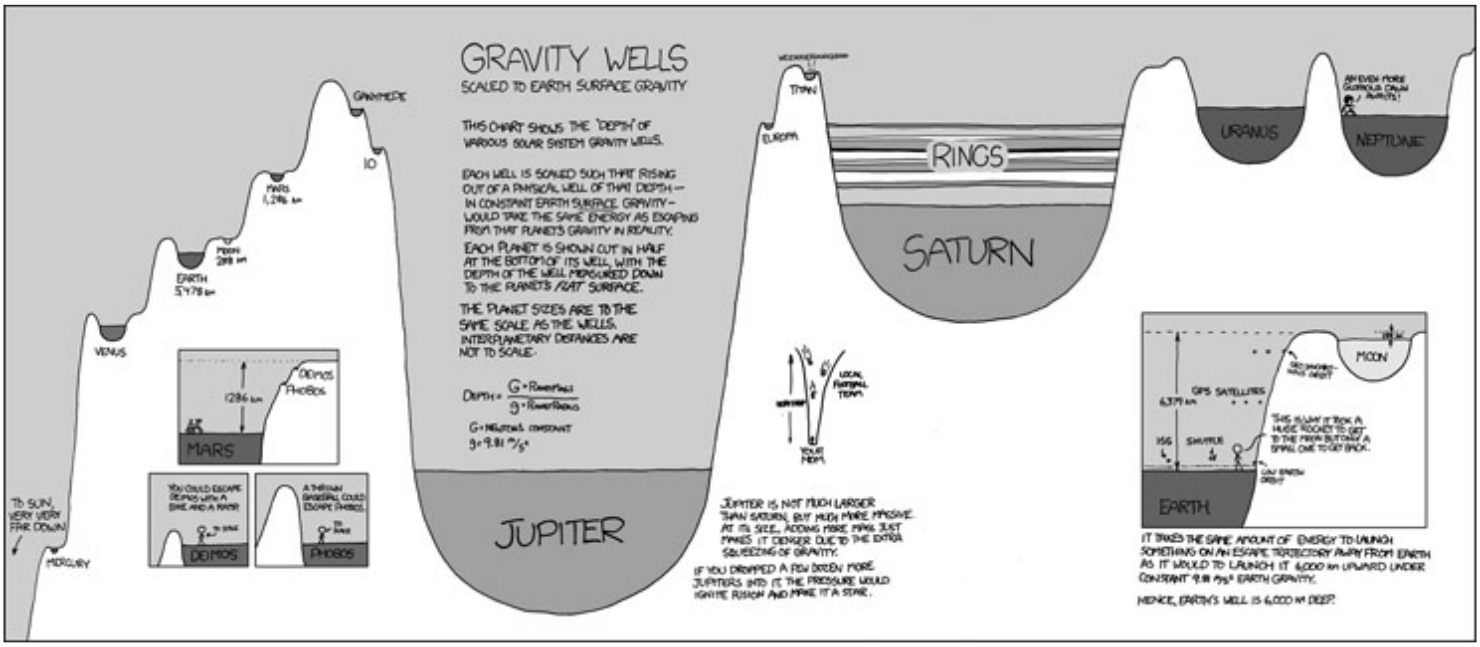


Photo courtesy of Randall Munroe, xkcd.com

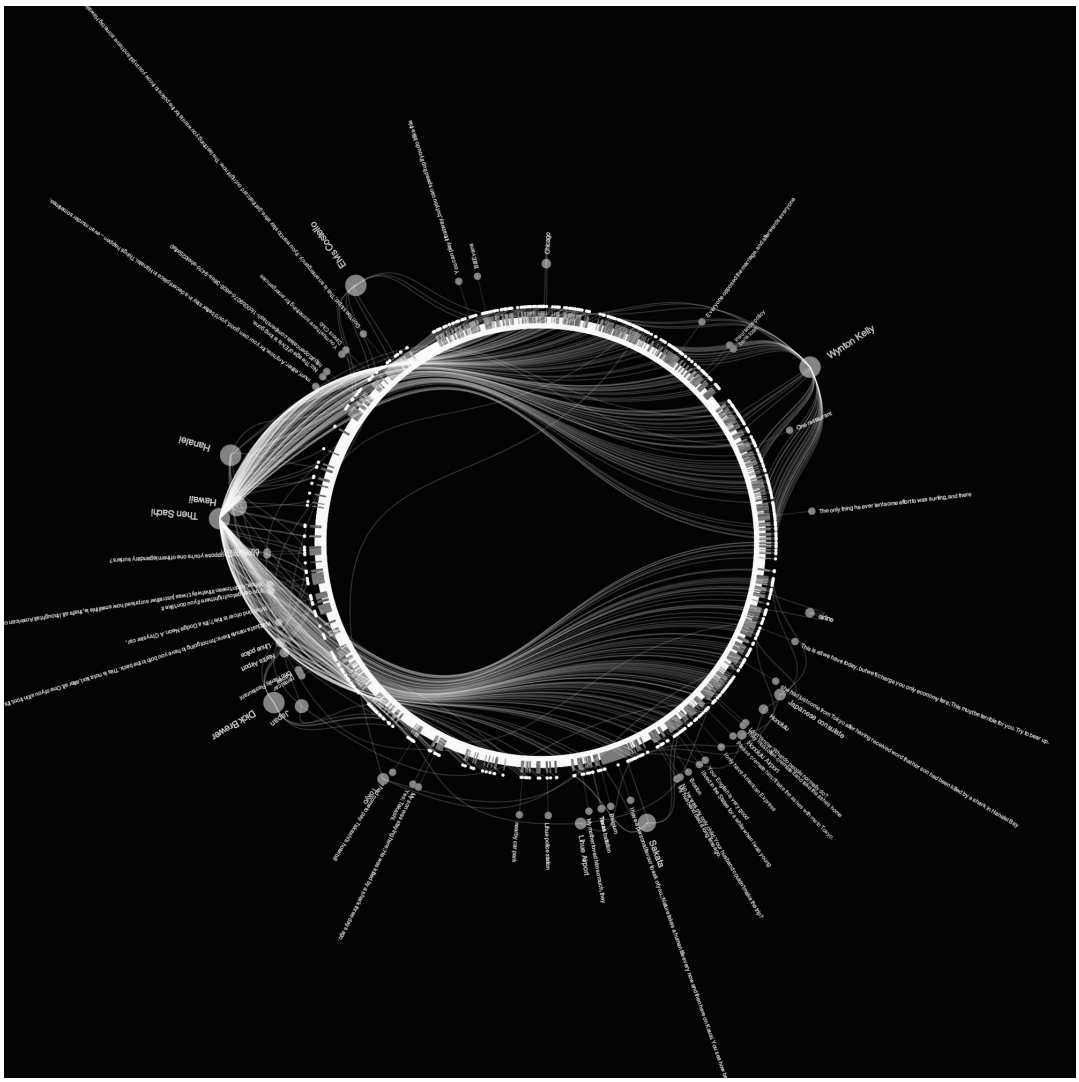


Photo courtesy of Jer Thorp, blprnt.com

Science Gone Wrong:

Getting down and dirty with NU science majors

BY SHANNON JONES, MARINE BIOLOGY, 2016

Science is hard to do. Ask any organic chemistry, physics, anatomy, or biology student. Every time someone enters a lab, there's a fearsome and catastrophic potential to break everyone and everything around him or her. Thankfully, that sort of thing doesn't happen often. But when it does, hilarity often ensues. So you don't have to wander around asking science majors their most embarrassing moments, with a blanket of strict anonymity, we at NU Science Magazine have collected some of the best tales here.

