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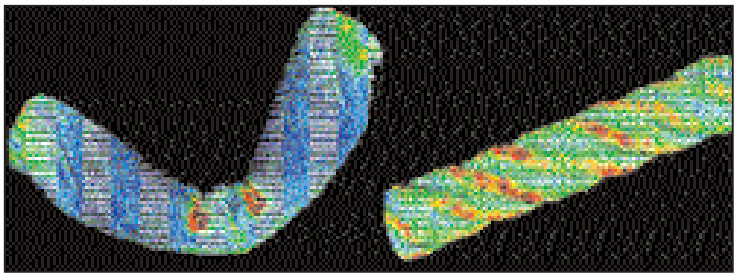
FISHER SCIENCE EDUCATION

# HEADLINE DISCOVERIES

MAKING SCIENCE MATTER™

# HUGE ADVANCES IN A TINY SCIENCE



*Multi-wall Carbon Nanotubes*

Discovered 15 years ago, carbon nanotubes are pencil-shaped molecules of carbon linked together in a configuration that resembles a cylinder made of chicken wire. They were the accidental discovery of a Japanese researcher at NEC. He was working with another revolutionary carbon molecule called a buckyball when he first observed carbon nanotubes. Researchers have since developed applications for nanotubes in fibers, textiles, materials science, and medicine.

Currently considered the strongest material for their weight known to mankind, nanotubes are nine times as strong as steel but only weigh one quarter as much. They can also transmit 1,000 times as much electrical current as copper. The challenge lies in developing ways to manipulate these extremely small building blocks. Nanotubes are only one or two nanometers in diameter and one millimeter in length. A nanometer is a measurement equal to one billionth of a meter! Compare that to a human hair, which is roughly 20,000 nanometers thick, and the magnitude of the challenge becomes clear.

## A Revolutionary New Material

In August 2005, Ray Baughman and his colleagues at the University of Texas in Dallas reported that they had developed a way to weave nanotubes into a material large enough to be commercially useful. Scientists had already produced long twisted fibers of nanotubes. Baughman and his team took those fibers and created an ultra-thin nanotube ribbon that is two inches wide and 33 feet long.

They are continuing to refine the process with the hopes of creating even bigger sheets. It is theorized that a sheet as big as an acre of land would weigh only a quarter of a pound but would be able to withstand more than 34,000 pounds per square inch of force without tearing. It would also be a good electrical conductor and could endure temperatures of up to 840°F without losing strength or conductivity.

The technologies that Baughman and his team are working on have enormous implications in the materials science industry. The Department of Defense has shown an interest in the research as well as manufacturers of helicopter blades, solar electric cells and robotics.

## Two Promising Medical Applications

There are two teams of researchers working to develop medical uses for nanotubes. It was theorized that they should make good candidates as delivery vehicles for drugs because the human body is able to absorb the carbon carrier once it reaches its target and delivers its passenger.

Stanford University chemists are developing nanotubes that seem to do just that—sneak into tumor cells to help kill the cancer from the inside. They coat them with folic acid, a molecule that binds with certain types of cancers, and introduce them into the tumor. Researchers then subject the tumor to near-infrared laser. The beam does not damage living tissue but it heats the nanotubes to a temperature that burns away the cancer cells bound to them. The nanotubes get so hot nearly all of the cancer cells are burnt away after one two-minute exposure to the infrared beam.

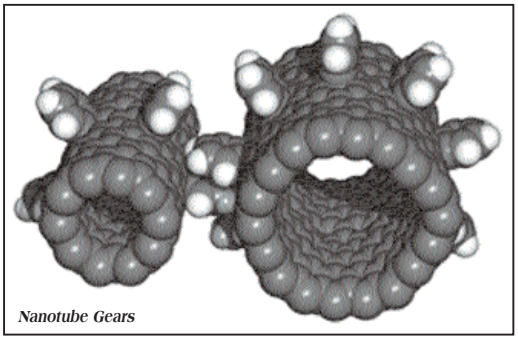
At the University of California at Riverside, researchers are using nanotubes to heal broken bones. Materials scientists have had some success coaxing hydroxyapatite, a bone-forming mineral, to grow on a nanotube scaffold instead of the collagen scaffold it typically grows on during bone formation. The result is a strong but flexible enhanced bone material that shows promise for healing shattered or worn out bone.

## Glimpses of the Future

In 2005, NASA sponsored two competitive events as part of their Centennial Challenges prize contest program. The Space Elevator contests were held at NASA's Ames Research Center in Mountain View, California and offered $50,000 as the prize for each.

The competition was based on the futuristic idea of a space elevator that would connect an orbiting spacecraft with the Earth's surface. The elevator would consist of a tether that stretches from a fixed anchor on Earth to a space station in space. The space station would act like a counter- weight held in its position above the Earth by the centrifugal force from Earth's rotation.

Robotic elevator cars would traverse miles of super-strong tether material to transport supplies and instrumentation to the space station. The elevators would traverse between the Earth's surface and the space station at speeds that are safer than the current method of blasting rockets and shuttles into orbit through atmospheric friction at 15,000 miles per hour (24,140 kilometers an hour). Theoretically, the elevators would be powered by electric motors and would use far less energy than launching a rocket uses. This could have a huge economic impact on space exploration. Some theorize that the cost of transporting materials could drop from $20,000 a kilogram on the current U.S. space shuttle to only $250 a kilogram.



*Nanotube Gears*

The competition concentrated on two different aspects of the space elevator concept. One event was for the creation of wirelessly powered robotic elevators and the other was for a super-strong carbon nanotube tether that would support the elevator's climb. To qualify for the cash prize, the winner of the nanotube tether competition would have to be the strongest entrant—provided that it was 50% stronger than the state-of-the-art "house tether" provided by NASA. Although none of the tethers produced qualified for the cash, the strongest tether in the competition weighed less than 0.07 ounce (2g), the weight of a penny and withstood over 1,700 pounds (770 kilograms) of force.

NASA uses this program of prize contests to stimulate innovation and competition in solar system exploration. Prize-winning teams must demonstrate that their new technology can actually achieve the specifications set forth by NASA. The program coordinators find that basing the awards on actual achievements, rather than just proposals, is the most effective way to engage non-traditional participants from academia, industry and the private sector.

## Fostering New Technology

Competitions such as NASA's space-elevator competition and the 2004 AnsariX Prize for the first private manned craft to reach space, keep alive a tradition that stretches back as far as Charles Lindbergh. It was the $25,000 Orteg Prize that inspired Lindbergh, an unknown among the adventurer/explorer types of the day, to attempt his famous solo flight across the Atlantic Ocean in 1927.

Although the space elevator may never become a reality, technologies such as carbon nanotube tethers that are developed in the quest for one will certainly prove useful in their own right. Scientists continue to uncover innovative ways to use these miniscule but powerful particles. Expect to see them used in the development of materials for buildings, cars and airplanes, thread for ultra-strong fabrics and clothing, and ultra-sensitive sensors that detect gases and chemicals.

So, while you won't be able to reserve your spot on the space elevator anytime soon, it is almost certain that you will see carbon nanotubes being used in more everyday products in the next decade... and beyond.

## Where nanotubes can be found today:

- Stain-free clothing, carpet, furniture and mattresses
- Lightweight, bullet-proof vests and shirts
- Insect repellent clothing
- Clothing that does not rip or wear out
- A wrist watch that runs off body heat
- Military uniforms that change color to adjust to weather conditions (temperature, lightning, wind, rain)


1912–1997

## PROFILE: CHIEN-SHIUNG WU

Born near Shanghai, China, Chien-Shiung Wu grew up in a time when girls gained their entire education at home. Her father, who is accredited with opening the first girls' school, encouraged her to break tradition and attend a class. This led to her enrollment at the National Central University in Nanjing where she received a Bachelor of Science in 1934 before moving to the US.

In 1940, Wu received her doctorate in Physics from the University of California, Berkeley. She taught at Smith College and Princeton University from 1942-1944. In 1944, she joined the research staff at Columbia University and began work on the Manhattan Project. She worked on diffusion techniques to separate uranium-235 from uranium-238 and helped to develop more sensitive Geiger counters.

Around this time, scientist Enrico Fermi proposed a new theory of beta decay. In many scientific communities, the theory was generally discredited for two reasons. First, serious discrepancies existed between the theory and the experiments to prove it. Second, it was in complete opposition to the conservation of parity. Parity is the symmetry of interactions under spatial inversion; most often referring to the left and right symmetry of mirrored, identical systems.

Wu's expertise in radioactivity led her to assisting Tsung-Dao Lee and Chen Ning Yang in their study to disprove parity. She designed the model to study the beta decay of radioactive cobalt-60.

