Volume 4, Issue 2 Fall 2008

Banish These from Your Labs!

! PEROXIDES AND PEROXIDE FORMERS, e.g., DIETHYL ETHER, p-DIOXANE AND CYCLOHEXANE !

! EXTREMELY POISONOUS MATERIALS, e.g., CYANIDES !

! EXTREMELY REACTIVE CHEMICALS, e.g., SODIUM OR POTASSIUM METAL, WHITE OR YELLOW PHOSPHORUS !

! CARCINOGENS, e.g., FORMALDEHYDE, BENZENE !

! PICRATES, e.g., PICRIC ACID !

INSIDE THIS ISSUE:

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Fisher Science Education

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HEADLINE DISCOVERIES

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THE CHALLENGE OF SAFE SCIENCE

In history class, the horror of the Hiroshima bombing was being discussed. There were no casualties in class.

In English class, the historic radio broadcast of Orson Welles' *War of the Worlds* held the students entranced. No one was vaporized.

Across the hall in sophomore chemistry, the class performed experiments with acids and bases. No students were injured—but only because of careful planning by the science teacher and careful work by alert, prepared students. Hands-on chemistry classes, while they teach students science in a meaningful, lasting way, can also create dangers with lasting consequences.

Teaching science in today's hands-on environment is not for the faint-hearted; however, the theory and practice of lab safety allows us to do our best teaching while managing and mitigating the risks.

The Reach of Lab Safety

Lab safety is only as good as the people at the heart of these life-saving programs and the practices that they devise and implement. In order to increase the chances safe practices will prevail, many schools are now required to have safety plans that cover activities in the classroom and lab. The most effective of these plans combines knowledge born of the experienced teacher with training, awareness of specialized materials and supplies, understanding of regulatory requirements and best practices, ability to design and outfit a safe learning space, and systematic management of chemicals.

Harm to students and teachers can come in a variety of ways, not all of them in chemistry classes. In Boston, for example, fifth-grade students became infected with salmonella after teasing apart owl pellets that had presumably been sterilized. All science classes should be approached assuming there will be risks that need attention; nonetheless, the chemistry classroom is often the location of student injuries and has received much of the lab safety focus.

Where to Start—Aprons and Glasses and Gloves, Oh My!

The most common way of controlling chemical exposures is through the use of personal protective equipment (PPE). This gear includes gloves, safety glasses, goggles, respirators, lab coats, and aprons. These come in a variety of materials and designs, suited to different chemicals and hazards.

Ideally, the truly safe lab would rarely, if ever, need to rely on these—other measures would ensure dangerous releases never occurred. But as many anecdotal incidents attest, no one can ever count on having a truly safe lab.

Lab Design and Furnishings

In addition to PPE, schools should be committed to carrying on demonstrations and student-participation activities using primary protective measures: operating behind shields, in specially designed workstations, or within fume hoods to protect students from reactions. In a number of disturbing accidents, teacher-led demonstrations—perhaps considered "safer" than allowing students to conduct the activities themselves—have frightened and injured students. Some of these have involved using methanol in open classrooms.

Even the design and size of a lab can promote or endanger safe lab performance. Studies have shown a correlation between the number of students in a lab and accident rate. Both from the discipline angle—more kids, less ability to oversee and control behavior—as well as the space per student, more is not better in a chem lab. For example, in one study, a class of 20 students yielded accidents in 24 percent of the labs studied. That rate increased to 40 percent as the class size increased to 24 to 30 students and jumped again to 57 percent for class sizes over 30. Various studies show different details, but the phenomenon remains the same. As space per student decreases, the accident rate increases: a drastic increase in mishaps correlates with a reduction of student space from 60 to 41 sq. ft.

As the Americans with Disabilities Act supports more and more children with physical handicaps participating in labs, lab designs and existing floor plans must be altered to accommodate. The turning radius of a wheelchair, lest additional risks be created in tight surroundings.

The Dangerous Legacy

Back in the recesses of the chemical storeroom lurk dangers that even individuals with access to this inner sanctum may not have noticed. Scores of middle and high schools across the country are struggling with a legacy inherited from their predecessors—stockpiles of old, unlabeled, potentially hazardous chemicals. Years ago, the shock to many Americans when the Russian satellite *Sputnik* was launched sent legislators in search of a jump-start to science education in our schools. The National Defense Education Act of 1960 granted billions of dollars to schools to purchase, among other supplies, laboratory chemicals. Almost 50 years later, some of these chemicals remain on lab shelves, their danger increasing the longer they remain. Because chemicals and their containers degrade over time, chemicals can become so "shock-sensitive" that they are too dangerous to move. Other chemicals may have been stored alphabetically for ease in locating, rather than with compatibility and reactivity in mind, risking a reaction if contact occurs. Efforts to dispose of these chemicals can lead to explosions, fires, and environmental degradation.

This is one area in which teachers—even the most chemically savvy—need to defer to professionals. Beyond carefully and accurately inventorying legacy chemicals, teachers will need to hire chemical removal firms to evaluate, pack, and dispose of these materials. Procedures and precedents for dealing with this storeroom time-bomb were lacking until 10 years ago, when Seattle's King County School District established a program called "Rehab the Lab," which brought in hazardous waste professionals to evaluate, inventory, and dispose of the worst of the schools' chemicals.

The EPA has subsequently supported programs of a similar nature for other localities. Their Schools Chemical Cleanout Campaign (SC3) has generated tools, resources, and outreach materials to support lab cleanouts. (For details, see **www.epa.gov/SC3**.)

Know Thy Chemicals and Minimize Them

There are certain chemicals that are considered simply inappropriate for use in schools. (See "Banish These from Your Lab!")

Many schools have become more systematic in their efforts to reduce the amounts and types of chemicals for which they are responsible. Chemical labeling and inventory systems allow even a faculty with high turnover to know what is in-house. MSDS sheets, always required in any chem lab, add to the resources every school has available. There are resources that suggest less risky alternatives to common lab exercises. Keeping lower chemical quantities on hand has become a basic tenet in many schools' safety and chemical management plans. Switching to microchemistry can cut down chemical usage by 50 percent using existing glassware. Using specialized glassware, it can cut chemical usage down to 1/100 or even 1/1000 typical amounts.

But There's More...

Many other factors contribute to the safety of our schools' labs, including teacher training and student awareness. Fortunately, there are more and more safety resources available. While funding for safety upgrades can be difficult and unpredictable, knowledge and understanding of safety risks and mitigation techniques are invaluable and available to every teacher.

As has been noted before, safety is something that happens first in our heads and second in the classroom.

—Merry Morris

DID YOU KNOW?

Iodine crystals can be used illegally to produce methamphetamine? Both the federal government and states now restrict the sale and use of iodine crystal and tinctures. For more information, visit **www.usdoj.gov/ndic/.**

PROFILE

MICHAEL FARADAY

The life of English chemist and physicist Michael Faraday began Sept. 22, 1791, in London. He was one of several children born to a blacksmith and a farmer's daughter of modest backgrounds. He earned a basic education before serving as apprentice to a bookseller at the age of 14. In addition to borrowing books from his boss and his associates, Faraday read the books he was to bind, adding to his self-education and learning the theories of various scientific scholars.

He became a journeyman bookbinder for another gentleman in 1812, and during this time, he was recommended to serve as a secretary for a noted English chemist whose eyesight was damaged in a nitrogen trichloride accident. Faraday served Humphry Davy of the Royal Institution and Royal Society for a few days, which gave him the courage soon after to send Davy a bound volume of his notes.

When an unexpected opening became available at the Institute for a chemical assistant, Davy contacted Faraday, who had always dreamed of working in science. He began at the bottom, doing menial tasks like washing bottles, though he greatly relished the opportunity to serve the apprenticeship. He traveled as an assistant and servant for Davy in Europe, learning foreign languages and speaking with noted philosophers and scientists of the day. He continued to work closely with Davy during his career.

Faraday was elected a member of the Royal Society in 1824 and appointed lab director at the Institute in 1825. "Nothing is too wonderful to be true if it be consistent with the laws of nature," he once wrote in his journal, "and in such things as these, experiment is the best test of such consistency." Faraday indeed made many scientific strides through his chemical and physical experiments and numerous publications.

In chemistry, he invented the system of oxidation numbers, discovered benzene, and developed an early form of the Bunsen burner. He laid the basis for electrochemistry as well with his First and Second Laws of Electrolysis; however, his discoveries in the fields of electromagnetism are widely considered his greatest achievements.

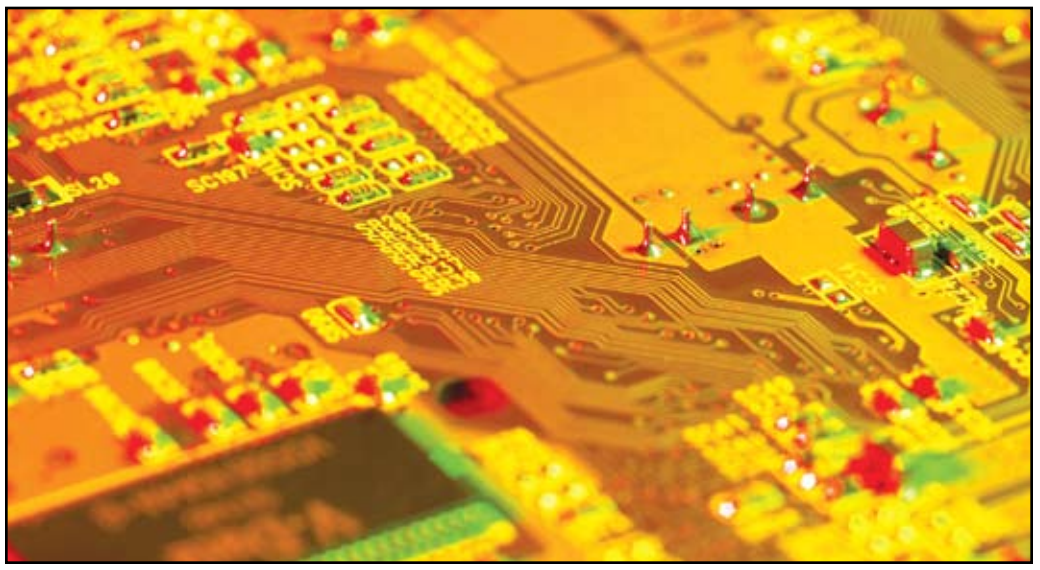
In 1831, Faraday discovered electromagnetic induction, the generation of electricity in a wire by means of the electromagnetic effect of a current in another wire. Later that year, he discovered how to produce a steady electric current with wires, a copper disc, and magnets, making what became the first generator and the precursor to the electric motor.

A humble man, Faraday rejected knighthood and refused twice the appointment of Royal Society president. He accepted the appointment of the Fullerian Professor of Chemistry at the Royal Institute in 1833, working there until his 1858 retirement. He died Aug. 25, 1867, leaving behind a legacy of scientific discovery.

—Aprile Smith

NEW PATHWAYS FOR ELECTRICITY

NANOTECHNOLOGY BENDS THE RULES OF ELECTRICAL CONDUCTIVITY



Rubber—once considered only as an insulator against electrical flow—is now being fashioned into conductive materials using a number of nanotechnological techniques. And their potential uses include a multitude of applications, including aircraft wings, artificial muscles, flexible and even wearable computers, and "smart clothing" stuffed with useful devices. Meanwhile, the now-venerable transistor has been revitalized via nanotechnology to be up to 50 times more energy efficient than before, offering the prospect of reduced energy consumption in a variety of electronic devices and an expansion of electromagnetic communications into previously impractical frequency ranges.

Metallic Rubber

A new material dubbed "metal rubber" promises electronic gadgets and materials that will stand up to a lot of abuse. Research shows it to be highly flexible and nearly indestructible. It can be heated, frozen, stretched—even doused with jet fuel—and still snap back into its original shape. What's more, the material is light in weight and conducts electricity as well as metal wiring.

Mating Rubber with Metal

Unlike conventional mixing or weaving of materials and textiles, the new technique uses a nanotechnology process called "electrostatic self-assembly." The base material, containing metal nanoparticles, is dipped alternately into solutions with positive and negative charges—protons and electrons. Nanoparticles with opposite charges bond to form electrically conductive layers; electricity flows through the tiny metal particles just as in a copper wire. Repeated dips in the baths produce more layers, providing choices in the material's thickness and electrical capacity. The benefits include less weight, lower manufacturing cost, fewer byproducts, and improved strength: textiles made of the metal rubber fabric stand up to repeated washing without disintegrating, while keeping their electrical conductivity.

Matching Material to Applications

The durability and flexibility of metal rubber suggest a multitude of uses—some in the near future, others some years away. Here are some possibilities to ponder:

- Flexible, electrically charged aircraft wings
- Artificial muscles
- Wearable computers
- Flexible antennas, circuits and cell phones that resist typical abuse
- Protective clothing, even washable "smart clothes" with sensors built in to monitor vital signs, impacts, air toxicity, electrical radiation and more
- Flexible displays
- Electromagnetic shielding
- Durable electronics to withstand conditions in outer space

Nanotechnology and the Transistor

Transistors began replacing power-gobbling vacuum tubes in electronic equipment over 50 years ago. They were able to amplify weak signals more efficiently and provided an enormous decrease in weight and heat in electronic devices. Since then, they've become ubiquitous in electrical and electronic appliances. But in the intervening decades, efforts to reduce the size of transistors—made primarily of silicon—were blocked by the problem of overheating, caused by the release of large amounts of energy from electrons in the material. Now, a new transistor type has been developed that offers 50 times the energy efficiency of silicon—the first transistor produced using nanotechnology.

