Special Report: *Chemistry Week goes super small*

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HEADLINE DISCOVERIES

Sep/Oct 2012; Issue 3

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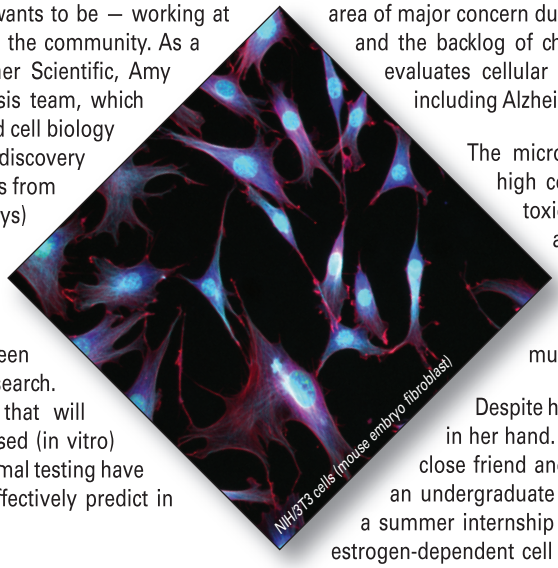
– Illustration by Michael Andrulonis

SCIENTIST IN THE SPOTLIGHT

By Terri Sota

Amy Laura is everywhere she wants to be — working at the office, in the lab and within the community. As a senior scientist at Thermo Fisher Scientific, Amy manages a high content analysis team, which provides software, hardware and cell biology protocols to help drive the drug discovery process. The team fields requests from a variety of industry customers to design tests (assays) that can identify site-specific cellular targets. Amy's group is also at the forefront of consumer safety, helping manufacturers proactively detect toxins.



On any given day, Amy divides her time between management responsibilities and scientific research. Recently, her team released a series of tests that will replace animal-based (in vivo) testing with cell-based (in vitro) alternatives. Bioethics, efficiency and the cost of animal testing have spurred the move to in vitro assays, which can effectively predict in vivo responses.

One of these assays looks at endocrine active chemicals (EAC) that mimic estrogen and androgen activity and can cause cancers and nervous, reproductive and invasive disorders. EAC are found in fertilizers, pesticides and packaging (including BPA in plastics), and can leach into water and food supplies. A goal of this testing is to detect compounds with potential endocrine activity and assess the magnitude and potency of the cellular response.

Another assay focuses on neuronal cell models, which can be used to evaluate the neurotoxic potential of compounds. Developmental Neurotoxicity (DNT) is an area of major concern due to the vulnerability of the central nervous system and the backlog of chemicals that have yet to be screened. The assay evaluates cellular changes that are tied to neurological disorders, including Alzheimer's.

The micronucleus assay is the latest achievement of the high content team. An important component of genetic toxicology screening and product safety programs, the assay detects agents that modify the chromosomal structure and form small nuclear fragments during cell division. This assay, and those mentioned previously, enable the testing of multiple compounds with greater accuracy and speed.

Despite her scientific success, Amy wasn't born with a pipette in her hand. Her interest in cellular biology was aroused after a close friend and neighbor succumbed to breast cancer. Although an undergraduate biology major, she wasn't career-committed until a summer internship led to graduate work investigating treatments for estrogen-dependent cell lines. Outside of the lab, Amy works with Thermo Fisher's Community Action Council and actively promotes STEM education throughout Pennsylvania.

CLASSROOM DISCUSSION

- Inquire if any students know someone working as a scientist or in another STEM field. Discuss the many career paths and industries in which STEM-enthusiasts thrive
- To what kind of testing do you think your food and water is submitted? What do these tests identify?

FLIGHT TO EXCELLENCE

By Ashley Peterson

All hands on deck. Welcome aboard Ambition, a landlocked, simulated aircraft carrier that is home to an educational adventure camp at the National Flight Academy (NFA), in Pensacola, FL. The installation combines the culture and thrill of aviation with cutting-edge technology and a challenging curriculum.

Located adjacent to the National Naval Aviation Museum, the National Flight Academy is a 102,000 sq. ft., four-story structure designed for at-sea immersion. The instructors dress in flight suits. The campers are assigned to squadrons and given missions in briefing rooms. They sleep in berths and eat in a mess hall. Crew members are alerted by bells and an intercom system. When planes "take off," loud jet noises sound throughout the vessel, causing the rooms to vibrate.

A project over 20 years in the making, the National Flight Academy opened its doors in May 2012 to high school students, with the hopes that the innovative instruction can foster a passion for math and science and encourage more students to pursue science and engineering degrees.

PREPARE FOR TAKEOFF ...

At the grand opening of the Academy, Captain Mark Kelly, who commanded the final mission of the shuttle Endeavor, lamented that the United States today produces three times as many lawyers as engineers. According to national statistics, the Science, Technology, Engineering and Mathematics (STEM) skills of American students are in decline. If this trend continues, the current generation will lack the talent and skills necessary to lead in the technology-driven 21st century world. Says Kelly: "When Neil (Armstrong) and Gene (Cernan) flew to the moon in the 1960s and early 70s — by any metric of education, the United States of America was number one on the list. And today that's not true anymore. In some measures we're not even in the top ten."

Offering three- to seven-day camp programs for 7th thru12th graders, the National Flight Academy hopes to inspire enrolled students to return to school seeking more challenging STEM courses. The program curriculum features aerodynamics, propulsion, navigation, aviation physiology and meteorology, with an emphasis on core values, leadership development, teamwork, effective communication and public speaking. The NFA also houses a high-tech broadcasting studio where the curriculum taught to the on-campus student aviators can be shared via on-demand webcasts with thousands of secondary classrooms across the country.

According to Ambition's commander and President of the National Flight Academy, retired Vice Adm. Gerald L. Hoewing, "This is an opportunity to give back in an area that is important. High-tech and engineering are what have made this country different, and we need to regenerate that enthusiasm if we are going to lead the world like we have done for so many years".

CLASSROOM DISCUSSION

- What may explain why the STEM skills of American students have been falling behind students in other industrialized countries?
- What skills and/or learning can a simulated flight mission provide that a book or video cannot?

JUST THE STICKY FACTS!

By Joe Giacobello

For all the time spent bubble-blowing with friends or breath-freshening between brushings, did you ever stop to think about that odd rubbery substance you were enjoying? What, after all, is it made of? Who invented it? And, most importantly, will it hurt me if I swallow it? Here are some gummy facts that you can really chew on!

HOW IS GUM MADE?

Prior to World War II, gum was made of chicle mixed with sugar and other flavorings. Chicle is a latex sap that comes from the Mexican sapodilla tree. A natural form of rubber, chicle does not dissolve when chewed. Most modern chewing gums are made with synthetic rubbers, which cost less and are more readily available.