"I'm currently on co-op at the Child Development Unit at UMass Boston. We have a variety of memory studies in place right now assessing at what age infants begin to remember their mothers from day to day. When I began my co-op, I walked into our lab suite one day and thought it was funny that this very old man was working in the suite next door. He had come through the door and was knocking on someone's door with his cane. I mentioned it to one of the other researchers, and she told me that it was T. Berry Brazelton. Our chief of research, Dr. Edward Tronick, has worked directly with him, including producing publications. Every psychology major learns about the Neonatal Behavioral Assessment Scale in Developmental Psychology, but I didn't recognize him at all! When I mentioned his name to my mom, she laughed and said that she actually followed his principles and books when she was pregnant with me."

"It was about a month into my first co-op, and I was just getting to know the ropes. Because it was my first co-op, I felt extra pressure to do a good job and prove myself. I was approached by one of the engineers and asked to sit in the lab while an automated test ran on a fuel cell stack. 'Just to make sure nothing goes wrong, and come grab me when it finishes.' No problem, right? About 20 minutes into the test the stack started sparking and caught on fire. I jumped out of my chair and quickly pressed stop on the test stand and searched for the bright red E-stop button to cut off the power, which was not so conveniently located on the wall outside the lab. After the button was pressed, the sparking stopped. Apparently this was the failure mode the engineer was looking for, without giving me any prior warning or even a heads-up. Since then, I have been no stranger to the red E-stop button when it looks like something is about to go wrong."

"In my chemistry class, we were working with a chemical that produced a mildly poisonous gas, and the teacher warned us not to smell it directly. I knew my lab partner didn't pay much attention, preferring to let me do the experiments while he recorded data. So, with the noble intent of gathering qualitative data, I told my lab partner to smell it. Instead of wafting it or staying at a distance, he put it to his face and directly inhaled. He spent the next twenty minutes coughing and dry-heaving out of the window."

"I was in the freshman chemistry lab a few months ago, and I had a test tube suspended over boiling water. As I was unscrewing the test tube, it slipped through my fingers and into the boiling water. As it hit the bottom of the beaker, the beaker shattered, covering my desk in both broken glass and boiling water. My T.A. and professor were less than pleased."

"I spent my first six-month co-op working in an acute psychiatric unit in a psychiatric hospital. One aspect of the job was to perform 15 minute checks on the patients to ensure their safety on the unit. When you have a large group of patients with different levels of psychosis, you never know what you're going to get. More often than I would ever want to recall, upon entering a patient's room they would be, to phrase it delicately, engaged in an intimate moment with themselves. Because of the various mental illnesses with varying degrees of severities, people had different levels of awareness and inhibition, or rather non-inhibition. Upon entering said situation, 1 of 4 things would occur.

1. The person would quickly and dramatically thrust themselves under their covers and pretend that they were actually sleeping the whole time. Convincing? Not so.
2. The person would pull a deer in the headlights. They did not move or cover up, but merely froze mid-act and stared at you, making you far more embarrassed and uncomfortable than they were.
3. They would unfalteringly carry on.
4. In some crude way or another, you would receive an invitation to join in the fun.

While my job did provide me with wonderful experience in the field, it also left me with some experiences that I easily could have gone without."

"I was on coop and I had to use a Bunsen burner and a beaker of ethanol to put my forceps in. We keep them in ethanol, and then sterilize them with the flame. First, I spilt the ethanol in the little beaker all over the table and all over my gloves. I'm like, 'I'll deal with that later because I have filters sitting there in the open air, and they need to be in petri dishes so they aren't contaminated.' I decided that first I'd deal with the filters, and then I'd deal with the ethanol. So, with my hands coated in ethanol, I picked up the tweezers (that are also coated in ethanol) and put them in the flame. The entire setup burst into flame, including my hand, which I luckily had a glove on, so it wasn't burned. I obviously was startled by my hand catching on fire, so I dropped the tweezers into the pool of ethanol, and proceeded to stare at it for at least four or five seconds before reacting. I just took the buffer water that I was using to run my samples and poured it on the flame. I told my boss the next day, and I guess other co-ops have done that before too."

"One day I was working in a lab on campus in collaboration with my co-op. I was in sweats because I was planning to go for a run that afternoon, during a break between the experiments. I rarely work with hazardous chemicals in this lab, because we mostly deal with proteins and mass spectrometry. That day I had to make a buffer for the mass spectrometer, which involved adding a small amount of 99% trifluoroacetic acid (TFA). While I was in the hood pipetting the TFA, I knocked over the bottle, and it splashed out of the hood onto my pants. I watched as the TFA sizzled on the counter. That is when it set in what had actually happened. I looked down at my pants and watched them disintegrating before my eyes. I heard someone shout, 'Get under the water!' I stripped down to my underwear and literally ran and jumped under the sink shaking. All of the women in the lab turned to stare at me (I mean, I was basically naked) as the guys cleaned up the TFA. Since it was an acid burn, I had to remain under the water disrobed for 15 minutes before I could leave the lab and head to Marino to take a full shower. I left the scene with a burn on my arm and inner thigh. It became the joke in the lab that if anyone angered the grad student that I had been working with, he would burn you. Not only will I never live the burn down, I will also be always remembered as the undergrad that had to strip down to his underwear mid-lab."

Learning from the Past

A look back at one of the worst chemical disasters in history and the resulting changes in process safety

BY BRAD WEST, CHEMICAL ENGINEERING, 2013

On the night of December 2, 1984 a runaway reaction at the Union Carbide India Limited pesticide plant in Bhopal, India, caused methyl isocyanate (MIC) to be released into the air and spread into the city. Over 200,000 peoplewere exposed to MIC and the documented death count was 3,787 with estimates for the total death count to be over 10,000. This chemical spill is thought to be one of the most devastating in history. Union Carbide, the primary share holder, was held responsible for the accident. They settled with the Indian government for $470 million, eventually causing the company to go bankrupt. It was eventually purchased by Dow Chemical.

MIC is an intermediate in the production of Sevin, a common pesticide used in the 1980's. The runaway reaction was caused by water entering a tank containing approximately 40 metric tons of MIC. As a result, a highly exothermic reaction occurred which lead to a sharp increase in temperature and pressure within the storage tank. The pressure relief valve on the tank functioned as it was designed, however all of the downstream mitigation measures were out of service or on standby for months prior. This caused the MIC to be released into the atmosphere without passing through the caustic scrubbing tower or the flare tower.If these two pieces of equipment were installed at the time, the effects of the runaway reaction would not have been nearly as severe.

