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HEADLINE DISCOVERIES

MAKING SCIENCE MATTER™

A DEEPER UNDERSTANDING THE IMPORTANCE OF UNDERGROUND LABORATORIES

Deep under the Earth's surface, scientists gather to perform bizarre experiments that could never occur anywhere else on the planet. To many people, the concept of underground laboratories sounds like something out of a comic book or science fiction novel. But to physicists, geologists, engineers, and microbiologists, these unique labs offer the opportunity to pursue exciting hypotheses and experiments.

Life Underground

Conditions beneath the surface are dark, warm, and under very high pressure. In this extreme environment, never-before-seen life forms endure in the pitch-black gloom. They survive off salty, alkaline water that has percolated through the solid rock over millions of years.

The appeal of this underground world to geoscientists and biologists is obvious. They have the opportunity to directly study geological structures, tectonic processes, and bizarre life forms up close. Microbes at these depths have survived conditions that are uninhabitable to commonly known microbes. Separated for a millennia from similar surface organisms, underground microbes could expose new clues into evolution or about the possibilities of life on other planets.

Many of the underground labs focus on physics studies because physicists were the first to go underground for research. In these murky depths, researchers can examine subatomic particles known as neutrinos, fundamental particles comprising the universe that are extremely difficult to detect on the Earth's surface.

Cosmic rays scatter when they hit the upper atmosphere and shower the Earth's surface with subatomic debris. For very sensitive particle detectors, this constant bombardment generates a lot of background noise. Subatomic particles, such as neutrinos, cannot be distinguished amid the debris.

Thousands of feet of rock protect ultrasensitive physics experiments from most of this cosmic activity. One subatomic particle, known as a muon, penetrates over 13,000 feet into the Earth's crust. Neutrinos can pass further, possibly through the entire planet.

Now able to study these cosmic subatomic particles, astrophysicists are coming up with new theories about what holds the universe together. New insight has astronomers talking about dark matter, which cannot be observed directly. Properties of this theoretical material have been observed in the existence of unexplainable gravitational effects on visible matter. Current studies believe that dark matter is similar to a very heavy version of a neutrino. Using underground laboratories and a linear accelerator, researchers are hoping to create dark matter and come to a greater understanding of its role in the ever-expanding universe.

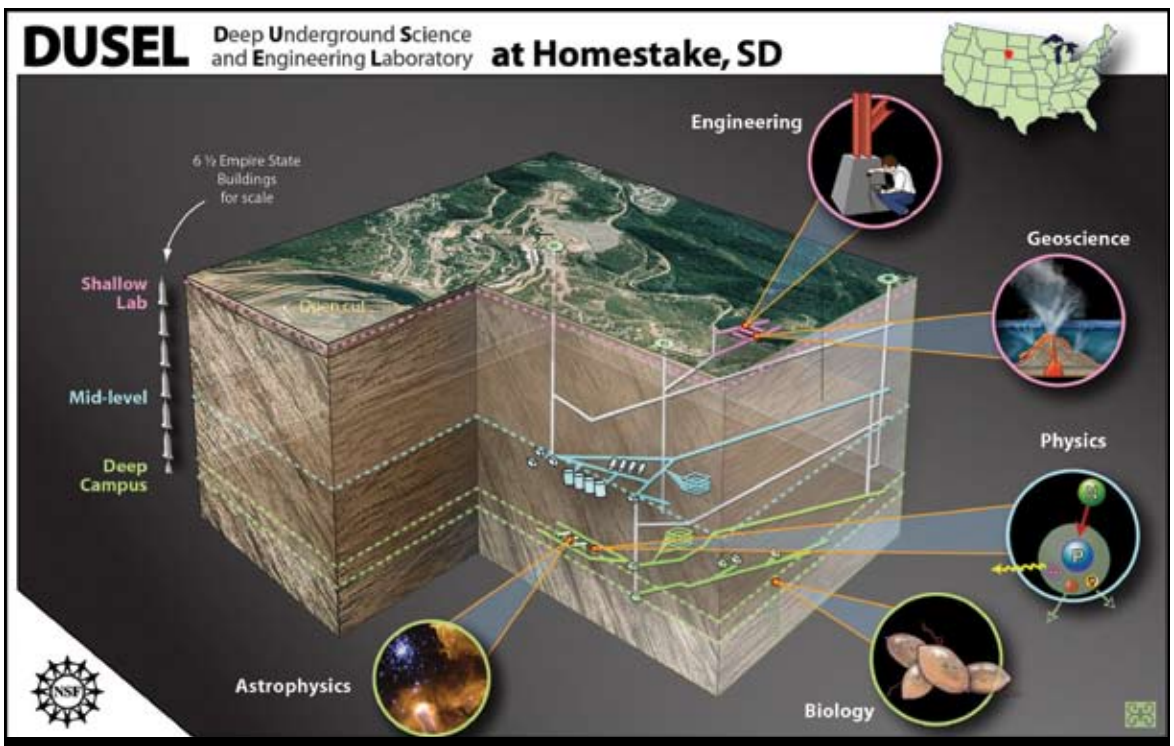


Photo credit: Zina Deretsky, National Science Foundation.

Another exciting area of physics is exploring the possibility of proton decay. Proton decay has never been observed in any experiment. Theorists believe that protons break apart into subatomic particles called positrons and mesons. Contemporary experiments lead researchers to believe that the proton's half-life could not be less than 10^{33} years. Discovering proof of this type of subatomic decay would help physicists glean insight into the Big Bang theory and how matter prevailed over antimatter.

Any signs of antimatter found on Earth are the result of radioactive decay or cosmic rays. That is because when antimatter comes into contact with matter (which everything on our planet is made from), they annihilate each other. Research into antimatter has generated and controlled it in very small quantities, and has found that it generates large capacities of energy. Subatomic particle research could lead to harnessing antimatter as a new energy source.

Reaching New Depths

Underground laboratories already exist in Europe, Japan, and Canada. The first U.S. Deep Underground Science and Engineering Laboratory (DUSEL), in its completed design, will be the world's largest and deepest research facility at 7400 feet below the surface. Currently, the Sudbury Neutrino Observatory Laboratory (SNOLAB) in Canada is the deepest at almost 6000 feet, but is dedicated solely to physics research.

Eight locations in North America vied for the prestige of hosting the DUSEL. Ultimately, the Homestake gold mine in South Dakota offered the greatest potential. Homestake was the oldest mine in the western hemisphere and had run continuously for over 125 years before it was sealed in 2002.

Additionally, the Homestake mine was used for physics research in the past. Dr. Ray Davies, Jr. won the 2002 Nobel Prize in physics for his efforts to detect neutrinos in 1969. While he had not been the first to find neutrinos, his discovery helped to identify that neutrinos could come from different sources.

With the mine being sealed for almost five years, some of the 375 miles of tunnels were flooded. Until the complete funding for DUSEL has been raised (projected to be 2010), an interim lab at 4850 feet will support experiments as early as next year.

There are only 20 underground laboratories around the world, with only three below 4000 feet. As more research requires this very limited amount of space, additional labs will take us to new depths and generate exciting discoveries.

The limited number of underground laboratories has brought the international science community closer. Because many of the labs are small, they have become specialized in different areas of research. This encourages researchers to travel and work with others in their field. As the size of the labs expands, so does the number of scientists eager to enter this underground world.

Interdisciplinary Action

Ultimately, the greatest benefits from underground research will involve a combination of multiple disciplines, which is what larger mines, such as Homestake, hope to accomplish. Each branch of science has its own vocabulary and instrumentation. As more researchers work in close proximity, they will share their research and look for synergies that cross the science barriers.

Some opportunities for this cooperation have already been put into action. Geological readings on tectonic movement help engineers build safer excavation methods. These better building techniques help laboratories withstand the additional pressure of deeper depths.

Geoscientists are working with physicists to identify neutrinos from within the Earth's core and solidify theories on the core's nuclear properties. Biologists are using photon detectors to examine the age of underground microbes, establishing individual ages from 100 to 100,000 years old.

Biologists, geochemists, and hydro-geologists are collaborating on many of the microbial discoveries. With several deep underground laboratories having been transformed from old mines, there is limited accessibility to uncontaminated environments.

Going Beyond Depth

As some scientific questions are answered, others will emerge. To solve the mysteries of these new questions, more research will have to be performed at even greater depths. And, to the delight of many, current technology is bringing those answers closer, faster.

—AJ Rodgers

DON JEFFRY HERBERT

Don Jeffry Herbert was born in Waconia, Minnesota in 1917. Following high school, he enrolled in La Crosse State Teachers' College to teach drama. In fact, drama was Herbert's primary occupation throughout college, until his graduation in 1940 with degrees in General Science and English. That summer, he played opposite Nancy Reagan (then Nancy Davis) at Coach House Summer Theater.

Herbert served as an army airman during WWII and completed 56 bombing missions over Northern Italy, Germany, and Yugoslavia with the Fifteenth Air Force. He left military service in 1945 with the Distinguished Flying Cross, the Air Medal with three oak clusters, and a rank of captain.

After the war, Herbert returned to civilian life by way of radio work in Chicago. His radio shows included popular children's shows like "Captain Midnight." He also sold a number of scripts for radio shows, too. During his work as co-producer on the health series "It's Your Life," an idea for a children's program about science began to take shape. He began studying general science experiments and examining television as a medium.

Don Herbert dared to put children and science demonstrations together on live television, making himself known to millions as "Mr. Wizard." His "Watch Mr. Wizard" series aired its first episode in March 1951 on Chicago's NBC affiliate. The show's format featured Herbert performing science demonstrations with household items for neighborhood children. During the 30-minute running time, Herbert and the children would explore one simple science question.

Herbert counted himself among the surprised adults when the show became a hit. Within four months of its first airdate, the show had reached third place among children's programs in the ratings, and its audience was growing. By 1955, over 100,000 children had applied for membership in the more than 5,000 Mr. Wizard Science Clubs. Eventually, the number of fan clubs would grow to 50,000. Although NBC canceled the original series in 1965, Don Herbert's career as Mr. Wizard continued for decades with guest appearances and shorter-lived programs.

During the nearly 14 years of "Watch Mr. Wizard," the show achieved distinction with numerous awards. These included a Peabody Award and three Thomas Alva Edison National Mass Media Awards for excellence in broadcasting.

Some scientists initially criticized the use of words like "magic" and "mystery" in the show's subtitle. However, Herbert told an interviewer for the New York Times in 2004 that "they came around eventually." Come around they did. In fact, the scientific community recognized Herbert's impact among students with citations from the National Science Foundation and the American Chemical Society.

One theme throughout Don Herbert's distinguished career was accessibility of science to all children. Despite prevailing attitudes of the day, "Watch Mr. Wizard" regularly included girls in its broadcasts. The first girl was added to the cast in 1952, early in the show's history.

Don Herbert died June 12, 2007, a month before his 90th birthday. He had been suffering from multiple myeloma.

—Lisa Jancarik

THAT FANTASTIC, CLEANING, WHITENING MAGICAL GOOP

Toothpaste—that mint-flavored goop that we use everyday—has most people brushing their teeth without even thinking twice about it. When they run out of toothpaste they go and buy more. It has become a common household item that most people consider a necessity for personal hygiene. But how much science actually goes into the tiny glop of goop on your toothbrush?

Before The Goop

Before toothpaste was invented, people had many different ways of cleaning their teeth. Abrasive materials such as burnt bread, eggshells, and charcoal were used to scrub teeth. The bones of dead animals were used to clean in between each tooth. Also pure white wine and old urine was used as a kind of mouthwash! It's no wonder George Washington had false teeth.