They aligned the cobalt in a strong magnetic field, then super-cooled it with cryogenics to minimize the atoms' random thermal motions. After tracking the emission of thousands of electrons, their team discovered a majority of electrons ejected in the same direction.

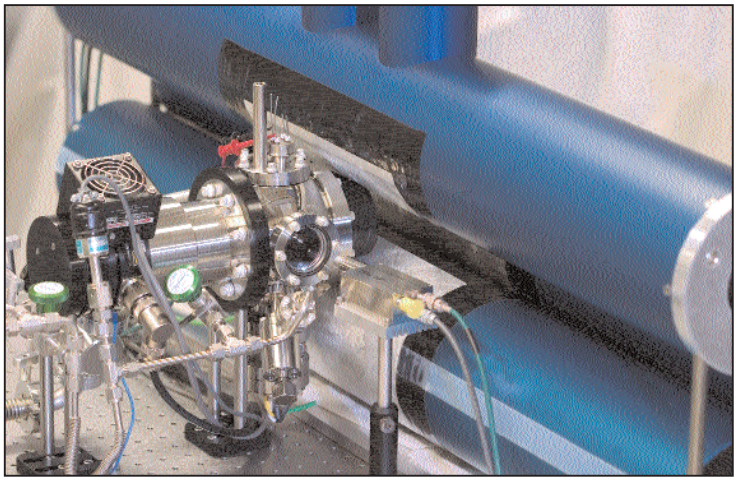
From 1949 through 1960, some of Fermi's assumptions were modified. However, their team could repeatedly display symmetry violations and created a model for weak nuclear force and electromagnetic currents.

This successful demonstration won Lee and Yang a Nobel Prize in 1957. While Wu did not share in the Nobel, her book entitled *Beta Decay* (1965) is still considered a nuclear physics standard. Her later research included molecular changes in the hemoglobin associated with sickle-cell anemia.

Wu broke through several traditional roles by becoming the first female instructor in the Physics Department at Princeton, the first woman awarded a Princeton honorary doctorate, and the first female president of the American Physical Society. Her list of honors, memberships, and awards is lengthy and includes the National Metal of Science (1975) and the first Wolf Prize in Physics (1978).

Wu died of a stroke on February 16, 1997.

# IT'S COLD. IT'S HOT. IT'S FUSION!



It's not a new sports drink. It isn't the latest band to climb the charts. Cold fusion (once again) has the scientific community buzzing.

Unlike fission, which is currently used to generate nuclear power, fusion has always been shunned by the nuclear energy community. Although it is believed fusion would generate more energy with less waste, it has been thought to be impractical because the of the massive devices required to generate the reaction and the enormous energy needed.

Michelle Thaller of the *Christian Science Monitor* describes cold fusion as "ramming protons and neutrons together so hard that they stick, and form a single, larger nucleus. When this happens with small nuclei (like hydrogen, which has only one proton or helium, which has two), you get a lot of energy out of the reaction."

The major problem with fusion is the tremendous energy required to connect nuclei. The positive charges in different nuclei create a barrier, as they try to repel each other. This is similar to when one tries to put two positive ends of magnets together. The similar charge pushes them apart.

One way to overcome this natural repulsion is to take advantage of the strong nuclear forces within a nuclei. When forced close enough together, these strong forces will push the protons from different nuclei together, overcoming the natural repulsion that pushes them apart. Unfortunately, to harness these strong forces, energy must be applied to force the protons within one millionth billionth of a meter. To visualize the smallness of the scale, that's 0.000000000000001 meters. Very tiny, indeed.

Proof that fusion works is provided by our very own sun. On that grand scale (300,000 times the mass of the Earth), immense gravitational pressures superheat the core. As a result, protons move at tremendous speeds and occasionally collide. This enables fusion to take place, as strong forces keep the protons together. You probably have noticed how bright and how warm the resulting release of energy is.

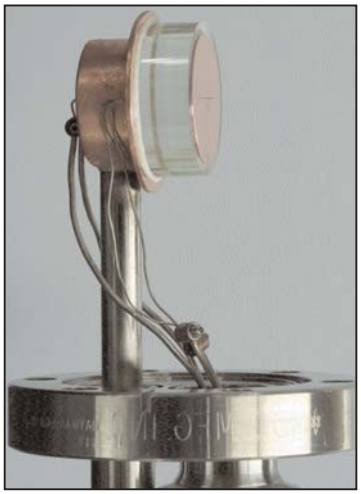
Buoyed by the example of the sun, scientists have for years been trying to figure out a way to harness the power of fusion on Earth. In 1989, some scientists declared that benchtop fusion was possible. Unfortunately, the glory was short-lived, as the scientists had to retract their claim.

But recently, Brian Naranjo, Jim Gimzewski, and Seth Putterman at the University of California at Los Angeles have built a tabletop device that shows some promise and has attracted a lot of interest. While not designed for nuclear power as we know it, the applications include research, scanning machines, and propulsion of miniature spacecraft.

So, how does it work? According to **physicsweb.org**, "the experimental setup consists of a centimeter-sized cylindrical crystal of lithium tantalate surrounded by deuterium gas. This material is pyroelectric, which means that positive and negative charges build up on opposite faces of the crystal when it is heated. This creates an electric field that is high enough to ionize any deuterium atoms that stray near a tiny tungsten tip attached to the positively charged surface. These deuterium ions get repelled from the surface and are accelerated by the field toward an erbium deuteride target, where the fusion reactions take place."

In other words, a crystal is heated to produce an electric field. A wire is brought near the crystal to produce a concentrated charge. This high charge forces the positively charged nuclei to leave the field, hitting other nuclei in the process. This method is different than other attempts, as it uses an electric field instead of heat or pressure.

Unlike other experiments that came before, this "pocket fusion" device has been thoroughly examined and replicated. It appears to be genuinely plausible. While major advances aren't expected in the near future, the impact of the little nuclear generator at UCLA has already been felt. As Naranjo and other scientists continue to build off these findings, the future of nuclear fusion looks to be bright.



# FISHER SCIENTIFIC OPENS BIOTECHNOLOGY LAB

The Fisher Scientific Biotechnology Lab opened at the Carnegie Museum of Natural History in Pittsburgh, Pennsylvania, in October 2005. The lab provides middle school students in grades 6 through 8 with a hands-on biotechnology lab experience and uses a curriculum that is based on National Science Education Standards.

As part of their experience, students learn the fundamentals of genetics, molecular biology, and microbiology. While learning about these topics, students get the chance to apply techniques of biotechnology in the laboratory through a series of hands-on experiments. Using sophisticated equipment, students extract DNA from several organisms and then identify the organisms based on their findings.

The Fisher Scientific Biotechnology Lab is made possible by a donation of equipment and supplies by Fisher Scientific, a company founded in Pittsburgh over 100 years ago. The Grable Foundation provided the funding for the curriculum that was developed by Ellen Wright, a science teacher at Perry Traditional Academy of the Pittsburgh Public Schools and a finalist for the 2005 National Biotechnology Teacher of the Year Award. "Biotechnology is a 21st century science," Wright said. "We hope that by having students conduct fun and engaging biotechnology experiments, we can capture their interest and encourage them to study and pursue a career in science."

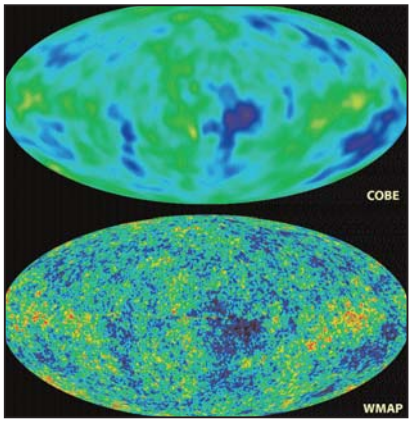
In addition to being available to school groups, the lab is also available to the general public on

Saturdays. Saturday programs introduce the basics of DNA and allow children and their families to participate in hands-on activities that demonstrate biotechnology techniques. Workshops for teacher training and career development, providing professional training for biology teachers in biotech science, are also planned.

"This is another exciting addition to Carnegie Museum of Natural History," said Dr. Bill DeWalt, Director of Carnegie Museum of Natural History, in announcing the Fisher Biotechnology Lab. "Our hope is the Fisher Scientific Biotechnology Lab will engage and motivate students to consider a career in the biotechnology industry."