It is unclear how the water entered the tank; two possibilities were proposed but both seem unlikely. The first proposal was that water from a cleaning line on the other side of the plant leaked into the storage tank through a leaky valve. Professionals deemed this conspicuous because the cleaning line was on the opposite side of the plant and a tremendous amount of pressure head was required to move over 500kg of water through a leaky valve. This explanation does not seem to hold up within the time frame of the accident. The second proposal was made by Union Carbide which claims sabotage. Carbide claims that the water was added to the tank purposefully and the pressure gauge was removed to cause the accident. This would have involved a very intimate knowledge of the piping system to be able to disassemble and reassemble the equipment. Additionally, the website Carbide has dedicated to this accident, claims that all of the process and safety controls were in place and would have prevented this type of leak from happening. At this point, no individual was held responsible for the accident, but a feud arose between the Indian Government and the Management of Union Carbide on who to blame.

After the incident in Bhopal, environmental awareness greatly increased in India with the Environment Protection Act, which passed in 1986, and the formation of the Ministry of Environment and Forests (MoEF). With the large increase in industrialization, with an average GDP growth rate of approximately 8%, MoEF works harder to reduce industrial pollution than ever. Additionally DuPont, looking to build a plastic plant in Goa, Indiawith minimal regulations, was denied entry. Protests by the people in Goa caused the deal to fall through. The people of Goa were aware of the disaster in Bhopal and did not want DuPont to move their plant without increased regulation. In 1986, US Congress passed the Emergency Planning Community Right to Know Act (EPCRA). This law required local governments to have plans in place, in the event of a chemical spill, fire, or explosion. This was a tremendous step forward in safety regulations because in the event that an accident similar to Bhopal were to happen again, local governments would be much more prepared with evacuation routes and clean up plans.

Changes were made internationally and locally in response to the tragedy in Bhopal, and regulations for manufacturing process safety are stricter. It is important to be aware of disasters like this so they are not repeated. Additionally, awareness of the possible consequences of actions when working with hazardous materials is crucial. Safety should always be a number one priority and if a safety concern is apparent it should be reported to a supervisor. Had a worker at the plant in Bhopal put more pressure on the management to fix the scrubber and the flare tower, the magnitude of this disaster could have been greatly decreased. n

Close to Home: A Common Feline Virus Could Affect Human Behavior

BY LAUREN HITCHINGS, BIOLOGY, 2014

As it turns out, there might actually be some scientific validity to the term "crazy cat lady." Toxoplasmosis, a parasitic disease transmitted primarily through cat feces, has always been recognized as a dangerous parasite for unborn babies and people who are immunocompromised. However, it was always thought to be harmless to healthy individuals. Recent research now suggests that the disease might actually be causing mental and behavioral changes in individuals previously considered asymptomatic.

Most outdoor cats are infected with a protozoan parasite known as *Toxoplasma gondii* that uses both felines and rodents to complete its lifecycle. In cats, the primary hosts, the parasite is in the sexual phase of its life cycle. In the asexual phase of its lifecycle, *T. gondii* uses rodents as secondary hosts. Cats contract the disease again after eating an infected rodent. This is how *T. gondii* propogates and spreads. The parasite is also capable of infecting birds, other mammals, and humans as dead-end hosts.

Humans can contract toxoplasmosis by eating raw or undercooked meat, or by handling cat feces containing the parasitic oocytes - cysts containing a zygote formed by the *T. gondii*. Though cats only excrete the oocytes for a few weeks of their life, and usually only when they are very young, the oocytes can survive in the environment for up to a year, and any hand to mouth interaction after coming in contact with the oocytes can lead to contraction. It is estimated that about a third of the world's population of humans carry the parasite.

Women are discouraged from cleaning the litter box during pregnancy, as toxoplasmosis is known to cause brain damage in unborn children. People who are severely immunocompromised, such as those living with HIV/AIDS, or recent organ transplant recipients are also susceptible to symptoms of toxoplasmosis including skin lesions, eye damage, and brain damage. Until recently, it was believed that healthy, immunocompetent individuals had nothing to worry about. Once inside, *Toxoplasma gondii* would simply form small, harmless cysts in muscle and nervous tissue, causing no symptoms or damage. New studies, however, suggest that oocytes that take up residence in the brain might be causing behavioral changes, even in people who appear otherwise entirely asymptomatic.

Studies on mice with toxoplasmosis in the last decade show clear behavioral effects of the parasite. These include a reduced ability to respond to danger, running towards cats instead of away, and even being attracted to the scent of cat urine. In terms of evolution, this behavioral control mechanism benefits both the cat and parasite, as fearless and oblivious mice make for easy prey. This allows *T. gondii* to cycle back into the primary feline hosts where it can reproduce and thrive.

Research recently done in Prague by scientist Jaroslav Flegr now suggests that *T. gondii* might cause similar behavioral changes in humans. According to his work, it is likely that toxoplasmosis can trigger schizophrenia in those predisposed to it. There may also be a correlation between toxoplasmosis and other mental and behavioral disorders. Similarly, he found a strong correlation to suicide rate.

Flegr went even further, and observed behavioral changes in even the healthiest men and women. In men, toxoplasmosis caused subjects to become introverted and likely to ignore rules. It also made them suspicious, yet unusually oblivious to other's opinions of them. In women, the opposite was true, and they became more outgoing, rule conscious, trusting, and very conscious about their images. Much like the lab mice, humans also became less fearful, and slower to respond to danger. Also similar to mice, humans infected with *T. gondii* were less put off by the scent of cat urine.

Tests for the presence of toxoplasmosis exist for felines, but are not particularly useful, as they do not reveal when the animal was exposed or if it is still shedding the parasite. Because it is currently unclear what exactly a diagnosis of positive for toxoplasmosis could mean, and because there is not yet a way to remove oocytes from the brain, human tests for toxoplasmosis are equally idle.

So how can one prevent being infected by *T. gondii*? There is no surefire prevention method, but keeping cats indoors rather than outdoors is a good start. Also, neither humans nor felines should eat raw or undercooked meat. Finally, thorough hand-washing after cleaning the litter box or handling raw meat can go a long way.