Making The Goop

Toothpaste is actually a very complicated solid created thanks to the power of chemistry. This soft solid is a mixture of finely blended liquids and small sandy particles also known as abrasives. Now think about this—the abrasives are heavier than the other ingredients in the paste. Researchers have found that it takes a long time for toothpaste to break down into separate layers. The particles do not sink to the bottom of the tube because molecules within the mixture hold everything in place, forming a network. This network also prevents the glob on your toothbrush from falling apart. Scientists use instruments like highly sensitive microscopes to measure the strength of these bonds. For the most part, toothpaste is a pretty strong bond.

New Types of Goop

Toothpaste companies spend millions of dollars annually looking for ways to tweak and add to the paste formula. The toothpaste aisle in the supermarket has doubled in size in the past few years. Consumers now have a plethora of choices. Not only does toothpaste clean the plaque off of teeth, but it can also prevent tartar build-up, whiten teeth, freshen breath, prevent bad breath, fight gum disease, strengthen enamel, and help with tooth sensitivity. The array of flavors must not be forgotten either. People can now buy toothpaste that is lemon flavored with a splash of vanilla. Sounds a little more appetizing than old urine, don't you think?

—Jennie Culver

TELEVISION: BRAIN ROTTING OR BRAIN FEEDING?

For over 50 years, the television set has been one of the top forms of entertainment for families around the nation. With daily news, movies, sit-coms, video games, how-to shows, and educational programming, television brings the world to our fingertips with the touch of a remote. There is so much that can be learned from national news stations, cooking programs, home decorating and remodeling programs, or even a good comedy.

Even with all of the learning possibilities, there could be a dark side to this great source of entertainment. As the television became a common amenity in the American home, so did the phrase "TV rots your brains!" Not everyone who owns a television set may agree whole-heartedly with this statement, but could TV truly rot your brains?

As Mr. Spock Would Say, "Affirmative Captain."

According to the *Journal of Pediatrics and Adolescent Medicine*, a case study conducted in New York claims that watching entertainment programming might contribute to learning problems in young adolescents. Researchers theorized that television took away from time that might otherwise be used for reading and completing homework. They also state that television requires little brainpower, promotes attention disorders, and encourages a disinterest in school.

Participation in the study included 678 families that resided in upstate New York. From 1983 to 1993, interviews about television habits and school problems were conducted with both parents and children. The interviews occurred three times: when the children were at an average age of 14, 16, and 22 years. Once participants reached an average age of 33 (between 2001-2004), they provided information about their secondary and post-secondary education.

The findings concluded that around the age of 14, 33.2 percent of the children who participated in the study reported watching three or more hours of television each day. Viewing TV at this rate contributed to the risk of frequent attention difficulties, recurring failure to complete homework assignments, negative attitudes towards school, overall academic failure in secondary school, and failure to obtain a post-secondary degree.

Researchers performed an additional 14 analyses with the collected data to investigate associations between attention or learning disabilities and subsequent television habits. Two of the 14 analyses suggested a relationship. According to the researchers, these conclusions further indicate that television contributes to learning complications.

The authors of the study reported that their overall findings suggest youths should spend less than three hours a day watching television. This may help reduce the risk of developing attention or learning disorders.

Maybe the warning should be, "*Too much* TV rots your brains!"

In the words of Cher from *Clueless*, "AS IF!"

There are existing arguments that television does the exact opposite of brain rotting. According to author Steven Johnson, television may make people smarter. He argues that 30 years ago, television shows were not as complex as they are today. Instead of having a single story line and typical antagonist and protagonist characters, today's TV shows have multiple subplots involving a dozen characters with a not-so-predictable conclusion. In addition, many shows are timely, including frequent references to politics or popular culture.

Similarly, video games may improve intelligence. Johnson believes that most people who condemn video games have never actually played them. Games that existed twenty years ago like Pac-Man only involved simple hand-to-eye coordination and pattern recognition. Today's video game player experiences an imaginary world with adjusting levels of complexity. Players must explore different theories in order to make sense of the game's environment. The goal is no longer to complete the last level—it is to solve the game.

Johnson believes that watching today's television requires brainpower. This aspect of popular culture may be one of the reasons why Americans have been gaining a higher I.Q. over the past twenty years.

Perhaps the phrase should change to, "TV feeds the brain!"

"Deal or No Deal?" —Howie Mandel

So it may seem that the debate still stands. Instead of arguing about the content of television, i.e. movies, sit-coms, and video games, there are some people who are looking at the medium. British researchers claim that the actual television set may be doing the brain rotting because the end result is the same regardless of the programming. Not only may the brain be rotting, but TV may also promote other physical ailments.

After reviewing over thirty studies, researchers have identified several negative physical and mental effects that may be linked to television exposure. Some of these negative effects include higher risk of obesity, sleeping disorders, diabetes, and Alzheimer's. According to researchers, television exposure elevates the risk of acquiring physical or mental ailments. These studies are not conclusive, but make an interesting point.

"Survey Says..." —Family Feud

Unfortunately, as long as the American public is fascinated, entertained, and educated by television programming, the shows will go on. Excessive television, to the exclusion of exercise and external stimuli, has some negative effects on the brain and body. However, if television is watched in moderation, it can be beneficial to one's self and mind.

—Jennie Culver

THE UNLIMITED POTENTIAL OF THE HUMAN BRAIN

We've all heard it said, humans use only 10% of their brains. And when that claim is followed by the potential to move objects or read minds, people want to believe it's true. From a scientific point of view, these claims are obviously false. There is physical proof to refute this myth.

Evolutionary Argument

The theory of evolution contends that if something isn't necessary or is a hindrance to the survival of a species, it will disappear over many generations. Compared to other primates, we lost our tails and started walking on two legs while our brains more than doubled in size.

From an evolutionary point-of-view, the size of a brain in proportion to the rest of the animal often reflects the intelligence level of the animal using it. An average human brain weighs about three pounds, whereas the average chimpanzee brain is just under one pound. This means that the average 157-pound person's brain is 2.1% of their total weight. Compare this to a 110-pound chimpanzee with a brain only 0.8% of its total weight.

If we only use one-tenth of our mental capacities, the brain should have eliminated the excessive neurons and shrunk.

Medical Argument

Only using a fraction of our brain would be helpful to many in the medical profession—after all, there would be 90% of our brain matter just sitting there, waiting to become active. Brain surgeons wouldn't need to map out neural pathways; head trauma treatments would be as simple as putting a Band-aid on a boo-boo; strokes and neurological diseases could go untreated for years.

With advanced medical scanning devices, such as PET-scans and MRI images, there is an overwhelming amount of data clearly demonstrating that the whole brain is active. Research results show that the degree of brain activity fluctuates depending on the task being performed. While some areas are more active, the rest of it does not stop working.

In fact, we even use more than 10% of our brain while sleeping, and many sleep studies have included the medical imaging to prove it. During light sleeping, (when we dream) the brain is just as active as when we are awake. During the deepest stages of sleep, certain chemicals are reduced, and communication between large areas of our brain slows down. However, those areas keep talking to themselves, even if their messages aren't going anywhere.

So Where Did It Come From?

The source of this confusion is unknown. If there were just one source, it would be easy to stamp out any further misconceptions. Its perpetuation is credited to psychics, paranormal experts, and basic misunderstanding.

From an evolutionary standpoint, some people will point out that we have all of the same basic functionality as animals with 1/10 our brain size. Animals such as sheep and gorillas (both 1/10 our total brain mass) eat, breathe, reproduce, and communicate with each other even though their brains are so small. But this misguided argument neglects that it's not just about brain size; it's about proportion to the animal's total size. An adult sperm whale has a brain five times the size of ours. Based on total brain size, we would be in serious trouble if the whale wasn't already using its full brain capacity.

From a medical standpoint, there is a lot that doctors and researchers don't understand about how the brain works. They have identified areas for the senses, learning, mobility, vital functions, and more. But, examining only the brain, they can't tell you why people with the same size brains have different IQs. Mainly, this is because we use all of our brains and researchers cannot dissect it to see how it works.

Another similar medical argument comes from experiments by Karl Lashley in the late 1920s. His research with rats found that they could relearn specific tasks after sections of their cerebral cortexes were removed. Similarly, after serious head trauma, remaining neural tissues take over and compensate for damaged cells in humans.

Researchers understand that this recovery doesn't activate neurons that were otherwise dormant. The brain will adapt and rewire itself in ways that no other organ can. These parts of the brain weren't just sitting idle and they aren't suddenly doing more. They are just communicating differently than they had before.

Another popular misconception has its roots in ideas about conscious and subconscious thinking. Believers will modify the 10% myth to say that we only consciously use 10% of our brain and that if we could consciously use more, bizarre and amazing things would happen. This is, in part, true.

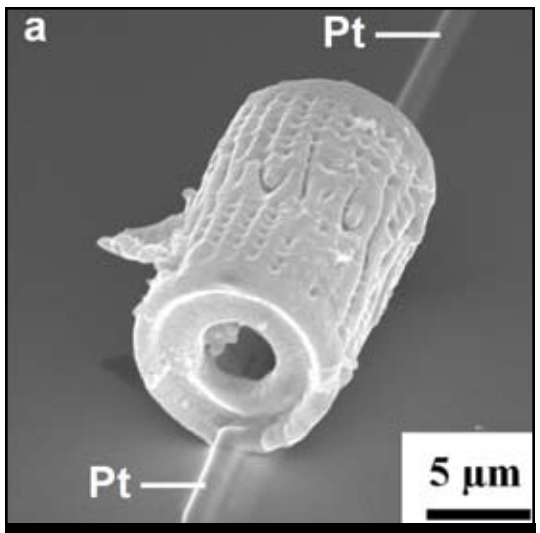
Our brain sends messages to the rest of our body faster than we could rationalize them. If we transformed those subconscious thoughts to conscious ones, we would never be able to sleep and our waking hours would be filled with thoughts of "breathe, breathe, breathe" and that only keeps our lungs working. We need those subconscious events to circulate blood, distribute nutrients, dissolve oxygen, eliminate waste, overcome infections, generate new cells, and basically keep us alive.

The Other 90%

Just because we're already using full brain functionality doesn't mean we're tapped out of potential. The most amazing feature of the brain is its ability to adapt and learn as we discover the world around us. What the average person can accomplish, when they put their mind to it, is immeasurable.

—AJ Rodgers

NATURE IN NANOTECH CREATES "GROWTH INDUSTRY"



This gas sensor was created from a microporous silicon structure converted from the shell of a single diatom.

Scientists have long envied nature's incredible manufacturing ability, and an increasing number of high-profile studies have focused on harnessing that efficiency. For chemical engineer Kenneth Sandhage, the search began on a bus trip when he was an Alexander von Humboldt Foundation fellow in 1991. Seated next to another Humboldt fellow, marine biologist Monica Schoenwaelder, Sandhage learned about her research into tiny aquatic algae called diatoms. The diatoms, with their elaborate structures and vast variety, captured his imagination. Today, more than 15 years later, Sandhage hopes to use diatoms as the template for a new class of gas sensors as well as numerous other nanodevices.

Complex Miniatures

Diatoms measure in the tens of micrometers but feature intricate microshells with shapes that include cylinders, wheels, fans, donuts, circles, and stars. Scientists estimate that there are roughly 100,000 uniquely shaped diatoms in nature's arsenal.

Diatom-derived nanostructure templates offer a level of complexity that can be difficult or impossible to achieve through the conventional method of photolithography. Photolithography creates three-dimensional silicon nano-structures through a slow and methodical process of adding and etching silicon layers, one at a time. Harvested diatom shells, on the other hand, are the product of cell fission—a reproductive process that allows a diatom to create two exact copies of its silica shell. In just 40 generations, a single diatom can turn itself into a trillion.

Microscopic Alchemy

Of course, the diatom's microshell has limited usefulness in its natural state. To use it in industrial applications, Sandhage assembled a team of biologists, geneticists, and electrical engineers to cultivate the silica shell with a synthetic replica, duplicating the structural features that made the diatom so attractive in the first place.