"Fisher Scientific is proud and excited to be part of the Carnegie Museum's laboratory initiatives," said Ed Pesicka, General Manager, Fisher Scientific Research. "Our goal in partnering with the Museum is to help educate young people and foster scientific discovery in the Pittsburgh region. Since its 1902 founding in Pittsburgh, Fisher Scientific has remained committed to serving science and our local community."

# "KISS YOUR UNIVERSE GOODBYE..."




*NASA is attempting to image the universe using infrared (COBE satellite) and microwave (WMAP probe) methods.*

The Universe is an exceedingly simple place. But it'll fool you.

It fooled Einstein. Twice.

For most of the history of science, people considered the Universe to be stable, ever-present and safe. Turns out: the Universe is not only flying apart, but that its rush to annihilation is accelerating. Creation is doomed. This is the (short) story of how we know.

## Expansive Math

It's 1914 and young Albert Einstein is in Berlin scratching his head. He's come up with a way to adjust Newton's theory of gravity to account for how light behaves. Einstein thinks that the very shape of space is created by the masses of the matter within it. The Sun makes a dimple in space and all the planets are trying to roll "downhill" toward it, etc. He'll publish this "General Theory of Relativity" next year. But first he has to fix a big problem. At least he thinks it's a problem. His theory fits the observable Universe like a glove, but Einstein's math is clearly telling him that the Cosmos is swelling up and spreading out. "Well, that can't possibly be," thinks Einstein. And he writes a fudge-factor—a "cosmological constant"—into the equations to calm his nervous Universe into the steady, stately sky that common sense demands.

At about the same time, on a mound called Mars Hill near Flagstaff, Arizona, Vesto Slipher is trying to capture the spectrum of every interesting thing in the night skies. A spectrum, of course, is what you get when you break up the light of a star, or planet, or galaxy, into its constituent colors. But not just colors; you also get a series of dark lines. Slipher can read these spectral lines like a book—a cookbook, in fact, for how the Universe makes each object. But Slipher is puzzled by something. The spectral patterns of different galaxies appear quite similar, but the spectral lines are "shifted" by varying amounts. Well, if you've ever heard a car or train horn blowing as it passed you by, you have a clue as to what Slipher was seeing. The horn's pitch rises as it comes toward you and shifts downward as it goes away. And so it goes with the light of galaxies. If they're moving away from you, they seem to get redder. Slipher has discovered what astronomers now call "redshift."

Fast forward to 1928. Astronomer Edwin Hubble has been spending inhumanly long hours high above Los Angeles in a cold, drafty observatory. Hubble and his assistant Milt Humanson (who began as a janitor) are hand-guiding a cranky behemoth of a telescope, holding it on various fuzzy targets for the hours and hours required to collect their ancient light. Five years earlier, Hubble had rocked the universe of astronomers by proving that the blurry object called Andromeda was actually a separate galaxy of stars, not just another nebula within our own. He did it by photographing a predictable type of star—called a Cepheid variable—within Andromeda, and comparing its brightness to nearby Cepheids whose distances are known. Now, Hubble and Humanson have bagged Cepheids in 20 different galaxies.

Hubble combines Slipher's spectra, which show motion, with his own brightness data, which gives distance. And he comes to a startling conclusion. Just about every galaxy seems to be moving away from every other—the farther from Earth, the faster they move. Hubble and Humanson, without ever really knowing much about Einstein's troublesome expanding Universe, have proven that it exists after all.

## Surprising Sameness: The Cosmological Principle

Hubble's proof rests on the assumption that the Universe is, well, universal. Let's say you put on SCUBA gear, shrank yourself to the size of a rice grain and went for a dunk in the middle of a milk shake. Once you're immersed in the frothy slush, it all looks pretty much the same wherever you look. That's what astronomers see when they look at groups of galaxies. It's a big fog of foam out there. The distribution of matter is approximately the same anywhere they swing their scopes. This texture of the Universe seems so universally similar that we're pretty sure alien astronomers in all those other galaxies are getting the same picture. Cosmologists call this "invariance under translation."

Now, because it all looks the same, words like "up," "down," "north," "south," "right," and "left" don't really have any meaning on the grand scale of the Universe. Locally, your science classroom looks very different from your bedroom (at least we hope it does). But as you step back and look at bigger and bigger things (stars, galaxies, clusters of galaxies, super-clusters of galaxies), space stuff looks more and more alike. So it gets harder and harder to give "road directions" as larger and larger landmarks have fewer and fewer distinguishing features. The Universe is pretty uniform. Cosmologists call this "isotropy."

And it is from the isotropy of the Cosmos that cosmologists come up with this amazing intuitive leap: "If something looks all the same, it probably is all the same!" (See, I told you this was all simple.) Take the evidence that it's all expanding. Add the evidence that it's all the same. And run the movie backwards. Result? Your Universe probably all came from one very tiny, very simple, very hot, very dense thing. Cosmologists call this a "singularity."

But somehow, it wasn't a completely perfect thing. If space and time were perfect, neither could actually exist. We wouldn't exist. Objects bust the perfection of space. And Events bust the perfection of time. Cosmologists call this "broken symmetry." When it broke, it broke fast. In a 1927 paper, Belgian priest and theoretical physicist Georges Lemaître calls it "a cosmic egg exploding at the instant of Creation" and a "primeval atom."

Twenty-two years later, astronomer Fred Hoyle, who prefers Einstein's fudged but steady state Universe, scoffed at Lemaître's concept, calling it "this Big Bang idea." And, as we all know, the name stuck.

# ON BEYOND PLUTO, REPORT #2

*Planet Xena (a.k.a.: 2003 UB313)*

Since we explored the Kuiper Belt region of the Solar System together (Headline Discoveries: Fall 2005), new and exciting discoveries have come to light. And "light" really is the key. All we know of these deep-frozen worlds comes to us through vanishingly tiny amounts of sunlight reflected back to our telescopes. In the case of Planet "Xena" (a.k.a.: 2003 UB313—still no word on her official name), is that dim light has run a 26-hour marathon since it left the sun.

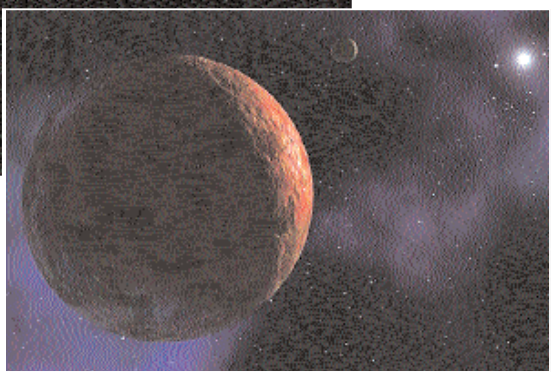
We now see Xena to be 3000 km (1,864 mi.) in diameter—very nearly as big as Earth's moon. And we've learned Xena has a moon of her own, 250 km (155 mi.) wide, called (for now at least) "Gabrielle" (Xena's TV pal). Observers have now calculated that a year on Xena is 560 Earth years long. You'd have to fly 9 billion miles—three times Pluto's current distance—to visit her today.

Closer in—but climbing even higher in orbital inclination (at 47°)—astronomers have spotted "Buffy" (2004 XR190). She's just a bit smaller than Pluto and rides a strangely circular orbit almost two times Neptune's distance from the sun. That's 58 times Earth's distance.

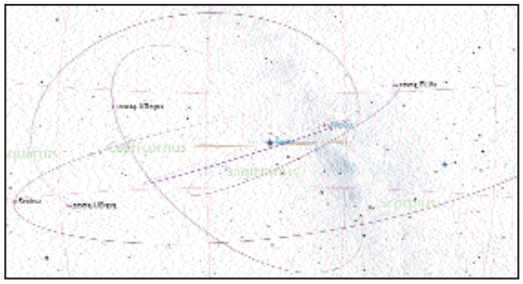
Hungry? Imagine a "sub" or "hoagie" shaped world, about a third the mass of Pluto, with a moon—maybe two—made of delicately flavored ice. That's the object known only as 2003 EL61. She was probably involved in a crash in her youth which scrunched her shape and blasted off the vapor that later coalesced into one or more satellites.

And Sedna, the farthest dwarf planet yet seen (76 times Earth's distance), has researchers completely in the dark. Nothing in our current understanding of Solar System formation predicts a Sedna. She may be trying to tell us that another star was involved in her birth.

Will Pluto still be listed as a planet 10 years from now, when NASA's New Horizons mission—the fastest spacecraft ever launched—streaks by for science operations lasting less than one Earth day? We can't say. But what we'll learn there is likely to re-write the book on the origin of our entire Solar System.