Indium Arsenide

The new transistor is made of indium arsenide, a material which allows electrons to move around more freely than in typical silicon transistors. This property should allow the new transistor to use less energy, providing a number of benefits. And even though the material is more difficult to work with than silicon, using the conventional technique of carving out transistors from the basic material, it's relatively easy to construct a transistor from indium arsenide when the transistor is constructed from the bottom up using the nanotechnology technique of "self-organization."

Less Energy, More Communications Bandwidth

Prospects for the new transistor's applications include:

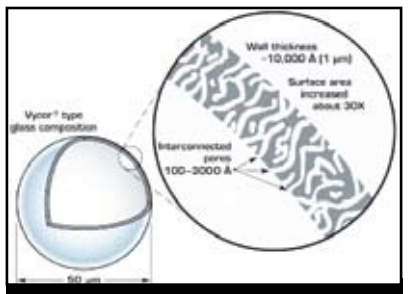
- Significantly reduced energy consumption, conserving energy
- Less frequent recharging of mobile phones, laptops and other mobile devices
- Eventual expansion of the usable frequency ranges for communications

—Ray Schafer

ENTHUSIASM BUBBLES OVER EMERGING MICROSPHERE TECHNOLOGIES

SRNL researchers removed the top of a glass microsphere to show how palladium has easily passed through the sphere's pores and assembled itself into a new nanostructure.

Unique nanostructures have been grown on both the interior and exterior of the hollow glass microspheres.



Schematic representation of microsphere wall porosity.

They're small, they're hollow, and they just might be the answer to the global energy crisis. The newest darlings of nanotechnology are tiny glass spheres that can collectively flow like water while carrying and protecting precious payloads such as hydrogen gas or critical medications. And there is every reason to think we are only seeing the beginnings of their usefulness.

An Expanding Sphere of Influence

Microspheres are not themselves new. Rather, they have been used as a low-density filler material in manufacturing since at least the mid-1960s. But recent advancements in microsphere design and production are changing the structure of microspheres and, therefore, their function.

In the June 2008 issue of *The Bulletin*, the monthly magazine of The American Ceramic Society, scientists from the Savannah River National Laboratory revealed their progress in developing spheres they have dubbed Porous Wall Hollow Glass Microspheres (PW-HGM). Characterized by the researchers as porous glass "microballoons," these spheres measure between 2 and 100 microns and feature interconnected pores in their thin outer walls that are generating lots of excitement in the manufacturing community.

Bubbles, Toil, and Trouble

PW-HGM spheres start off as 20 to 40 micron glass powders. Heated in a flame-former apparatus, they become soft spherical particles. A latent blowing agent in the glass becomes unstable as the particle continues to be heated, and it forms a bubble that establishes the overall shape of the object. At this point, each particle remains an intact sphere—an HGM rather than a PW-HGM.

To create a porous wall microstructure, SRNL material scientists first heat treat, then acid leach (with hydrochloric acid) the HGMs. Phase separation in the glass that makes up the microsphere results in one phase rich in silica and another rich in sodium borate. The morphology of the latter phase is worm-like and leaves interconnected pores when consumed by the leaching process. The result is a microsphere shell with open channels extending from the outside into its core.

It's All in the Delivery

These open channels make it possible for this type of microsphere to act as a carrier for any number of potential payloads. Thus far, researchers G. G. Wicks, L. K. Heung, and R. F. Schumacher of the Savannah laboratory have been able to fill microspheres with gas-reactive absorbents such as palladium, a material used to contain radioactive forms of hydrogen.

The spheres' ability to capture, contain, and release hydrogen gas is sparking immediate interest on the part of energy researchers and the general public alike. Trapped inside these glass "cocoons" in a solid-state storage system, hydrogen could be utilized as a fuel for cars of the future. And since the mechanical properties of the tiny microspheres can be tweaked to allow them to flow like a liquid, PW-HGM spheres could presumably be used in hydrogen gas storage and delivery systems based on the existing gasoline distribution infrastructure.

Interest in this application by automobile manufacturers is more than casual. The Savannah River National Laboratory is already working in partnership with Toyota to study the feasibility of microsphere-based hydrogen storage. In a letter to the American Ceramic Society, Dr. Rana Mohtadi, a Toyota researcher, writes, "The storage of hydrogen is one of the key challenges in developing a hydrogen economy...much more research is required to further validate and optimize this technology."

Seeing the Light

Of course, just collecting hydrogen gas isn't enough. For microspheres to function as a safe, reliable, and reusable storage medium for hydrogen fuel, they need to be able to capture and release the gas on command. As part of the U.S. Department of Energy Hydrogen Program and in collaboration with the Savannah River National Laboratory, researchers from New York's Alfred University and the Missouri-based Mo-Sci Corp. are investigating photo-induced hydrogen diffusion from doped microspheres.

As James E. Shelby of Alfred University explains in the FY 2007 annual report for the project, several significant milestones have been achieved in demonstrating the validity of its underlying concept. The idea is to retain hydrogen in the microsphere until it is needed, at which point it is released by exposure to intense light of a specific wavelength. So far, the project team has managed to fill hollow microspheres to 10.35MPa of pressure without any significant loss of spheres to fracturing, and their research suggests hydrogen can be stored in a microsphere for at least a month at ambient temperatures with little loss of pressure. The rapid attainment of these benchmarks bodes well for future commercial application of such technologies.

Whether the field is alternative energies or drug delivery, it's easy to see how microspheres could play a significant role in many future nanotech advancements. While more work needs to be done, it's clear the microsphere revolution is one bubble unlikely to burst anytime soon.

—Ed Schock

FIBER OPTIC TECHNOLOGY TURNS STREAMFLOWS INTO DATA STREAMS

The next time you see a group of waders casting nets into your favorite lake or river, be sure to take a closer look. It could very well be that the catch of the day isn't fish but facts.

Researchers are increasingly utilizing fiber optic cables to collect detailed data about environmental dynamics such as the hydrology of streams, the airflow within valleys, the climate of glaciers, and the accumulation and melting of snow. This fiber optic sensing technology, called Distributed Temperature Sensing (DTS), has been available for some time, but until lately it had been the exclusive province of an industry not often associated with environmental causes.

A Big Thank You to "Big Oil"

Perhaps ironically, the successful commercial development of DTS technology has largely been driven by a desire to optimize oil well productivity. But as Oregon State ecology professor John Selker points out in a May 2008 *Sensor* Magazine article, the same features make this technology attractive to both oil producers and environmental researchers; specifically, "the power of DTS is its combination of the ability to operate in extreme environments (such as those experienced down an oil well during drilling) with the ability to read temperature, at each location, over the entire length of the fiber optic cable."

These synergies might not be obvious to everyone, however, so Selker has worked hard to overcome the obstacles inherent in adapting an existing technology to applications not envisioned by its creators. In 2006, Selker and colleagues set out to demonstrate five hydrologic and water resource applications of DTS: a) temperature measurement of the lakebed at Lake Geneva in Switzerland, b) temperature profile of a decommissioned mine shaft in the Czech Republic, c) temperature profile of the air-snow interface above a glacier, d) measurement of the air-water interfacial temperature in a lake (also performed at Lake Geneva), and e) temperature distribution along a first-order stream (the Maisbich in Luxembourg). The results of their experiments, published later that year in the journal *Water Resources Research*, showed tremendous opportunities for even the crudest of improvised, first-generation instruments. (In the first test, for example, seasonal temperature profiles of the Lake Geneva lakebed were conducted using spare telecommunications cables.)

How It Works

So what exactly is Distributed Temperature Sensing, and how is it so superior to previous data collection methods?

DTS makes use of the effect that temperature has on the light transmission characteristics of glass fibers. When an intense laser pulse is sent down a fiber optic cable, most of the light proceeds unimpeded; some of that light bounces back as a faint echo however, and it is the analysis of that backscattered light that yields critical environmental data.

Comparison of three wavelengths of the backscattered light—the wavelength of the injected light, the wavelength of the band just above that frequency (the Stokes band), and the wavelength just below the frequency of the injected light (a wavelength called the anti-Stokes band)—can identify the temperature of the cable at the source of the echo. Location of the backscattering is then determined by the arrival time of the backscattered light, with each additional nanosecond of delay corresponding to one foot of glass fiber. In essence, the entire fiber acts as a single sensor capable of communicating information about multiple data points.

This methodology offers superior results both in terms of its high spatial resolution (one-meter intervals along fibers that can exceed 10 kilometers in length) and its high temperature resolution (0.01°C). When you remember that the analysis is being performed with rugged, telecommunications-quality fiber optic cable capable of in situ temperature measurements in harsh environments, it's not hard to understand excitement on the part of environmental researchers who had previously relied on traditional "point measurement" instruments. Says Selker, "[This] technology's outstanding temperature resolution in both space and time is filling gaps in understanding that have stymied research of complex ecological processes...This is the stuff of which scientific revolutions are made."

One Size Doesn't Fit All

The complex ecological processes John Selker mentions are the factor that sets an ecologist's "laboratory" apart from others and makes the discipline an ideal proving ground for DTS. As he explains, "Environmental dynamics reflect processes spanning from centimeters to kilometers, and this mixture of scales presents profound challenges for description, modeling, and observation." A stream, for example, may be fed by underground aquifers through multiple imperceptible fissures. Point measurement instruments that work fine in a lab setting would be hard pressed to identify all of these invisible groundwater contributions as easily as a single spool of optical fiber stretched across the whole length of the stream.

Workshops Selker conducts in the H. J. Andrews Experimental Forest in the Cascade Mountains spread expertise in these unusual new sampling techniques to other environmental scientists, while also expanding the technology's already impressive resume. In one experiment described in a June press release, researchers crisscrossed cables across a mountain valley, revealing an invisible river of cold forest air that travels down the mountains with the approach of dusk.

More of the pioneer's future plans focus on moving from passive observation to active environmental control, using the timely feedback that DTS can provide to predict events such as thermally induced fishkills. Another upcoming project may involve atmospheric profiling using tethered blimps.

Whatever the application, one thing's certain. Ecology in the age of fiber optic technology promises to be anything but boring.

—Ed Schock

ECONOMICAL...WITH A HANDY DESIGN

All cylinders are not alike—just look at these Vista cylinders with a detachable, sturdy plastic base!

- Supplied in two parts
  - a strong, accurate, glass "To Contain" cylinder with ±5% tolerances
  - colored, easy-to-find base absorbs impacts to reduce breakage
- Easy to store—remove base to stack cylinders
- Bumper guards protect cylinder—supplied with 25, 50 and 100mL sizes
- For careful pouring and reading, the 10mL cylinder comes with a funnel top
- Snap caps provided for all sizes

CAT. NO.	CAPACITY	NO. PER PACK	PRICE
S95186	10mL	12	$69.60
S95186A	25mL	12	$63.20
S95186B	50mL	12	$70.55
S95186C	100mL	12	$89.40

CORNING

QUICKSILVER CHRONICLES—MERCURY'S DARKER SIDE

Mercury, or quicksilver as it is sometimes called, is the stuff of mythology, planetary nomenclature, and chemistry. Over the years, mercury (Hg), the element, has been very important in industry and research. As useful as it has been, it has also left a haunting legacy, for all its positive qualities are equaled by the specter of its human toxicity and role in environmental degradation. On the personal level, keeping mercury out of contact with individuals is a critical goal for industry, labs, the general public, and schools. On the environmental level, history has shown us unthinkable environmental disasters that we must mitigate (or, preferably, avoid).

Elemental mercury is a silvery liquid metal at room temperature. A naturally occurring element in the earth's surface, mercury cycles between soils, the atmosphere and surface waters. It doesn't degrade, nor is it destroyed by combustion. Instead, mercury changes into a vapor that can travel long distances when volatilized. As an organometallic, it is highly toxic and bioaccumulative.

Why the Hatter Was Mad

Mercury has a checkered past. The phrase "mad as a hatter" may bring to mind Lewis Carroll's beloved children's book *Alice in Wonderland*, but the term was already being used decades before Carroll's time to describe the effects of occupational mercury poisoning.

In the early nineteenth century, hat makers used mercurous nitrate to mat down the fur incorporated in felt hats. (The process was called "carroting," as application of the mercury compound turned the fur orange.) Working in poorly ventilated spaces, these hatters would breathe in the compound and begin to accumulate toxic levels of mercury in their bodies. Symptoms of such mercury intoxication included slurred speech, loss of coordination, shaking/trembling, anxiety and/or irritability.

Lab Tragedy

While no longer a scourge of the apparel industry, workplace mercury poisoning (or Mad Hatters Syndrome) is not unheard of in the modern world. Most famous and tragic among these incidents is the story of Karen Wetterhahn, the late Dartmouth College professor. A renowned chemist with experience in the field of heavy metals, Wetterhahn died in June 1997 following what may have been a single drop of exposure to an especially toxic and volatile form of mercury. As Karen Endicott of the *Dartmouth Alumni Magazine* explains in her memoriam "The Trembling Edge of Science," "The dimethylmercury, clear like water but three times as dense, hadn't burned or otherwise announced itself as it seeped into her skin. Even the wetness of the drop or two would have been indistinguishable from the clamminess that builds up inside rubber gloves. There was no reason for Karen Wetterhahn to think that she had been exposed... On February 6, barely three weeks from the moment she noticed anything was wrong, (she) slipped into a coma." As Endicott points out, the form of mercury that Wetterhahn was exposed to is a rare one, used exclusively in heavy metals research. The single drop that contacted her skin carried with it a concentration of mercury 80 times the toxic threshold.