Using Aulacoseira diatoms, Sandhage developed a chemical process which transforms the silica of the shells transforms into a composite containing the common semiconductor material silicon and magnesium oxide; hydrochloric acid dissolves the magnesium oxide, leaving a thin-walled silicon structure with most of the detail of the original diatom shape.

Attaching these new structures to electrodes, Sandhage's team created a microscopic nitric oxide gas sensor with impressive performance. Sandage explained that "our single diatom-derived silicon sensor possessed a combination of speed, sensitivity, and low voltage operation that exceeded conventional sensors." He further states, "The unique diatom-derived shape, high surface area and nanoporous, nanocrystalline silicon material all contributed towards such attractive gas-sensing characteristics."

Other Natural Templates

While Sandhage's breakthroughs with diatoms represent a novel approach, his is by no means the only effort to incorporate natural materials or processes. Angela Belcher of the Massachusetts Institute of Technology has achieved worldwide renown as a pioneer in the field of biomimicry–the reverse engineering of biological processes like bone or shell production. Belcher told *Forbes* magazine in a 2003 interview that the integration of so many different disciplines requires a willingness to unlearn old ways of thinking and look at every process from a completely different angle. "I ask [prospective team members], 'Are you willing to start from scratch and learn an entirely new approach?'" As her field moves more and more into the mainstream, she reports that the number of researchers willing to embrace this methodology has increased dramatically.

Belcher's own forays into nanotech design have involved the use of viral proteins in nanoscale assembly. Tweaking the DNA sequence of the M13 bacteriophage, a six-nanometer-long tubular virus, she was able to engineer a version that would attach to nanometer-sized quantum dots of semiconductor material. The viruses were then collected into thin films, and have since been used to form metal nanowires that can be used in high energy-density electrodes. In the future, these viruses could be grown on a film to create a metal oxide coating capable of serving as a thin-film battery.

What Does Tomorrow Hold?

Belcher's and Sandhage's approaches to nanoscale manufacturing share seemingly limitless potential coupled with a need for commercial application and refinement.

Sandhage has already explored or postulated theories about multiple variations on his process: using catalyst-coated diatoms to destroy pesticides, exploiting photo-luminescent diatoms for computer displays, and using highly porous silicon shells to immobilize enzymes for purifying drugs in high-performance liquid chromatography (HPLC). Sandhage also believes that his diatoms could make for improved electrodes in lithium-ion batteries. Says the professor, "Because diatom-derived silicon structures have a high surface area and are thin walled and highly porous, the rate at which you can get lithium ions into and out of such silicon structures can be high."

Ultimately, Sandhage's research team hopes to move beyond simply cultivating existing diatoms; eventually, they plan to engineer diatoms to grow in specific shapes not found in nature.

Belcher's aspirations for biomimicry are broader, though potentially no less attainable. Having once worked with abalone to control their production of calcium carbonate, Belcher recalls having been inspired one day while standing on her desk and surveying the periodic table. "I thought, 'Well nature hasn't evolved the ability to control these other elements and materials, so let's do it ourselves!'"

Whether the goal is merely to use natural processes as a starting point for nanotech design or if it is to bend natural processes to meet our nanoscale manufacturing ends, Mother Nature still holds the secrets that are key to our success or failure. Time will tell how well she keeps them.

—Edwin Schock

GET INVOLVED IN BEST RECYCLING PRACTICES

Americans throw away enough writing and office paper each year to build a 12-foot wall that would stretch all the way from New York City to Los Angeles—a staggering thought when you consider that more than 75% of all paper generated in offices is recyclable.

Recycling daily consumables like paper, glass, plastic, and other items is becoming more and more common. Not only does it keep waste from overflowing our landfills, but it also saves resources, money, and energy. Making new things from old things takes significantly less energy than making them from scratch; for example, making old paper into new paper takes 30-55% less energy, and making a soda can from recycled aluminum uses 95% less energy.

Many items we use in everyday life can be reprocessed into new products.

Metal

Scrap metal and soda cans, percentage-wise, are the most recycled products. They can be recycled indefinitely, used over and over again and reformed into cans, automobile parts, siding, appliances, and building materials. (Remember to rinse out those cans before tossing them in the recycling bin.)

Plastic

Americans drink billions of bottles of bottled water a week. The bottles are molded from polyethylene terephthalate (PET), which is made from natural gas and petroleum, non-renewable resources. Yet only 23% of recyclable bottles actually end up being recycled. Those bottles get chopped into small pieces and melted down into white pellets of PET, which can then be remolded into new bottles.

Even plastic shopping bags can be recycled; many grocery stores now collect the bags onsite. Furthermore, environmentalists advise not to take a bag unless you really need it; or better yet, bring a reusable fabric bag for your purchases. Recycled plastics are made into more bottles, recycling bins, paint brushes, flowerpots, and shower stalls, among other things.

Glass

Clear, green, brown, and blue glass can be recycled into new glass repeatedly with no loss of quality. It is crushed and added to a mix of new, raw material in a melting furnace before being blown or molded into new jars and bottles. Some is even used to make glassphalt, a road surface composed of 30% recycled glass.

Paper

Almost all paper is recyclable: white and colored paper, white and colored envelopes, newspapers, magazines, fax/copy paper, telephone books, manila folders, greeting cards, receipts, cardboard, etc. The recycled pulp is mixed with fresh pulp to make new paper. Using less paper is just as important as recycling that which you do use. There are tons of ways to cut back on paper use: writing on both sides of your paper and cleaning with a rag or reusable sponge (rather than disposable paper towels) are just two examples. Unlike glass or metal, paper can only be recycled so many times before losing quality. Consider, however, that it takes 75,000 trees just to make one edition of the Sunday New York Post. With paper in such high demand, reusing as much of it as possible is an important goal to attempt.

Computer Supplies

Ink-jet, toner, and laser cartridges are all recyclable. Many office supply stores and other companies collect their used ink and toner cartridges and refill the reservoir to sell to another customer.

Getting Active

Recycling has become such a focus in some communities in the last few years that they pay customers for the products they recycle—pay them by the pound, that is. For example, in Grand Rapids, MI, curbside recycling bins feature a chip embedded in the plastic. The trucks that pick up the bins are equipped with scales to weigh how much is inside. The amount is attributed to a specific family via the embedded chip; they get credit and earn points for the more they recycle. They can check their total online and use their points to get coupons for gas, Starbucks coffee, groceries, and lots of other products and services.

This is just one way community leaders have enticed citizens to recycle. In Philadelphia, PA, a similar program increased city-wide recycling efforts dramatically—from 6 to 90%. Recycling in whatever way possible is becoming more and more vital to maintaining our planet's resources—whether your community has curbside service or you make a weekly drop-off at your local recycling center. Giving away old clothes, toys, and other usable goods is even a form of recycling, because it keeps waste from filling our landfills. Every little bit helps.

—Aprile Smith

FISHER GOES GREEN

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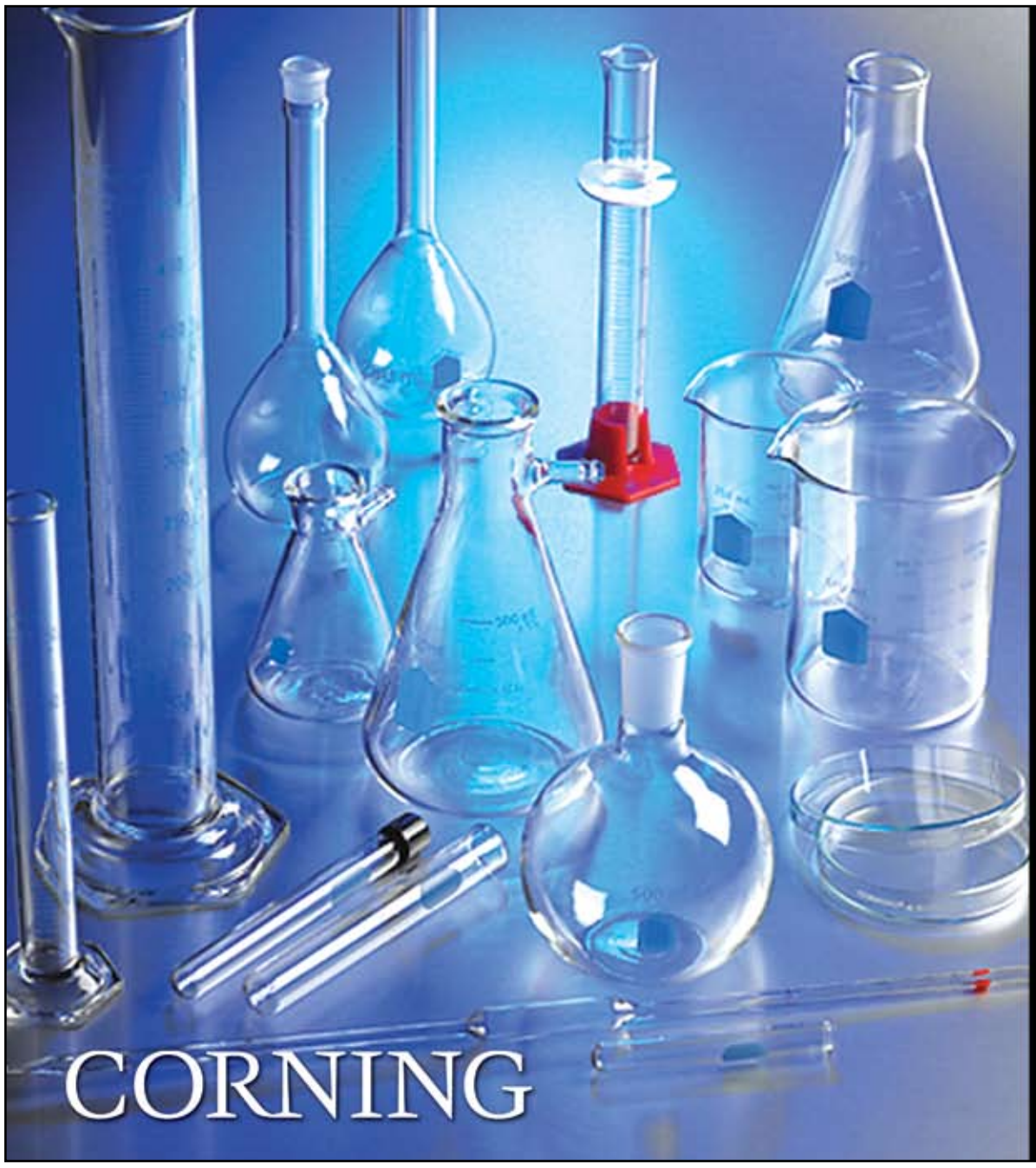
To save energy, Fisher corporate offices turn off air conditioning and turn down lights during nights and weekends.

To find out more about what Fisher Science Education is doing to help our environment, go to www.fisheredu.com and click on the Think Green link.