WHO INVENTED IT?

The history of chewing gum goes back a long way and traverses many cultures, each with its own version of the chewy treat. In 2007, an archaeology student in Finland found a 5,000-year-old piece of chewing gum made of birch bark tar. The ancient Greeks chewed a sticky, stringy substance from the bark of the mastic tree. The Mayans in Central America chewed chicle mixed with tar and insect grease. And, the American Indians chewed a gummy substance produced by spruce trees.

It is difficult to credit any one person with the invention of gum as we know it today; many were involved in its development. John Curtis, in Maine, was the first businessman to sell gum in 1848; Amos Taylor, in Ohio, was the first to patent gum in 1869. In the late 1800s, Thomas Adams attempted to make toys, boots and bike tires out of the chicle from sapodilla trees. His experiments were largely failures, until he popped a piece of disposal-bound chicle into his mouth and discovered that he liked the taste. Soon after, he opened the world's first chewing gum factory and Adams' New York Gum began selling for a penny a piece.

IS IT HARMFUL TO SWALLOW GUM?

Almost everyone has accidentally swallowed a piece of gum at some point, and it can be a little bit scary. Folklore suggests that gum will sit in your stomach for seven years before it can be digested (not true)! Although gum cannot be digested, it will pass through the digestive system within about three days and be excreted. Only the calories will accumulate.

CLASSROOM DISCUSSION

- Discuss reasons for bans on gum chewing (in school, theme parks)
- Discuss potential health risks to chewing gum on a regular basis. Can you think of any possible advantages?

BIRDS OF A FEATHER

By Patricia Rogler

Most birds have very colorful feathers: the parrots' are bright green, bluebirds' are shiny blue, and goldfinches' are a lovely yellow. So where do these colors come from? Usually, they are a product of pigmentation and structural design.

THREE TYPES OF PIGMENTS

There are three different pigments that affect the colors of feathers. They are called melanins, carotenoids and porphyrines. Melanins produce a variety of colors, including black and shades of reddish browns and yellows, which are expressed based on concentration and location (on the feather). Melanins not only give feathers color, but also strengthen the wings. Carotenoids are found in plants, and birds that eat these plants can have red, orange and yellow feathers. If the carotenoids interact with the melanins already in the feathers, they can produce shades of green. The third group of pigments, porphyrines, produces colors such as pinks, browns, reds and greens.

STRUCTURAL COLORS

Some colors in birds' feathers are due to the structure of the feather itself and the way light bounces off of it. At different angles, the feathers appear to be different colors. The hummingbird, for example, appears to have iridescent feathers because the structure of its feathers breaks up light into a range of colors that shimmer and change. Sometimes the structural color interacts with the pigments and creates a different color of feather. Parrots, for example, have a blue structural color and a yellow pigment color, resulting in green-colored feathers. Some feather structures reflect light in the ultraviolet range. Because many birds can see a greater range of colors than humans can, a bird's own feathers may appear to be a different color to species members than to humans.

With over 9,000 species of birds in the world, there are almost as many varieties of feather colors due to the various structures and pigments and how they combine.

CLASSROOM DISCUSSION

- What color combinations can you create by mixing a structural color with a pigment?
- Name your favorite bird and what different combination of pigment and/or structure could create the color of its feathers

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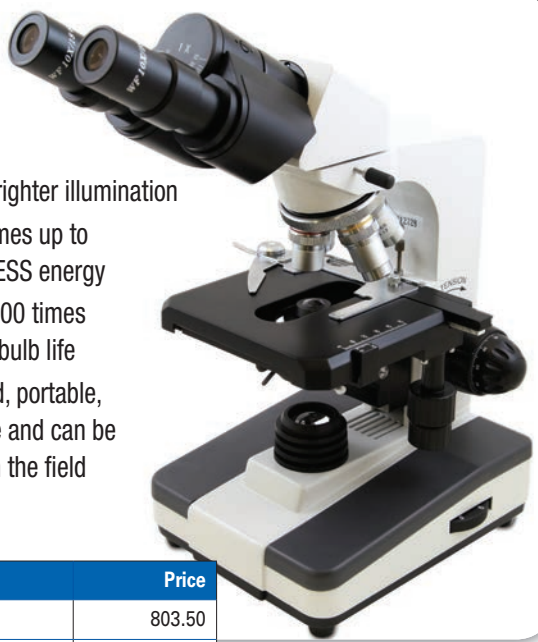

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HOPE AHEAD

Generating mini livers from lymph nodes

By Reema Deb

The human liver is prone to a number of diseases due to its strategic location and multifunctional nature. Advanced liver disease is normally fatal without a transplant, but a recent breakthrough may change this. Functional liver tissues can now be generated from lymph nodes, offering new hope for future illness sufferers. The liver plays a vital role in detoxification, protein synthesis and production of biochemicals for digestion. In people with cirrhosis and fibrosis, the scar tissue forms a barricade against healthy cells and impedes normal liver function. The only successful treatment for advanced forms of the disease is a liver transplant, but just six livers are available for every 100 patients who need this life-saving operation.

A REMARKABLE ALTERNATIVE TO TRANSPLANT

Dr. Eric Lagasse, associate professor at the University of Pittsburgh, took liver cells from a healthy mouse and injected them into kidneys, under the skin and into spleens of diseased mice — without success. Next, he grew liver cells within mice bellies, and using fluorescent markers, tracked the liver cells' migration into the lymph nodes. Here, Lagasse observed the growth of healthy liver cells; the nodes have the capacity to accommodate growth and the nutrients and signaling agents necessary to nurture growth. When Lagasse attempted to grow cells directly within the lymph nodes, he was able to produce 20 to 40 mini livers that functioned in concert with the unhealthy liver.

A great deal more research is needed before humans benefit from Lagasse's results, but the findings bring hope for new types of treatment. With the help of immunosuppressant drugs and pluripotent stem cells, livers grown inside and out of patients may be more readily available for transplant.

CLASSROOM DISCUSSION

- What other organs are researchers attempting to grow?
- What hurdles might researchers face when implanting liver cells in humans?

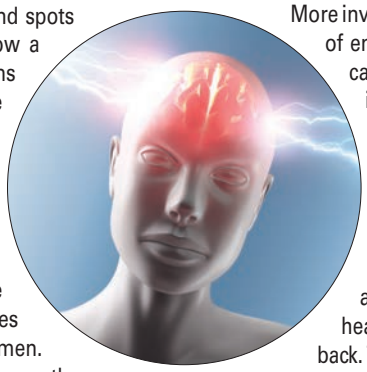
MY, OH MY, OH MIGRAINE!