*Dwarf Planet Sedna*



*The orbits of these newly discovered planets vary greatly from the main plane of our solar system*

# SPLITTING HAIRS

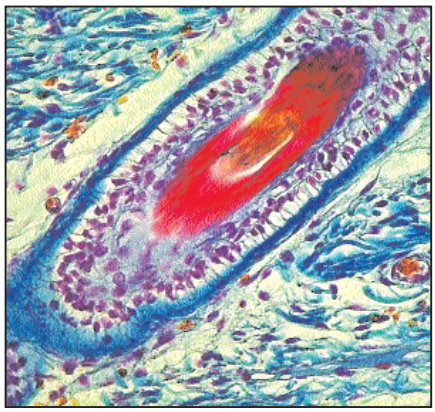
In every struggle between an attacker and a victim, hairs, fibers, and other minute pieces of evidence are transferred from one to the other. This type of evidence is found at crime scenes and on victims and it can be used to link a suspect or a suspect's belongings to the crime. Hair is a very important clue for investigators because aside from burning, it is practically indestructible. Scientists are able to examine hair that has been collected from objects at the crime scene and from bodies, even severely decomposed bodies, to uncover clues to the crime.

## The Composition of Hair

Hair is a combination of protein substances, but is comprised primarily of keratin, a strong structural protein. Hair follicles in the skin produce a hair for a certain period of time, usually many months, before the hair falls out and a new one starts to grow. Head hair grows about 2.5mm per week while facial hair grows faster and body hair more slowly. Contrary to the popular myth, hair does stop growing at death. It's the shrinking of the skin after death that gives the effect of the hair having continued to grow, especially the facial hair.

A hair shaft has three layers: the cuticle, the cortex, and the medulla. The tough outer layer, called the cuticle, is comprised of overlapping scales that protect the inner layers. Examination of these scales under a microscope gives a quick indicator of whether the hair came from an animal or human—the scales look very different in animal hair.

Below the cuticle is the cortex. This layer is comprised of spindle-shaped cells that give the hair its texture and house the pigment that gives hair its distinct color. The distribution of this pigment can be used to determne if a hair is likely to have come from a specific individual.



The innermost layer is a hollow tube called the medulla. The physical appearance of the medulla has many variations, it can be continuous, fragmented, or even absent from a hair sample. Human hair usually has a fragmented or absent medulla except for Asian people whose hair has a continuous medulla. The medulla can look different in two hairs taken from the same person, even if it came from the same area of the body. Animal hair generally has thicker medulla and cortex layers than human hair because it is an important means of insulation and protection for the animal.

## What Hair Can Tell Us

Microscopic forensic analysis of hair focuses on hair color and structure. If a hair sample includes the root structure, its examination can indicate if the hair fell out naturally or was forcefully removed as might happen during a struggle. An intact sample with the root can also give a good determination of the full length of the hair. As discussed above, hair analysis can determine whether the hair came from a human or animal, and if human, can indicate if the source is a member of a particular race. Scientists can also determine if the hair has been dyed, cut in a certain way, and what part of the body it came from.

Hair can be examined under a light microscope and compared to reference samples or samples from a suspect. For this type of comparison, the hair is typically dry mounted on a glass microscope slide and viewed under a comparison microscope. It can also be embedded in a wax block and sliced in a microtome to produce wafer-thin sections that are then mounted on glass slides. This allows the scientists to examine the cross-sectioned shape of the medulla. Occasionally, pattern impressions of the scales of the cortex are preserved in cellulose acetate for more detailed study. A variety of tests are available to the forensic scientist for examining hair that has been dyed and for examining hair for age.

Hair's absorbent properties make it an important tool in assessing deaths from poison or drugs. But, it could takes weeks for a hair sample to indicate the presence of a toxic substance so while it's not a good indicator of exposure to toxins within the past few days, it can be an excellent indicator of long-term exposure or drug abuse.

A technique called neutron activation analysis, introduced in the 1950s, is one of the methods used to identify toxins in hair samples. Hair samples are bombarded with neutrons that collide with trace elements in the sample and cause them to emit gamma radiation. The levels of radiation emitted are compared to known reference levels and allow scientists to measure every constituent part of the sample. The technique is not limited by small sample size and a single hair can realistically yield results for up to 14 different elements. It was first used in a 1958 murder case to determine that hair found clasped in the victim's hand came from the suspect. The ratio of sulphur radiation to phosphorus radiation emitted by the sample was found to be consistent with a sample taken from the suspect, thus connecting him to the crime.

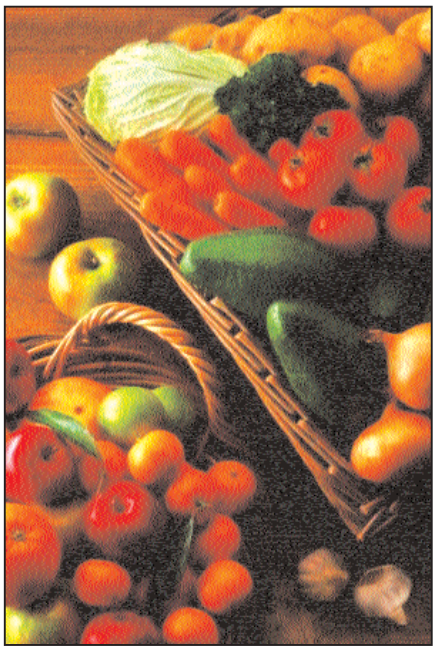
## A Maturing Science

Forensic hair analysis isn't a new technique. One of the earliest scientific papers on the subject was published in 1857 in France and by the early 1900s microscopic examination of hair was well established. In 1931 Professor John Glaister published a paper titled *Hairs of Mammalia from the Medico-legal Aspect*, which was considered a standard reference work thereafter.

As forensic science advances with computers and increasingly more accurate means of detecting the component parts of small samples, trace evidence may soon play even more significant roles. A hair sample with the root or other tissue attached to it can now offer genetic information such as blood type or a person's genetic makeup. Even if the root isn't present in a sample, mitochondrial DNA analysis can still provide information useful to the case. Both of these methods of DNA analysis are currently used to provide DNA evidence for criminal and paternity cases.

But, positive identification cannot reliably rest on hair evidence alone. The best that a forensic scientist can do is present scientific evidence that a crime scene sample is consistent with a suspect. And while it can't be the proverbial smoking gun, it can be used to exclude a suspect based on race and where it can't exclude, it can provide valuable corroborating evidence of guilt.

# FOREVER FOOD?



If you went on a camping trip and only had a backpack for necessities, how would you pack food to last for the duration of the trip? Some people might say, "That's easy, I would just take trail mix!" Although trail mix is a tasty treat, it cannot suffice as a full meal. So how do you pack a full meal that won't spoil, for each day of the trip, without filling up your backpack? Ever hear of freeze-dried meals?

## The History

Freeze-drying (scientifically known as lyophilization) is the sublimation (turning ice straight into vapor) of water from a frozen food. The end result is a very lightweight, dry piece of food that retains its natural taste, color, texture, and—most importantly—nutrients. This piece of food can last up to ten years!

The earliest form of freeze-drying food dates back to the ancient Incas of the Peruvian Andes. The Incas stored their food crops, like potatoes, on the mountaintops of Machu Picchu. The cold temperatures of the mountain heights froze the food. The water inside the food gradually vaporized under the low air pressure found at such high altitudes.

The freeze-drying process was first commercially exploited during World War II. It was used to preserve blood plasma and penicillin. In 1938 freeze-dried coffee was produced. This led to the development of other freeze-dried foods, including powdered food. To date, over 400 types of freeze-dried foods have been commercially manufactured.

## The Process

In most circumstances, a machine called a freeze dryer is used to freeze-dry products. This instrument has a large chamber for freezing, and a vacuum pump for removing moisture. To reconstitute freeze-dried food, one simply needs to add water.

The four fundamental steps of freeze-drying:

1. **Freezing:** Hence the word "freeze" in freeze-dry; the product is frozen.
2. **Vacuum:** Allows the frozen solvent (typically water) to vaporize without passing through the liquid phase (sublimation).
3. **Heat:** This speeds up the sublimation process.
4. **Condensation:** The separation process is completed with low-temperature condenser plates. These plates remove the vaporized solvent from the vacuum chamber by converting it back to a solid.

## The Benefits

Almost any type of food or ingredient can be freeze-dried while retaining its original characteristics. Freeze-dried food requires no refrigeration, resists spoiling for a long period of time, and is conveniently reconstituted in water. Freeze-dried foods have a shelf life of up to 10 years if packaged in a can and up to three years if in a polybag container.

Other benefits include: production of little or no waste during the freeze-drying process, an end product that is significantly lighter than its original state, and a higher quality dry product as compared with other drying methods. You can even freeze-dry ice cream!