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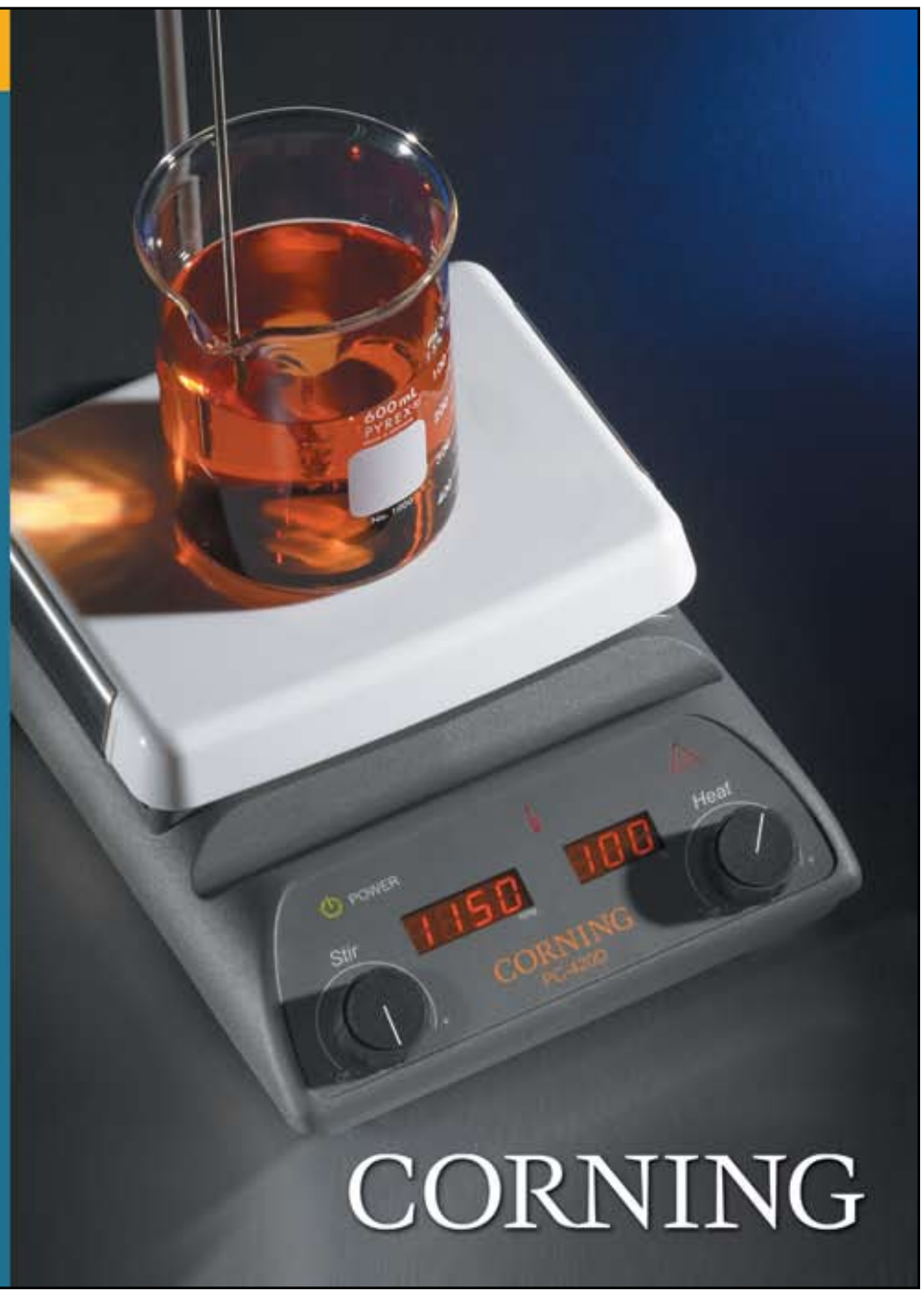
- ✓ Affordable and dependable
- ✓ Pyroceram® glass ceramic top plate

Corning's new digital hotplates, stirrers, and stirring hotplates give you precision heating and stirring with simple, easy-to-use controls. The optional external temperature controller assures temperature accuracy of the liquid as opposed to the temperature of the plate. No more constant monitoring of temperature and stirring…just set the controls and you are free to work on other things.

DESCRIPTION	CAT. NO.	PRICE
35 sq. in. (130cm²), 5 x 7"		
Hotplate	**S90870A**	259.95
Stirrer	**S90870B**	270.80
Hotplate/Stirrer	**S90870C**	415.00
100 sq. in. (645cm²), 10 x 10"		
Hotplate	**S90870D**	404.00
Stirrer	**S90870E**	455.00
Hotplate/Stirrer	**S90870F**	545.00



CREATING DRINKABLE TAP WATER

The Earth is called a "water planet" because it holds 326 million trillion gallons of water. Unfortunately for us, not all of that is "potable," or fit to drink. Many natural characteristics of water in the environment make it less than appetizing, and many manmade pollutants degrade water to the point that it's no longer a healthful beverage.

Water, Water, Everywhere

Most of the water found on the planet's surface is in the oceans. Some experts estimate that 97.5% of all Earth's water is in the oceans. However, these waters are unfit to drink because of the presence of sodium chloride and other minerals. Desalination involves removing salt, minerals, chemicals, and biological matter from salty or brackish water. Desalination, though widely used in some areas of the world, is expensive and energy demanding. It can also degrade the natural environment if the very salty leftovers from the process are not handled properly.

Threats To Potable Water

Unpleasant as it sounds, much of the available freshwater was, at one time, contaminated by human waste products as a result of poor or nonexistent sanitation. In many parts of the world, this is still the case.

Diarrhea, vomiting, and flu-like symptoms are common symptoms from sewage-contaminated water supplies. Historically, waterborne diseases have been deadly, spreading killers such as cholera, typhoid, shigella, polio, and meningitis. In the U.S., effective water treatment practices kill the offending bacteria, viruses, and protozoans.

Water can contain a number of different minerals, for example, iron, manganese, calcium, hydrogen sulfide (rotten egg smell). At normal levels, these minerals create aesthetic problems, but the water is still safe to drink.

This is not the case for nitrates and many other organic and inorganic chemicals, many of which are from manmade pollution. Human health problems may develop quickly or only after years of consistent exposure to these chemicals. Strict health limits have been determined to show where the levels become dangerous.

Sources of Drinking Water

The safest water for drinking in most areas is from deep underground water sources (aquifers). The layers of soil that water passes through naturally filter dangerous microorganisms and some toxins. As the water travels through great distances over long periods of time, the percolating water becomes very clean as bacteria are adsorbed to particles and die in the inhospitable, low-oxygen conditions. Some manmade contaminants are also adsorbed, though others can pass through the soil to affect quality of groundwater.

The number of deep wells is limited by geology and the economics of well-drilling. Surface rivers, lakes, and reservoirs often provide a majority of freshwater supplies. The exposure to the elements, including nutrients and sunlight, can cause excessive growth or blooms of algae. These blooms degrade the water by adding toxins and lowering its pH. Low-lying water bodies are subject to runoff from farms and urban/suburban runoff that drastically increases the bacterial content and the types of chemicals found in these potential water sources. And, in the past, many sewage and treatment industries dumped wastes untreated to further degrade water quality.

Not surprisingly, surface water supplies tend to require the most careful storage and treatment. Reservoirs are placed at higher elevations where urban and agricultural runoff can be avoided. Creating a safe zone around reservoirs further protects water quality by holding contamination to a minimum.

Finally, water can be collected from various atmospheric conditions. This high quality water contains no solid particles like other water sources. In dry areas that lack surface water or access to groundwater, home roofs can be designed to direct water into storage cisterns. Unfortunately, though the water quality is high, on a large scale, methods to collect atmospheric water require more space and energy than other methods of collection and treatment.

Floods and hurricanes can bring large amounts of water to an area, but none of the water is safe to drink. The excess water raises low-lying water supplies and compromises high-level water supplies. Mud, soil, and sewage mix heavily with the water, making it undrinkable.

Treatment Processes

Processes used to bring water to drinking water standards vary in cost and complexity. Even very clean groundwater, when brought to the surface by natural means (geysers) or man-made pumps, acquires particulates from soil and minerals like sulfates and magnesium. For large-scale water treatment, the most common process involves directing water into basins where large particles can settle out.

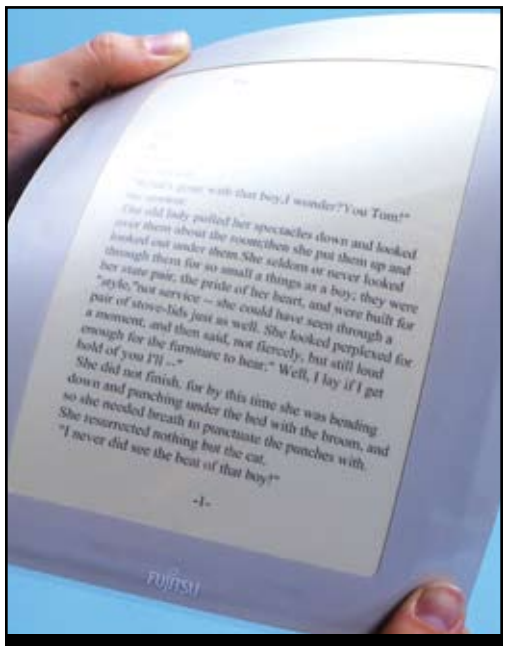
Most treatment centers place water in large flocculation basins to allow larger particles to settle on the bottom. After sedimentation, water is passed through several filtration and micro-filtration methods. Disinfection processes use chemicals and UV light treatment to kill bacteria and pathogens. Depending on the water's source, additional steps may be needed to neutralize the pH level or adjust ion levels.

Other methods do exist, but are not as effective without combining several of them together. Boiling and distillation must last for one to three minutes (depending on altitude) to kill microorganisms. Any dissolved chemicals with a higher boiling point than water will remain in boiled water; any with lower boiling points will transfer with the water vapor during distillation.

Chemists and environmentalists are looking for faster, more portable methods to purify water. Some of their methods will help Third World countries where treatment plants don't exist or the amount of water available is limited. Some would assist emergency response to natural disasters around the world.

—Merry Morris

E-BOOKS AND NEWSPAPERS FIND NEW HOME IN E-PAPER



Electronic paper prototype employing a new material developed by Fujitsu Laboratories.

Electronic trends are changing the way that people communicate. Email and instant messaging are now more popular than mailing handwritten letters through the post office. Newspapers offer electronic copies of their articles on their web sites for faster, searchable browsing. In fact, many magazines and newspapers post additional news articles on their web sites that never appear in print. (We're no exception, check out **www.fisheredu.com** for extra science news.)

Full-length books have even been making the transition, just much slower than their quick-paced literary brethren. New e-books can be downloaded from publishing house web sites and read at your convenience on your computer screen. These books are often cheaper because there is less publishing cost incurred. They also save on paper, unless you decide to print the entire book on your home printer.

However, you do need a computer to read them. As many people know, staring at a computer screen for hours on end isn't very easy on the eyes. Plus, computers are cumbersome. Avid readers often want to curl up in a comfortable chair or stretch out on a sandy beach while reading a book. Sitting at a desktop computer removes this cozy comfort, while laptops are limited by their battery life.

To remedy this problem, computer engineers have been creating "e-paper," a sheet of flexible plastic designed to mimic the qualities of traditional paper. However, unlike traditional paper, e-paper can be reused indefinitely.

E-paper, short for electronic paper, is capable of holding text or images indefinitely without the use of electricity. Much like a computer screen, the paper displays its contents using hundreds or thousands of pixels, too small for the human eye to detect. Unlike a computer screen, which backlights its contents with eye-hurting brightness, e-paper reflects light, has no glare, and can be viewed at any angle.

In 1973, physicist Nick Sharidon was working at Xerox's Research Center when he saw the need for an electronic screen that didn't emit light. His solution was the first electronic paper, created from billions of two-toned polyethylene spheres. Each 0.01mm diameter sphere was embedded inside a sheet of silicone rubber. The bead's white half held a positive charge, while the black half held a negative charge. Using an electronic pulse to rotate the spheres, the page would cover itself in words or images and hold them without the use of electricity. The "paper" could then be changed again and again with new zaps of information.

Competition forced Xerox to change its focus from electronic paper to other printing technology projects. E-paper was forgotten about for almost twenty years until Sharidon, now as a senior researcher, was once again allowed to research his earlier invention. Benefitting from an additional 20 years of computer manufacturing know-how, his e-paper (called Gyricon) has been made more lightweight, more flexible, and with a higher resolution. Sharidon is hoping to have a Gyricon-based newspaper available in three years.