By Merry Morris

There are few things more distressing to a migraine headache sufferer than the sneaking feeling that the pain is on its way. Sometimes a migraine announces itself with nausea, other times with vomiting, fatigue/yawning, mood changes or sensitivity to light, motion or sound. These symptoms are not unique to migraines, but there is one classic phenomenon: auras.

LIGHT SHOWS YOU DON'T WANT TO ATTEND

Auras can appear as flashing lights, bright squiggly lines, blind spots in your visual field or even hallucinations. Regardless of how a migraine begins, the results can be debilitating. With symptoms so severe — throbbing pain (usually localized on one side of the head), more nausea, vomiting and light sensitivity — sufferers seek refuge in darkness, silence and absolute stillness.



AND THE LUCKY WINNERS ARE ...

Aging — somewhere around 50 or 60 — is associated with fewer migraines, but youth is not spared. In children, boys are more affected than girls; in adulthood, women suffer migraines in much greater numbers — roughly three times that of men. Estimates suggest that 1 in 6 women experience migraines; on the whole, more than 36 million Americans suffer from migraines.

The cause of migraines is not clear. For years it was believed that the brain chemicals serotonin and dopamine provoke a flood of immune response cells to the brain, causing the brain's blood vessels to open wide and constrict, resulting in the pounding headache. More recently, some doctors believe that genes contribute by affecting certain brain cells. The observation that migraines run in families supports this belief.

BECOMING A HEADACHE DETECTIVE

There is no cure for migraines. Treatment ranges from simple measures like retreating to a dark, quiet room with a cold compress to over-the-counter pain relievers (acetaminophen) and non-steroidal anti-inflammatories (ibuprofen). Stronger prescription pain medications, drugs that affect blood vessels, beta-blockers, antidepressants or anticonvulsants may be needed.

More invasive measures like neurostimulation — delivery of tiny pulses of energy to the thalamus — and deep-brain stimulation may be called for in especially tough cases. Why these measures work is unclear, but any effective and safe treatment will be greeted with excitement and, for sufferers, relief.

Migraines are triggered by a variety of things — including foods, stress, anxiety, depression, hunger, menstruation, flickering or fluorescent lights and visual patterns. Avoiding these triggers can avert the kick-off of a headache. Keeping a daily diary of possible triggers and matching them to headaches when they occur, is one important way you can fight back. The detective work is not easy, but the results are apt to be greater than the effort.

CLASSROOM DISCUSSION

- If you were a researcher seeking a new treatment for migraines, how would you approach your search?
- Try keeping a diary for a few days, recording those factors that might cause a migraine

IONIC STRENGTH

By Terri Sota

Calcium has made a name as a builder of strong bones and teeth, but is deserving of credit for so many supporting roles. Not only does calcium facilitate nerve transmission and regulate blood pH, it is also at the heart of muscle function. Stored in the muscle cells in minute quantities (99 percent stored in bone and teeth), calcium enables the chemical reactions that create force and enact movement.

Muscle fibers contain many filament-filled myofibrils (cylinders of proteins). These filaments do the "heavy lifting" of motion and are of two types: thick strands made of myosin (protein) and thin filaments made of actin (also a protein). Two other proteins – tropomyosin and tropomin – are the molecular switches that enable the thin filaments to slide along the thick ones, causing muscle tension and contractions.

Voluntary muscle contraction is controlled by the central nervous system. When stimulated, the brain sends an electrical signal (action potential) that prompts the release of a neurotransmitter (chemical message), which crosses the gap (synapse) between nerve and muscle cell. This message initiates another action potential, which enters the muscle cell and opens the gates of the sarcoplasmic reticulum, the membranous organelle responsible for storing and pumping calcium ions. Once released, the ions flow into the cytoplasm and bind to troponin-tropomysin molecules located within the thin filaments. This action displaces tropomyosin and exposes actin-myson binding sites where thick filaments can grab onto the thin, pulling them forward in a sliding motion. As a result, contractions occur simultaneously down the length of the myofibril, and the muscle moves as the brain intended. Once the action . û ntial has passed, the calcium gates close and calcium pumps on the reticulum remove calcium from the cytoplasm.

Calcium is not produced by the body and must be obtained from foods or supplements. Dairy products contain the highest concentration per serving of absorbable calcium, but there are plenty of other sources available if milk, cheese and yogurt are scarce or contraindicated. The recommended requirement varies with age. Children between the ages of four and eight need 1,000mg; those between nine and 18 require 1,300mg. According to the Institute of Medicine, most people in the U.S. get enough calcium with the exception of teenage girls. Bone loss occurs at an accelerated rate for women mid-life, and without adequate bone mass built in their youth, older women are at greater risk for osteoporosis.

CLASSROOM DISCUSSION

- Ask students to keep a food diary for a week; compute their average daily calcium intake
- Have students plan real-world menus, which would ensure proper calcium consumption

INVASION OF THE SUPERWEEDS

By Samba Lampich

On 12 million U.S. acres, farmers are battling the rise of superweeds — mutant crop destroyers that are a real threat to agriculture. These weeds have developed a resistance to the most commonly used herbicides. Superweeds reduce crop quantity by competing for moisture, light and nutrients; they also harbor insects and diseases that destroy crops.

About 15 percent of U.S. corn, soybean and cotton crops are now infested with superweeds. They are more likely to grow near or with genetically engineered (GE) crops that were created (ironically) to withstand large applications of herbicides and pesticides. GE crops were first planted in the 1970s and grew in popularity due to their ability to increase crop yields and reduce farming costs (fewer herbicides required). Today, they account for an average of 90 percent of the superweed-plagued crops in the United States.

Over the years, these weeds mutated and became herbicide-resistant, passing the mutation from generation to generation. In a retrospectively ill-conceived response, farmers began using more and multiple herbicides to save their crops, which only fueled the growth of superweeds. The weeds spread from farm to farm by air or water, and/or were carried by insects and animals; soon superweeds were cropping up across the country. Today, there are at least 20 weed species in the U.S. that no longer respond to herbicides.

The rise and rapid spread of superweeds has triggered discussions about the use of GE crops, herbicide alternatives and unconventional weed-control practices. Some companies are working on engineering new GE crop varieties with stacked herbicide resistance traits that can tolerate multiple herbicides. There is concern that these new crops will only create more herbicide-resistant weeds — super superweeds. Other scientists and farming reformers want farmers to practice preventive strategies that rely less on chemicals and more on traditional farming techniques. These include crop rotation using certified seeds, cutting and destroying crops infested by weeds, and maintaining a clean farm to prevent weed seeds from spreading. The discussions have also focused on how and where food is grown, the use of chemicals and their impact on the environment, and the prevention of a new ecological problem — insects resistant to pesticides or superbugs.