As of now, it is unclear how dramatic the behavioral effects of toxoplasmosis really are. As a result of the current research more scientists are now on board with the data relating toxoplasmosis to mental disorders, behavioral changes and suicides. If the patterns noticed by Dr. Flegr and other leading researchers continue, the next step will likely be the creation of a T. Gondii vaccine for livestock and house cats. In the meantime, when you see your local crazy cat lady surrounded by her twenty feline friends, remember that toxoplasmosis might be to blame. n

NUCLEAR ENERGY GONE WRONG:

What happens when a nuclear disaster strikes

BY KATE BARRAL, HEALTH SCIENCES, 2015

The world's population is estimated near 7 billion people. With more people born everyday a greater stress is put upon the precious resources we depend on. Energy, electricity, heat, fuel, and gas are resources in high demand. Electricity is manufactured from a number of sources such as coal power plants, nuclear power plants and renewable resources. The burning of coal produces energy and renewable resources convert the sun's rays or the wind's power into useable energy. But how much is known about nuclear energy? The issue of nuclear power is on the top of political agendas and is a serious issue to environmental advocates who stress the risks of radioactive particles and its carcinogenic effects. Most current are the devastating effects that result when a nuclear power plant faces a meltdown. The three major catastrophes that stand out when mentioning a nuclear disaster are the Three Mile Island disaster, the Chernobyl disaster, and most recently the Fukushima Daiichi disaster.

The possibility of destruction is what makes nuclear power so controversial. Nuclear power plants have been in operation for decades and with only a few major meltdowns it is considered a greener alternative to burning fossil fuels. With 439 nuclear power plants operating in 31 countries throughout the world, its time to take an in depth look at what nuclear energy really is and ask the question: is it safe?

After the discovery that radioactive elements such as radium and uranium released vast amounts of energy, scientists began work on harnessing that energy. They found that through a process called fission, that energy could be utilized. Nuclear fission is the process of splitting an atoms nucleus into smaller nuclei resulting in a release of large amounts of energy.

The discovery of nuclear fission and atomic science came on the cusp of World War II and began the world's arms race for most advanced nuclear weaponry. The first man-made reactor was part of the Manhattan Project, which built large reactors to utilize plutonium and enriched uranium to use in the first ever nuclear weapons. Those weapons evolved into atomic bombs, which were used on Hiroshima and Nagasaki.

Scientists saw the potential for atomic energy and after World War II research and experiments continued in the hopes that nuclear power would be used for good. By 1954 the USSR boasted the world's first nuclear power plant to generate electricity fro a power grid. England followed soon after with the first commercial nuclear power plant and in 1957 the Shippingport Reactor was the first nuclear generator to be operational in the U.S.

While nuclear power plants continued to rise in number, concerns grew over the health and safety of nuclear energy. The scientific community expressed concerns about nuclear accidents, nuclear proliferation, nuclear terrorism, radioactive waste disposal, and the high cost of nuclear power plants. By the 1970's nuclear power became an issue of major public interest with anti-nuclear activists demonstrating and protesting in France and Germany. It wasn't until the first nuclear

disaster struck that construction of nuclear power plants halted in many countries. The accidents that occur from nuclear power plants are far outnumbered compared to number of accidents that occur from energy production from coal burning. However, nuclear accidents have incredibly devastating effects to people, animals, and the environment as well having the highest economic cost repair. The incredibly devastating effects that a nuclear disaster can cause are far-reaching. The disasters that occurred at the Three Mile Island power plant, the Chernobyl power plant and the Fukushima Daiichi power plant had effects that reached political, economical, cultural and global platforms.

On March 28th, 1979 the U.S. experienced the worst accident in the nation's power plant history. When he Three Mile Island power plant in Dauphin County, Pennsylvania experienced a nuclear meltdown, amounts of radioactive gases and elements were released into the environment. The meltdown started at 4 a.m. when the pumps feeding the filters suddenly stopped and more failures resulted when a bypass valve wouldn't open. With no flow of water to the main feedwater pumps the steam generators couldn't produce steam and stopped working. The reactor went into emergency shut down. A pressure relief valve opened when excess pressure built up in an auxiliary tank but the valve didn't close after the pressure was released. Much needed coolant water escaped quickly adding to the meltdown crisis. A general emergency was declared and local agencies were contacted. With many systems defaulting, workers took manual readings from the thermocouples and sampled the loop water. Seven hours after the declared emergency new water was pumped into the primary cooling loop. After sixteen hours all primary loops were running and the temperature in the core reactor finally began to fall. However, the troubles were not over. Part of the core had melted and a hydrogen bubble had formed in the dome of the pressure vessel. If the bubble burst, a hydrogen explosion could result in a massive breach of the vessel, leaking radioactive material into the area. Over the next week, steam and hydrogen were directly vented into the atmosphere and the plants had controversially dumped 400,000 gallons of waste directly into the Susquehanna River. Voluntary evacuations were ordered within a 20-mile radius adding to the panic of the disaster.

In the end the crises was brought under control but the unit was too badly damaged to continue operations. Cleanup of the reactor started in August 1979 and ended in December 1993, 14 years later with clean-up costs totaling $1 billion dollars. Although the Three Mile Island accident was dangerous and cause the state and country to panic, no serious or dangerous outcomes arose. Despite the gases poured into the atmosphere, most of them turned out harmless with very little radiological contamination reported in the surrounding areas of the plant.

The Three Mile Island accident was a significant turning point in the global development of nuclear power. The development of nuclear power plants in the U.S. drastically decreased and the argument against nuclear energy gained some steam. It wasn't until the much more devastating Chernobyl disaster that the strong decrease in nuclear power was observed globally.

The Chernobyl disaster occurred on April 26th, 1986 and the Chernobyl power plant in Ukraine, part of the USSR at the time. The plant bordered Belarus and the Dnepie River. Chernobyl is considered to be the worst nuclear power plant disaster in history. Thousands of evacuees remained displaced today; thousands more are dead or dying of radiation related diseases and an entire forest turned red and died after direct exposure to radiation that the disaster created.

The nuclear disaster started early that morning when a system test was being conducted. During the test an unexpected surge of energy caused operators to attempt an emergency shut down which would reduce the output of energy. The shutdown was never completed because an even stronger power surge occurred. This surge led to a rupture in the reactors vessel causing a series of catastrophic explosions in the plant's core reactors. The most damaging explosion struck when the graphite moderator caught fire resulting in highly radioactive smoke billowing from the plant. The smoke dispersed into the atmosphere, drifting over forests, towns, cities, and into other European countries. Most operators within the core died within 48 hours from acute radiation poisoning or radiation poisoning. The pollution spread across 80,000 square miles with radioactive rain reaching as far as Ireland. The most affected areas included Belarus, Russia, and Ukraine. Areas of Europe that recorded elevated exposure to radiation included Sweden, Finland, Austria, Norway, Bulgaria, Switzerland, and even others in lower concentrations. The Chernobyl disaster was reported only after operators at a nuclear plant in Sweden detected incredibly high amounts of radiation and set off alarms forcing Ukrainian operators to admit and accident had occurred.

The disaster in Chernobyl ranked a number 7: major accident on the International Nuclear Event scale. The explosions at the Chernobyl power plant released 400 times more radioactive materials than the atomic bomb on Hiroshima. The blame of the Chernobyl disaster was attributed to many different failures: failure of protocol, safety regulations, appropriate response and action. Many blamed the operators for complacency and ignorance, lack of training, unpreparedness and human error.