In the mid-1990s, others had begun to see the benefits of a reusable paper. Joseph Jacobson imagined a newspaper that would not only re-print itself on e-paper, but update the articles automatically once a day. To realize this dream, Jacobson started E Ink. Their method involves millions of tiny capsules that are filled with charged dyes that gather based on the electronic charge passed through the paper. While their technology has been used with retail signs, the E Ink newspaper is still a decade away.

Interest in e-paper has really taken off. Many companies such as IBM, Bridgestone, Apple, Sony, and others have entered the e-paper race. Some, such as 3M, are working in cooperation with Gyricon or E Ink. Others are seeking unique materials for more durable e-paper, but relying on pixel presentations similar to the E Ink concept of charged dye particles.

In every case, there are many difficulties in distributing e-paper to a mass market. As was already mentioned, creating a paper that's durable and flexible is a challenge. But people do more with paper than jam it in their pockets. We doodle, color, take notes, jot down reminders, and highlight sections of what we're reading.

Because all types of e-paper use electronic charges to create their displays, special "e-pens" are being created for use with e-paper. They send an electronic charge across the many pixels that they touch and copy notes or doodles that are put into the margins. E-paper manufactured to respond to this new, specified charge will then save the page before sending out a charge and uploading the next page.

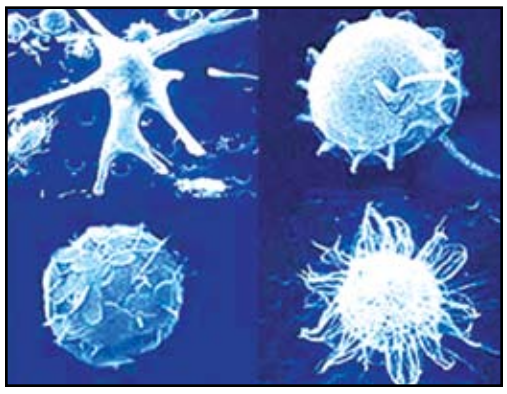
Adding multiple colors, however, is a more daunting challenge. Swapping out black and white displays to be black and gold, silver and green, red and white, or any two-tone contrasting colors is simple enough. However, all text and displays created on that e-paper would be limited to the two predetermined colors. Full-color displays, such as seen on book covers or Internet pages, are a long way off.

E-paper has the same limitless possibilities as the Internet with the convenience of a pocket notebook. Musicians could store an entire concert performance of sheet music. Store owners could display banners and promotions. Restaurants could change their menus every week. Subway or bus tickets could switch between maps and a list of arrival or departure times. Decorative posters in your house could be changed from fine art to personal photography to sports banners at the press of a button.

—AJ Rodgers

QR-LPD e-paper from Bridgestone.

THE BENEFITS OF BACTERIA



In H.G. Wells' classic novel, "The War of the Worlds," an army of alien invaders wages a devastating attack on the Earth. In the end, the creatures are destroyed, not by machine guns, grenades or bombs, but by exposure to microscopic, disease-causing microbes to which they have no immunity.

People have long thought of bacteria and germs as a destructive force to be reckoned with, and microbiologists have primarily focused on studying the bacteria that cause disease.

Recent studies have prompted a renewed interest in the world of microbes, and the results are revealing that, in many cases, those pesky bacteria are helping rather than hurting us.

New Research Techniques

In the past, it has proven difficult to study human-microbial populations because the majority of such microbes cannot be cultured in the lab. Recent scientific advances can now extract DNA from a sample and quickly identify thousands of bacterial species without having to grow each microorganism in a dish.

Using these new lab techniques, researchers discovered that microbes can actually aid in our general well-being throughout our lives, playing a critical role in digesting food, metabolizing drugs and maintaining overall good health. Further, they have found that disruptions in these microbial communities are related to a variety of conditions including obesity, inflammatory bowel disease, vaginal infections, and gum disease.

The importance of our body's microbiota is not an entirely new idea. As far back as the 19th century, Louis Pasteur declared that normal microbes are important in human health and that their disruption can lead to disease.

The numbers of microbes living on and inside us are astounding. From the time we are born, millions of bacteria take up residence on our skin and gastrointestinal tract. Our bodies contain ten times as many microbial cells as there are human cells. Some 500 to 1,000 types of bacteria reside in the gastrointestinal tract alone. It is so dense and diverse, in fact, that it is commonly referred to as a "microflora" living in our intestines.

Gut Germs that Keep on Giving

A thousand times more abundant in the guts of people and mice than the widely studied *Escherichia coli*, the microbe *B. thetaiotaomicron* provides a variety of health benefits. Some scientists have suggested that in return for a steady food supply, this bacterium breaks down indigestible complex carbohydrates into easily absorbed sugars and produces other substances, such as vitamins, that benefit its host.

Jeffrey I. Gordon of Washington University School of Medicine and his team used *B. thetaiotaomicron* as a prototype for studying how microbes influence the gastrointestinal tract. This bacterium normally becomes a predominant member of the intestinal community about the time that an animal is weaned from its mother's milk. Gordon discovered that the microbe turns on specific intestinal genes, promotes the growth of blood vessels necessary for the gut's function, and triggers chemical production to kill competing bacteria. Given this information, researchers are now wondering to what extent gut bacteria actually help to regulate the human body.

Germ-Free Rodents

Traditionally, germ-free mice and rats helped scientists study how particular pathogens caused diseases. A more modern approach uses these rodents to determine the significance of intestinal microbes by watching what happens when an animal doesn't have them. The germ-free animals are delivered by cesarean section into sterile environments and carefully maintained there.

One of the most significant characteristics noted in germ-free rodents is that they must consume about 30% more calories to maintain their body weight than a typical rodent does. They are also much more susceptible to infections. This is most likely because the microflora in a normal gut ward off foreign pathogens.

As a way to study a simplified society of gut bacteria, Gordon introduced the bacterium *B. thetaiotaomicron* into germ-free mice. He found that the presence of the bacterium could actually change what sugars the intestine produces, suddenly enabling the production of the simple sugar fructose, which is commonly found in the intestines of typical mice.

Next, Gordon looked at the gene activity in the mouse intestines. He compared tissue from the germ-free mice to that of the mice hosting the *B. thetaiotaomicron*, and found that the presence of the bacterium significantly affected the activity of several rodent genes.

According to Gordon, some of the genes activated by the microbe help mammals to absorb and metabolize sugars and fats. Other triggered genes fortify the cellular barrier that prevents bacteria from sneaking out of the intestine into other tissues and the bloodstream. And still other genes determine how the intestine detoxifies compounds and how the gut matures.

Absorption of Nutrients

One of the most significant genes activated by *B. thetaiotaomicron* is one that is suspected to stimulate the growth of new blood vessels. To explore this further, Gordon decided to investigate the microbe's control over the blood vessels that extend throughout the GI tract. These vessels are crucial to the body's absorption of nutrients. As suspected, he found that the germ-free mice have a poorly formed network of capillaries that supply the inner intestinal surface with its blood supply. This is a possible explanation as to why the germ-free animals have such difficulty absorbing nutrients.

The research team found that they could stimulate germ-free mice to grow a normal network of intestinal capillaries by exposing them to either a full complement of microflora or just *B. thetaiotaomicron*. This shows that the physical development of the gut can depend on the microbes that normally inhabit animals.

Looking Ahead

New research on microbes clearly shows that the bacterial communities living in our bodies do make a significant contribution to our health. The knowledge gained from such investigations could have an enormous impact not only on understanding human health and disease but also the development of new therapies. We hope to learn more about the chemical signals that microbes might use to manipulate human genes. Also, drugs may eventually be developed that target specific bacterial compounds to restore a microbial community in the body to its normal state. Ultimately, according to Gordon, "we will have a broader view of ourselves as a life form, as a composite of different species."

—Joe Giacobello

WHAT'S UP WITH ALTITUDE?

For athletes to astronauts and everyone in between, life at high altitudes—3000 ft. or more above sea level—is affected by the laws of physics and physiology. On the playing field, in the kitchen, in the great outdoors, and in outer space, altitude is both measurable and at times perplexing.

Peak Performers

Olympic athletes understand the challenges of performing at high altitude locations such as Mexico City (7349 ft. above sea level) or Salt Lake City (4226 ft.). The thinner air taxes an athlete's spirit and stamina, and conditioning takes on added importance. Each year, hundreds of world-class performers train at high-altitude sports complexes specifically to acclimate themselves to rarefied venues. One such complex, the Center for High Altitude Training at Northern Arizona University (7000 ft.) has turned out 191 Olympic and Paralympic medalists since 1996. It offers facilities for track and field, rowing, cycling, and team sports such as basketball and soccer.

Why is high-altitude training critical to an athlete's success? To adjust the athlete's body to the fact that oxygen absorption is lessened at altitude—hemoglobin in the bloodstream delivers oxygen to the muscles more slowly. This is especially key for runners, swimmers, or performers in other low-speed endurance sports. Over a span of a few weeks, the body adjusts to its surroundings, giving the athlete the best possible physiological preparation for competition.

Mile-High Mashers

Coors Field in Denver, CO is the home of baseball's Colorado Rockies. When the ballpark opened in 1995, the Major Leagues got a taste of baseball at 5280 ft. Physicists had predicted that a baseball would travel 10% farther at Coors than at a sea level diamond like Boston's Fenway Park. In the thinner air, curveballs would 'flatten out'—break less—due to less air resistance and spin, aiding hitters. The predictions were accurate. Despite spacious dimensions relative to most other stadiums, Coors Field became a slugger's haven, and the Rockies' heavy hitting lineup earned the nickname, "Blake Street Bombers."

Unfortunately, the mile-high slugging results didn't follow the Rockies to road parks at lower altitudes. The Rockies were mediocre hitters, at best, away from Coors Field, and visiting batters benefited from the ballpark's effects as much as the Rockies did, negating any true home field advantage. In 2002, in an attempt to 'normalize" Coors Field, the ballclub began to store a game's supply of baseballs in a climate-controlled humidor with a fixed relative humidity of 40% (vs. a typical 10% outdoors in Denver). The heavier baseballs worked as hoped; offensive numbers dropped significantly. Despite the humidor, Coors Field remains one of the best hitters' venues in baseball.

High-Altitude Cooking

Atmospheric pressure affects cooking and baking at altitudes of 3500 feet or more. Water boils at a much lower point in the thinner air—about 1°F lower for every 500 feet of ascent—thus extending the time needed to boil foods.

Cake baking at high altitudes requires a few adjustments to the standard recipe. A regular mix will rise faster and possibly topple due to a faster heat exchange. (As heat rises in the oven, the lower air pressure cannot offset the upward pressure, causing more rapid expansion.) Bakers compensate by adding a tad more flour (to disperse leavening) and water (to counterbalance rapid evaporation), and by raising the temperature slightly to help set the crust.

Altitude Sickness

Mountain climbers must take precautions to prevent Acute Mountain Sickness (AMS), a common occurrence above 8000 feet. Typically AMS happens after a too rapid ascent. A headache combined with fatigue, dizziness, or nausea is symptomatic of AMS. Untreated, AMS can cause a fatal pulmonary or cerebral edema (fluid buildup). The condition can be prevented with a controlled climb at a slow pace and by avoiding overexertion.

Flying over Everest

Even though thought of AMS may make you weak in the knees, certain animals live and thrive at the top of the Earth.

Take the bar-headed goose, the world's greatest high-altitude flyer. Each year, countless flocks of these five-pound birds with oversized wings migrate from their winter feeding grounds in the Himalayas to their nesting areas 1000 miles away in Tibet. Quite often, these birds pass over the world's tallest peak—29,028-foot Mount Everest!