Minimata Disease

Mercury's toxic trail also leads into the environment where tragedies have occurred on a grander scale. A now-classic case of environmental pollution occurred in Minimata, Japan.

In the 1950s, strange things began to occur in Minimata. Crows fell from the sky. Seaweed disappeared from the shore where residents launched their fishing boats. Cats were seen to exhibit abnormal behaviors, appearing to go insane or commit suicide. Their erratic movements and convulsions led residents to refer to a "cat dancing disease". In 1956, the first human case of what is now called "Minimata Disease" was recognized—the first of over 2000 cases.

The "Strange Disease," as it was originally called, seemed to develop without warning and started with numbness in hands and feet that led to loss of fine motor skills and a stumbling gait, followed by vision and hearing loss, and difficulty in swallowing. These led to convulsions, coma and death.

After years of corporate denials and false mitigation measures a local chemical manufacturer, Chisso Corporation, was found to be the source of toxic discharges that carried the mysterious disease agent into the environment. Their use of mercury as a catalyst in the manufacture of acetaldehyde led to the discharge and bioaccumulation of methyl mercury, a dangerous neurotoxin. Any human or animal consuming fish from the affected waters—like cats or crows—was stricken.

Even today, congenital effects of this scourge—originally mistaken for cerebral palsy—can be found in those who were exposed to organic mercury in their mother's womb. Unlike with many other chemicals, the placenta does not protect; rather it concentrates methyl mercury, resulting in greater exposure to the fetus.

New Tool to Support Environmental Stewardship

We've come a long way in environmental protection since the 1950s. Laws and regulations in many countries have limited gross discharges of mercury compounds, and environmental cleanups have reduced the exposure from some earlier incidents. On a global scale, however, we are not making much progress.

Continued on page 7.

Quicksilver Chronicles, continued.

According to Gregory Tew, professor of polymer science and engineering at the University of Massachusetts Amherst, "global mercury emissions continue to rise from incineration of solid waste and the combustion of fossil fuels." He notes that mercury has a long lifespan in the atmosphere, a trait that can lead to its distribution over large tracts of land and—ultimately—many different groundwater resources. Where elemental mercury is deposited, bacteria can convert elemental and ionic mercury into methyl mercury, the same agent as in Minimata disease.

Analysis and investigation are among the first steps for effective environmental action. Analysis has not always been as straightforward as we need it to be. Generally speaking, existing technologies fall short by requiring the user to choose between speed and reliability. Atomic absorption/emission spectroscopy and inductively coupled plasma mass spectroscopy are not technologies that lend themselves to rapid, on-the-spot analysis. On the other hand, states Tew, previous colorimetric or fluorescence field sensors have suffered from interference by competing metal ions, have proven incompatible with aqueous media, and/or have exhibited slow response times for ionic mercury.

By contrast, a mercury detection process developed by Tew and his associates and reported in the March 2008 issue of the journal *Chemistry—A European Journal*, is virtually instantaneous, totally portable, and seemingly unaffected by the presence of environmentally relevant ions.

In the Pink

The dipstick-style device created by the Amherst team was made by coating cotton filter paper with a polymer containing terpyridine, a molecule known for its ability to bind to metals. The result is a sensor that immediately turns pink when dipped into a solution with a mercury concentration of 2 parts per million. The sensor will also turn pink within 30 minutes following an exposure to mercury concentrations down to 2 parts per billion (the safe drinking water limit established by the U.S. Environmental Protection Agency).

The implications of this soon-to-be-patented technology for environmental field monitoring are obvious, and the breakthrough couldn't be more timely. Inexpensive, reliable field tests for mercury will help researchers to assess the scope of an emerging environmental crisis we would have to be "mad as hatters" to ignore.

Mercury in the Classroom and Lab

Because it conducts electricity, expands uniformly with temperature and easily forms alloys with other metals, mercury has been widely used in many products found in schools. Elementary or secondary schools may have elemental mercury from science experiments or a variety of mercury-containing products in their facility, such as batteries, chemical compounds, lamps, and thermometers. Increasingly, laws are being enacted that restrict or prohibit the sale of mercury and mercury-containing products to communities and schools, but the legacy remains.

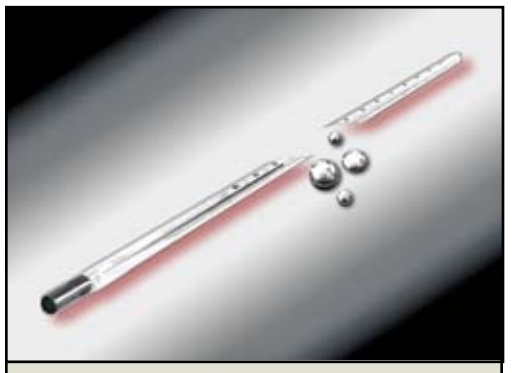
Schools can reduce use of mercury-containing products and encourage recycling for products with mercury. Good mercury management practices include:

- Using videos to demonstrate the chemical principles and phenomena associated with mercury in science experiments and laboratories
- Replacing mercury-containing compounds or reagents in laboratories with mercury-free alternatives
- Substituting zinc air or silver oxide batteries for mercuric oxide (mercury-zinc) batteries
- Using safe, non-mercury cleaners and degreasers in labs, housekeeping departments, and maintenance areas
- Establishing a battery collection program
- Continuing to use fluorescent lamps (as they use much less energy than regular bulbs) but switching to low-mercury fluorescent lamps
- Recycling or disposing of mercury-containing products in an environmentally sound manner
- Labeling instruments containing mercury
- Ensuring students and workers are familiar with school policies on proper disposal practices when working with mercury solutions in the lab
- Following proper procedures when cleaning or refilling instruments containing mercury; instrument cleaning or refilling should be done in a well-ventilated area and over a tray to contain any spills
- Establishing spill response measures to ensure the mercury already in the school is handled in a safe and proper manner

To assist educators, the Mercury in Schools Program has developed a curriculum guide to help students learn about the health and environmental concerns associated with mercury, find out where it is in their school and homes, and help school officials and family members do something about it. To download a copy of this guide, visit *http://www.mercuryinschools.uwex.edu/curriculum/index.htm.*

With continuing efforts to improve our analytical options, as with Gregory Tew's breakthrough, and attention to mercury exposure reduction, the stage is being set for environmental improvement. While eliminating global mercury contamination is well beyond our individual means to control, we can follow good mercury practices to make our schools and our students a little safer.

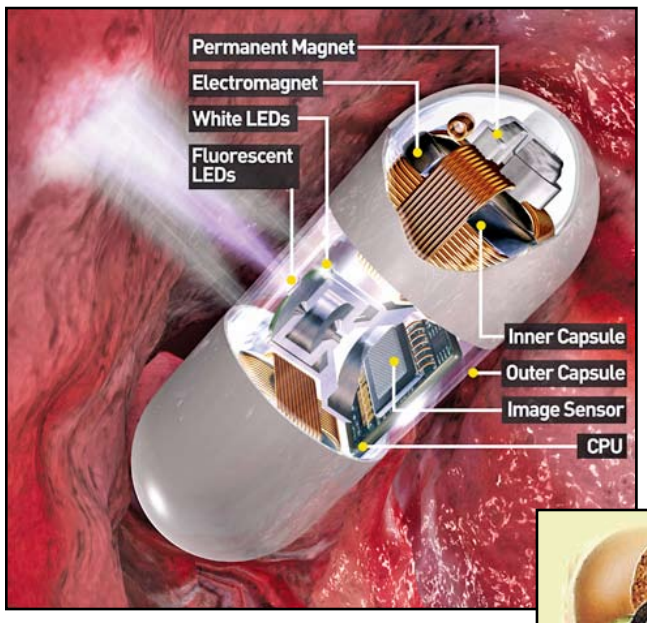
—Edwin Schock, Mary Rose Thomas-Glaser, Merry Morris



MERCURY EXCHANGE PROGRAM

Fisher Science Education, in conjunction with Thermo Scientific ERTCO, is actively working to help schools eliminate mercury-containing instruments. Through our Mercury Exchange Program, schools and educators can recycle a mercury-containing thermometer each time a new non-mercury thermometer or sling psychrometer is purchased. Your old mercury instruments will be properly reclaimed free of charge! To learn more, call your Fisher Science Education Customer Service Representative at **1-800-955-1177.**

LOOKING FOR TROUBLE: CAMERA IN A PILL DETECTS EARLY SIGNS OF DIGESTIVE SYSTEM PROBLEMS

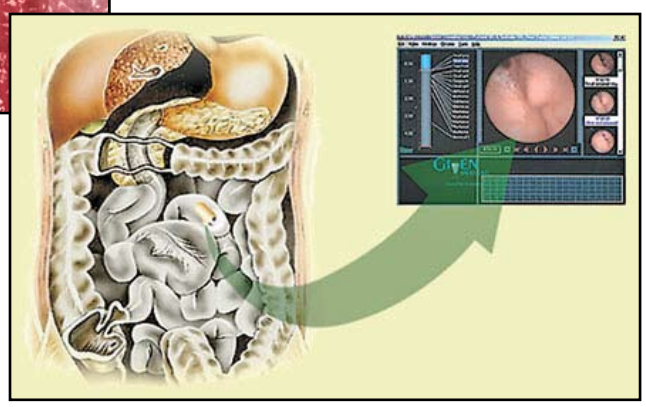


Each year, more than three million people in the U.S. are hospitalized with gastrointestinal disease. The cause is never found in about one third of those cases. Examination of the esophagus (endoscopy), the stomach (gastroscopy), and the colon (colonoscopy) yields some information, but they are expensive procedures that cause the patient distress. And the small intestine has remained inaccessible.

Thankfully, technology advances. Researchers have developed camera pills ("pillcams") that could mean the end of such procedures and give physicians a clear picture of what's going on in the entire digestive tract.

Camera pills have been around for about five years, but until recently they were useful for examining only the upper and lower gastrointestinal tracts. That's because they travel too quickly through the esophagus to the floor of the stomach to render any useful information on the way. Once in the intestine, however, two to four images per second are transmitted to a receiver the patient wears on his/her belt. The images are then retrieved and analyzed for evidence of hemorrhages, polyps, or cancer.

Unfortunately, those who must have their esophagus and/or stomach examined still had to endure endoscopy. The procedure is routinely done on an outpatient basis but requires sedation, a healthcare facility, attendance by healthcare staff, and several hours of recovery time—not an inexpensive or particularly pleasant experience. Fortunately, recent advances in pillcam technology have come to the rescue.



Easier to Swallow—Costs Less, Too!

The PillCam ESO records the state of the esophagus. It's more comfortable for the patient and cheaper to use than a traditional endoscope. A smooth plastic capsule about the size of a large vitamin pill, it has video cameras on each end and is equipped with a battery and internal light source.

This procedure starts with the patient lying down after swallowing the camera pill. The pillcam then glides slowly through the esophagus. It takes about 2,600 color pictures (14 per second), which are transmitted to a recording device and viewed on a computer screen. The patient sits up gradually to help the pillcam on its journey, and the capsule is passed naturally in less than 24 hours with no discomfort.

Within 20 minutes of ingestion, the PillCam ESO gives physicians enough information to evaluate and diagnose trouble, such as gastroesophageal reflux disease (GERD) and Barrett's esophagus, a precursor to cancer.

Up and Down, Back and Forth

Remote control is the latest concept in pillcam technology. The IBMT device is similar to other pillcams with one additional feature: a magnetic device about the size of a chocolate bar steers and stops the camera as it travels. After the pillcam has been swallowed, the doctor moves the magnet up and down the patient's body. The pillcam follows precisely, even standing still in the esophagus for about 10 minutes while the subject sits upright.

This level of operator control enables the doctor to stop the camera in the esophagus to closely examine a troublesome area and to scan stomach walls. A prototype has been successfully tested and should be available in the near future.

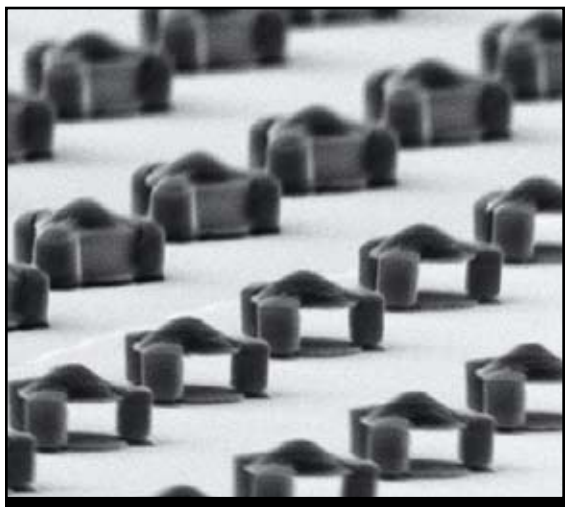
Spinning Wildly Under Control

The Sayaka pillcam gives physicians an inside look at an area that's always been difficult for them to examine: the small intestine. And it's unique: it continually spins 360 degrees as it travels through the digestive tract, shooting pictures directly at the tissue walls. Cameras in other pillcams face forward, so they shoot pictures only at tissue that's in their periphery.