CLASSROOM DISCUSSION

- How do pesticides and herbicides help/hurt?
- What are some advantages and disadvantages of genetically engineered (GE) foods?

THE CHANGE IN MSDS

By Brianne McCurley

Material Safety Data Sheets (MSDS), a popular tool used in the classroom by science teachers to identify the risk of hazardous chemicals in lab experiments, will be changing later this year to address potential hazards of inconsistent information. MSDS are defined by the Occupational Safety and Health Administration (OSHA) as safety documents that contain data about the physical properties of a particular hazardous substance. They are designed to present consistent information to the end user. MSDS are required to be written for a variety of materials including chemicals, compressed gases, flammable and combustible liquids, oxidizing materials, poisonous or infectious material, corrosive material and dangerously reactive materials. Currently, the wording in an MSDS can vary depending on the manufacturer and who authored it. This issue not only affects science teachers in the United States, but end users throughout the world.

OSHA hopes to address potential hazards of inconsistent MSDS with a rule change to the Hazard Communication Standard (HCS). The HCS is a national standard that addresses chemical management and employee safety. The revised HCS will adopt the Global Harmonized System for the Classification and Labeling of Chemicals created by the United Nations to provide a global standard for safety hazards. This new rule will replace MSDS with Safety Data Sheets (SDS) and standardize hazard classification, labels and information and training throughout the United States, European Union and Asia Pacific.

The 16-section format established by the American National Standards Institute (ANSI) standards for preparation of SDS allows the end user to better understand and locate important safety and health information. The 16 sections are as follows:

1. Identification
2. Hazard(s) identification
3. Composition/information on ingredients
4. First aid measures
5. Firefighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

The new regulations will force companies to author new SDS, create new safety labels and update entire MSDS libraries, but will help science teachers become more conscious and educated on the dangers and risks of hazardous chemicals in the laboratory.

CLASSROOM DISCUSSION

- Why is it important to have consistent and standard Safety Data Sheets throughout the world?
- What type of companies would benefit from SDS?

AT THE END OF THE RAINBOW

By Terri Sota

If you are searching for gold, you'll find it in some expected and not-so-expected places. In the Periodic Table, it is sandwiched between platinum and mercury, vertically linked with Group 11 members copper, silver and roentgenium. As one of 38 transition metals, gold has valence electrons – negatively charged particles that enable compound formation – housed in multiple energy shells. Elementally speaking, gold runs rings around its neighbors. Unlike prone-to-tarnish silver and copper, gold is notoriously non-reactive, yet is easily manipulated. It also conducts electricity, can be fashioned into wire, and melted, cast and alloyed (mixed) with other metals. It also may be pounded into thin sheets; a single gram of gold can be beaten into a wafer one meter square.

Throughout history, across many divergent cultures and civilizations, gold has reigned as a symbol of power, beauty and success. In scarce supply and both durable and portable, gold has been used as a medium for commerce for more than 6,000 years. In the United States, from 1900 to 1933, domestic currency was backed by a legislated "gold standard." Every deposit, dollar or bond was literally worth its weight in gold; upon request, owners could convert their paper wealth into a fixed-price equivalent of cold hard gold.

While fancied for its luster, gold's conductive properties are especially appealing to electronics manufacturers. It is ideal for use in low-voltage devices because it efficiently carries tiny currents without corruptive corrosion. It is used in connectors, switches, relays and soldered joints that comprise cellphones, global positioning systems, calculators and televisions. In computers, gold facilitates the flow of digital information; connectors used to mount chips and to attach cables all contain gold.

As prices fluctuate, so goes the demand for gold in dentistry. Its hypoallergenic inertness and malleability make it the perfect metal for the mouth. In medicine, radioactive isotopes of gold are used as a radiation source for treatment of cancers. Gold is also used for diagnostic testing (as a beta emitter) and in the manufacture of some surgical instruments.

Gold is found deep within the earth and miles above the planet. NASA uses gold in hundreds of different ways on each and every spacecraft it launches. Gold-coated polyester film, used to cover exterior surfaces, reflects infrared radiation and protects against heat absorption. The multi-faceted metal also serves as a lubricant, enabling the sliding of moving parts.

CLASSROOM DISCUSSION

- Where else is gold found (seawater, human body)?
- What happens to the gold supply when cellphones and other utilities are upgraded (and not recycled)?

A CHRONOLOGY OF CHEMISTRY

By Naga Nandini

Once upon a time, humans respired without knowledge of oxygen and the chemical properties of gases, benzene defied molecular description and broken bones healed without the mending benefits of x-ray technology. While most of the well-known breakthroughs in chemistry resulted from years of hard work, many were happy, observational accidents. Here are some of the notable discoveries made in recent centuries and the scientists who made them.

MAJOR MILESTONES

1864: Julius Meyer, a German chemist and competitor of Dmitri Mendeleev, prepared a table of 28 elements grouped into six families, using atomic weight and valence for classification purposes. Meyer understood that an atom's affinity for bond forming could be used to classify and predict the behavior of elements yet-to-be discovered.

1898: Isolation of polonium and radium. Marie and Pierre Curie discovered these highly reactive substances derived from uranium ore. They shared the Nobel Prize in Physics with Henri Becquerel for their joint discovery of the radioactivity.

1913: Introduction of the Bohr model of the hydrogen atom. The Danish physicist, Niels Bohr, demonstrated that electrons travel around a positively charged nucleus in circular orbits, with electrostatic forces causing attraction.

1932: Discovery of the neutron. James Chadwick identified this uncharged particle in isotopes, which accounts for why atoms with the same atomic number can vary greatly in mass.

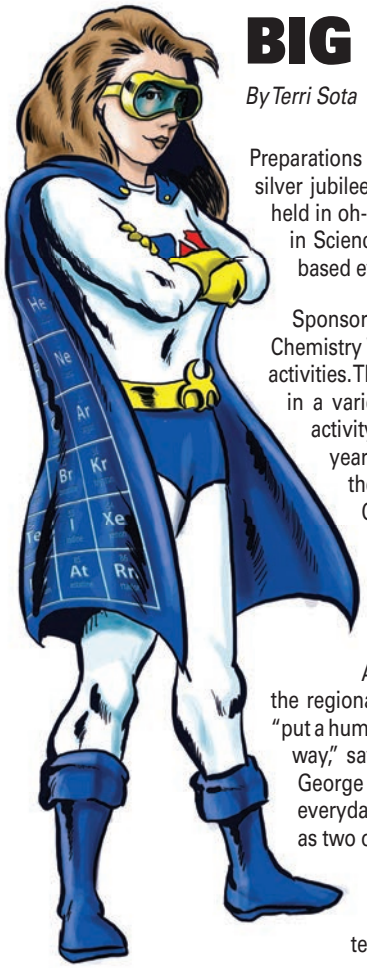
1938: Nuclear fission achieved. The process of fission in uranium and thorium was discovered by Otto Hahn, the Father of Nuclear Chemistry. Hahn and his associates worked on uranium fission reactions and listed about 25 elements with 100 isotopes. He was awarded the Nobel Prize for his outstanding work in fission of heavy atomic nuclei.