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## Some Food For Thought

**Did you know...**

Freeze-dried coffee is the best-known freeze-dried product.

Watermelon and lettuce are two of the worst foods to freeze-dry, because of their high water content.

There is no named inventor of the freeze dryer. It seems to have developed over time.

Food is not the only product that can be freeze-dried. Plants, like flowers, commonly undergo this technique for preservation of beauty.

## EXPERIMENT WITH FREEZE-DRYING...

You do not need a freeze-dryer to experiment with this food drying technique. If you have a refrigerator, perforated tray (cake cooling rack), a knife, and apples, carrots, or potatoes you can experience the marvels of freeze-drying. For full instructions go to: **http://home.howstuffworks.com/food-preservation4.htm .**

# SWEET SCIENCE

**Announcer 1:** This is going to be a great match-up. Is there any indication of who is favored to win?

**Announcer 2:** That is a tough question. This is one of the most debated match-ups in the food industry today. Sugar will always be the favorite. But Artificial Sweetener has an edge with the reputation of being low calorie. Tough decision! Let's go to center ring for the action.

**Ring Announcer:** In this corner...weighing in at 4 calories per gram and wearing white...introducing the current heavyweight champion of the world, known as The Natural—Sugar!

And in this corner...weighing in at 0 calories per gram and wearing pink and blue...we have the challenger—Artificial Sweetener!

Ladies and gentlemen, welcome to the main event. **Let's get ready to SWEEETEN!**

## Round 1: The Introduction

**The Natural**
Table sugar (or sucrose) is produced from sugar cane or sugar beats and then crystallized. Your body breaks it down into glucose and fructose, which in turn feeds the body with energy and keeps the brain operating. Sugar is still the most commonly used sweetener in the industrialized world. Natural sugar can be found in a variety of states or versions including molasses, honey, and brown sugar.

**Artificial Sweetener**
The following are some of the most popular artificial sweeteners used to replace natural sugar:

***Aspartame,*** better known as NutraSweet® or Equal®, was discovered in 1965 by researcher James Schlatter, at G.D. Searle & Company. Aspartame is composed of two amino acids, phenylalanine and aspartic acid. The body digests these acids the same as it would any other protein. The U.S. Food and Drug Administration (FDA) approved the use of aspartame as a "general purpose sweetener" in 1981.

***Saccharin,*** or Sweet' n'Low®, was discovered in 1879 by researchers at Johns Hopkins University. The world's oldest artificial sweetener does not provide the body with any energy because it does not metabolize. Saccharin is chemically formed with carbon, hydrogen, nitrogen, and oxygen. It was approved for use in the United States in 1879.

***Sucralose,*** commercially known as Splenda®, was discovered in 1976. It is formed by selectively substituting three chlorine atoms for three hydroxyl (-OH) groups on the sugar molecule. This process prevents the end product from being digested as a carbohydrate. The FDA approved use of Sucralose in 1998.

## Round 2: The Myths

The following is a list of commonly heard rumors about health risks associated with sugar and artificial sweeteners:

**Myth 1:** Sugar is the leading cause of obesity.
**Fact:** The leading cause of obesity is overeating. Sugar actually contains fewer calories than fat. However, overconsumption of sugar may lead to tooth decay.

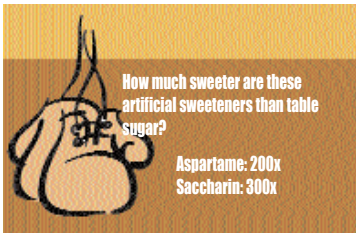
**Myth 2:** Aspartame (NutraSweet® and Equal®) is linked to brain cancer/tumors, diabetes, birth defects, epilepsy and other health complications.
**Fact:** No significant statistical association between aspartame and the diseases listed above has been established. People with a rare genetic disorder called PKU (phenylketonuria) need to limit their consumption of any phenylalanine, which is a main ingredient of aspartame.

**Myth 3:** Saccharin (Sweet' n'Low®) leads to cancer.
**Fact:** A population study involving 9000 people uncovered no evidence that saccharin increases the risk of cancer. In December of 2000, Congress passed legislation to remove the warning label indicating that saccharin may lead to cancer.

**Myth 4:** Sucralose (Splenda®) can lead to enlarged liver, enlarged kidneys, a decreased red blood cell count, and other health-related issues.
**Fact:** Since sucralose is relatively new, it has not been subjected to a large number of studies. Some studies have indicated that there is a possible link between sucralose and the health ailments listed above, but there is no conclusive evidence.

## Round 3: The Decision

So the question remains: which is better, sugar or artificial sweetener? With the exception of diabetics and other people who cannot consume excessive amounts of sugar due to their condition, most people find it's a matter of personal preference. So far, these two rivals seem evenly matched. There are many ongoing studies taking place to find out if sugar or artificial sweeteners can lead to health problems. Until one such study identifies a competitive advantage for sweetener, a particular consumer and his/her taste buds will continue to decide the winner.



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| DESCRIPTION | CAT. NO. | PRICE |
|---|---|---|
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| pH Meter, Meter only, pH/Temp./mV | **HS90525** | 361.95 |
| pH Meter, Meter with electrode, pH/Temp. | **HS90526** | 351.95 |
| pH Meter, Meter with electrode, pH/Temp./mV | **HS90527** | 402.95 |
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|---|---|---|
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|---|---|---|---|---|
| Analytical | 65g | 0.1mg | HS93500A | 1603.95 |
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Available in several precision models ranging from 150 x 0.001 grams to 8100 x 1 gram. Two analytical models are also available with a capacity of 65 or 210 grams.

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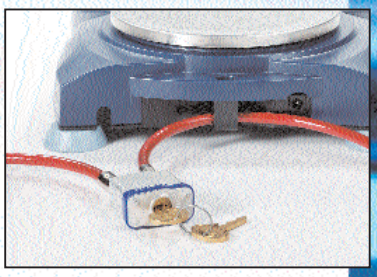

| MODEL | CAPACITY | READABILITY | CAT. NO. | PRICE |
|---|---|---|---|---|
| SPE202 | 200g | 0.01g | **HS67074PROMO** | 1799.70 |
| SPE402 | 400g | 0.01g | **HS67075PROMO** | 2590.20 |
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**Offer valid thru June 30, 2006. Only valid on three models listed.*
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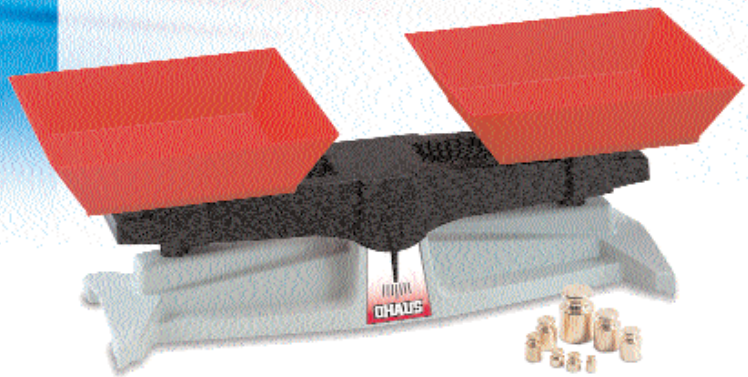
# Ohaus School Balances



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| DESCRIPTION | CAT. NO. | PRICE |
|---|---|---|
| School Balance | **HS63485** | 31.00 |

# WHAT'S ALL THE HEAT ABOUT GLOBAL WARMING?

In the wake of Hurricane Katrina, global warming is making news and raising provocative questions about the impact of human activity on the Earth's climate.

As highly charged as summer lightning, the global warming controversy has split the scientific community. Proponents warn that unabated global warming will lead to a "point of no return"—and our planet's doom. Skeptics argue that warming trends are a normal part of Earth's climactic cycle, not a cause for alarm.

So what is the truth? Are we headed for a planetary catastrophe? Or is Earth just experiencing a natural heating spell?

Global warming is an increase in the average temperature of the Earth's atmosphere and oceans. Debate centers on whether or not human-induced factors intensify the "greenhouse effect" in the atmosphere. According to the National Academy of Sciences (NAS), the planet has warmed by about 1°F in the past century.

The greenhouse effect is the rise in temperature that the Earth experiences from a thermal layer of gases that blankets the planet and traps energy from the sun. Carbon dioxide is one of these gases. This thermal layer insulates the Earth and makes it habitable—without the greenhouse cover, heat would escape into space, and the planet would be 60°F colder.