While the total cost of the disaster is difficult to estimate, the amount Belarus has had to pay to recover and decontaminate the country is close to $235 billion dollars. In December of 2000 the last of the running reactors at the power plant in Chernobyl was deactivated, officially decommissioning the power plant.

The effects of Chernobyl reached countries in different ways. In 1988, Italy decided to phase out all of its nuclear power plants while countries like Japan continued its endeavors into nuclear power. A much needed resource for its increasing population. Although the world hoped to never again witness a nuclear meltdown again, disaster struck in 2011 as Japan suffered not just a natural disaster but a nuclear one as well.

On March 11th, 2011 an earthquake occurred off the northeast coast of Japan that measured a 9 on the Richter scale. The tremendous earthquake triggered a tsunami that engulfed entire towns. The death toll was in the hundreds immediately with hundreds more missing. While Japanese citizens were reeling from the immediate destruction from the tsunami, workers and operators at the Fukushima Daiichi nuclear power plant were struggling with a different disaster.

When the earthquake struck the resulting ground accelerations exceeded the plants maximum limits causing an automatic shut down of Units 1, 2, and 3 within the plant. Electricity, the normal source of power for the plant stopped after the reactor shut down and on-site diesel generators began powering the plant's cooling systems. Fukushima's sea wall reached 19 feet so when the tsunami's 45-foot wave crashed into the power plant; the basement flooded disabling the emergency diesel generators. The threat of a core meltdown approached and the plant was in a state of disaster. Authorities were alerted and the government ordered that seawater be pumped into the unit in order to cool the reactors. Over the weeks that followed fire truck equipment was used to pump water into the plant while systems were being repaired. As the plant stabilized function over the course of the next several weeks, it took months for the Fukushima Daiichi plant to repair and regain control. By December 2011, Japan's prime minister, Yoshihiko Noda declared technicians had regained control over the reactors, ending the disaster in Japan.

Proponents of nuclear power argue that it is a sustainable resource that has fewer carbon emissions. People in favor of nuclear power contend that it produces no greenhouse gases and is a viable alternative to the burning of fossil fuel for energy. Opposing forces contend that the threats of nuclear energy include people's lives, the environment, and problems with storage, transportation and the environmental effects of uranium mining. Scientists, politicians, and leaders remain divided on the issue of nuclear energy because of its harmful effects yet immense energy output. But Nuclear energy isn't the only option. Renewable resources are at our fingertips. If more time and money went into developing better ways to harness energy from renewable resources like the sun, wind, and water, the dangers of nuclear power might not even be an issue.

When fossil fuel burning goes wrong it results in pollution, possible death, and costs to fixing the problem. When nuclear power goes wrong it results in the possible death of thousands, massive destruction of the areas surrounding it, and billions of dollars in repair. One thing is for certain: while nuclear energy is containable, it is not safe. n

A Pioneer in Neuro-Imaging: Craig Ferris

BY MATT COTTLE, BEHAVIORAL NEUROSCIENCE, 2013

All photos courtesy of CTNI, Northeastern

Professor Craig Ferris, PhD, was an exciting edition to Northeastern University, joining the school upon completion of the Center for Translational Neuro-Imaging (CTNI) about four years ago, serving as the center's director. This lab, tucked away in the basement of Mugar Life Sciences Building, houses state-of-the-art technology that scans the brains of awake animals. The CTNI is the first lab in the country using Magnetic Resonance Imaging (MRI) and molecular imaging in this way. "I tip my hat to Northeastern," says Ferris, explaining that scanners this advanced are almost never really found at academic institutions. Technology like this exists mainly in large biotechnology and pharmaceutical companies.

Dr. Ferris is a pioneer of imaging unanesthetized animals. Eighteen years ago, while Ferris was working at the University of Massachusetts Medical School, he was approached to start up a hypothesis-driven Behavioral Neuroscience department that would focus on the study of mental illness. "The challenge of studying mental illness is that there is no place in the brain where it can be visually pinpointed," says Ferris. Psychiatric disorders manifest over time. Faced with finding a way to see mental illness in the brain, Ferris led a team which developed a way to perform neuro-imaging on awake animals, including inventing the machinery -restraints, receptors, and software- which made it all possible.

When people are imaged, they are not under anesthesia, so it is far more useful to have an animal model that is studied in the same way. With Ferris's technology, brain activation in the mentally ill can be studied in animal models over the course of a lifetime, providing more insight into the development and progression in humans, ultimately leading to improved therapies and drugs.

One study currently underway in the CTNI is looking at the effects of ketamine and phencyclidine (drugs used recreationally and better known for their street names Special K and PCP, respectively) in the rat brain. These drugs show side effects such as gating blockage and produce an animal model that is similar to schizophrenia in humans. Studying this could lead to a better understanding of schizophrenia and more advanced ways to study, diagnose, and treat it.

Ferris and the CTNI do not only study mental disorders like schizophrenia and PTSD. His research extends to the neurobiological bases of neurodegenerative disorders, autism, drug addiction, and violence. Funding for his research comes from the National Institute of Mental Health (NIMH) and the National Institute on Drug Abuse (NIDA).

Though Ferris and his team focus primarily on the brain, his magnets are capable of seeing all parts of the anatomy, be it a rodent's or a monkey's (the subjects upon which his research is performed). Researchers from all over come to use the equipment here at Northeastern to study everything from oncology to cardiovascular diseases.

On top of Ferris's already impressive list of credentials, he is also president and co-founder of InsightMR, a company specializing in the developing imaging products, and co-founder and consultant of Ekam Imaging Inc., a company that performs MRI on awake animals for pharmaceutical and biotechnological companies based out of the CTNI. Ekam is the only contract research organization that does imaging on awake animals.

As far as Dr. Ferris's words of advice for those of us interested in his and related fields, "You have to have a passion," he says, "there is a lot of delayed gratification... There are not enough people imaging. [It is] an exciting field, and a marketable field." Ferris believes there is a huge future for imaging studies, especially as technology is advancing. Scientists who run experiments at CTNI can access the results of their experiments anywhere they go via specially-designed software. Ferris is hopeful that this technology could be translated into a lab course here at Northeastern, where students could design and run their own experiments and experience this revolutionary technology first hand. n

Groundbreaking, Heartbreaking:

Study finds drug-induced senescence can't cure cancer

BY JESSICA MELANSON, JOURNALISM, 2014

Cancer is one of the most difficult illnesses to treat. Various organizations fundraise millions of dollars each year to spend on researching and finding a cure. About 1,638,910 people will be diagnosed with cancer in 2012, and about 577,190 Americans will die of cancer this year, according to the American Cancer Society. To add to this, scientists have uncovered a new fact that's even more depressing: Cancer cells do not die.

Cancer cells are, by definition, cells that multiply irregularly and uncontrollably fast. What also makes cancer so virulent is the fact that, unlike a majority of cells, cancer cells live indefinitely, bypassing the natural process called senescence that causes cells to age.