1953: Double helix structure proposed. James Watson and Francis Crick discovered the ladder-like structure of DNA and proffered a new understanding of heredity using some data gathered by Rosalind Franklin. They shared the Nobel Prize in Medicine with Maurice Wilkins in 1962 for this great leap forward.

In the past century, the very existence of the atom was questioned. Today, it is possible to maneuver atoms using a scanning, tunneling microscope. Chemistry has come a long way in a relatively short period of time; it plays a prominent role today in genetics, biotechnology and nanotechnology.

CLASSROOM DISCUSSION

- What are some other fields that chemistry plays an important role in today?
- What are the most important discoveries and breakthroughs in chemistry in the past two decades?



BIG WEEK FOR SMALL THINGS

By Terri Sota

Preparations are under way for National Chemistry Week's (NCW) silver jubilee. This year, big celebrations around the nation will be held in oh-so-small ways. Nanotechnology: The Smallest BIG Idea in Science is the overarching theme for the many community-based events occurring October 21–27, 2012.

Sponsored by the American Chemical Society (ACS), National Chemistry Week relies on 187 regional coordinators to plan local activities. These volunteers are free to incorporate the year's theme in a variety of ways. Lectures, chemistry demonstrations and activity stations are some of the all-admission goings-on each year. Held mainly at malls, community parks and libraries, the events are also staged at several city science centers. Coordinators secure the venue, manage budgets and scale, package giveaways and amass additional volunteers. Offers ACS Communities Activities chair Lynn Hogue, "We also get to share our love for science."

Alvin C. Collins III, Ph.D., is the liaison between ACS and the regional coordinators. The annual event is an opportunity to "put a human face on chemistry and present it in a non-intimidating way," says Collins. The brainchild of former ACS president Dr. George C. Pimentel, NCW promotes awareness of chemistry in everyday life; this year, bicycle frames and sunscreen will serve as two of the illustrative examples.

A key component of all the fun is the ACS-produced Celebrating Chemistry publication. Written by "theme team" members, the booklet is distributed at events (and may be ordered/downloaded online beginning in August) and contains articles, interviews and at-home experiments targeting both English- and Spanish-speaking fourth, fifth and sixth graders (much of the material can be adapted for an older student audience and for classrooms). This fall, the illustrated pages will convey the contributions of nanoscience to energy, materials, health and the environment. Chemistry enthusiasts can find articles defining nanoscience and a behind-the-scenes look at sunscreen and spf, buckyballs, graphene (pencil lead) and hydrogels. The content is easily accessible for both parents and students; high-level concepts are distilled down for the enjoyment of all. In addition to the publication's do-it-yourself investigations, the NCW website lists more than a hundred classroom experiments, as well as suggestions for theme-based outreach activities (for coordinators).

ACS is the world's largest scientific organization and it sponsors a second annually occurring event — Chemists Celebrate Earth Day. To find a coordinator in your area and learn how your class can participate in the Illustrated Poem Contest (K-12) and attend local festivities, please visit: **www.acs.org/ncw**.

CLASSROOM DISCUSSION

- Identify real-world examples of chemical principles in action
- Participate! Download Celebrating Chemistry, have students compose poems and/or attend a nearby event

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PHYSICS OF SPORTS

By Brianne McCurley

Watching a baseball soar over the Green Monster at Fenway Park, seeing a tennis ball hit at more than 100 miles per hour at Wimbledon, witnessing Tiger Woods drive a golf ball onto the green in Amen Corner or Ben Roethlisberger throwing a 40-yard touchdown pass are commonly observed sports performances in which physics play a key role.

Magnus (effect) force is a reaction that the Encyclopedia Britannica defines as "the generation of a sidewise force on a spinning cylindrical or spherical solid immersed in a fluid (liquid or gas) when there is relative motion between the spinning body and fluid." The Magnus force reaction occurs in many sports with the curve of a baseball, soccer ball, golf ball and tennis ball.

The force and torque exerted on the handle of a baseball bat, as well as the spot where the ball meets the bat, all determine how far and where a baseball will travel. To hit a baseball the maximum possible distance, the trajectory off the bat should have a 35-degree angle. A batter exerts between 6,000 to 8,000 pounds of force on the ball. This force is required to change a 5 1/8 ounce ball from a speed of 90 mph to a speed of 110 mph. This distorts the baseball to half of its original diameter and the bat is compressed one fifth of its size.

When a soccer ball travels through the air, wind flow, air speed and pressure can all affect its trajectory. As a player's leg comes in contact with the ball, the drag and force strongly influences its trajectory. A Magnus force reaction occurs when a player strikes the ball, attempting to induce a shot that bends.

Golf balls are dimpled to increase the Magnus effect. As a golf club comes in contact with a ball, the presence of the Magnus force reaction occurs because the ball has backspin. That same Magnus effect can cause a ball to hook or slice if it has sideways spin.

The windup, the toss and the strike of a tennis ball are all steps in completing a serve. Physics is a factor in each of the steps. As a player tosses the ball up, he or she presses their feet against the court, using ground reaction forces to create elastic potential energy. The rotations of their legs, hips, trunk and shoulders produce the maximum angular motion in order to hit the ball at exactly the right time with the right amount of force. In biomechanics, this is known as "the kinetic chain principle."

Next time you are watching a sporting event or casually playing a game on your own, think about the physics involved each time you touch the ball.

CLASSROOM DISCUSSION

- Other than in sports, where does physics play an important role in everyday life?
- Corking a baseball bat is illegal. Why would a cork-lined bat give a batter an advantage?

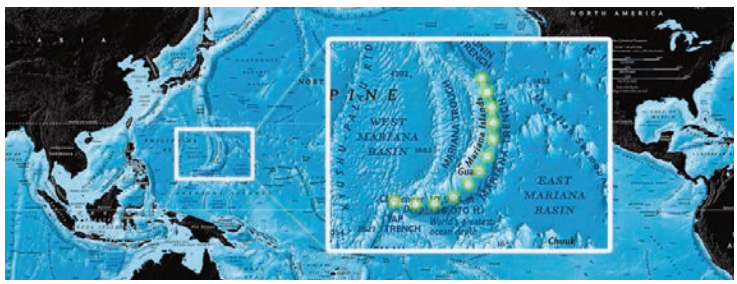
MAN'S DEEPEST DIVE

By Gwen Myslinski

On March 26, 2012, James Cameron — yes, the Academy award-winning director of *Titanic* and *The Abyss* — reached new depths. He took a solo journey in his underwater vessel Deepsea Challenger to the ocean's deepest known depth. Voyaging to the "Challenger Deep" area, nearly seven miles (36,070 feet) down in the Mariana Trench (near Guam), has been compared to landings on the moon.