The theory of anthropogenic global warming—warming caused by human activity—argues that burning fossil fuels like gasoline and coal increases the level of carbon dioxide in the atmosphere. The result is a thicker greenhouse layer of gaseous insulation, and a warmer planet.

While scientists on both sides of the argument agree that the Earth is warming, they disagree about how much global warming is caused by natural factors and how much by human activity.

## Advocates: Act now

Environmental groups are at the vanguard of global warming believers. The Sierra Club and the National Wildlife Federation (NWF), to name two, promote public awareness, "green" initiatives, and grassroots activism on global warming issues. These tenacious global warming watchdogs target companies and governments for "environmentally unfriendly" policies.

Advocates use data and scientific observations to support their case for global warming. Tidal changes, geological measurements, and species distribution and mortality are but a few of the thousands of factors studied. One recent NWF study states that the shrinking Arctic ice cap is threatening polar bear and seal populations through habitat loss. NWF blames global warming.

At the extreme, alarmists predict a bleak future for the Earth. James Lovelock, a prominent Earth systems scientist, wrote in a February 2006 article that the U.S., China and India will not make the necessary emissions cuts soon enough to avoid catastrophic global warming.

## Skeptics: No proof

Skeptics argue that the evidence to "prove" global warming is either inconclusive or insufficient. They contend that the Earth's climate is too complex a system for changes to be tied directly to human causes, and that natural climate cycles are responsible for the trends we observe.

The National Center for Public Policy Research refutes global warming, citing a United Nations study stating that if global warming were happening, the troposphere - the lower — atmosphere—would be the first area to heat under the greenhouse effect. According to NCPPR, no empirical data exists to support this. NCPPR also notes an NAS report that identifies water vapor and clouds as more critical factors to global temperature than carbon dioxide. This study also estimates that a doubling of $CO_2$ in the atmosphere would have a minimal effect on temperature.

## Eye on hurricanes

The 2005 hurricane season—the worst in the 151-year history of record keeping—touched off a Category 4 storm among meteorologists. The question: Is global warming causing more violent hurricanes?

William Gray, a preeminent professor of atmospheric science at Colorado State University, ardently dismisses global warming. Dr. Gray attributes recent storms' intensity to natural factors such as upper-air currents that can maneuver storms ashore and make them more destructive. The National Oceanic and Atmospheric Administration essentially agreed with Dr. Gray in a December 2005 statement. "Increases in hurricane activity are primarily the result of natural fluctuations in the tropical climate system," wrote NOAA.

Other respected climatologists vehemently disagree, including Greg Holland of the National Center on Atmospheric Research who contends that global warming caused by human activity does not affect the number of hurricanes, but appears to increase the intensity of more storms like Ivan, Katrina and Wilma.

## Toward a greener Earth

Corporations and environmental groups are working to find alternative energy solutions that will lower the levels of greenhouse gases. For example, BP is investing $350 million over five years to reduce its internal $CO_2$ emissions by up to one million tons annually and is leading the push for lower-carbon fuel technologies. Sierra Club launched its "Cool Cities" program, designed to make urban areas more "green" through the use of cleaner-running vehicles, improved energy efficiency and renewable energy resources. Cool Cities include Charlotte, NC and Twin Falls, ID.

With no consensus in sight, how can a responsible citizen contribute to a healthier atmosphere? Making practical energy-saving choices and supporting organizations that promote a green environment is a good start.

# SHHH...THE TREES ARE TALKING

Tree-ring research, or dendrochronology, can reveal environmental clues about an area from mild winters to severe hurricanes. Using these circular patterns in wood grains, researchers can determine where and how long ago a wooden object, such as a violin, was created.

## Listening with your eyes

A tree's trunk consists of several layers that envelope each other in a concentric pattern. The bark consists of two layers, an outer bark that protects the tree and an inner bark, or phloem, which carries sugar from the leaves to the roots.

The cambium, a thin layer between the bark and the rest of the trunk, produces both the phloem and the tree rings that can be seen in a cross-section view of a trunk. Each tree ring, also known as an annual ring, consists of a light and dark layer. During the rapid growth term in the spring, the tree creates large cells that are lighter in color. In the summer, the growing conditions are less ideal and smaller, darker cells are formed. By counting these dark rings, it is possible to determine how old a tree is.

The newest tree ring that the tree has created—called sapwood or xylem—carries food from the roots back to the leaves. The older rings, or heartwood, no longer carry sap and are often darker in color than the xylem because its water-carrying tubes are clogged. Depending on the tree, it can be many, many years before heartwood is created.

## A tree never forgets

A tree can grow for hundreds or, sometimes even thousands of years. It will encounter overcrowding, fires, objects like rocks or logs leaning against it, and insect infestations. If the tree survives all of these, its rings will tell the tale.

The thickness of a ring will display the quality of growing conditions. Thick rings signify quick growth and tell of a year with plenty of water and good access to sunlight. Narrow rings could mean a drought or groups of narrow rings could signify that the tree was fighting with surrounding, taller trees for sunlight. When in doubt, a researcher counts the rings to determine which year's ring is in question. They then compare its thickness to weather records for that year.

Recorded weather trends can tell us about seasonal conditions for a large area. Tree rings can pinpoint these differences in much smaller areas. When studying a specific area, dendrochronologists can also compare the rings of newly cut trees to older logs and stumps in the area. Once they've found similar rings, they can use the older stump's inner rings to extend their research past the oldest living trees.

Reversely, dendrochronologists can study a wooden object and determine how old the object is based on the rings and the type of wood used. The most famous example relates to dating the Messiah violin. The controversy focused on determining if the famous Antonio Stradivari created the violin or if it was a counterfeit. Dr. Henri Grissino-Mayer led the review panel, which determined that the spruce wood used to make the instrument grew between 1577-1687. This matched the time period in which Stradivari created his violins and not when other known counterfeits were created.

## Storm recorders

In Georgia, dendrochronology and geochemistry came together in a study of longleaf pines in an environmental preserve. The combined effort has provided a hurricane history for the past 220 years.

Rain has two major isotopes of oxygen—O-16 and O-18. Long rainstorms, like those associated with hurricanes, have an unbalanced isotope ratio with more O-16. As areas become saturated by rain, plants absorb the water and record the unbalanced isotopes as they create new cells. Because much of the water will run off before absorbing into the ground, plants with shallow roots, like the longleaf pines, rely upon rainwater more than groundwater for their growth. And they will record more isotope difference than plants with deeper roots.

Hurricanes often occur in the late summer when growing conditions are not ideal and trees create narrow rings. Pulling this isotope information from the narrow dark bands of the tree is not easy; but it's worth the effort. Weather records of hurricanes that hit the area matched the isotope ratios in the tree rings. However, the trees also recorded older hurricanes, which were not on the weather records.

Using this information, researchers hope to discover whether the recent increase in hurricane activity is part of a long-term trend or the result of pollution and global warming. The research continues, and by eventually studying multiple populations of trees from all the southern states that feel the effects of hurricanes, scientists hope to provide an important piece of the global warming puzzle.

# AN INVASION IN YOUR BACKYARD

In addition to air and water pollution, we humans cause another type of pollution when we transport plants and animals from around the globe into new habitats. The introduction of an alien species may be accidental, as when international vessels release ballast water in a foreign port, or when stowaways travel the world in shipping containers. However, some species are imported intentionally to satisfy human desire for exotic pets or ornamental plants. No matter what the method of introduction, alien organisms can wreak havoc on the environment into which they are introduced, and the cost to eradicate them grows every day.

## What Are They?

An "invasive species" is defined as one that is non-native (or alien) to the ecosystem under consideration, and whose introduction causes or is likely to cause harm to the economy, the environment, or to human health (Executive Order 13112, Appendix 1). Invasive species can be plants, animals, insects, or microbes. Most of the foreign species that have been imported into America are harmless or even beneficial. For example, who could deny the benefits that imports such as wheat, rice, and cattle have brought to our country? But one in seven of the almost 50,000 organisms imported throughout our country's history have proven themselves to be troublemakers. And one study estimates their economic toll to be near $137 billion per year.

## Some Known Invaders

There are an estimated 7,000 invasive species in North America today. Each has their own unique method of competing with native species for food and habitat, decimating crops and forests, or spreading disease to cattle and humans. So who are these troublemakers? Here are a couple examples:

The Kudzu vine, a native of Japan and China, was introduced as an ornamental plant in 1876 and promoted by the U.S. Soil Conservation Service between 1935 and 1942 as a solution to soil erosion. It was declared a weed in 1970 and now encroaches on thousands of acres of forests from Texas to New England. If left uncontrolled Kudzu will eventually grow over almost any fixed object in its proximity including buildings, parked vehicles, and other vegetation. It will even eventually kill trees by blocking the sunlight. A number of abandoned houses, vehicles and barns covered with kudzu can be seen in Georgia and other southern states.