Over eight hours, the Sayaka pillcam captures up to 870,000 images. The patient wears a vest that transmits power to the pillcam and captures the images. Doctors can replay images as video and magnify any area up to 75-fold to study details. Through it all, the patient feels nothing and eliminates the pillcam naturally.

—Alida Cataldo

COLORING THE MRI



Credit: G. Zabow, NIST/NIH

Frequent Uses

Physicians are better equipped with MR images to evaluate certain parts of the body and certain diseases than they would be with other imaging methods, such as x-ray, ultrasound, or CT or CAT (computed tomography) scanning. The MRI scan is most commonly used to evaluate the organs of the chest, abdomen and pelvis (i.e., the heart, lungs, liver, kidneys, spleen, and pancreas). MR imaging is also used to assess reproductive organs, pelvic and hip bones, and blood vessels. Physicians use MR imaging to help diagnose tumors, heart abnormalities and problems, lesions on the liver and other organs, arterial and vascular irregularities and diseases, and an array of other diseases or aberrations.

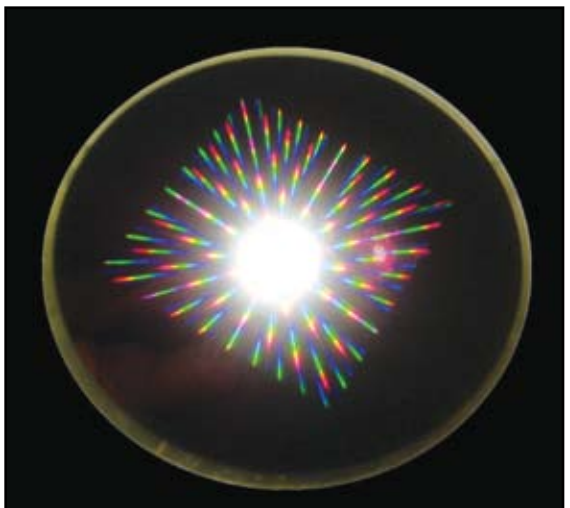
Scientists have discovered a way to add color to magnetic resonance imaging (MRI)—a discovery that might possibly improve and enhance the accuracy of the information the MRI scan collects.

Unlike x-ray machines that use ionizing radiation, magnetic resonance imaging (MRI) techniques produce detailed images of the human body using a powerful magnetic field, radio waves, and a computer. The resulting gray-scale pictures depict organs, soft tissues, bone, and virtually all other internal body structures. They can then be examined directly on a computer monitor or printed. These images assist physicians in the diagnosis and treatment of various medical conditions. Chemical contrast agents like chelated gadolinium ions help improve the readability of the images, but they still are typically only in shades of gray.

Seeing the Color

MRI creates its gray-scale images as it scans identifying radio waves produced by hydrogen protons in water molecules as they relax from stimulated magnetic states. The variations in the signal, based on the water content of different tissue types and their chemical and magnetic surroundings, are what is shown on the images. The chemical contrast agents injected to highlight some signals only show the distinction between light and dark areas of the gray-scale image.

However, the development of tiny magnets—specially designed to create specific signals in narrow radio frequency bands that are picked up by MRI scanners—could change all that. These micro-magnets could allow different structures in the body—such as blood vessels or tumors—to be lit up in different colors. The tiny magnets would be made into a serum that would replace the chemical contrast agent. Being able to see various colors in an MRI scan will enable physicians to have more accurate information and see things they may have not seen before.



Credit: G. Zabow, NIST/NIH

Each micro-magnet is made up of two round discs stacked on top of each other with a gap in the middle. As water flows between the discs, protons within the water's hydrogen atoms create radio-frequency signals that are more specific and powerful than free water molecules. By changing spacing, size, and thickness of the magnets, scientists can manufacture any color desired. Each color could highlight a different area of the body. Red could be used for tumors, blue for blood vessels, green for normal cells, and so on.

Still in the Gray (for Now)

Even though the creation of these micro-magnets is a huge medical milestone, this new technology has a long way to go before anyone will see it used in an MRI scan. First of all, receiving the approval to use new contrast agents, such as the micro-magnet serum, could take up to 10 years, and the new agent has yet to be tested in biological systems. Second, and probably most important, scientists have constructed the prototype micro-magnets out of nickel. Unfortunately, nickel is toxic to the human body; however, scientists are confident the magnets can be fashioned out of biologically safer metals like iron.

Once approved, tested, and biologically safe, scientists claim the new micro-magnet technology would add functionality to complement existing MRI techniques, allowing physicians to more accurately and quickly diagnose or monitor abnormalities and disease.

—Jennie Culver

HOW DOES AN MRI WORK?

Would you believe that the MRI machine actually reorients your atoms? Indeed it does. It aligns atoms along the MRI's magnetic field. Many of the atoms are in opposing directions and cancel out each other's charge. Some aren't, and these are the most important for imaging. When hit with a radio pulse generated by the MRI, these atoms spin in a characteristic way for the tissue in which they exist. When the pulse is removed, these atoms shed energy. That energy is converted to an image that gives a visual representation of the tissues involved.

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SURGICAL ROBOTS: ON THE CUTTING EDGE

Allegheny General Hospital recently held an open house to introduce the newest member of its staff—a $1.5 million da Vinci Surgical Robot. Doctors at the Pittsburgh hospital have already used the new surgical assistant to treat prostate cancer and gynecological conditions; now, they are considering it for cardiac surgery. As "futuristic" as this concept may sound, the surgical robot is, in fact, one of modern medicine's latest and most innovative technologies, and has become a fast-growing trend in hospitals nationwide.

The Wave of the Future

About 700 hospitals across the country are now using the robotic system, according to Craig Nicholson, clinical sales representative for Intuitive Surgical in Sunnyvale, Calif., which markets the da Vinci robot. The device was named after the famous painter, Leonardo, because he is credited by some with having created the first robot. Cleared by the FDA in 2000 for general laparoscopic surgery, the robot is now being used for a wide range of procedures, including cardiac valve repair, prostate removal, hysterectomies, pediatric gallbladder removal, heart bypass, and gastric bypass, to name a few.

Dr. Don L. Fisher, a cardiologist who graduated from medical school in 1943, was more than impressed when he tried out the robot for the first time. He never imagined one day he would use his fingertips to command a robot to precisely maneuver tiny surgical instruments. "I can think of so many uses for this," said Fisher. "For minimally invasive surgery, there are great advantages. With no massive tissue recovery, you could send patients home in a day."

Advantages

There are a variety of benefits to robotic-assisted surgery. First of all, the robot eliminates the possibility of tremors from a surgeon's hand, which obviously could be disastrous if a vital organ were nicked. Further, a surgeon can scale, or ratio, his finger movement to that of the robotic instrument. A movement of inches at the console can be scaled down to centimeters in the patient. Finally, the fatigue factor is eliminated because the surgeon does not have to hold his arms steady for long periods of time as is often required in complex operations.

Dr. John F. Boggess, a gynecological oncologist who has used the robot for gynecological procedures, said he found the robotic operation more precise than conventional surgery. "It allows a patient to return to normal activities much more quickly, with a shorter hospital stay. We also found a reduced use of pain medications after robotic surgery, with fewer complications."

In robotic surgery, the da Vinci robot acts as an extension of the surgeon's hands in a way not previously possible with minimally invasive surgery via laparoscopy, said Boggess. "That's the key to its success. The robot takes us a big step beyond traditional laparoscopy. It allows us to operate more naturally, the way we do in open surgeries, but still preserve a minimally invasive approach with small incisions."

How It Works

As with laparoscopic procedures, robotic-assisted surgery begins with the creation of small incisions measuring one- to three-fourths of an inch. Sleeves are inserted into these incisions as ports for placement of a video camera and other specialized instruments. According to Boggess, "Robotic surgery allows us to virtually place our hands inside the patient without the need for large incisions." After the sleeve is inserted, the robot is wheeled into position.

About the size of a large man but resembling a post with three arms, the robot stands hunched over a surgical table. Its center arm is docked to a port that holds the camera. Its other arms are docked to instrument ports, each holding an interchangeable surgical tool such as miniature forceps or scissors. From a distance of several feet, the surgeon is seated at a console looking at a screen that projects a magnified, three-dimensional image of the surgical site. Placing his/her fingers into small Velcro® loops, the surgeon pinches and twists his fingers to control the movement of the robot's arms. Magnification is controlled by foot pedals.

While laparoscopy allows manipulation of instruments up, down, and side-to-side, the da Vinci robot allows more natural wrist movement. Its arms have wrists with eight degrees of freedom, allowing the surgeon to bend more easily around corners and work with a more natural, full range of motion. Direct, natural eye-hand instrument alignment is similar to open surgery, with excellent all-around vision and an added benefit—the ability to zoom in and out.

Future Outlook

The da Vinci robot offers surgeons more flexibility, range of motion, precision, and stamina to perform delicate operations involving fine tissue manipulation. It also offers patients a less invasive surgical option with fewer complications and improved recovery time. Dr. Eugene Scioscia, the Chairman of Obstetrics and Gynecology at Allegheny General, believes this is indeed the wave of the future. "This is the next phase in surgery," he says. "In a few years residents are going to say to me, 'Dr. Scioscia, how did you operate without this?' "

—Joe Giacobello

Ancient Robots

While "robots" are generally perceived as modern-day wonders, the idea of the robot was actually conceived as far back as the Middle Ages. In the year 1206, Al-Jazari, an engineering genius of the Islamic world, designed and constructed the first programmable humanoid robot. It consisted of a boat with four automatic musicians that floated on a lake to entertain guests at royal drinking parties. A programmable drum machine with cams and levers enabled the "drummer" to play different rhythms and patterns. The robot band performed more than 50 facial and body actions during each musical selection.

PHOENIX—RISING FROM THE ASHES TO INVESTIGATE THE MARTIAN ARCTIC

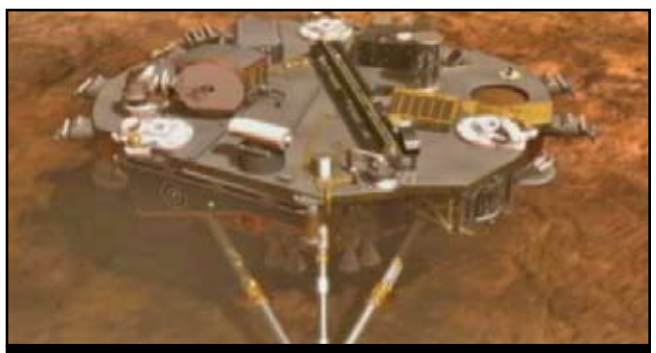

Photo credit: NASA/JPL-Caltech/University of Arizona/Texas A&M University

Named for the mythical bird that arises from ashes of its predecessor, the Phoenix Mission to Mars is reusing components of previous unsuccessful Mars missions—the Mars Surveyor Program 2001 lander and scientific instrumentation from the Mars Polar Lander are back in action to attack critical questions on the history of water and potential for life on the Red Planet.

Does Mars Have a Watery Past?

Currently Mars is a frigid, desert planet with no liquid water, but the Mars Global Surveyor, Odyssey, and Exploration Rover missions suggest that enough liquid water flowed billions of years ago to erode canyons and collect in shallow lakes. This is a tantalizing possibility because liquid water is a prerequisite for biological life.

As part of NASA's Mars Exploration Program, Phoenix seeks to verify the presence of water and habitable conditions in the martian arctic. Previously, the Odyssey Orbiter revealed large amounts of subsurface water-ice (as opposed to carbon dioxide-ice) in the northern arctic plains, so Phoenix will build on this observation by digging into the soil and water-ice just below the surface. These ice deposits may have been liquid water as recently as 100,000 years ago.

Traces of Life in Martian Soil?

Earth's soil is teeming with microscopic life. Also present are dormant forms such as bacterial spores that can remain unchanged for millions of years. Given the right conditions, they can break their dormancy and resume normal cellular functions. Could there be similar colonies of dormant microscopic life in martian soil, waiting for the times, maybe every 100,000 years or so, when the harsh climatic conditions are mitigated enough to support life?

Is there a habitable zone in martian soil or a zone favorable for life at the soil-ice boundary? Or is there a toxic material in the soils, perhaps an oxidant acting in high UV light conditions, that suppresses or eliminates biological life? If so, perhaps digging down just a few centimeters could reveal a more habitable zone.

Tools of the Scientific Trade

To provide answers to these questions, Phoenix Mission advisers have assembled tools that are accurate, yet robust enough for extra-terrestrial use. The "muscles" of the operation, the Robotic Arm, digs trenches, scrapes up water-ice, and carries samples to the science deck for analysis. It also takes visual images and temperature measurements. The Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) records pH, presence of minerals, conductivity, and redox potential. Its microscope examines soil to determine its origin and mineralogy. The Thermal and Evolved Gas Analyzer (TEGA), a high-temperature furnace and mass spectrometer, heats and analyzes samples to answer questions about the chemical nature of the soil. The Meteorological Station (MET) transmits laser light pulses into the atmosphere, which bounce off particles in their path. The reflected light and time of return to the MET reveal details on the particles and their location.

Only time will tell if Mars' many secrets will be revealed, but as the mission proceeds, you can follow the day-to-day action—practically as it happens. See "Martian Diaries" to find out how.