CAMERON'S PRECURSOR

This deepest sea dive was accomplished once before on January 23, 1960, by the U.S. Navy with a vessel called The Trieste. Manned by Jacquard Piccard, the son of the vessel's designer, Italian Auguste Piccard, and U.S. Navy Lieutenant Don Walsh, the two-man vessel reached the ocean floor in four hours and 48 minutes. Then, after only 20 minutes on the ocean floor, it began its ascent. A long three hours and 17 minutes later, the vessel emerged and the pilots saw the light of day. After this arduous trip, the men had only their verbal account and mental images to share with the waiting world.



DIFFERENCES

The two missions were completed more than 50 years apart, and in the interim, technologies evolved that aided Cameron in his dive. The Deepsea Challenger was built much lighter by using a special foam that gave it protection and buoyancy beneath the surface. It was also designed to reach the ocean floor much faster, investigate a lot longer (six hours or more), and then ascend to the surface in a third of the time that it took the first craft. Additionally, The Deepsea Challenger is able to take the photos and 3-D images and collect the samples that The Trieste could not.

	TRIESTE: 1960	DEEPSEA CHALLENGER: 2012
Weight	150 tons	11.8 tons
Number of pilots	Two	One
Descent	4 hr., 48 min.	2 hr.
Ascent	3 hr.	1 hr.
Number of cameras	Unable to take photos	8 HD cameras
Time on ocean floor	20 min.	6 hr.

CLASSROOM DISCUSSION

- The pressure on the ocean floor is crushing; the first expedition cracked an outer Plexiglas window. If the crack had reached to the inside, what would have happened to the pilots and why?
- How long do you think the planning for a dive like this takes? What kind of planning is involved (including building the vessel)?

COSMIC COLLISIONS

By Robert Marshall

CARNEGIE SCIENCE CENTER

It has been almost 100 years since Edwin Hubble measured the universe beyond the Milky Way. Today, astronomers believe that as many as 100 billion other galaxies may be sharing the cosmos. Classified by shape, most of these cosmic islands are either spiral or elliptical, but star-gazing scientists have discovered galaxies that don't quite fit these molds. Common to the "irregular" category are galaxies which interact with other galaxies. These gravitational interactions are often referred to as mergers and their existence invites the question: Is the Milky Way collision-prone?

If the answer is yes, could a collision happen in our lifetime? What would happen to our sun? To Earth? To evaluate the probability, look no further than the most distant object the human eye can detect — to the Andromeda Galaxy (M31), located more than 2.5 million light-years away. It appears as a small fuzzy patch in the sky but there is nothing miniature about Andromeda. Similar to the shape (spiral), size and mass of the Milky Way, M31 is home to a trillion other suns. Astronomers have known for decades that our galactic neighbor is on the move and closing in fast — at approximately 250,000 miles per hour.

Andromeda's blueshift — a decrease in electromagnetic wavelength caused by the motion of a light-emitting source (star) as it moves closer to the observer — is by no means breaking news. However, data recently collected from the Hubble Space Telescope predicts a merger with certainty, in an estimated four billion years. Our sun will still be shining. Whether humans still inhabit the planet is unknown, but Earth will most likely survive the impact. Galaxies, although single units of stars gravitationally tied together, are mostly gigantic voids. One can think of a galaxy-on-galaxy collision as similar to the pouring of one glass of water into another. The end result is a larger pool of water, or in the case of a collision: stars.

NASA, ESA, Z. Levay and R. van der Marel (STScI), T. Hallas, and A. Mellinger

A glimpse into the future. This image depicts the before, during and after of the impending cosmic collision; notice how all the orbits are altered.

CLASSROOM DISCUSSION

- Look at a number of photographs of different galaxies. How would you classify them? Now look up "Hubble's Tuning Fork" and evaluate how your results differ. Why?
- Where in the sky is Andromeda located? Is it more visible at a particular time of year?

USING GRAVEL TO TEACH GEOLOGY

By Brianne McCurley

A hands-on subject, geology can take students out of the classroom to nearby locations, to learn what rocks are all about. Taking field trips to places such as rock quarries, geology or mineral museums, and sand and gravel operations is a great teaching tool and has been shown to enhance students' problem-solving and critical-thinking skills. Studying gravel is not hugely popular, but using local gravel samples to teach geology can be a cost-effective and easily accessible resource for science classrooms. Local gravel samples can be gathered from parking lots, streams or along highway shoulders.

Gravel is defined by geologists as an accumulation of unconsolidated rock pieces with diameters ranging from 2 to 256 millimeters. Gravel investigations in the classroom can also guide discussions toward climate change, evolution and geologic time, as well as to uses in construction, erosion control and manufacture. Previous research shows that studying rocks and fossils aid in student comprehension of the biological and geological "big picture."

Rocks, minerals, models and study kits can be purchased from Fisher Science Education at **www.fishersci.com**.

SAMPLE GRAVEL ACTIVITIES:

- Investigate samples and analyze similarities and differences (hardness, color, streak, luster and specific gravity); have students consider where they have encountered these gravels and describe potential uses
- Sort and classify; discuss weathering, erosion and transportation
- Compare chemical composition of gravels and discussion of rock cycle, including the processes by which rocks change from one type into another over time
- Search for fossils addressing geologic time, paleoecology, climate change and extinction of organisms
- Investigate its effectiveness as a filtering device

DID YOU KNOW?

- All rocks are made of two or more minerals, but minerals aren't made of rocks
- Gravel occurs naturally as a weathering product at Earth's surface
- Pumice is the only rock that floats

CLASSROOM DISCUSSION

- There are four agents of erosion — gravity, wind, glaciers and water. Discuss each agent's effect on rocks
- What are the three types of rocks? Where does gravel get classified?