The Rusty Crayfish, a native of the Ohio River Basin, has spread to many northern lakes and streams where it is having an environmental impact. They often displace native crayfish and reduce the amount and variety of aquatic plants, invertebrates, and some fish. They are now found in parts of Michigan, Massachusetts, Missouri, Iowa, Minnesota, New York, New Jersey, Pennsylvania, Wisconsin, Ontario, and many other northern waterways. Scientists theorize that anglers who used them as bait facilitated the northward spread of the crayfish. Interestingly enough, once their numbers reached noticeable proportions in their new habitats, they were actually harvested and sold as bait as well as to biological supply companies, further proliferating their population.

The crayfish are opportunistic feeders and dine on a variety of aquatic plants, aquatic worms, leeches, clams, insects, crustaceans, decaying plants and animals, fish eggs and small fish. The rusty is aggressive and forces out other species of crayfish that are more passive. They also compete with young fish for food, something that native crayfish don't do. This in turn reduces the amount of food available for fish and translates to smaller fish populations.

While the displacement of native crayfish is troublesome, the bigger impact of this invasive species is destruction of aquatic plant beds. This is a serious concern for northern bodies of water that have scarce plant beds to begin with. The plant beds provide a habitat for invertebrates, shelter for young fish, nesting places for fish eggs, and erosion control. And, although all crayfish eat aquatic plants, rustys with their higher metabolic rate and appetite can decimate a plant bed in no time.

## This Is War!

Invasive species have been recognized globally as a major threat to biodiversity, as well as to agriculture and other human interests. The seriousness and scope of the problem continues to grow as international travel and trade increase. Studies aimed at improving import/export regulations and management practices for areas already infested by invasive species are being initiated in countries all over the world. Invasive species are a concern of international conservation scientists, and are the subject of cooperative international efforts such as the Global Invasive Species Program (GISP).

In February of 1999, President Clinton issued Executive Order 13112 that established the National Invasive Species Council to help coordinate efforts and ensure cost-efficient and effective Federal activities. The Council is co-chaired by the Secretaries of Interior, Agriculture, and Commerce; and its members include the Secretaries of State, Treasury, Defense, Transportation, Homeland Security, Health and Human Services, and the Administrator of the Environmental Protection Agency.

## Future of the Environment

The number of invasive species and their cumulative impact continues to accelerate at an alarming rate. They have damaged our waters, farms, forests, and even our backyards. By creating the National Invasive Species Council and its respective subcommittees, our government is taking a crucial step toward educating America about the invasive species problem and the steps we need to take to protect our environment.

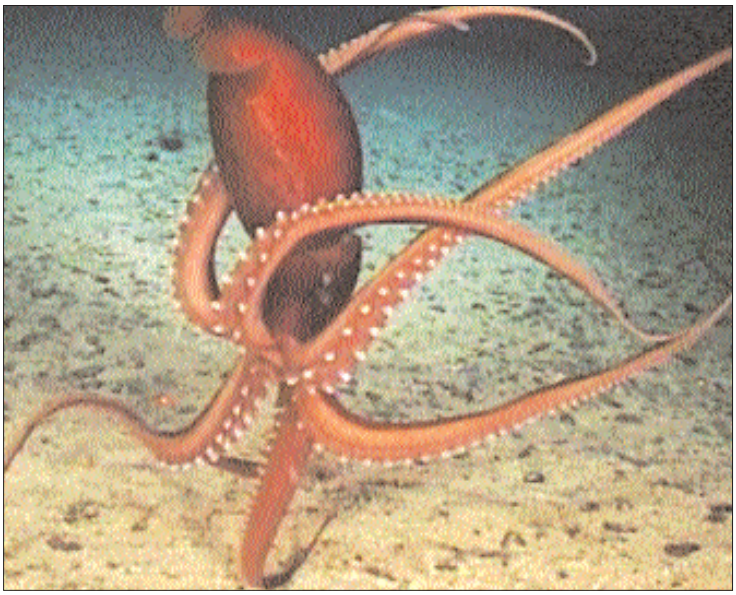
# IT'S ALIVE!

## True Sea Monster

Tales of sea monsters attacking ships have been around since ancient times. One of the most common descriptions of the creatures found throughout history is that of a huge animal with many tentacles and giant eyes that could latch on to a ship and sink it. The centuries-old Norwegian legend of the Kraken is thought to have been spurred by giant squid sightings. In 1850, Japetus Steenstrup, an eminent Danish biologist, authored several papers on the giant squid. It was he that first used the term "Architeuthis," Greek for ruling squid, to refer to the creatures.

Giant squid are members of the Architeuthidae family. It is comprised of as many as eight species of the genus Architeuthis. These animals live in the deep oceans of the world and can grow to an estimated length of 34 feet for males and 44 feet for females from the caudal fin to the end of the two long feeding tentacles. The thin feeding tentacles are much longer than the rest of the body. They can be up to 35 feet in length and broaden to clubs covered with suckers—suction cups lined with rings of sharp, serrated chitin. The suckers latch onto prey through both suction and perforation. Suckers also line the four pairs of arms that are shorter than the feeding tentacles and are used by the squid to hold onto its struggling prey and move it toward the animal's beak.

They have the largest eyes in the animal world—up to twelve inches in diameter. The squid dwell at depths that are not penetrated by light even during the day. Their eyes must be able to detect the small amounts of light that do exist, including bioluminescent light emitted by other deep-sea creatures.



## Say Cheese

Although scientists don't consider the giant squid endangered or even rare, the only evidence that such creatures really exist were the dead carcasses that washed up on shore or the dying specimens caught in fishermen's nets. But that changed on September 30, 2004 when two Japanese scientists captured the first images ever taken of a live giant squid in the wild.

They concentrated their search in areas that were known to be hunting grounds for sperm whales, the giant squid's number one predator. For years whalers had reported finding large numbers of squid beaks in the stomachs of sperm whales. The beaks are indigestible and collect in the whale's stomach until they are coated with a waxy substance called ambergris and excreted. Scientists had conducted in-depth observation of whales in the hopes of collecting data on their prey.

Theorizing that the shy giants were scared away by larger boats and noise, the scientists waited patiently for the squid to come to them. From 2002 to 2004, Tsunemi Kubodera of the National Science Museum in Tokyo and Kyoichi Mori of the Ogasawara Whale Watching Association cruised a five-ton fishing boat with only two crewmembers in the North Pacific Ocean in search of their elusive prey. On their third visit to a spot 600 miles south of Tokyo, they dropped their 3000-foot line into the water and waited. Attached to the line were a camera, a depth recorder and a weighted jig to snag the squid. They used common squid and shrimp as bait.

In waters 2950 feet deep, the camera snapped 550 images of the giant squid that took the bait. After more than 20 attempts that day, a 26-foot giant squid attacked the lure. As the squid wrapped its long tentacles around the bait, one of them got snagged on the jig. For four hours and 13 minutes the squid struggled to free itself and the camera continued capturing images.

When the squid finally escaped, it left behind a severed tentacle attached to the line. The retrieved portion was 18 feet in length and DNA testing confirmed that it belonged to Architeuthis. The tentacle was still moving when it was hauled aboard and repeatedly latched onto the boat deck and the researchers' fingers.

## More to Come?

The images already seem to dispel a long-held belief that giant squid were inactive, opportunistic predators who used their tentacles like fishing lures to snag whatever happened by. Kubodera and Mori's images show an aggressive hunting pattern and an impressive display of speed and power while it tried to free itself from the line.

As expected, scientists from around the world are excited about the images. They believe that much can be learned about the squid's behavior by analyzing the photos. And now that they have a better idea of where to look for the giant squid and how to attract them, they anticipate that more footage will unveil a whole new understanding of this mysterious creature.

**Fisher Science Education offers numerous services to make your job easier. For datasheets describing these capabilities, contact your representative or visit www.fisheredu.com.**

# TOADS THAT GO POP IN THE NIGHT

The city of Hamburg, Germany faced an unusual problem in April, 2005 when toads in a local pond began exploding in the night. The unfortunate amphibians swelled to three times their normal size and burst with enough force to send toad parts flying up to three feet. As the death toll rose to at least 1000 in just a few days, local residents began to refer to the pond as "Tumpel des Todes" or Pool of Death. Soon reports of a similar phenomenon were coming from across the border in Denmark.