—Merry Morris

MARTIAN DIARIES

You can feel part of the Phoenix Mission by following daily happenings posted on the official Phoenix Mars Mission Web site (http://phoenix.lpl.arizona.edu). Click on "News" to get each day's activities. Here are some days in the "life" of the Phoenix Mission:

June 15 – A trench, informally called "Dodo-Goldilocks," is enlarged and shows white objects. Are they water-ice, carbon dioxide-ice, or salt?

June 19 – The pieces of shiny white materials observed on the 15th have disappeared! Is it ice that vanished as it sublimed (changed from solid directly to gas)?

June 20 – Scientists confirm the presence of water-ice by the Mars Lander! Carbon dioxide-ice would not have been stable for the period observed. Salt would not have disappeared. Experiments can now commence to determine the ice's mineral—and perhaps organic—components.

June 23 – Wet chemistry lab tests its ability to melt ice for analysis with stored sample of water ice.

INFINITE POSSIBILITIES

Over-caffeinated mornings, obligation-crazed afternoons, and deadline-fueled evenings have become a ritualistic routine for the corporate-oriented adult. It's often difficult to look back and remember a softer time, when the weightlessness of childhood was the only sensation that mattered.

Parents, educators, and researchers alike are recognizing the innate creativity present in every child is a sculptable clay. This moldable material is a blueprint, and with the right guidance, this blueprint can be used to build an early enthusiasm for learning. Research has shown that by applying basic scientific principle to creative, unstructured play, we are preparing our children to become more perceptive, better-educated adults.

Take a pile of building blocks; add a five-year-old child's imagination and the positive guidance of an actively involved adult. The byproduct of this union is a question-and-answer session that could lead into an introduction to inductive thinking. Marian Edelman Borden, professional writer and celebrated author of *SMART START, The Parents' Complete Guide to Preschool Education*, writes "a child learns about gravity, stability, weight, balance and systems from building with blocks." What makes this play unstructured is its ability to happen naturally. What makes this play beneficial is its ability to stimulate an unknown concept through an unlikely channel.

Applied allegorically, the building blocks of math and science construct concepts that outline life. In a survey conducted by the National Commission on Mathematics and Science, it was reported jobs requiring math and science skills have increased by 5.6 million this year alone. Further research reveals, that as we evolved into the career-focused adults who obtained these 5.6 million jobs, we did so by building on a foundation formed as play-centered children. The parallels are undeniable. Toy microscopes become real microscopes; inquisitive and creative children become inquisitive and creative adults.

Childhood play enhanced and nourished every aspect of our development. Highly respected American philosophers and logicians like John Dewey and Charles Sanders Peirce have collaboratively documented that "childhood play is not only well aimed, but the very basis of our civilization." As the work-in-progress products of play, it's time to roll up our sleeves, interact, and share our wealth of experience.

We have the knowledge. We have their attention. They have everything to gain.

Kelly Burgess, author of *The Science of Play*, offers the following activities to introduce children to the sciences:

Plants: Plant two of the same kind of seeds in a small pot. Use one as the control, and treat it normally with water, fertilizer, and good sunlight. Do different things to the other plant, such as denying it sunlight, watering it irregularly, etc. Observe the differences. If you have more than one child, have them each plant different plants. What is the effect of environment?

Measuring: Toss a marble and measure how far it rolls from where it falls. Estimate the length of anything around the house, from towels to teddy bears, and measure them to see how close you are. What are the differences in centimeters and inches?

Magnets: Using a horseshoe magnet, explore items around the house and see what items are attracted to magnets. For example, paperclips are; money is not. Try bringing two rectangular magnets together; do they repel or attract? Turn one magnet around; what happens next?

Density: Water is always fun to play with. Try playing, "Does it float?" Using soap, small pebbles, spoons, and anything else that can't be ruined by water, see if the object sinks or swims. This can also be combined with some fun weighing. What's the heaviest object that floats?

Gravity: They know what they drop goes down, but why and how fast? How can they affect the result, such as making a nest for an egg and dropping it from the top of the jungle gym—or perhaps an egg parachute? What happens after something hits the ground and why? Does it bounce or just go splat?

Physics: Build a long bridge from any available materials, such as cardboard, blocks, straws, or whatever else is available. How can you support the bridge when the center begins to sag? How can you reinforce the bridge to hold weight?

The concepts are as easy to comprehend as smearing a glob of silly putty onto newsprint and giggling at the outstretched outcome. The possibilities are infinite.

Tightly woven within the thick masses of life's strata was an unpublished roadmap that guided us from child to adult. We know what type of adult we became and how our interactions and introductions to life's concepts applied. Isn't it exciting to think their journey could only benefit from the gentle coaching of a back-seat guider?

—Angela Rydeski

FOUR GREAT TIPS FOR TEACHERS

1. **When children are given the freedom and opportunity to explore, wonder, and ask questions, they will naturally pick up information, expand their experiences, and draw new conclusions.**
2. **Constructive discussion is incredibly valuable, but make sure to follow the child's lead and cater to their interests (to the extent you can in the school environment). Encourage their creativity.**
3. **Remember to keep a patient and open mind—even when lessons and experiments don't turn out the way they were anticipated. Explore and learn simultaneously.**
4. **By encouraging children to appreciate science, we are encouraging children to appreciate the beauty, order and complexity of our natural world. Science is all around you; jump in and have fun.**

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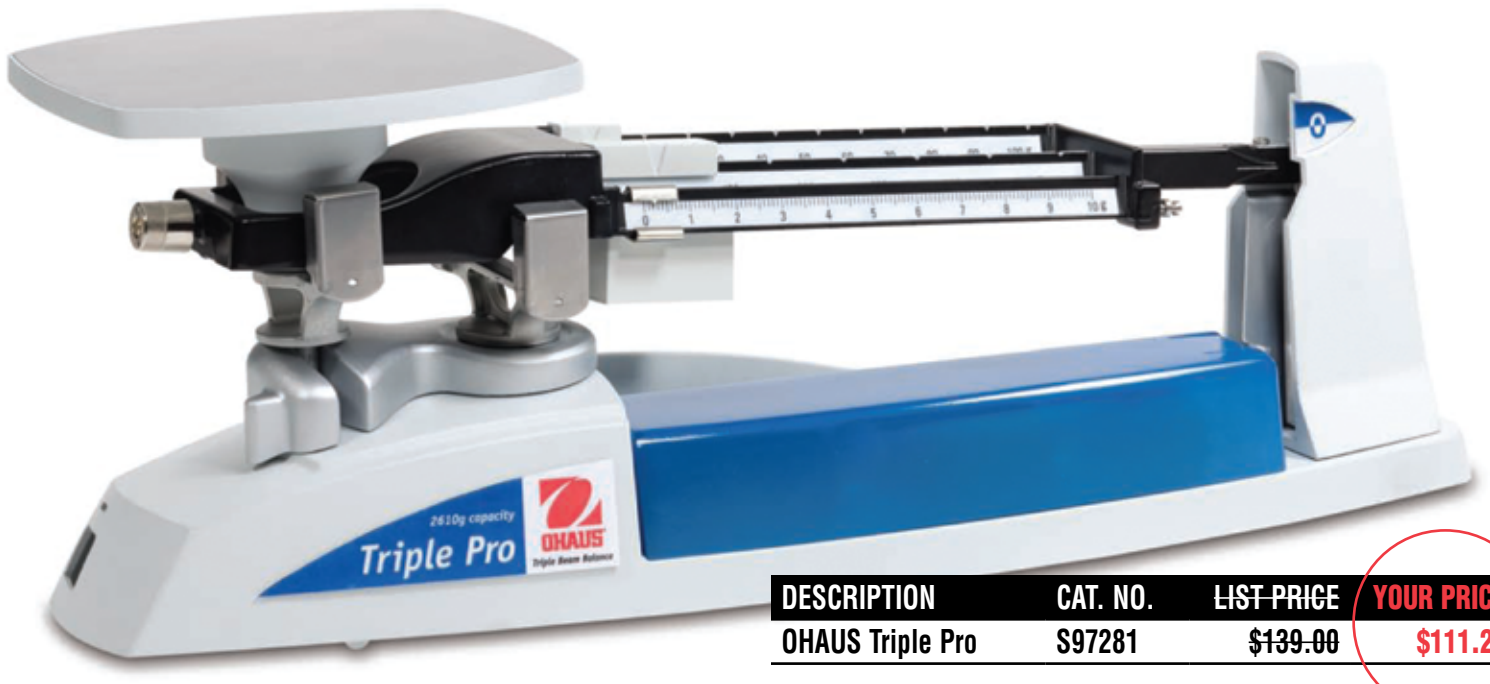

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IMPORTANCE OF PLAY

Be it "follow the leader," dodge ball, Red Rover, blind man's bluff, or tag with the neighborhood kids, some adults might be hard pressed to estimate the hours of their youth spent on these and other children's games or climbing around the jungle gym at the school playground. Surprisingly, today's young minds may not have the same difficulty; recent surveys show increased testing standards and other academic demands have led one-third of elementary schools to eliminate recess from their daily schedules altogether. What is at stake, however, is more than just a half-hour to blow off steam; current studies indicate play has a direct impact on brain development.

Why Do We Play?

After decades of interest and research, the function of play remains largely a mystery.

Most theories relate back to natural selection; play must aid in survival and benefit reproduction or it would have been weeded out of the species long ago. Though its purpose is unclear, play studies repeatedly indicate its importance for children's health, well-being, and skill development.

In general, scientists have gathered the same basic facts about play. It is characteristic of vertebrates, particularly mammals; it is prevalent in youth and mimics normal behavior adapted from its usual context. For example, children learn to talk and walk by playing: through babbling and crawling. Dramatic play between preschoolers teaches how to lead, follow, compromise, and negotiate. Physical activity has been shown to improve concentration in class, academic performance, and attitudes toward learning.

Researchers looking at play behavior generally classify three types: object play—pushing, throwing, or manipulating something inanimate; locomotor play—frolicking, somersaulting, jumping, or similar physical action; and social play with others, which is probably the most studied. With arguments for and against each, a majority of studies have attributed play's function to training, whether physical, social, or cognitive.

Biological Benefits of Play

A 2007 report from the American Academy of Pediatrics found play promotes not only behavioral development, but physical brain growth as well. Researchers note the amount an animal species plays correlates to its brain size. Sergio Pellis of the University of Lethbridge in Alberta, Canada, and Andrew Iwaniuk of Monash University in Melbourne looked at measurements for 15 orders of mammals and discovered larger brains are linked to greater levels of play while relatively small brains are linked to lower levels of play. In addition, they found the amount the brain grows between birth and maturity in primates reflects the amount of play in which they engage.

Similarly, other scientists have noticed that time spent playing peaks during particular periods of brain development. John Byers of the University of Idaho and Curt Walker of Dixie State College in St. George, Utah, found a link between playing patterns and cerebellar synapse formation. The cerebellum provides critical coordination to the limbs as well as hand-eye coordination. In one study, they found mice started playing at 15 days old and peaked in locomotor play activities from days 19 to 25, which corresponds to the creation of synapses.

Evolutionary anthropologist Kerrie Lewis from University College in London hypothesizes one step further. She compared the size of the neocortex among primate species and found that the larger it was, the more social play the species practiced, as opposed to object or locomotor play. The neocortex of the brain is responsible for social reasoning. Her findings support her theory that different types of play evolved over evolutionary history to allow different brain regions to develop.

Her ideas mesh with Byers' studies involving locomotor play and cerebellum development. Skeptics caution these theories are based on observing animals and perhaps do not relate to human play. However, these initial findings could suggest that when it comes to developing intelligence, play is just as important to children as hard work and study.

—Aprile Smith

OTHER RESOURCES FOR CHILDREN'S PLAY

The International Play Association (IPA) interdisciplinary organization seeks to protect, preserve, and promote children's right to play. **http://www.ipausa.org**

The Frost Research Collection at the University of the Incarnate Word. The largest children's play and play environment research collection in the U.S. **http://www.uiw.edu/frost**

The National Institute for Play Seeks to bring unrealized knowledge, practices, and benefits of play into public life. **http://www.nifplay.org**

The American Academy of Pediatrics (AAP).Committed to optimal physical, mental, and social health and well-being for all children. **http://www.aap.org**

A DINOSAUR EXHIBIT EVOLVES

The Carnegie Museum of Natural History has turned dinosaurs loose on the public in Pittsburgh, PA. On June 15, the museum opened the final phase of a three-year, $36 million renovation project, unleashing 19 fossil skeletons in an 18,600 square-foot space.

Dinosaurs and Biodiversity

Renamed "Dinosaurs in Their Time," the main exhibit's dioramas surround visitors with scenes from the Triassic, Jurassic and Cretaceous periods. Not only have fossils been remounted in scientifically accurate and active poses, but they now have a place within appropriate ecosystems, sharing their space with the plants and small animals also living during those periods to illustrate the rich biodiversity of life in the past. Familiar species like buttercups and a magnolia tree populate the Late Cretaceous Period exhibit.

You've Come a Long Way, Dippy

In 1898, Andrew Carnegie decided that his museum in Pittsburgh needed dinosaurs after reading about an enormous skeleton discovered in the western U.S. The following year, excavation in Sheep Creek, Wyoming, yielded *Diplodocus carnegii*, a well-preserved sauropod with an especially long neck. Nicknamed "Dippy," the fossil created an international sensation when a cast of the specimen was unveiled in London's British Museum of Natural History. Similar casts were made for museums throughout Europe and the Americas.