Senescence is the biological aging of cells in certain organisms, which occurs after that organism reaches maturity. The process, though non-existent in some animals, is common in humans and other mammals. At the cellular level, senescence occurs when a cell loses its ability to divide and multiply. General senescence at the organism level manifests itself most plainly in aging – in humans, for example, health issues grow more common among elderly people. It makes sense that as an organism's cells start to die, so does the organism.

According to a study published in the Jan. 19 issue of the open-access journal "PLoS Computational Biology," cellular senescence can occur spontaneously in melanoma cancer cells. However, that senescence cannot stop the spread of cancer. Senescence occurs in cells that do not determine the spread of melanoma cancer. Instead, melanoma cancer stem cells that do not undergo senescence continue the spread of the melanoma.

The study was a collaboration between Caterina A. M. La Porta, a University of Milano cancer biologist, and physicists Stefano Zapperi, from the National Research Council of Italy, and James Sethna, from Cornell University. The three observed melanoma cells' natural evolution, tracking the amount of senescent cells. They found that, after about three months, most melanoma cells' growth had stopped due to senescence, but the melanoma cells did not completely stop growing. Eventually the level of senescent cells declined to about the original level, indicating that while most cells may grow senescent, the melanoma stem cells preserve the growth of the cancer.

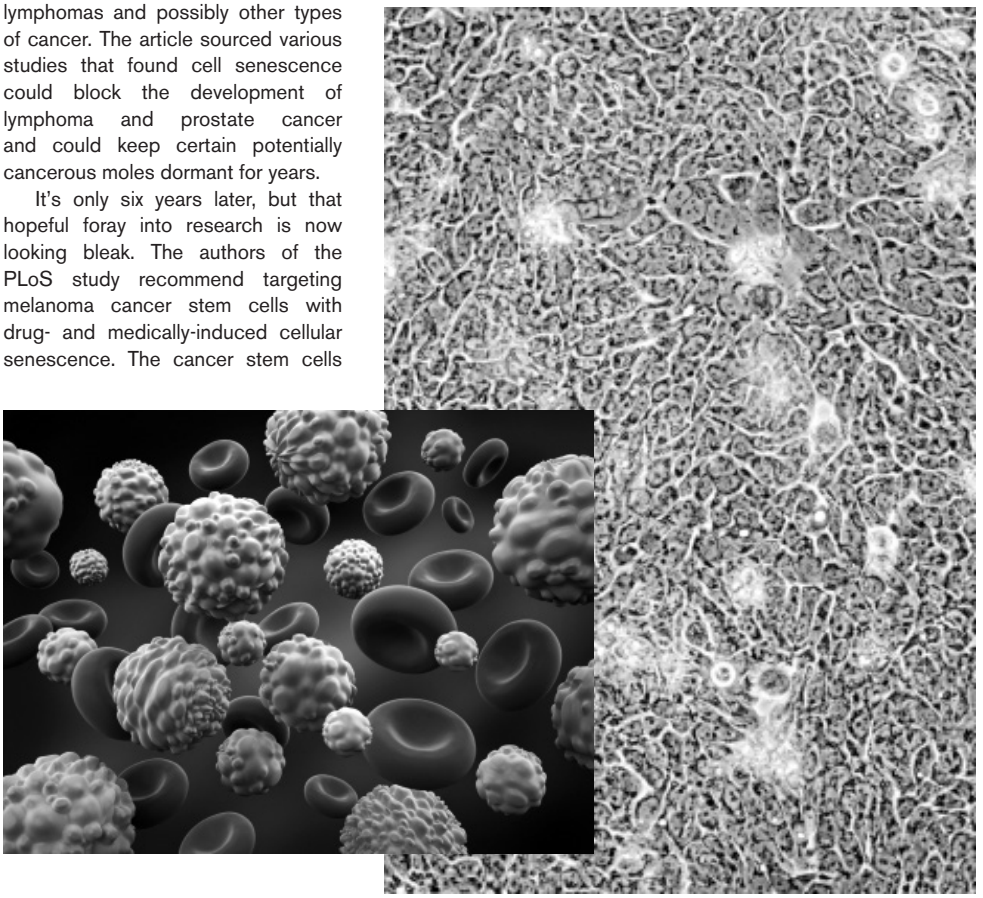
The three mathematically modeled the growth of melanoma cancer and allowed for the existence of melanoma cancer stem cells, a somewhat controversial subject within the scientific community. Their results indirectly confirmed the existence of melanoma skin cancer stem cells, shaking up the scientific community a little bit.

Besides its contentious confirmation of the existence of melanoma cancer stem cells, this study is ground-breaking in a way that has broken the hearts of many scientists who are searching for effective cancer treatments. Based on the results of the PLoS study, a possible treatment for cancer has been almost completely ruled out.

Drug- or medically-induced senescence in cancer cells was initially thought to be a possible cancer treatment. In a 2005 "Nature" journal article, for instance, scientists showed interest in using medically induced senescence as a treatment for lymphomas and possibly other types of cancer. The article sourced various studies that found cell senescence could block the development of lymphoma and prostate cancer and could keep certain potentially cancerous moles dormant for years.

It's only six years later, but that hopeful foray into research is now looking bleak. The authors of the PLoS study recommend targeting melanoma cancer stem cells with drug- and medically-induced cellular senescence. The cancer stem cells are really the only ones that are affected enough by senescence to stop the spread of a cancer. But in narrowing down what cells need to be targeted, the scientists have also come across a problem: Cancer stem cells are the cancer cells most resistant to drug-induced senescence.

If scientists can take anything away from this study, it's a refinement of what they need to research. Though cancer stem cells are highly resistant to drug-induced senescence, it makes sense to focus research efforts on just those stem cells that are causing the unstoppable cancer growth. Rather than pointlessly looking into senescent cells or most cancer cells, scientists should hone in on the root of the problem to produce a cure. If scientists could target melanoma stem cells with drugs to induce senescence, then maybe they could stop the spread of cancer. n



Narcotic Medications:
How some medicine may cause addiction

BY JULIETTE KASSAS, BIOCHEMISTRY, 2015

Andover, Massachusetts. You wake up. Go through your daily routine of work or school, and then come home to do additional activities. Maybe go to the gym. Watch some television. Relax and go to bed. Repeat. While you were going through your day, did you once think about the lives of the people in your state? Were you aware of the fact that two people in your state died to opioid overdose that day? You think: that could never be me. I would never do drugs. I'm a well-to-do person, not one of *them*. How could it possibly have an effect on me? The fact of the matter is that drug abuse is a *real* problem that *real* people suffer through everyday.