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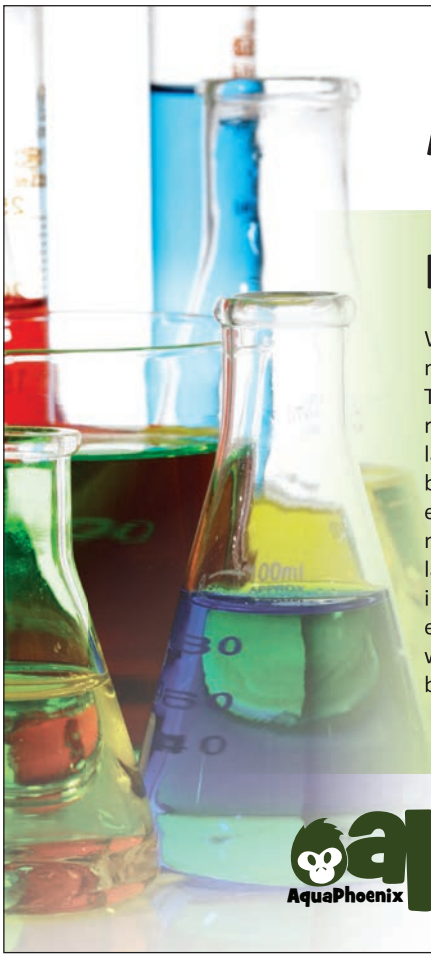

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Fisher Science Education

E-SKIN: YOUR DOCTOR AT HOME

By Sayantani Dastidar

As futuristic as it may sound, wearing a wireless device to monitor your health may be around the corner. John Rogers, a materials scientist at the University of Illinois, and his team worked for about 15 years to make this science-fiction-like feat a possibility. The researchers developed an epidermal electronic system consisting of multifunctional sensors integrated on a flexible thin patch. According to their recently published study, the patch can be mounted on the skin to extract biological information.

READY-TO-WEAR

The new device can monitor key functions of the human body such as heart activity, brain waves and muscle movement in a completely noninvasive way, without tangle-prone, bulky wires. Its ultra-thin nature enables it to stick to the skin with the help of relatively weak (but powerful) van der Waals forces, rather than adhesives that can cause irritation.

Rogers and his team compared the electrophysiological information from EEGs, ECGs and EMGs recorded by the monitors, with data obtained from bulkier, commercially used devices. The results from the miniscule monitors were as accurate as those from the larger instruments.

The wearable monitor shows great potential for use as a human–computer interface. It can be especially useful for people suffering from laryngeal diseases, premature infants or for improved control of prosthetics, which haven't been optimized by conventional medical sensors thus far.

This low-modulus device, with "skin-like" stretchiness, consists of biocompatible antennae, light-emitting diodes, electrodes, electronics, sensors, power supply and communication components. It can be applied and removed like a temporary tattoo and can be used on many parts of the body without the risk of tearing.

As of now, the sensor can only be used (continuously) for a few days. Researchers are still looking for a new technology that would enable months of monitoring. The research group also made several recommendations for future development, including the addition of piezoelectric devices for uploading data or commands. Health monitoring will no doubt become less complicated and more convenient with time.

CLASSROOM DISCUSSION

- What possible steps should be taken to bring "E-skin" to the mass market?
- What advantages does the "E-skin" possess over traditional devices?

SELF-SCULPTING "SMART SAND"

By Ashley Peterson

Imagine what you could create with a bag of self-sculpting sand material that had the ability to morph on command, effectively transforming in shape within seconds.

Tiny self-assembling robots that can coordinate to form functional tools may sound like sci-fi fare, but this truth is stranger than fiction. According to researchers at MIT's Distributed Robotics Laboratory, a "smart sand" product may be ready for market in as little as 10 years.

The work is being done by Danila Rus, a professor of computer science and engineering, and her student, Kyle Gilpin. According to Gilpin, the technology will allow the duplication of tools or mechanical parts almost instantly.

THE SCIENCE BEHIND THE MAGIC — HOW IT WORKS:

To begin, the user places a scaled-down version of whatever they wish to create into a container of "Smart Sand" granules. The user then specifies the desired size. The individual grains transmit messages back and forth via an algorithm that senses the shape of the object and maps it in 3-D form, to the to-scale size. The grains not used for building simply fall away.

The technology could be used soon to reduce waste in our daily lives. The sand can create new parts; if a car rod shears, the broken part can be duct taped together, placed in the sand and used to form a new part. A major advantage of this type of material is that it is reusable and lends itself to producing things that aren't necessarily needed forever. When an item has outlived its usefulness, it can be returned to the pile and reused to make something else.

Currently, the research team is working with 10-millimeter cubes (dubbed smart pebbles) to test out the algorithms behind the technology. They face the significant engineering challenge of scaling the technology down to sand grain size, and supplying each grain with sufficient computational power to run the algorithms.

Although there is still a lot more work to be done, Gilpin predicts that this "magic sandbox" could be on the market in as little as a decade. "In 10 years you might see a product on the market that starts to rival traditional manufacturing approaches. I think we might all be surprised at how quickly this advances once people really start looking at the technology."

CLASSROOM DISCUSSION

1. Can you think of a time in your life when "Smart Sand" would have been useful?
2. Do you think Gilpin's 10-year launch target is too aggressive? What are some of the obstacles new technologies face?

THE NEXT "WAVE" IN POWER GENERATION

By Ritwika Bhattacharya

Oceans constitute about three-fourths of the Earth's surface and are a tremendous source of energy, both non-renewable, such as oil and gas, and renewable, like wave and tidal energy. Thermal energy, relayed by the sun, and mechanical energy, produced by crashing waves, can be harnessed from ocean waters.

CAPTURING THE OCEAN'S POWER

The sun warms the ocean's surface, creating a temperature gradient between surface and deeper waters that gives rise to thermal energy. This can be used for several applications, including the generation of electricity. There are three types of electricity generation systems: closed-cycle, open-cycle and hybrid. The closed-cycle system uses a fluid with a low boiling point (e.g., ammonia) that can be vaporized using warm seawater. This vapor expands and rotates a turbine, which activates a generator and produces electricity.

The open-cycle system uses seawater directly to generate electricity. Seawater is boiled in a low-pressure container and the resultant vapor is used to rotate a turbine and activate a generator.

The hybrid system is a combination of both open and closed cycles: warm seawater is evaporated in a vacuum chamber and used to vaporize ammonia which, in turn, drives a turbine to produce electricity.

Ocean-based, mechanical energy systems use kinetic energy from the moving waves and tides to drive a turbine and generate electricity. Usually, electricity is generated from tidal energy in a dam, where gushing water is directed through turbines that activate a generator.

Waves are driven by winds and tides, which wax and wane with the moon's gravitational pull. The motions of the oceans are, therefore, intermittent sources of energy, as compared to the more constant supply of thermal energy.

Ocean energy systems have many valuable by-products such as aquaculture, desalinated water production and air-conditioning. The main drawback is cost; building plants to harness the energy is very expensive. Still, as the price of traditional fuels rises and sources dwindle, there is an increasing need for alternative and renewable sources of energy; ocean energy may be the wave of the future.