In the decades since Dippy's excavation, scientists have learned a great deal more about dinosaurs. As knowledge about these animals expands, museum displays need to be updated to reflect that knowledge. Dippy's remounted posture is decidedly less sluggish—no more tail-dragging for the famous diplodocus or any of the other specimens in Dinosaurs in Their Time.

T. Rex Gets Competition

One of the museum's two *Tyrannosaurus rex* skeletons on display is the holotype specimen, i.e., the original specimen that defines the entire species. Discovered in 1902, the specimen was purchased by the Carnegie Museum in 1941 from the American Museum in New York. Once reassembled, *T. rex* dominated the museum's Dinosaur Hall for 60 years. In the current depiction, *T. rex* has to fight for its supper, as another *T. rex* (a cast of a specimen nicknamed "Peck's Rex") challenges it for an Edmontosaurus carcass. The new fighting posture is part of the dramatic remounting done to animate the creatures. Outside the main exhibit space, a juvenile *Tyrannosaurus rex*, nicknamed "Jane," seems to be making her escape.

"Dinosaurs in Their Time" is now the third-largest collection of real, mounted dinosaur fossils in the United States. However, The Carnegie fossil collection is not significant only for its size. More than 75% of the approximately 230 fossil bones on view are real fossils, not replicas. Juveniles like "Jane" and the museum's baby Apatosaurus collected in 1901 also increase the scientific importance of the exhibit because they are exceedingly rare finds. The dinosaurs are gone, but the science behind exhibiting their fossils continues to evolve in collections like "Dinosaurs in Their Time."

Headline Discoveries wishes to thank Ellen James in Media Relations for The Carnegie Museum of Natural History for her personal interview.

For more information about "Dinosaurs in Their Time" or to visit Webcams viewing the exhibit space, check out **http://www.carnegiemnh.org/dinosaurs/index.htm.**

—Lisa Jancarik

HD'S GREEN GAZETTE: 2008 ANNIVERSARIES DOT PATH TOWARD A GREENER PLANET EARTH

USGBC: 15 Years of Green Building

The U.S. Green Building Council celebrated its 15th anniversary in May. The organization, which certifies sustainable construction practices through its LEED program (Leadership in Energy and Environmental Design), is collecting Top 15 Lists for green building practices, products, and technology breakthroughs that have emerged in the past 15 years. Want to nominate your favorite green innovations? Visit **USGBCturns15@usgbc.org** for details.

Grizzly Backers Hail Bear's Tale

The Interagency Grizzly Bear Committee marked its 25th birthday in June with a public ceremony at Montana's Blackfoot-Clearwater Wildlife Management Area. The IGBC was formed in 1983 to help ensure recovery of viable grizzly bear populations and habitat in the lower 48 states through interagency coordination of policy, planning, management, and research. IGBC participants include the USDA Forest Service, National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and state wildlife agencies of Idaho, Montana, Washington, and Wyoming, plus the Canadian Wildlife Service.

Rachel Carson Centennial

Marine biologist, conservationist and author Rachel Carson (1907-1964) helped spearhead the global environmental movement of the mid-20th Century. In the 1950s, Ms. Carson wrote a trilogy of bestsellers about ocean life, but it was *Silent Spring*, her signature 1962 work exposing the negative effects of synthetic pesticides, that sparked America's change in attitude toward environmental issues. Supporters credit Ms. Carson's legacy for the subsequent ban on DDT and other pesticides and for inspiring the creation of the Environmental Protection Agency. Critics assailed her writings for spawning excessive environmental laws that purportedly restrict economic freedom.

Ms. Carson was posthumously awarded the Presidential Medal of Freedom in 1980. This year marks the end of events commemorating the 100th anniversary of her birth.

Greener Games in Beijing

The 2008 Olympics featured some innovative green designs. Among them:

1 The new Beijing National Stadium included greener features, such as a rainwater collection system and natural ventilation

2 The National Aquatics Center was enclosed in a series of plastic "pillows" that cut energy usage by an estimated 30 percent. After the Games, the facility will be converted to a commercial/leisure center.

3 The seven main Olympic Stadiums were powered by Beijing's first wind farm.

4 The Olympic Village water system was heated by solar power.

5 The Chinese government planted thousands of trees in and around Beijing to offset the impact of greenhouse gases resulting from Game-related traffic surges.

Green Energy Defined

As oil prices skyrocket, you've probably read about green energy and energy independence in the news. But what does it mean?

The term "green energy" describes sources of energy considered environmentally friendly, nonpolluting, and often derived from natural energy-producing processes. These factors distinguish them from traditional energy sources, such as fossil fuels (coal and natural gas) or nuclear energy. Examples of green energy are geothermal (from geysers), wind, solar, tidal, wave, hydro (rivers), biofuels and biomass (from biological materials like sugar cane).

Green energy is commonly associated with home and commercial heating and electricity. Consumer demand for environmentally friendly energy is on the rise and with it a corresponding growth in startup companies that are exploring alternative sources. Several companies are developing technology to harvest energy from algae!

"Energy independence" is the ability of one country to meet its energy needs without undue reliance on imported energy. In the United States, these options include developing alternative sources or opening commercial access to off-limits petroleum reserves.

—Dan Skantar

GREEN BITS

Major League Baseball added a touch of green to the 2008 All-Star Game festivities in New York in July, unveiling an Eco-Play playground built with 85 percent recycled materials at a youth recreation facility in the Bronx. Clean-air hybrid buses carried fans from transit terminals to the All-Star fan festival at Javits Center.

IS ECO-TOURISM HARMFUL TO GREAT APES?

Tens of thousands of people flock to Africa each year seeking a unique opportunity to track and observe great apes. But the money they pay for this experience isn't the only thing they're bringing to the wild, according to new research. A study published in *Current Biology* shows recent respiratory outbreaks among chimpanzees and gorilla populations are due to human viral infections, likely introduced by researchers and eco-tourists.

A Susceptible Population

Tissue samples taken from chimpanzees that had died in outbreaks dating back to 1999 tested positive for two human respiratory viruses, human respiratory syncytial virus (HRSV) and human metapneumovirus (HMPV). Known to be major sources of human infant mortality in the developing world, the presence of these potentially fatal infections in ape populations is the first direct evidence of virus transmission from humans.

Respiratory viruses, including the common cold, are so widespread in humans there is an almost 100 percent antibody prevalence. The development of natural antibodies means many of us are carriers, never exhibiting any symptoms.

Great apes, by contrast, have had limited exposure to these illnesses, leaving them with little or no acquired immunity. Given our genetic and physiologic similarities, virtually all diseases that can harm us are also harmful to them.

Reasons to Stay

Opening great ape habitats to tourists has been considered a huge step toward conserving these endangered species. Adventurers spend hundreds of dollars each for a permit to track gorilla groups into the densely forested mountains of Rwanda, Uganda, and the DR Congo. This money is a critical source of income for these governments who use it to protect and maintain the national parks that are home to these animals.

In addition, studies show the presence of researchers and tourists has a very positive effect on primate health by suppressing poaching. Population densities near these sites are much higher than in surrounding areas. This protective effect outweighs the chimpanzee mortality caused by the introduction of human disease, suggests Christophe Boesch of the Max Planck Institute for Evolutionary Anthropology. "However, it comes with some hygienic problems which need to be addressed," he added.

Maintaining Distance

Scientists are leading the charge to find ways to protect the apes. Members of Tony Goldberg's team out of the University of Illinois at Urbana-Champaign have started wearing masks to reduce the spread of viruses. They also keep separate garments and footwear within camp and have disinfection baths for boots and clothes at the edge of camp.

Travel companies are now telling tourists with cold- or flu-like symptoms to forego the trek. However, the trips and permits are quite expensive and often non-refundable, making it tempting for travelers to hide or ignore their illness.

Other proposed safety measures include requiring tourists to submit proof of vaccination, increasing the viewing distance from 7 to 10 meters, and requiring the use of masks.

But, as wildlife epidemiologist Dr. Fabian Leendertz of the Robert Koch-Institute in Berlin pointed out, "If you have spent all that money, the very least you want is a photograph of yourself with the gorillas. And the photograph doesn't look as good if you have to wear a mask. But we hope the type of people who go on these holidays will take that responsibility."

Evidence of human viruses jumping to wild apes has highlighted the need to be more proactive in shielding these animals from human contact. Finding more effective ways to limit the spread of disease will help to preserve endangered species, while allowing travelers and scientists to continue to explore this region, maintaining the economic and conservation benefits of their visits.

—Debbie Kopyta

- Great apes (family Pongidae) include gorillas, chimpanzees, bonobos, and orangutans
- Deforestation and poaching are the two greatest threats to great ape survival
- Mountain gorillas are a critically endangered species, with fewer than 650 individuals left in the wild; none exist in captivity
- Bonobos and chimpanzees are the closest living relatives to humans, sharing approximately 98.4 percent of their DNA with us
- Orangutan habitats have decreased by more than 80 percent in the last 20 years; unless drastic measures are taken, they are expected to become extinct within the next two decades.
- Chimpanzees live in social groups called "communities" and communicate with a wide range of calls, postures, and gestures
- Koko, a gorilla, has a working vocabulary of more than 500 signs and understands about 2000 spoken words; she has a tested IQ of between 70 and 95 on a scale where 100 is considered "normal"

THE SCOOP ON POOP

Stool, excrement, feces, poop, waste—every organism on Earth produces it. It has a direct impact on our health; to produce too little or too infrequently *causes* illness. At the same time, it is directly affected by our health; to produce too much or too frequently *indicates* illness. It is obviously important, but besides providing fuel for bathroom humor and grade school taunts, what real purpose does it serve?

Lab Scats

Jim Mead, director of Northern Arizona University's Laboratory of Quaternary Paleontology, has one of the largest collections of dung available, and scientists from all over the world send him stool samples to identify the animals from whence they came. But his lab does more than pinpoint origin; studying feces, or scatology, can tell a tale that might otherwise go untold.

With bones and fossils, scientists gather certain data: they know the average *T. rex* height and weight; they determine an animal's age or sex by comparing new findings with other specimens of the species. Dung, however, provides biochemical data—what plants the animal ate, how healthy it was, the climate of the surrounding environment, and more.

Mead's lab has fossilized feces from 40,000 years ago through present day. He tracks and compares dung DNA samples to determine gender, food and water sources, air pollen, parasites, and even evolutionary clues. In short, he uses new poop to analyze old poop and get a glimpse into the past; for example, he can figure out when bison first roamed through the Grand Canyon (at least 23,000 years ago).

Nature's Use of Refuse

Besides this historical value, the animal kingdom demonstrates functional uses for what would

otherwise be "waste." Animals mark their territory with feces or scent a trail for other members of their pack to follow. Koalas, elephants, and bats feed excrement to their young who have yet to develop certain microbes that help break down hard-to-digest food. Rabbits and guinea pigs eat waste to glean every possible nutrient from the food they ingest. Birds use other animal's poop to build nests or hide their eggs.

We don't often stop to think of alternate uses for feces in the human world. Pioneers burned buffalo "chips" to heat their homes. Some African tribes mix cow poop with mud to build the walls for their dwellings. In recent years, an increased number of environment-, scientific-, and economic-minded researchers have forayed into the world of waste experimentation.

From the Farm to the Floor

One sector interested in other potential uses for poop are farmers. Back in the day, farmers used livestock manure to fertilize crops or to convert into compost. With the ever-increasing size of large livestock-raising operations, however, farmers sometimes have more fertilizer than they have land needing fertilization. Manure left lying around too long contaminates groundwater, and having it removed is expensive—up to an estimated $200 per cow per year for a typical dairy farm.

Anaerobic digestion, a process in which wastes are broken down by microorganisms in the absence of oxygen, produces different products than if oxygen is present. One is methane, which is a very valuable "biogas." Methane can be used for local uses such as cooking, heating, cooling, and lighting applications, as well as to generate electricity—and these uses preclude its release to the atmosphere where it contributes to global warming. The residual liquids and solids can be used for fertilization without the extremely high levels of certain nutrients that can "burn" crops.

Last year, researchers at Michigan State University tested methods for turning cow manure into fiberboard. Preliminary findings suggest the fibers in the manure-based product interlock better than fiberboard made from wood. In addition, the manure board meets or exceeds standard requirements for particleboard.

The benefits include environmental efficiency as well as a second revenue source for the farmers, though consumer analysts say customers might be apprehensive about purchasing the product at first. The USDA lab in Madison, WI, is nearing the end of an 18-month study to test the manure-based fiberboard's strength and examine the economic practicality of the process overall.

Turning Poop into Gas

In another recent study, the National Institute of Standards and Technology (NIST) analyzed manure-based crude oil to determine what it would take to turn pig manure into fuel. As mentioned earlier, turning manure into a revenue-generating product would address current overabundance of animal waste and, in this case, provide an alternative oil supply. Once processed, the crude would be similar to diesel.

The solution, unfortunately, did not prove a viable one. Produced at the University of Illinois Urbana-Champaign, the pig crude contained 83 compounds, with water composing 15 percent. While each pig might produce 21 gallons of crude in its lifetime, the processing required to render it vehicle-ready would outweigh the benefits. However, the NIST scientists did successfully develop a methodology for future analysis in the application value of other biofuels.

A final note in poop-turned-petroleum news: Scientists in Silicon Valley have found some initial promise experimenting with genetically altered bacteria that feed on agricultural waste and excrete crude oil. The fatty acids these small bugs excrete naturally are only a few molecular stages removed from crude oil; following a change to the bacteria's DNA, the excreted substance is reportedly almost ready for consumer use. The fuel would cost an estimated cost $50 a barrel. Researchers hope to have a demonstration-scale plant operating by 2010.