This past summer I did an internship at a primary care physician's office on the North Shore; this is where I was first exposed to the reality that average people can unintentionally become addicted to prescription medication. For the first couple of weeks of my four-month stay at the office, I was responsible for familiarizing myself with the how things were run and learning how to perform certain tasks. This included rooming patients and taking their vitals, and also going over their medications with them and answering any other questions that they had, prior to their meeting with the physician. In the beginning, I didn't know much about the medications I was typing into the patients' profiles, Percocet, Oxycodone, and Morphine, to name a few. Looking back on it now, I was so naïve to think that mostly everybody lives a normal lifestyle, free of pain, worry, and suffering. Over time, I started to find my place at the office and befriended some of my coworkers. The physicians started to let me shadow them more frequently, and started to give me more responsibilities. When I shadowed, I usually sat in the corner of the room and pretended as if I wasn't even there, like a fly on the wall, just listening carefully trying to analyze and the particular scenarios of each patient. Over the course of the summer, I felt a vast array of emotions ranging from happiness, anger, sadness, and angst from my small seat in the corner. There were truly some people and some stories I will never forget.

He was the last patient of the day, and I was dying to go home. I was craving a Starbucks iced latte and my nightly seven-mile run. I would have done just about anything to leave, but the doctor insisted that I sit in on this patient's visit because he told me it would be "a unforgettable learning experience." I reluctantly chose to stay, and began the patient's check-in process. I took his vitals and briefly went over his medications. He told me he often played tennis at a nearby country club, and that he was going on a date with his wife downtown that evening. The doctor entered in a few moments and began discussing the patient's concerns and problems. I listened intently as the patient revealed his true identity. He had been in a horrific car accident just a few years back, and he was still

struggling with neck and back pain. He exclaimed to the physician that he was trying his hardest to go about his daily routine, but he was reliant on Percocet to do so. He couldn't get out of bed in the morning without it. He started to tear up as he made statements like, "I want my life back … I don't want to be a burden to my wife and children … I can't take this anymore." It was a real eye opener to see a middle-aged man crying over the fact that he was reliant on prescription medication. He continued by saying that he needed a higher dose because the amount he was currently taking was losing its potency. The doctor shook his head at the man and told him that he refused to prescribe him something more potent because he had never written a script for a dose that high, and suggested that the man visit a pain clinic. The man finally calmed down, and they discussed a few other things prior to him leaving the office. Once he was gone, the doctor pulled me aside to explain the situation in greater detail. He said that the man had been seeking help from new doctors in hopes of getting prescribed a higher dose of his pain medication. He told me that the man has built up a tolerance for the Percocet and is at the level of addiction. It wasn't his fault that he got into an accident, it could have happened to anybody. The manner in which his treatment was carried out may have been flawed, but it needed to be dealt with. But, why does this happen? Why couldn't the man just decide to stop taking the medication? What classifies a person as an *addict*?

The human brain is made up of a network of cells, like all of the other organs in the body; however, the brain cells are commonly referred to as neurons. What differentiates neurons from other bodily cells is their unique structure, which consists of three major parts: the soma, the axon, and the dendrites. The responsibility of these cells is to receive and transmit information to and from each other, therefore producing signals, which turn into actions. In short, these cells are responsible for human thought and actions, voluntary and involuntary – they make up what we know as our nervous system. The cells are activated through a concentration or depletion of certain corporal chemicals. Generally speaking, signals are received through the dendrites, processed in the soma, and carried out through the axon and axon terminal. The dendrites receive signals from neurotransmitters from axon terminals of surrounding cells, which pass on the signal to the next cell, launching a domino effect. This process is responsible for every single action we do! While you are reading this sentence, millions of neurons are working together to process these words and provide them with meaning.

This system unfortunately is altered in the brain of an *addict*. When a person takes a drug, lets take an opioid for example, the molecules will attach to receptors on the dendrites. Upon attaching, they will

send signals to the brain which tell the body to calm down by slowing down breathing and blocking any pain. They can do this because opioids have similar molecular structures to natural bodily opioids. For this reason, the drugs fasten onto the nerve cells and activate them. In order for them to relieve the body of pain, the nerve cells are filled with dopamine. When the brain experiences excess flooding of this neurotransmitter, the body experiences a euphoric state. This is because the role of dopamine in the body is to "reward" good behavior, therefore making people want to repeat the actions that lead them to having this good feeling. An addict would keep taking a certain medication because the body craves this good feeling. Eventually the brain would require higher and higher doses of the drug in order to "feel good" because of an increased tolerance to the particular drug. This process is similar for drugs that do not fall into the opioid category, but the specific neurotransmitters, drugs, and chemicals can vary significantly.

Eventually, a person would no longer be able to live without blocking this pain out of their lives. On top of the pain they are trying to prevent, they will experience pain from withdrawal of their euphoric state because the human body cannot produce enough natural opioids to stop the feeling of severe pain. This would generally cause a person to want to take more and more of a drug over a certain period of time. At this point, many would classify the person as *addicted*. This is no laughing matter, nor something to simply look over considering that people die from overdoses on a daily basis. There is not a simple solution to this problem, considering that the person cannot just live without the medication. Becoming drug free is a long process, which takes multiple steps and an ample amount of determination and motivation. Generally, it is something that must be done professionally and is very difficult to do alone without help. During my internship this summer, the doctor I worked with tried to avoid prescribing opioids in the first place and would warn patients of their harmful, negative effects. Addiction and dependence to certain substances are difficult and noble things to overcome. They are also extremely important to be aware of considering they affect average people, so don't ever think "that will never be me." n

ESTROGEN MIMICS:

HOW UBIQUITOUS INDUSTRIAL CHEMICALS CAN CHANGE YOUR HORMONE SYSTEMS

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE, 2013

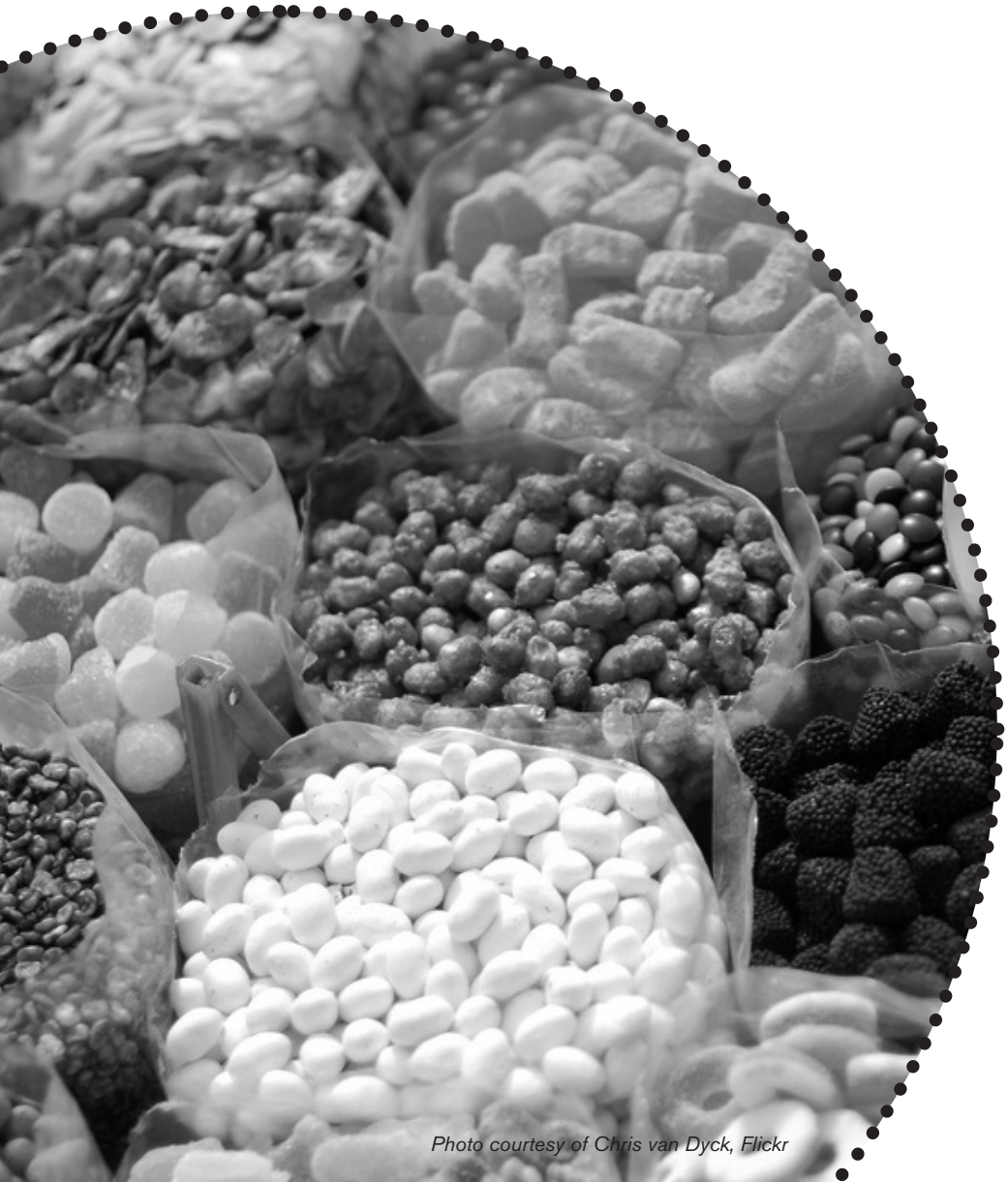


Photo courtesy of Chris van Dyck, Flickr

Estrogen mimics, also known as xenoestrogens, are compounds that either activate estrogen receptors, or bind receptors and prevent their activation by the estrogen that all humans produce and require to be healthy. These chemicals are everywhere. The most obvious ones are hormonal birth control and hormone replacement therapy. But others include compounds found in soy products, pesticides, plastics, air fresheners, and even lavender oil. While there is much debate over how much each chemical affects our hormonal systems, they have been strongly linked to infertility, developmental defects, reproductive cancers, and behavioral problems in children.

Currently, there are over 3,000 food additives regularly used in the United States. Few of them have been tested for their activity on hormones. The FDA only has toxicological data on 2,000 of them. In 2008, Italian scientists used computer modeling to scan 1,500 food additives for structural similarities to estrogen. They took the 13 that could theoretically bind to estrogen receptors and exposed human cells to them in a petri dish. Two were found to be estrogen mimics, meaning they bound to estrogen receptors in living cells. Whether they would do so in the body is still unknown. One of these, propyl gallate, is used to prevent fats from spoiling. It is found in candy, mayonnaise, shortening, dried meats, and dried milk. It is also used in cosmetics and hair products. The other, 4-hexyl resorcinol, is used to keep shellfish from discoloring.

Starting in 1997, studies on bisphenal A – more commonly refered to as BPA – linked exposure at levels comparable to what humans currently experience to developmental defects in the reproductive systems of animals. By 2010, enough evidence of toxicity had accumulated that Canada and the European Union banned the use of BPA in baby bottles. Additional studies have shown that people with high levels of BPA in their urine have a significantly higher rate of coronary heart disease; higher levels may also

be linked to diabetes, recurrent miscarriage, erectile disfuction, and immune and liver problems. A study in February of 2012 showed that exposure to BPA increases insulin production, which could increase the chance of developing diabetes.

Subsequently, a number of companies, including Nalgene, agreed to phase BPA out of their production. Other companies, such as Wal-Mart and Toys-R-Us, stopped selling baby bottles that contained BPA in the United States. However, BPA is still regularly found in water bottles, tampons, receipt paper, the lining of aluminum cans, and many other plastic products. BPA-containing bottles are generally labeled on the bottom with recycling codes 3 and 7.

In 2007, a study in the New England Journal of Medicine linked high exposure to lavender and tea tree oils with prepubertal gynecomastia, or the abnormal development of breasts in prepubescent boys.

Estrogen mimics aren't only dangerous to humans. Exposure to hormonal birth control and other sources of estrogen, including industrial waste, negatively affects the sexual development and behavior of fish, amphibians, birds, reptiles, and invertebrates. Female snails exposed to TBT, an ingredient in boat paint intended to reduce barnacles, grow penises that block their oviducts. Snails grown in Polyethylene terephthalate (PET, recycling number 1) water bottles emptied of their original contents and refilled with fresh water doubled their reproductive rates in 8 weeks. Male fish found near freshwater sewage outputs in England's Aire River have high rates of intersexed characteristics, less motile sperm, and high blood levels of estrogen.

Of the cricket frogs collected in Illinois between 1852 and 1929, the year the class of chemical organochlorines (which have not yet been declared estrogen mimics) was introduced to industrial agriculture, less than 1% were intersexed ,meaning they either had eggs in their testes, or had both testes and ovaries. Between 1946 and 1959, the years with heaviest use of the compounds, up to 17% of frogs were intersexed. The last study, ending in 1996, showed a decrease in intersexed frogs to 9%, which corresponded with a decline in the use of organochlorines.

Male alligators in Florida's Lake Apopka that were exposed to dicofol, an industrial pesticide (which, again, has not officially been classified as an estrogen mimic), have also been found to have high rates of feminization, including low testosterone levels, smaller than average penises, and testicular abnormalities. Females in the same population have high rates of ovarian malformation. DDT, a pesticide closely related to dicofol, was banned in the US and many other developed countries after being shown to cause egg shell thinning that led to the near-collapse of many bird populations. DDT, an anti-mosquito agent, has been officially classified as an estrogen mimic. Dicofol is still widely used in the United States; DDT is still frequently used in developing countries with high rates of malaria.

Photo courtesy of Claire Gribbin, Flickr

Exposure to low doses of one estrogen mimic might not cause any ill effects on the human population. Unfortunately, no one is exposed to just one – they come from so many sources in our environment and food supplies. It would be impossible to study the effects the dozens (if not hundreds) of hormone disruptors all interacting in the body. Truly, it would be impossible for a consumer to avoid all sources of estrogen mimics. In addition, there are many chemicals that mimic other hormones, including testosterone. This cocktail could be responsible for any number of health affects. It will likely take many years of research, as well as strong governmental intervention, to discover and limit exposure to these dangerous chemicals. n

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