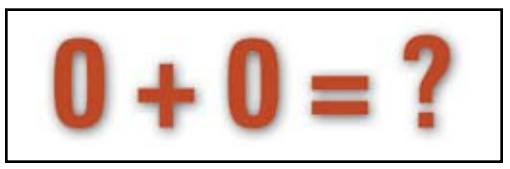
Bar-headed geese have evolved to withstand a harsh environment that freezes a human's skin on contact, and where the air's oxygen content is just one-third of what it is at sea level. Like all birds, their bodies contain a series of chambers that store inhaled air that has passed through the lungs, and pass it back through the lungs before exhaling. (Mammals pass air through the lungs just once.) Their blood contains a special hemoglobin that absorbs oxygen very quickly. This recirculation system allows for exceptionally efficient oxygen transfer, even at 5.5 miles above sea level. In addition, bar-heads have extra-large wings relative to their body length, making them capable of flying up to 50mph under their own power, or riding a Himalayan tailwind to speeds of 200mph.

Astronauts and Altitude

We've all seen footage of astronauts in space floating practically weightless in the microgravity of their spaceships. But did you know that astronauts must exercise regularly in space to offset the effects of long-term weightlessness? When bones and muscles aren't used to support the body's weight, they atrophy over time. An exercise regimen including a stationary bike, treadmill and resistance machine counters the loss of bone density and muscle mass.

—Dan Skantar

NOTHING REALLY IS SOMETHING



How do you name something that is really nothing? For centuries this question stumped scientists, mathematicians, and philosophers. The answer is the numeral zero. According to Merriam-Webster's online dictionary, the definition of zero as a noun is the arithmetical symbol denoting the absence of all magnitude or quantity. In other words, zero is the symbol or name for nothing.

The Concept of Nothing

In today's time, the concept of zero is so common that we could not imagine everyday life without it. For instance, when a person has ten dollars in his or her pocket, and those ten dollars are spent on lunch, there are zero dollars left in that person's pocket. This example shows the relationship between counting and zero.

From Hawaii to Australia, the enactment of counting is universal. The idea of counting with different symbols and rules was developed by many ancient cultures including the Sumerians, Indians, Chinese, Egyptians, Romans, and Greeks. However, the idea of zero did not exist for quite some time. It is estimated that between the sixth and third centuries B.C., zero made its debut in the Sumerian number system. The Sumerians represented zero as a slanted double wedge. However, Al-Khwarizmi, a Persian mathematician, was the first to present zero to the world centuries later. Al-Khwarizmi was also known as the founder of algebra.

The Benefit of Nothing

Zero makes today's way of counting simple. In the decimal system, all numbers are made up of ten digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Once past nine, the digits are repeated in sequences where any number can be composed with just ten digits. In the Roman number system there was no symbol or placeholder for zero. For every increment of ten, a new symbol was added to the number expression. So the higher the number, the longer and more complicated the symbol.

The Properties of Nothing

In the math world, the idea of nothing can be quite confusing. In mathematical terms, all real numbers, except zero, are either positive or negative. Zero is neither positive nor negative. Other mathematical properties of zero include:

Additive Identity: Adding zero to any number x equals x.

Multiplication Property: Multiplying any number p by zero gives zero.

Exponent Property: Any number other than zero raised to the power zero equals 1.

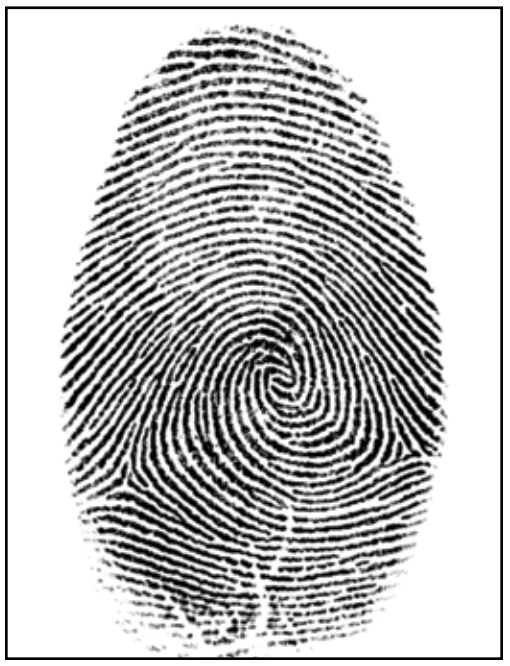
Division Property: A number cannot be divided by zero. Therefore, division by zero is undefined.

Much Ado About Nothing

While zero is accepted by mathematicians as a number, some philosophers would argue the contrary. They state that one cannot have zero of something. Yet others argue that if one has a bank account balance of zero, that poor individual has a specific balance of money in that account—namely none. While philosophers could debate the ability of having nothing, mathematicians agree that there is a need for the zero placeholder.

—Jennie Culver

NEW FINGERPRINTING METHODS SHOW MORE THAN RIDGES



Fingerprints left at the scene of a crime are incredibly delicate. Unlike what you may have seen on TV or in the movies, a print can be disturbed by picking up the evidence with a handkerchief or placing it in a plastic bag. And the same finger can leave prints that look different depending on how wet or oily a person's hands were.

Traditional print collecting methods can alter the evidence as the print is being identified. Dusting, the most common method, applies a dark powder to the evidence. The powder sticks to the oily residue in the fingerprint. The excess powder is brushed away, and an adhesive tape pulls the print off of the original surface. Sometimes, a fluorescent powder is used if the original evidence has bright colors or detailed patterns in it. This contrast enhancement helps make the print stand out from the background.

Other methods spray chemicals onto the evidence to make the print develop, much like photographic paper. Or sometimes molds are used, if the print was created in a soft surface like mud or snow.

Beyond altering evidence, these methods can destroy hidden chemical compounds that were distributed with the print. To combat these issues, forensic scientists are coming up with more advanced ways to collect prints. Chemists have discovered that there's more to fingerprints than the ridges, loops, and whorls. The oil or dirt that creates the fingerprint in the first place can provide additional evidence against a criminal.

Using a process called micro x-ray fluorescence (MXRF), forensic scientists collect fingerprints without damaging the evidence. The mini x-ray beam blends with the atoms in the fingerprint. Chemical elements within the print emit and absorb radiation at different light frequencies. Criminologists use a spectrograph to identify the sweat salts that create ridge patterns from the dirt or substances that were on the finger.

This method can separate fingerprints from surfaces with busy backgrounds, textures, and even human skin. Because the chemical composition of one person can be different from another, the amount of sodium, potassium, and chlorine would be different when seen through a spectrograph.

Another distinct advantage of MXRF is the possibility of finding more fingerprints from missing children. Children's prints are often harder to detect because their hands don't secrete sebum, an oily substance in the skin. However, MXRF can detect chemicals from dirt, saliva, or food to help find these elusive prints.

Noninvasive MXRF is promoted as a first step since some fingerprints may not contain enough chemicals to be seen. This method opens the door for additional fingerprinting to be done while providing information on which type of printing should be done next.

Because the sweat left behind in a print carries antibodies, researchers in Britain have discovered that a fingerprint could be used to identify a smoker from a nonsmoker.

For distinguishing smokers from people who may have handled tobacco products, chemists attached a cotinine-specific antibody to a gold nanoparticle. The body creates cotinine after consuming nicotine. When the nanoparticles are applied to a fingerprint, the antibodies attach to cotinine, if present. This then causes the print to fluoresce if the print's owner was a smoker, and do nothing if he or she was a nonsmoker.

Fingerprinting's History

Anthropologists have traced handprints back to prehistoric petroglyphs, some of which included drawn ridge patterns and creases. Clay tablets and seals from both China and Babylon include thumbprints as part of a signature on official documents.

The first declaration that no two fingerprints are alike came from a Persian government official in the 14th century. At that time, many Persian documents included fingerprint impressions.

In 1686, Marcello Malpighi documented the thick layer of skin on fingertips, which came to be known as the Malpighi Layer. In 1823, Johannes Purkinje identified nine distinct fingerprint patterns. Neither anatomy professors' notes indicated using fingerprints as a method of identification.

Then, in 1858, the idea that fingerprints are unique re-surfaced. Sir William Herschel used handprints on contracts between the British magistrate's office and Indian citizens. Herschel used this method to intimidate signers into keeping their end of the contract because people felt more obligated from a handprint than a signature. As this became common practice in India, Herschel theorized on the possibility of using them for personal identification.

The first proof that fingerprints could identify someone came in 1880 from Dr. Henry Faulds. Faulds fingerprinted a laboratory bottle and correctly matched it to an inked copy of an assistant's print. He then developed a classification system.

Sir Francis Galton compared Faulds' work with Herschel's collection of handprints. His assessments provided the first scientific proof that no two fingerprints were the same and that the odds of finding identical prints were 1 in 64 billion. Furthermore, he discovered that fingerprints didn't change over the course of a person's lifetime.

In 1896, the first database of criminal fingerprints was made part of the official process for tracking criminal behavior. Almost a century later, electronic versions of fingerprint records replaced paper card copies, helping law enforcement match records faster.

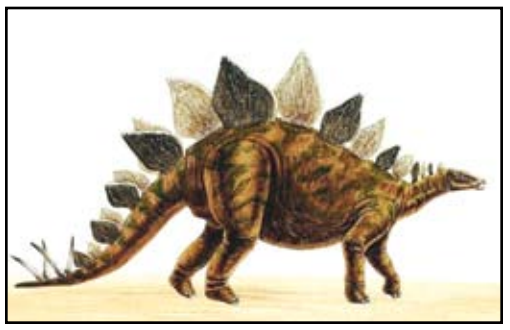
Fingerprinting's Future

Fingerprints as a form of identification can do more than just solve crimes and detect drug usage. Faster, biometric fingerprinting is offering a new type of security to offices and shopping outlets. This electronic fingerprinting method would stop a computer from turning on or a purchase from transferring money if the required fingerprint does not match what's on record.

The biometric method is faster because it is completely automated, but is vulnerable to mistakes or hackers. To verify a match, the computer only needs to match a certain threshold of points before it accepts the print. Criminal investigations still use a person for final verification because of how delicate and unique a fingerprint can be.

—AJ Rodgers

TRACKING BABY STEGOSAURS



Scientists recently concluded that tiny fossilized tracks discovered in the foothills of Colorado belong to two baby stegosaurs. Matt Mossbrucker, director of the Morrison Natural History Museum, discovered the tracks on a boulder last year. However, Mossbrucker needed to dig further and study the tracks before concluding that the tracks belonged to baby stegosaurs.

Each footprint is slightly larger than a U.S. quarter. They suggest small, wide feet with three toes tipped with stubby claws. Not everyone is convinced that these tracks belonged to juvenile stegosaurs. Ken Carpenter, curator at the Denver Museum of Nature and Science, points out that many other dinosaur species populated Colorado during the same time period when the stegosaurs would have been present. Houston Museum of Natural History curator Robert Bakker initially resisted the idea, but now believes that the tracks were made by baby stegosaurs.

Researchers believe the babies to have been about the size of turkeys. Adults grew to 10 feet high and 30 feet long, weighing in at around six tons. Bakker notes that judging by the infant stegosaurs' tracks, they would have been about one-eleventh the size of adults. Tracks belonging to baby dinosaurs of any species are exceedingly rare – duckbills in Montana, an allosaur in Wyoming, and some other species in China. In each case, Bakker noted, the dinosaur hatchlings are about one-eleventh the size of adults, a ratio he believes to be significant.

Familiar to school children as the dinosaurs with large plates on their backs, stegosaurs lived about 150 million years ago during the Jurassic Period. Although the first stegosaur fossil was discovered in Morrison, Colorado, stegosaur fossils have been discovered as far away as China and Europe. Scientists agree that stegosaurus was an herbivore based on the structure of its mouth. However, little detail is known about the plants in its diet because there are few fossilized impressions of plants from its environment. How long stegasaurs lived or how quickly they grew is still being investigated.