CLASSROOM DISCUSSION

- What are some of the concerns surrounding ocean energy plants?
- Do you think ocean energy systems could be a solution to the world's energy problems?

WASTE NO MORE

By Terri Sota

There is a better way to look at trash, and the Zero Waste Alliance has a vision it wishes to share. This national, sustainability-supporting organization promotes waste as "a resource in disguise." When organic, non-biodegradable waste is removed from the landfill disposal stream — and composted or recycled instead — a continuous cycle of resource production is established. In contrast, when landfill is created, the cycle is interrupted and the renewal process grinds to a halt. Methane gas is also added to the atmosphere as a consequence. The good-for-the-planet news is that universities, government, businesses and community groups are coming around to the Alliance's way of seeing.

At Ohio State University, Buckeye football fans produced more than 58 tons of recyclables and 12.5 tons of compost in a single season. This accomplishment was a product of the university's Zero Waste Initiative, which re. û ed in an average [landfill] diversion rate of 75.2 percent. Within the stadium, volunteers replaced all trash bins with recycling and compost containers. Signs and workers —strategically placed throughout the facility — instructed fans where to stash their trash. Instead of petroleum-lined paper cups, kiosks sold reusable and recyclable plastic souvenir cups. Sustainability coaches added paperboard trays to the lineup, effectively benching the plastic nacho carriers. During the season, program administrators monitored the materials stream, analyzed the leftovers and called audibles along the way. Hopes are high to post a 90 percent diversion rate on the coming season's scoreboard.

An entire Colorado city has gotten in on the green game. In 2009, the Steamboat Ski & Resort in Steamboat Springs launched its initiative to eliminate all waste from its food and beverage outlets. In the first year, the resort saw a 62 percent reduction in landfill and cut waste from several dumpsters per week to two per month. The next year, the Free Summer Concert Series "went zero"; the public schools followed in 2011.

Whether the event is a citywide festival or a backyard barbecue, all party planners can achieve zero waste success. On Bainbridge Island, in Washington, party-throwers follow a few simple rules. The first step toward no trash is (no surprise) planning ahead. Identify what will be served and what kind of tableware and serving utensils will be needed. Next, bring the guests into the fold; communicate the waste-free goal from the outset. Create reminders by receptacles, and enjoy.

CLASSROOM DISCUSSION

- Consider ways that your classroom can go waste-free
- Plan a waste-free party/event

Anita Borg (1949-2003)

ANITA BORG BLAZED TRAIL FOR WOMEN IN COMPUTER SCIENCE

By Alida Cataldo

Radical? Feminist? Superstar? Anita Borg was called all of these but was most proud of the "Tech Feminist" moniker, for her lifelong efforts to interest more women in the high-tech industry.

Born in Chicago, Illinois, in 1949, Anita Borg showed an interest in math early in life. She later discovered a love for computer science, while a student at New York University. Borg earned her Ph.D. in 1981 with a dissertation on the principles of operating systems. After graduating, Dr. Borg worked at the Digital Equipment Western Research Laboratory, the Network Systems Laboratory and, finally, the Xerox Corporation Palo Alto Research Center.

IT ALL STARTED WHEN ...

In 1987, Dr. Borg attended a technical conference and noticed that only a few attendees were women. This prompted her to start *Systers*, an electronic mailing list for female engineers in technology that enabled networking and information sharing. Membership has grown to more than 3,000 in countries around the world.

In 1994, Dr. Borg co-founded the *Grace Hopper Celebration of Women*, a conference held every two years for women in information and computer sciences. Three years later, she founded the nonprofit *Institute for Women and Technology* to encourage women considering the technology industry. After Dr. Borg died in 2003 of brain cancer, the name was changed to *The Anita Borg Institute for Women and Technology*. This organization is supported by the biggest names in computer science and finance, and more than 13,000 women subscribe to its newsletter.

***In 1992,** the "Systerhood" learned that the Barbie® doll was programmed to say, "Math class is tough." They protested this demeaning message to women, and Mattel® removed the phrase from the doll's microchip.*

AND IT CONTINUES ...

Dr. Borg's legacy lives on. *Systers*, the Grace Hopper Celebration of Women conferences, and The Anita Borg Institute for Women and Technology continue to grow; the *Google Anita Borg Scholarship* honors her efforts to open STEM fields to women.

CLASSROOM DISCUSSION

- What other fields are still dominated by males? Why do you think more women aren't going into those fields?
- Name some traditionally male-dominated fields that have recently begun to attract women

ACCIDENTS HAPPEN: THE INVENTION OF THE MICROWAVE

By Alida Cataldo

Like so many other innovations, the invention of the microwave oven wasn't intentional. Its genesis was in a laboratory at Raytheon Company where, in 1946, Percy LeBaron Spencer was testing a tube (magnetron) that produced microwaves for Britain's radar system. When he discovered that the chocolate candy bar in his pocket had melted, he decided to experiment.

First Spencer placed some corn kernels near the tube. Soon he had popcorn strewn all over the lab. Then he set an egg near the tube and watched a colleague get covered in yolk when the egg exploded. Spencer correctly deduced that these results were generated by exposure to low-density microwave energy. And then he wondered: Could the magnetron raise the temperature of other foods and cook them faster than a conventional oven?

Spencer built a metal box into which he could feed microwave power. The power was contained, so it created a higher density electromagnetic field. He found that foods exposed to microwave energy in the box got very hot very quickly ... and the microwave oven was born.

CLASSROOM DISCUSSION

- In addition to cooking food, how else can the microwave oven be used?
- Name other "modern marvels" that were invented by accident

FROM THE LAB AND INTO THE HOME

Raytheon was excited about this new technology and set about designing a "real" microwave oven. When completed, the unit was 5½ feet tall, weighed more than 750 lb. and cost about $5,000. In 1947, the Raytheon "Radarange" was successfully tested in a Boston restaurant; it was available for commercial sale by 1954. Because of its size, cost and the fact that special plumbing was needed to run it, the microwave oven was relegated to restaurant and institutional use only.

In 1967, Amana (a division of Raytheon) produced a countertop microwave oven for home use. Interest was tepid at first; but by 1975, microwave oven sales exceeded those of gas ranges. Today, almost every home has one.

ABOUT THE INVENTOR

Percy LeBaron Spencer was a self-taught engineer and inventor. He didn't finish grammar school but was educated in wireless telegraphy while serving in the U.S. Navy. Spencer joined Raytheon in the 1920s and remained there until his death at age 76. During his career, he accumulated 150 patents and was inducted into the National Inventors Hall of Fame in 1999.

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