—Aprile Smith

DID YOU KNOW?

Several companies make paper out of animal waste; Sheep Poo Paper operates out of Wales and offers do-it-yourself home instructions for the adventurous: **www.creativepaperwales.co.uk**

Bird poop is white because birds do not urinate; their urea excretes in the form of uric acid, which emerges as white paste.

VIRTUAL FENCES: GPS BRINGS CHANGE TO THE RANGE

Global Positioning Systems (GPS), the mapping technology used in automobiles, cell phones, and other commercial applications, is finding a new home—to help manage livestock on the open range.

Animal herd managers face daunting challenges. Open rangeland can encompass hundreds of thousands of acres. Grazing animals wander, and tracking and herding them over such an expanse takes a lot of manpower. Fences are costly to install and maintain. With GPS, ranchers can control their herds efficiently, economically, and without fences.

Tracking Old Bessie

For centuries ranchers developed an intuitive "feel" for their herds and flocks—which animals were leaders, how herds moved to water and feeding grounds, etc. Today GPS quantifies these behavior patterns with unerring precision.

Researchers at Oregon State University have tested GPS on cattle, goat, and elk herds for nearly a decade. Animals are fitted with homemade tracking collars that receive a GPS satellite signal, then return it to a handheld GPS device that records a time-dated location every 30 seconds. The data collected creates profiles for individual animals and entire herds—where, when, and how long animals move, feed, and rest. The data reveals facts that would be difficult to obtain by other means. Oregon State's team learned that cows take the easiest path to feeding and watering sites, allowing herd managers to locate food and water so the rangeland is used evenly, with a minimum of overgrazing.

Herding by Satellite

Ranchers traditionally manipulate herd animals with sensory cues, such as a cowboy's voice commands or the touch of a shepherd's staff. GPS applies a 21st Century spin on this ancient practice.

Scientists from the U.S. Department of Agriculture and engineers from Massachusetts Institute of Technology have developed a Walkman-like headset that allows the rancher to "whisper" wireless GPS commands to cows to manage their movements and herd them into corrals or keep them from crossing forbidden boundaries. Used this way, GPS serves as both virtual cowboy and virtual fence.

One obstacle to the widespread use of GPS is the cost. Today a single collar costs $4,500. Once the technology becomes commercially viable, GPS-based herd management systems will eventually become the industry standard, and the truly open range will be a reality.

—Dan Skantar

TINY AQUATIC ANIMALS PROVE TO BE THE MOST ECCENTRIC OF SCAVENGERS

There are lots of things you might be willing to borrow from a casual acquaintance: a pencil, change for the soda machine, maybe even a jacket on a cold day. Odds are pretty good you'd draw the line at their DNA, however. Research into bdelloid rotifers would suggest not every member of the animal kingdom is quite so picky.

Buddy, Can You Spare A Gene?

Of course, bdelloid rotifers don't borrow DNA so much as they collect it from other organisms that aren't using it anymore. And the process is extremely passive, so you needn't worry about tiny predators putting your chromosomes up on blocks while you aren't looking.

A microscopic freshwater invertebrate, the rotifer has become nothing short of a celebrity in recent months, thanks to research performed by Harvard University scientists Irina Arkhipova and Matthew Meselson. As they explain in the May 2008 issue of the journal *Science*, the world of the bdelloid rotifer is a topsy turvy place where up is down and down is up as far as biological norms are concerned.

First, bdelloids are all female. Second, they seem to be able to survive incredible traumas—including complete dessication and intense irradiation—through an unusual process of DNA repair. Now, as if those other features weren't enough to distinguish the bdelloid line, it has been revealed these rugged ladies can actually incorporate foreign genetic material into their repaired DNA.

What is especially interesting about the scavenged genetic material is the bdelloids are able to pass it on to subsequent generations. Though they do not reproduce sexually, bdelloid rotifers nevertheless produce eggs that are eventually expelled from the parent and develop into offspring through parthenogenesis. The ability of the rotifer to incorporate new genetic material into its progeny—however accidental—may explain how the organism has made a stunning success of a potential evolutionary dead-end.

Breaking Up Is Hard to Do

Bdelloids clearly thrive on adversity, for the very traumas that would kill most organisms seem to give the rotifers a chance to refresh their genome with outside genetic detritus. The bdelloid rotifer can survive in a dehydrated state for months or years before "reviving" upon rehydration. But the bdelloid ability to survive total desiccation comes at a price: ruptured membranes and shattered DNA.

When the amazing repair ability of the rotifer kicks in, shreds of foreign genetic material from other bdelloids as well as unrelated species can work their way into the mix. Says Meselson, "We found many genes that appear to have originated in bacteria, fungi, and plants."

This process of communicating genes from one organism to another rather than from parent to child is called horizontal transfer. While found in some types of parasitic or symbiotic relationships, it is not practiced elsewhere on the same scale observed here; as many as one third of the bdelloid genes analyzed by the Harvard team (which has thus far looked at one percent of the total genome) may have been derived from other organisms.

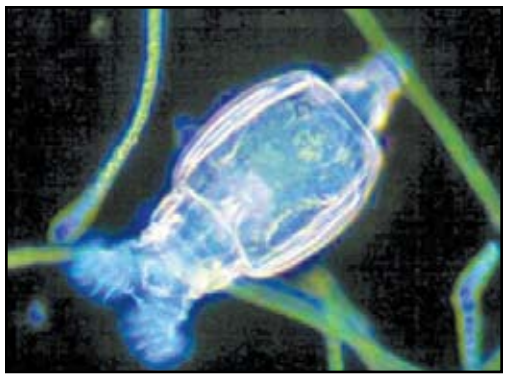
You Are What You Eat

So where do you find discarded genetic material anyhow?

Irina Arkhipova points out that "not only the rotifer desiccates, but also everything it just consumed." Therefore, anything that the rotifer would consider food has a fair chance of being added to the rebuilt genome.

Of the bdelloids' unique evolutionary success as gene recyclers, Arkhipova writes, "Bdelloids may have the capacity for tapping into the entire environmental gene pool, which may be of adaptive significance during expansion into new ecological niches, and may even contribute to bdelloid speciation."

One big question that remains to be answered is the ultimate fate of the genes the rotifers pilfer.



Consider the magpie: if it steals a bright yellow sequined scarf from a park bench, it does so to adorn its nest; the magpie may use the scarf, but it doesn't wear it as a scarf. That begs the question of how the rotifer utilizes foreign genetic material—as the owner had used it, or as a novel genetic expression.

In one experiment, the researchers took a bacterial gene from the bdelloid rotifer and inserted it into *E. coli* bacteria. The gene proceeded to encode the enzyme it usually makes to construct cell walls within bacteria. But while the gene may have survived intact as a part of the bdelloid genome, it is unknown what purpose it may have been serving in that new environment. It would also appear the incorporation of alien genes occurs not in the middle of bdelloid chromosomes—where interference with existing protein-coding genes could be detrimental to rotifer life—but rather at the ends, where Arkhipova and company speculate the addition of genetic material may contribute to the protective function of the telomeres.

Certainly, curiosity into how (and how much) foreign genes contribute to the life of this rotifer will ensure research on this subject continues. That research will doubtless contain yet more surprises for the followers of these tiny contrarians.

—Ed Schock

THE GIRL WITH EIGHT LIMBS

In October 2005, Lakshmi Tatma quietly entered the world in a remote Indian village in the Bihar region, an area without electricity or running water and populated by poor Hindu farmers. Despite her humble beginning, her arrival caused an immediate sensation throughout her village and soon made news around the world. Lakshmi was born with four arms and four legs.

Her arrival coincided with the Festival of Lakshmi, a celebration devoted to Vishnu, the four-armed Hindu god responsible for preservation of the universe, and her consort, Lakshmi, four-armed goddess of wealth and prosperity for whom the baby was named. Villagers did not see deformity. They believed the infant was the reincarnation of Lakshmi and lined up outside her home for a darshan, or blessing.

Why Did She Develop Extra Limbs?

Lakshmi was actually the survivor of a pair of ischiopagus conjoined twins—twins who are joined at the front pelvis and lower spine and whose spines are at 180 degree angles to one another. Only a few hundred pairs of conjoined twins are born around the world each year (estimates range from one in every 20,000 to 100,000 live births) and only an estimated three percent of conjoined twins are ishiopagus.

In Lakshmi's case, her body had actually absorbed the limbs and internal organs of a parasitic twin whose head had atrophied and chest remained underdeveloped. Lakshmi's pelvis, spine, nerves, and several internal organs were intertwined with the parasitic twin. As a result, she looked like one child with four arms and legs.

What Causes Conjoined Twins?

Conjoined twins are always identical, and about 70 percent are female, though scientists don't know why. Twins can be joined in many ways and are described based on where they are conjoined and the suffix "-pagus" for the Greek word "fixed." For example, thoracopagus twins are joined at the upper chest, craniopagus twins are joined at the head, and parapagus twins are joined side-by-side at the torso.

Teratologists and embryologists have two theories on what causes the formation of conjoined twins. The "fission theory" speculates conjoined twins happen when a fertilized egg begins to split, but is interrupted and develops into two partially formed-yet-connected individuals.

In the "fusion theory," twins become conjoined after the fertilized egg splits into identical twins, and the embryos fuse together while lying side-by-side in utero. In their earliest development, embryos consist of three cell layers that search for similar cells in order to fuse together to form individual organs. The fusion theory suggests that when newly separated twin embryos are next to one another, signals may become confused—cells attach to like cells, but ones that belong to the other twin.

In rare cases, one conjoined twin will stop developing for unknown reasons, receive inadequate nutrition, or die. Doctors hypothesize that, as the parasitic twins body atrophies, its circulatory system reverses and the surviving twin begins to supply blood. As in the case with Lakshmi, the remnants of the parasitic twin remain fused to the otherwise normal twin. In the extremely rare case of fetus-in-fetu, or inclusion twin, the parasitic twin actually develops inside the surviving twin and can range from a mass of tissue to a fairly well-developed twin.

The Future for Lakshmi

Though born in poverty-stricken India where female infanticide is common, Lakshmi's parents, who earn less than one dollar a day, protected and cherished her. As a two-year-old, she was able to drag herself on all fours, but her movement was impeded by her attached twin. Her mother Poonam said, "Lakshmi is a miracle, a special blessing from God. But she is my daughter and she cannot live like this." Doctors agreed, believing that without surgery, Lakshmi would likely die in her teens.

Fortunately for the Tatma family, Dr. Sharan Patil and Sparsh Hospital in Bangalore, India, agreed to donate medical services to remove Lakshmi's extra limbs and reconstruct her body. In November 2007, a team of 30 surgeons began a 27-hour surgical marathon. First, they removed a functioning kidney from the parasitic twin and transplanted it into Lakshmi, who had only one kidney. Next, they spent hours untangling internal organs, including the intestines. Doctors then focused on the most delicate aspect of the surgery—separating the two spines without damaging nerves and reconstructing her pelvis. Lastly, the arms, legs, and remainder of Lakshmi's parasitic twin were removed.

In the months following her landmark surgery, Lakshmi has recovered at a charity school. She's taken her first steps with help of a walker. Though she faces additional surgery to correct her club feet, doctors believe that with extensive therapy, she will continue to improve and will be able to walk.

—Mary Rose Thomas-Glaser

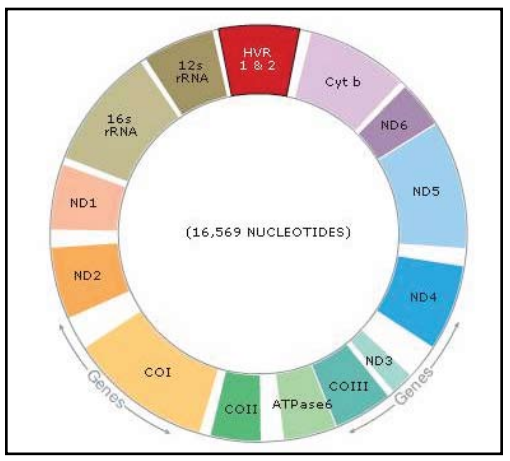

siamese twin egg

MORE ON CONJOINED TWINS

- Forty percent to 60 percent of conjoined twins arrive stillborn, and about 35 percent survive only one day.
- The overall survival rate of conjoined twins is between 5 percent and 25 percent.
- Approximately 70 percent of all conjoined twins are girls. Although more male twins conjoin in the womb than female twins, females are three times as likely to be born alive.
- Conjoined twins are genetically identical and are, therefore, always the same sex. They develop from the same fertilized egg.
- In 1689, German physician G. Konig performed the first successful operation to separate a pair of conjoined twins.

— Source: University of Maryland Medicine

MITOCHONDRIAL DNA—A GIFT ONLY A MOTHER CAN GIVE



Mitochondrial DNA (mtDNA) testing, a close cousin to the better-known nuclear DNA testing, is making a name for itself in applications from law enforcement to ancestry tracing to understanding chronic diseases. Unlike the more common nuclear DNA (nDNA) testing, mitochondrial DNA provides a unique perspective—it provides lineage information specifically from mother to daughter and can be used to trace mother-daughter relationships back thousands of generations. For certain investigations, mtDNA is the genetic material of choice. (See "What is Mitochondrial DNA?")