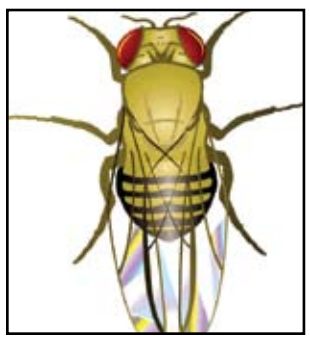
Morrison, CO is not only home to the Morrison Natural History Museum, but also the site where the first stegosaur bones were unearthed 130 years ago. This first find of the adult dinosaur's bones in 1877 by M.P. Felch led to adoption of the stegosaurus as Colorado's state fossil. Other stegosaur fossils have also been quarried there. In fact, the boulder into which the baby stegosaur tracks are etched sat undiscovered along the road to a previous dinosaur quarry for about 70 years. Two years ago, the boulder was moved to the Morrison museum where it went on permanent display during the museum's May 2007 "Dinosaur Days" event.

Mossbrucker observes that paleontologists often overlook sites like Morrison, possibly because it is not an exotic location. The Morrison tracks were found a little more than 10 miles west of metropolitan Denver. In spite of its location practically in sight of Denver's skyscrapers, Mossbrucker feels that the site will interest anyone who studies paleo-ecology.

—Lisa Jancarik

If you love dinosaurs, visit **www.fisheredu.com** to find additional *Headline Discovery* articles on how researchers study and preserve dinosaur tracks.

DROSOPHILA RESEARCH INTO IMMUNITY AND LIFE SPAN



In 2000, the sequenced genome of *Drosophila* was released; it now provides a valuable tool for understanding gene function, making the organism even more important to human health. Approximately five thousand researchers are currently using *Drosophila* as a model system to study all biological aspects of the fly, ranging from cancer to immunity.

Fruit flies are being sent up in space shuttles to study what happens to their immune systems following exposure to weightlessness. Due to the similarities between the immune system of flies and humans, researchers working with NASA believe that the findings can be applied to astronauts in an attempt to keep them healthy during space travel.

An organism's body contains specialized cells that patrol it looking for foreign objects, such as bacteria that can cause disease. However, it is important that these cells can tell the difference between foreign objects and the body's own cells so that it does not attack itself causing auto-immunity, as occurs in the human disorder Lupus.

In NASA's Life Science Research, flies and their offspring were exposed to space and were then compared to flies that did not travel in space. Both groups of flies were exposed to a fungus *(Beauveria bassiana)*—one that is not harmful to humans—to determine its effect on their immune systems. The space-traveling flies showed immune suppression, or the inability of the immune system to be turned on in response to invading organisms, which could result in illness for humans. In addition, microorganisms (fungi or bacteria) grown in space were shown to change when exposed to microgravity, becoming more likely to cause disease.

Based on these findings, the combination of a suppressed immune system and more virulent strains of fungi or bacteria could lead to decreased health of astronauts following prolonged space travel. Therefore, it is important to continue immunity studies using model systems such as *Drosophila* to help protect astronauts during and after their missions.

Another recent study using fruit flies has revealed a new way to block protein receptors involved in the process of aging and disease in various species. This study, conducted by Richard Roberts and colleagues from the University of Southern California, showed that blocking a single protein could increase the lifespan of *Drosophila*. As amazing as it is that a single genetic change can alter the longevity of an organism, the ability to develop inhibiting proteins could also be used for therapeutics and drug discovery.

Receptors are defined as intracellular proteins that bind to a ligand (known stimulus) and transmit a signal across the cellular membrane. When the receptors of the flies were blocked with "short proteins," researchers were able to increase the flies' lifespan by approximate 33% with no observable side effects.

These studies represent only two examples of important research using fruit flies. The ultimate benefits of these findings could result in the treatment or cures for many human diseases. So you might want to think twice about the usefulness of these sometimes annoying creatures while you are swatting them.

—Stephanie E. Winter, Ph.D.

SOAPY SOLUTIONS ACTIVITY*

If you think health inspectors are picky about water that people swim in, you won't believe how many other kinds of water they test. Health inspectors do a lot of sleuthing when it comes to disease. Are you surprised that it is someone's job to make sure that people who touch our food wash their hands? Can washing our hands make them that much cleaner? Is how we wash our hands really important? Try this fun activity and find out!

Materials Needed:

- Cooking oil, 3 tablespoons
- Cinnamon, 3 teaspoons
- Sink with hot and cold water
- Liquid hand soap
- Paper towels
- Clock or watch

Procedure:

1. Divide class into three teams. Each team will need a student as a hand washer, an oil measurer, a cinnamon measurer, a soap dispenser, a towel dispenser, and someone to control the faucet. Everyone else can observe and watch.
2. Put 1 teaspoon of cooking oil in each of the palms of the three hand washers. Rub oil all over their hands until completely coated.
3. Sprinkle 1 teaspoon of cinnamon on each of the three hand washers' hands. Rub it around until evenly distributed. The cinnamon represents bacteria. It's everywhere!
4. Hand Washer #1: Wash hands with COLD water and NO SOAP. Rub briskly for 20 seconds.

   Hand Washer #2: Wash hands with WARM water and NO SOAP. Rub briskly for 20 seconds.

   Hand Washer #3: Wash hands with WARM water and SOAP. Rub briskly for 20 seconds.
5. Observe all three sets of hands.

Observations and Conclusions:

1. The method that removed the most "bacteria" was soap and warm water.
2. If only cold water and no soap are used to wash, all of the "bacteria" might not be removed.
3. The warm water makes the oil less sticky.
4. Soap helps to trap bacteria so the water can carry it away. Rubbing also helps to loosen bacteria.
5. Bacteria may linger everywhere!

*Adapted from the Partnership for Food Safety Education. Visit **www.fightbac.org** for more info.

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FINDING THE BIG DIPPER, POLARIS, AND NORTH

Throughout history, people have used the stars as clock, compass, and calendar. The yearly star cycle determined the best time for planting, harvesting, and other annual events. They used the cycles of the Sun, moon, and stars to reckon the passage of time. People also used the stars to navigate over land and sea.

Tools for Teaching brought to you by:

Starry Night
A Division of IMAGINOVA

Objectives:

Introduce students to the constellations and show them a method for finding your way around in the sky. They will learn to find the Big Dipper and Polaris.

Math Note: Students will be introduced to the concept of angular measure by measuring angles in the real sky.

Materials Required:

- A place where you can see the stars at night
- A clear night sky and hands to measure it
- Sky chart (Use a digital planetarium program for customized charts)
- Pencil and paper
- Small flashlight (preferably with a red filter)

Time Required:

25 minutes

Procedure:

The Big Dipper is the first star grouping that most people learn in the Northern Hemisphere.

It is not a proper constellation. It is an asterism, which is a well known grouping of stars. The Big Dipper is part of the constellation Ursa Major (Latin for the Great Bear). We will use it to learn about measuring the sky.

Take a look at Figure 1 to see how you can use your hands to measure the sky. The size of your hands is proportional to the length of your arms; small hands and big hands all work the same for this activity.

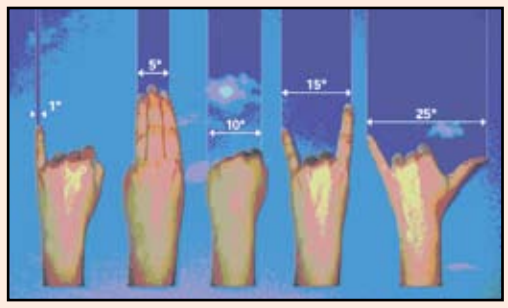


Figure 1: Hands held at arm's length can measure angles in the sky.

If you can locate the Big Dipper in the sky, go directly to Step 5. For help locating the Big Dipper, start here.

1. Use Digital Planetarium Software to print a northern sky chart for your date and location. It should look similar to Figure 2. If you do not have Planetarium Software, monthly star charts can be downloaded from **www.space.com/nightsky**
2. Label the constellations and Polaris. Find the Big Dipper and Polaris on the chart.
3. On the first clear night, take the chart outside and face the northern horizon. A red-filtered flashlight will illuminate your chart you without losing your night vision.
4. Use the chart to locate the Big Dipper in the sky.
5. Use the Dipper's pointer stars (two stars at end of the bowl) to find Polaris. They line up to point directly at Polaris.
6. Hold your hand out at arm's length and measure the Big Dipper with your hands. Refer to Figure 1.
7. Record the size of the Big Dipper in your worksheet.
8. Measure the height of Polaris above the horizon with your hands.
9. Put your sky chart away and make a drawing of how the sky looks from your location. Your drawing should include the horizon, the Big Dipper, Polaris, and the location of due north. (HINT: The horizon's north point is directly under Polaris. To find it, first find Polaris and then draw an imaginary line from it straight down to the horizon.)
10. Mark all of your angular measurements on your drawing.
11. Draw an arrow to show how the Big Dipper can be used to find Polaris.

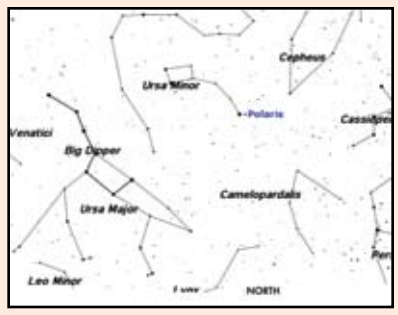


Figure 2: Sample star chart showing the Big Dipper and Polaris. Courtesy of Starry Night Software.

Discussion Questions

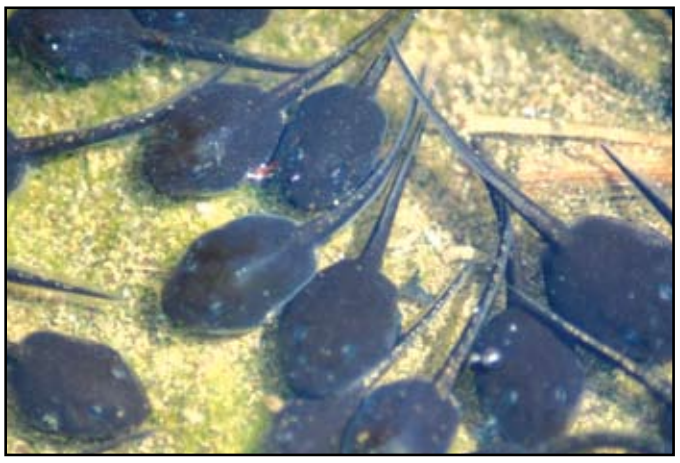
A. Were you able to "star hop" from the Big Dipper to Polaris?

B. What is the height of Polaris in the real sky?

C. What is your latitude? (HINT: The height of Polaris in the sky is equal to your latitude)

D. Why does the height of Polaris match your home latitude?

TEACHING LIFE SCIENCE THROUGH THE WONDERS OF ONTOGENY!



There is overwhelming evidence that teachers who expose students to the amazing sights found in nature produce, students who develop at least a love of nature if not a professional scientific career. One lesson that is rich in producing excitement and even awe, whether it is done at the kindergarten or high school level, is to let students observe the development of an organism, be it an insect or amphibian (frog or salamander), from egg to adult.

These kinds of observational studies are extraordinarily rich because of the many parallel lessons that can be included. Students can be introduced to ideas or an entire life sciences curriculum based on the ontogeny (developmental sequence) of an organism. Example conversations over a semester could include:

- Eggs are sourced from females
- Eggs are larger than the sperm (male gamete if your students are too young for the "S" word)
- Eggs are the non-motile gamete; sperm are motile (a non-motile gamete is actually what defines one as female, while males produce motile gametes)
- Eggs are the source of most of the cytoplasm of the offspring (i.e. we are more of our mothers than our fathers)
- Mitosis (cell division) is necessary to produce the adult organism
- Growth as a term can mean increase in size or increase in cell numbers
- Developmental stages can be recorded and discussed individually, incorporating ideas such as differences in food needs, niche filled, etc.
- Metamorphic (structural) changes over time relate to niche being filled, or changes necessary to match needed food resources (i.e. tadpoles have elongated guts because they are herbivorous, caterpillars have different mouth parts than adult moth or butterfly, not to mention they lack wings, etc.)
- You can also explore topics like food webs, pyramids, population regulation, etc.

At first, taking such a broad approach—introducing excited students to so many basic life science topics and tenets—can be daunting. There are easy ways to have great success, but they take a little planning and a little understanding of the biology. Ever since Monarch butterfly studies were introduced in the late 1980's, many teachers have let students observe butterfly metamorphosis. But this experience is limited. Students watched the butterflies hatch or, more likely, they saw eggs on a leaf; one day there were caterpillars, and the next day there were butterflies. There are ways to get better observations, and why not use what is happening to introduce some of the ideas listed above?

One way to record changes over time is to utilize video cameras capable of time-lapse photography. A number of inexpensive cameras are available from Ken-A-Vision, with either medium or high resolution. Many of the following ideas can be utilized to allow the students observe any organism metamorphosing.

More complicated metamorphosis has the advantage of taking more time than that of a butterfly, allowing some of those ancillary topics to be introduced before being seen. Sources such as amphibians (frogs or salamanders) or Zebra fish (Danio rerio) can be easily obtained from biological supply houses carrying inducing kits. Alternatively, areas with indigenous populations of salamanders (Maine to Georgia on the east coast or Washington, Oregon, and northern California on the west) have embryos available from local ponds in the spring.

Aquatic eggs can be placed in small, coverable dishes (such as Petri dishes) and spring water. Most aquatics are sensitive to chlorine, so local spring water or de-chlorinated water is important. The eggs will be in a relatively clear gelatinous egg envelope. If there is a green tint to the envelope, it is ok; this is a symbiotic alga, from the water or the female's cloaca. The symbiotic relationship involves the algae photosynthesizing and producing oxygen, and obtaining carbon dioxide from the respiration of the eggs/embryos. Organisms will have to be moved to larger dishes after they have hatched. Biological supply houses can provide food for the newly-hatched organisms.

Before putting the eggs in the dish, place a small mirror at the bottom. A series of structures develop (Morula, Blastula, Neurula) as the cells undergo mitosis and migrate to their positions in the embryo.

On the Blastula a very discrete structure develops called the Blastopore. Because the density of the cells near the Blastopore is greater, aquatic embryos tend to rotate so that the Blastopore is down at about 4 o'clock, necessitating the need for a mirror to see the bottom of the developing embryo.

Every day, students can observe changes directly or as part of a classroom experience using a camera and projector. By putting the camera close to the water's surface (not in the water), you can record time-lapse sequences and review progress over a series of days.

Amphibian eggs are a good choice for recording early cell division and the subsequent formation of a Morula. Once at the Morula stage, start looking for the Blastula stage and the formation of the Blastopore. At that time, you may want to focus a camera on the mirror rather than the eggs.

The Blastula will then become a Neurula, and the ontogeny will continue. Do be aware that this developmental sequence is temperature dependent—slower at cooler and faster at high temperatures, lethal around 35°C in most species.

So pick your organism, and let the development of a new organism be the backbone of this year's life science curriculum! In the context of carefully watching the metamorphosis, complex topics such as mitosis and growth will take on a whole new meaning.

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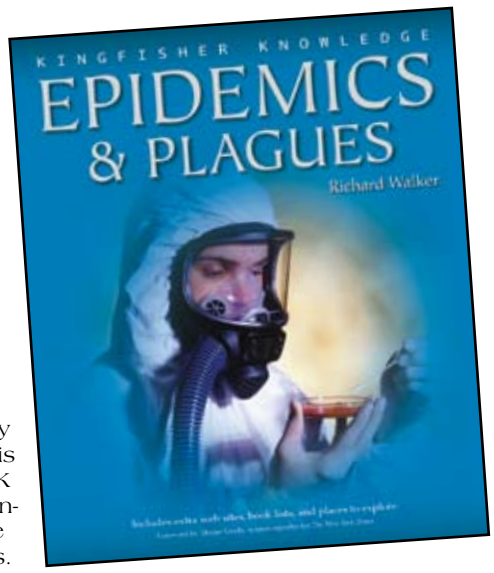
EPIDEMICS AND PLAGUES



By: Richard Walker
Kingfisher Knowledge Series
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Throughout human history, deadly diseases plagued us—literally. This addition to the award-winning KFK series offers an age-appropriate, in-depth view of how diseases have transformed into worldwide killers.

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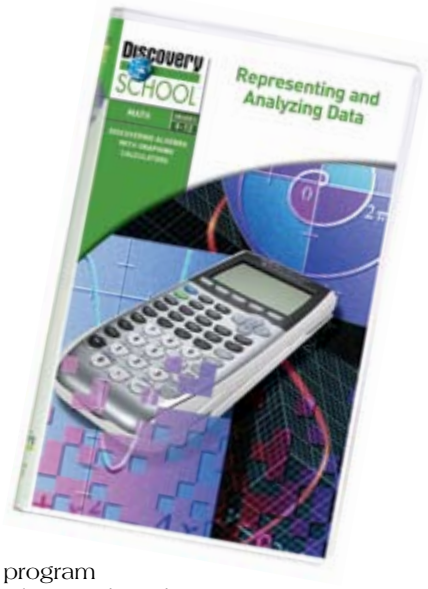
To order Epidemics and Plagues **(S96843, $12.95)** visit **www.fisheredu.com** or call **1-800-955-1177.**

BOOK REVIEW

REPRESENTING AND ANALYZING DATA



Discovery School
2007, Running time: 25 min., Grades 9-12

Part of the new Discovery Algebra with Graphing Calculators series, this video explores the many functions of graphing calculators and their real world application.

Written and hosted by renowned mathematics instructor Monica Neagoy, this program demonstrates how to represent and analyze data, make inferences, and draw conclusions. Students learn to create line graphs, histograms, and other mathematical forms for data analysis.

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Includes a teacher's guide with program description, learning objectives, classroom connections, classroom activities, target vocabulary, and academic standards.

To order Representing and Analyzing Data as VHS **(S95445, $59.95)** or DVD **(S95445DVD, $69.95),** visit **www.fisheredu.com** or call **1-800-955-1177.**

VIDEO REVIEW

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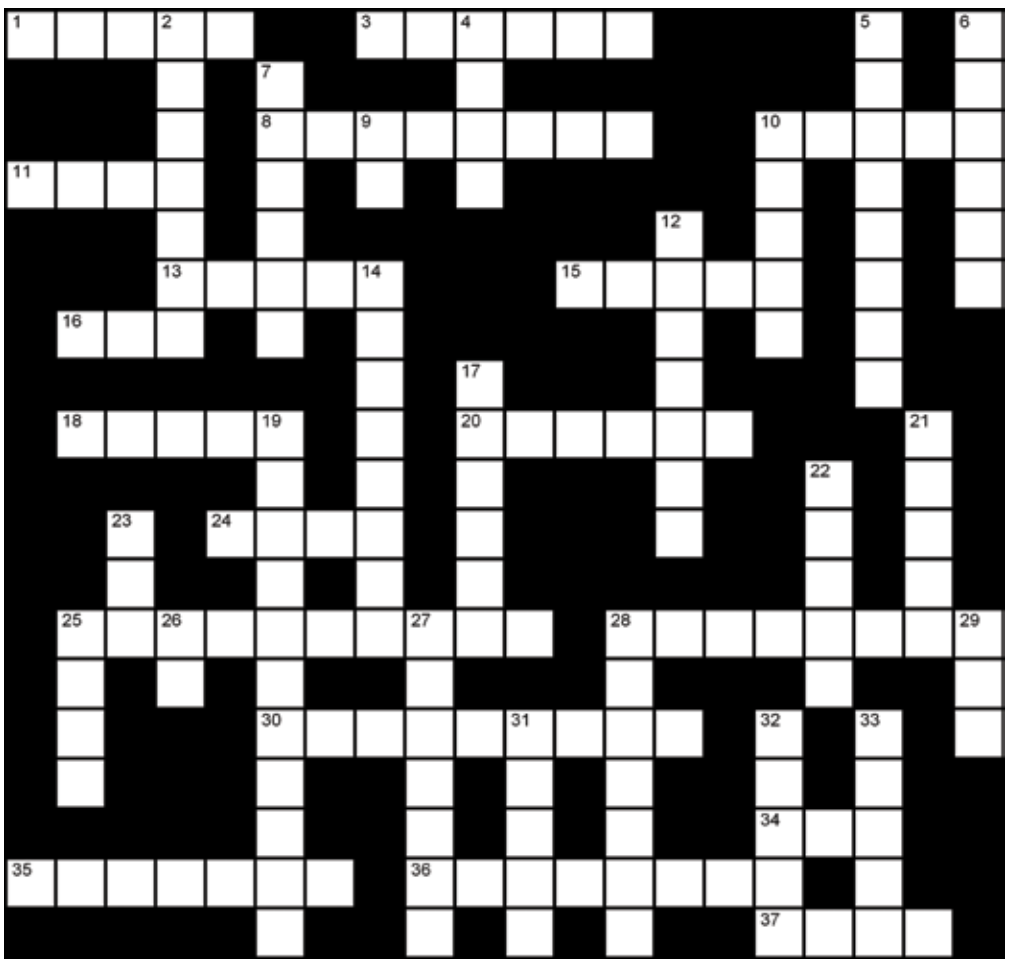

Answers can be found at www.fisheredu.com on the Headline Discoveries page.

Across

1. Toothpaste is made from these (p. 2)
3. Known stimulus (p. 15)
8. Subatomic particle that can only be studied underground (p. 1)
10. Add more of this to cakes at high altitudes (p. 13)
11. Computer screens ___ light (p. 9)
13. Word that scientists protested the use of in Mr. Wizard's TV show (p. 2)
15. Largest brain on Earth (p. 4)
16. Nanotechnology is improving these sensors (p. 5)
18. Above surface, freshwater sources (p. 8)
20. Small dots of color used in computer screens to create images (p. 9)
24. Made today's method of counting simple (p. 13)
25. Gathering of bacteria in our gastrointestinal tract (p. 12)
28. Number system to first use numeral zero (p. 13)
30. Excessive TV watching can create problems with this (p. 3)
34. Acute Mountain Sickness (p. 13)
35. Proposed that bacteria is important in human health (p. 12)
36. Video game players test these to reach the next level (p. 3)
37. Desalination purifies this type of water for drinking purposes (p. 8)

Down

2. Aquatic algae helping generate new nanotechnology (p. 5)
4. Added to the cast of Mr. Wizard in 1952 (p. 2)
5. A danger to underground laboratories (p. 1)
6. Comparitive size of baby stegosaurus (p. 15)
7. Recycling uses less of this than new manufacturing processes (p. 6)
9. Light treatment for water purification (p. 8)
10. Sent into space to study immune systems (p. 15)
12. Experimented with rat brains (p. 4)
14. An abrasive used to clean teeth before toothpaste (p. 2)
17. Electronic paper (p. 9)
19. Baby dinosaur leaving tracks near Denver (p. 15)
21. Used thumbprints as identification in clay seals (p. 14)
22. Baseball field that transformed the Rockies into the Blake Street Bombers (p. 13)
23. Medical images proving brain activity (p. 4)
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28. Fingerprinting uses cotinine-specific antibodies to identify these (p. 14)
29. TV station to first air Mr. Wizard (p. 2)
31. Reusable computer cartridge that should be recycled (p. 6)
32. Crushed and melted with new materials during recycling (p. 6)
33. Deep Underground Science and Engineering Laboratory (p. 1)

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