New Technology Helps Build Solid Cases

In law enforcement, the need for nDNA and mtDNA analysis is accelerating at record-breaking rates. The high level of activity in the FBI's Quantico, Va., DNA Crime Lab shows just how important DNA testing has become. Thankfully, advancements in laboratory automation are making analysis of the thousands of DNA samples faster than human hands could ever accomplish.

The increasing volume of DNA samples for analysis suggests a complete turnaround has occurred in public reliance (specifically, jurors' reliance) on DNA evidence, which is now influencing their readiness to convict. Back in the days of the O.J. Simpson trial, the whole idea of DNA testing was strange and complex. Now, says Mitchell Holland, professor of Forensic Science at Penn State, "Some jurors are saying they needed this forensic evidence when there was probably enough in the case already to convict."

In the FBI's highly sophisticated Quantico laboratory, hundreds of DNA samples are prepped and analyzed, largely without the use of human hands; robotic equipment handles all the "heavy lifting." For analytical power, the lab is using a mass spectrometer to "weigh" individual molecules, a first for measuring mitochondrial DNA in crime work.

Bringing Closure Where None Was Thought Possible

At Quantico, the FBI's DNA Analysis Unit II, with its associated Mitochondrial DNA Missing Person Database, is filling a critical void—analyzing evidence from cold cases and mass casualty incidents. Because mtDNA testing is more sensitive than routine DNA testing, small amounts of biological material can produce valid results, and data locked in poor quality DNA, degraded by time or environmental conditions, can be investigated. Across the country, medical examiners are responsible for an estimated 40,000 unidentified deceased individuals, many of whom have left behind families agonized by absence of information about their missing loved one.

While mtDNA testing does not specifically identify an individual, its maternal inheritance characteristic makes it possible for forensic scientists to compare a sample from a cold case with that of maternally related individuals. Take the case of Stephanie Sempell, a 15-year-old who went missing from Boca Raton, Fla., in 1976. Stephanie was quite possibly murdered that year, but her bones, found scattered around a vegetated area of Grassy Keys, an island in the middle of the Florida Keys, were never connected with a missing persons case. At the time of the discovery, dental records and facial reconstructions failed to identify the victim. The remains of this Jane Doe remained unclaimed for decades. Finally in 2007, mtDNA analysis and much cooperation and communication between agencies successfully brought Stephanie's remains and her grieving mother together at last.

For the relatives of the 2,749 casualties in the World Trade Center attack, the co-mingling of remains has prevented identification of individuals. mtDNA testing will help sort out the tangled web, so specific loved ones can be identified.

Museums Hold a Treasure Trove of Historical Information

On a lighter note, mtDNA analysis may support a whole new area of inquiry, "museomics", by allowing fragments of museum specimens to be tested for maternal relations back over thousands of years. A single hair shaft or a piece of a feather—certainly not enough sample to destroy the integrity of the subjects—could allow an investigator to look at generations of genetic diversity. Imagine having mtDNA from Darwin's finches to trace back in time!

Unlocking Some of the Secrets of Chronic Diseases and Aging

As we pass down our mtDNA from generation to generation, the genetic material accumulates points of damage, leading to effects on tissues and organs and the onset of clinical disease. A recent study led by Douglas Wallace, director of the Center for Molecular and Mitochondrial Medicine and Genetics at UC Irvine, has shown a single change in mtDNA can cause degenerative heart and muscle disease. According to Wallace, a complete understanding of the importance of mitochondrial defects caused by either mitochondrial or nuclear DNA mutations could lead to treatments effective for age-related diseases that affect millions worldwide.

—Merry Morris

WHAT IS MITOCHONDRIAL DNA?

Mitochondria are structures located within a cell's cytoplasm and are often described as the "powerhouse" of the cell.

Mitochondria carry their own genetic material, around 16,000 DNA base pairs arranged in a double-stranded circle. Because of its presence outside the cell's nucleus, all mitochondrial DNA (mtDNA) is inherited from the mother.

Testing for mtDNA provides a number of advantages compared to the commonly used nuclear DNA. It is:

- protected within structurally strong mitochondria and so may be of good quality in older or degraded samples,
- easier to find and analyze because of the presence of so many mtDNA molecules in our cells—less sample material is necessary for effective analysis, and
- extractable from a greater variety of biological sources, e.g., hair shafts.

BOOK REVIEW

FISHER SCIENTIFIC LABORATORY SAFETY MANUAL

A must-have for every school lab, this comprehensive resource guide outlines lab safety and training requirements to ensure the safety of staff and students. This manual provides teachers and school administrators with basic guidelines on how to comply with various OSHA rules and regulations and includes numerous resources, such as:

CAT. NO.	PRICE
SFTYMANUAL	$49.95

- Suggested best practices for laboratory safety, including information about proper personal protective equipment use, laboratory design, and emergency response planning
- A sample Chemical Hygiene Plan (CHP)
- A lab safety contract for students and parents
- A sample laboratory inspection checklist
- Information about chemical packaging, labeling, and Material Safety Data Sheets (MSDSs); chemical dangers and incompatibilities; control measures; and storage, handling, and disposal
- Occupational Safety and Health Administration (OSHA) "Right to Know" Rules
- An outline of laboratory safety training requirements

THE PEPPER EPISODE OF 2008

When we admonish others saying, "Eat your vegetables," we assume our food supply is safe. But when problems arise with food safety, we rely on epidemiology to ferret out the connections, something that is becoming more difficult in our modern society.

In April 2008, a startling number of cases of salmonella were observed across the country and reported to health agencies. As time progressed and more cases were reported, details began to emerge. None of them were pretty.

According to Centers for Disease Control and Prevention (CDC), between April and mid-June, 707 persons in 37 states fell prey to a fairly rare serotype of salmonella, *Salmonella stpaul*. In the previous year over the same period, only three persons were identified as being infected with *Salmonella stpaul*. Clearly something was afoot, causing this sudden flurry of infection.

The sufferers ranged in age from less than one year to 99 years. While 76 were hospitalized, no deaths were reported to have been directly caused by the illness. The victims shared common symptoms—diarrhea, fever, and abdominal cramps that lasted four to seven days. In most cases, they were treated as salmonella victims normally are, by oral rehydration and, in severe cases, intravenously supplied liquids.

Mysteries to Be Solved By Science

Each year there are millions of cases of salmonella poisoning. When a larger-than-normal number of cases occur, questions need to be answered. Are any of these cases related to the others or are they all isolated occurrences? Only in retrospect is this an easy question to answer. In the 2008 food poisoning episode, thanks to DNA identification, particular cases could be linked—for these victims, their particular bacterial assailants shared the genetic fingerprint of *Salmonella stpaul*.

Could cases in a number of different states be connected? This answer was teased out of the mass of related information as a result of the efforts of the CDC, collaborating with public health officials in many states, the Indian Health Service, and the U.S. Food and Drug Administration (FDA). An epidemiological study (See "What is Epidemiology?") focused on the food-borne exposure route and compared the food eaten both by stricken persons and persons free from salmonella symptoms. Initally, the results pointed to tomatoes—specifically, raw red plum, red Roma, or round red tomatoes. Consumption, shipping and serving of tomatoes dropped drastically as a result of government advisories.

This is, of course, critical information, but not enough to eliminate sources of infection. With the food source narrowed down, the FDA was charged with finding the locations from which the contaminated food was coming. In today's produce markets, vegetables may be picked and moved, and washed and moved, and packaged and moved—leaving a web of confusion rather than the proverbial bread-crumb trail. The exercise to track the source down to specific farms, called a traceback investigation, is always a challenge.

As more information was compiled, the case against the tomato just did not come together. As studies continued, what emerged as the causative agents were peppers—jalapeno peppers—commonly eaten at the same time as tomatoes. So, many of the victims had eaten both vegetables—at the same time, at home or in restaurants.

Finding Contamination Pathways

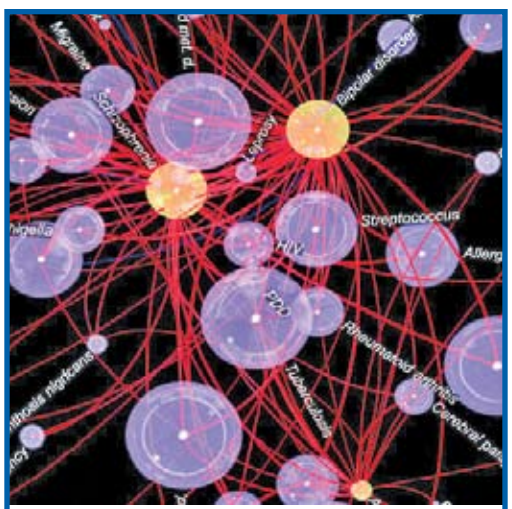
Salmonella live in the intestinal tracts of many animals (cattle, poultry, wild animals, and birds as well as pets). Though commonly associated with food stuffs such as poultry, eggs, pork, and raw milk, salmonella is also associated with contaminated fruits and vegetables. Obviously, bacteria on the outside of the vegetable can be carried to the inside of the vegetable from contamination of a cutting instrument or from the surface of the fruit. But also, as scientific experiments have shown, the insides of uncut vegetables also can be contaminated with salmonella.

Will Our Future Vegetable Supply Be Safe?

According to some, a future without fresh tomatoes and jalapeno peppers is almost unthinkable. Unfortunately, evidence suggests outbreaks of food-borne illness associated with vegetables are increasing. Since 1990, there have been 13 multistate outbreaks of salmonella poisoning just related to tomatoes which, according to the Centers for Disease Control and Prevention, are particularly susceptible to contamination. Apparently peppers share some susceptibility, too.

Is better surveillance of our food supply highlighting contamination incidents that would have been "invisible" to the consuming public in the past? Probably so. Has our food supply gotten less secure? This may be true as well. Outbreaks now appear to be less localized than in the past—with fresh produce coming from distant states and foreign countries. This is a logical consequence—and a cause for worry. When outbreaks occur, the widely scattered victims and complex web of food supply sources will make it harder than ever to pinpoint the source and the culprit.

—Merry Morris



WHAT IS EPIDEMIOLOGY?

Epidemiology is the study of a population's health and illness. Based on statistical observations, these studies look for unbiased relationships between factors related to a particular situation or outcome. It is the basic tool scientists use when trying to link a causative agent with collected facts regarding the nature and occurrence of disease. In food poisoning incidents, the epidemiologist uses knowledge of the types of organisms present in affected individuals, the foods eaten, and the occurrence of symptoms and locations of infections, along with traceback studies, to isolate the contamination source, making possible its elimination or mitigation.

CROSSWORD PUZZLE

Across

2. Scientists have been able to make _____ out of cow manure instead of wood. (p. 18)
4. Born with four arms and four legs. (p. 20)
6. A familiar plant in the Late Cretaceous Period that still fourishes in the present day. (p. 15)
8. The study of feces. (p. 18)
9. They were placed under the protection of the federal Endangered Species Act in 1975. (p. 16)
14. The original specimen that defines the entire species. (p. 15)
16. Spheres that feature interconnected pores in their thin outer walls. (p. 4)
18. A $1.5 million surgical robot. (p. 10)
19. She was awarded the Presidential Medal of Freedom in 1980. (p. 16)
20. In April 2008, a startling number of _____ cases were reported across the country. (p. 23)
22. A new material dubbed metal _____ promises electronic gadgets that are flexible and nearly indestructible. (p. 3)
23. The presence of researchers and tourists suppresses _____ in primate habitats. (p. 17)
24. Discovery of Michael Faraday. (p. 2)
27. Electrostatic self-_____ involves products "building themselves" from the bottom up. (p. 3)
29. This play is associated with pushing, throwing, or manipulating something inanimate. (p. 14)
30. Scientist that Faraday served under. (p. 2)
32. All bdelloids are _____. (p. 19)
34. They are expected to become extinct within the next two decades. (p. 17)
35. Robots eliminate the possibility of a surgeon's hand _____, resulting in a nicked organ. (p. 10)

Down

1. Doctor who donated medical services to remove girl's extra limbs. (p. 20)
3. A type of fiber optic sensing technology. (p. 4)
5. New micro-_____ technology may show color in an MRI scan. (p. 8)
6. According to researchers, play actually encourages physical _____ development. (p. 14)
7. Hatters became exposed to mercury vapors while engaged in a manufacturing technique called _____. (p. 6)
10. The "_____ the Lab" program brought in hazardous waste professionals to evaluate inventory and dispose of the worst of a school's chemicals. (p. 1)
11. The analysis of backscattered _____ in an optic fiber yields critical environmental data. (p. 4)
12. Sale of iodine is restricted due to covert manufacture of this controlled substance. (p. 1)
13. Microspheres could presumably be used to store this gas as a commercial fuel. (p. 4)
15. Part of the brain that is responsible for social reasoning. (p. 14)
16. These could give a physician a clear picture of what's going on in the entire digestive tract. (p. 8)
17. mtDNA testing identifies the _____ inheritance characteristics. (p. 21)
21. The most common way of controlling chemical exposures in the classroom. (p. 1)
23. This can prepare a child to become a more perceptive and better-educated adult. (p. 12)
25. Because of its presence outside the _____, all mtDNA is inherited from the mother. (p. 21)
26. The _____ camera pill takes pictures of the small intestine. (p. 8)
28. Records pH, presence of minerals, conductivity, and redox potential in samples taken from Mars. (p. 11)
31. The main obstacle to herding by satellite. (p. 19)
33. This enables ranchers to control their herds efficiently without fences. (p. 19)