Local officials were puzzled by the explosions. Most cases of animal explosion occur after an animal has died. Exploding whales, for example, are a result of the buildup of gases during decomposition. But, the toads in Hamburg were exploding while they were still alive.

A variety of explanations were proposed, including a bacteria or virus in the water, the introduction of a fungus by South American racehorses running nearby, pesticides, or exposure to increased ultraviolet radiation as a result of ozone depletion. Tests did not reveal any evidence of viruses or bacteria in the water. And other wildlife in the area, even frogs, was doing just fine.

Berlin veterinarian Franz Mutschmann collected toad corpses and performed autopsies. Mutschmann noticed that the toads had identical incisions in their midsections. Further investigation revealed that aggressive crows were pecking through the skin between the toad's chest and abdominal cavity and plucking out the tasty liver. The toads responded with their natural defense, puffing themselves up. The hole in their bodies plus the missing liver led to a rupture of blood vessels and lungs, resulting in the explosions. Such a large number of toads were affected because crows are intelligent animals and were able to quickly learn the liver-plucking maneuver by watching other crows.

# YOUTH MAY NO LONGER BE WASTED ON THE YOUNG

From early mythology to modern day science, the search for eternal youth has been on our minds. While we no longer believe in a magical fountain of youth, modern scientists are studying anti-aging medicines and hormones in hopes of maintaining health and vitality. After all, there's a lot more to aging than wrinkles and gray hair.

## Growing old without aging

Growing old and aging are two different terms. Experiences, and the ability to mentally develop from them, are a key component of growing older. This is an important distinction since gerontologists, or researchers who study aging, only want to slow down aging in order to maximize a person's life experiences.

Aging, according to gerontologists, begins shortly after puberty. From the time of conception through the start of reproductive abilities is considered development. While various processes in the development phase of a person's life can affect how they age, most research is focused on slowing the aging process that begins after the development stage. Aging is also progressive, which is to say that it only gets worse with time. However, most people don't address their aging symptoms until the first physical manifestations present themselves—often with the onset of menopause or adult diabetes.

Hormones such as estrogen and testosterone will drop as a person ages. The drop in hormones can lead to physical discomfort as well as shifts in mood. At the same time, other hormones will increase. The body's tissues build a resistance to insulin, which can lead to increased risk of diabetes, cardiovascular complications, and cancer. The stress of these changes may also increase elevations of cortisol, which affects the body's weight retention, brain functions, and immune system.

## A hormone's fate revealed

In 1997, Japanese researchers discovered a mutated gene that accelerated age-dependent loss of function in mice. They named the gene klotho after one of the mythological Greek Fates who held the string of life. The mice with the mutated gene that produced less of the klotho's protein developed atherosclerosis, osteoporosis, and emphysema.

Further investigation in 2002 at the Johns Hopkins Institute studied over 2000 anonymous human blood samples for patterns and forms of the klotho gene. They found that samples with two copies of a klotho variant were twice as prevalent in infants as it was in adults over the age 65.

While they still didn't understand the gene's influence on health, it did seem that people who were born with two variant genes would produce less klotho protein and subsequently die sooner than those with only one or no variant genes. Further comparison studies have also determined that the klotho variant appears with relative frequency across different ethnic populations.

Last year, a team from the University of Texas, led by one of the Japanese gerontologists who first discovered the gene, engineered mice with overactive klotho genes. The increased klotho protein levels actually slowed down the aging process and the mice lived between 19-30% longer.

Despite its connection to aging and longevity, researchers still know very little about how the gene works. The protein seems to block the insulin-like Growth Factor-1 pathway. Previous studies with that pathway have extended the life of worms, flies, and mice.

With studies progressing so quickly, little is known about the possible side effects. Within the mice, the resistance to insulin raised the level of insulin that their body produced. Extending life could be at the expense of becoming diabetic. Additionally, the mice that lived longer had fewer offspring than the control group.

## Current anti-aging methods

Another area for debate in the anti-aging community is the effect of calorie restriction (CR) on the aging process. The results are not as dynamic as those found in the klotho studies, but the side effects are less severe. While positive results have been recorded in mice and primates, similar results in humans have been inconsistent.

CR is a lifestyle change that is often associated with weight loss because biochemical research has discovered that CR helps regulate metabolism. Excess weight is known to increase the possibilities of several health risk factors from diabetes to heart disease. In addition to weight loss, CR is shown to lower blood glucose, cholesterol, and blood pressure.

The key to successful lifestyle change is to cut back on the calories and balance adequate nutritional needs. It is highly recommended to include a daily multi-vitamin supplement. Exercise helps to maintain lean tissue during the initial weight loss, but some research suggests that it may reduce some of the advantages of CR. Generally, experts still recommend regular physical activity and mental stimulation in order to combat circulatory and brain diseases.

People, unlike lab animals, are subject to stress factors and can't live in the same sterile environments that have successful proven longevity results. Left to monitor their own diets, people have had side effects including mild depression, muscle weakness, lightheadedness, hemorrhoids, and higher susceptibility to colds and illness.

Because CR is available to everyone without prescription or medication, a person should talk to his or her doctor before beginning this type of lifestyle change.

# ILLUMINATING THE MYSTERIES OF BIOLUMINESCENCE

In the deepest recesses of the ocean you might expect there to be complete darkness. But thanks to bioluminescence, this hidden world is host to an ever-changing light show. In this surreal landscape (between 200 and 1000 meters below the ocean surface), almost 90% of the inhabitants are bioluminescent.

Bioluminescence is the emission of visible light by a living organism. The luminous nature of creatures residing in the ocean depths has been documented for centuries by mariners who reported seeing mysterious "milky seas"—an eerie white glow that extends for miles across open water. While most prevalent among the deep sea population, bioluminescence can also be found on land, including earthworms, some bacteria and fungi, and, of course, the firefly.

## Cold Light

The primary components necessary for bioluminescence are oxygen, luciferin (a molecular substrate), and luciferase (an enzyme). While the process differs slightly between species, the oxidation reaction is the same in every creature. In the presence of oxygen, enzyme and substrate act in combination to produce a short burst of visible light. And the reaction is quite efficient. A firefly converts into light almost 100% of the energy generated in bioluminescence, compared to an electric light bulb that loses over 90% of its energy to heat.

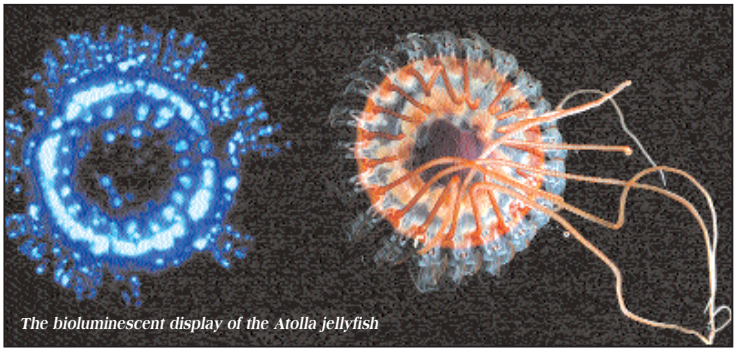
The resulting light is concentrated in the blue-green range of the spectrum, although other colors have been observed. For example, the dragonfish creates a rare red beam to locate its prey. This "night vision" is particularly effective since most sea animals cannot detect it.

## Why Glow?

In the dark seas, bioluminescence is a key means of finding and attracting prey. The anglerfish uses a light organ filled with bacteria that dangles from its forehead; in the same way a fisherman might bait a brightly colored lure. The aptly named flashlight fish uses a light, produced by symbiotic bacteria living in an organ below its eye, to illuminate potential prey. Glowing fungi use their light to attract insects, not as prey, but to serve as a delivery service for their spores.

Many sea creatures use bioluminescence as camouflage or to defend against predators. Some fish can become virtually invisible by matching their glow to the color and shading of sunlight, in a process called counter-illumination. When attacked, the Atolla jellyfish generates expanding rings of blue light that can last more than half a minute. Scientists suspect this response may attract larger fish, which in turn consume the original predator. The Caribbean's Mosquito Bay contains an unusually high concentration of tiny underwater plankton called dinoflagellates, also known as "fire plants." They produce quick pinpoints of light when startled; the result of this natural burglar alarm is a spectacular display that can last all night.

Fireflies provide perhaps the best-known example of bioluminescence, in which males and females communicate using flashes of light. There are more than 1900 known species of firefly, found in all parts of the world except Antarctica. Although not all are bioluminescent, each light-producing species uses a unique sequence of flashes to signal the opposite sex.



*The bioluminescent display of the Atolla jellyfish*

## Light in the Lab

Dinoflagellates, one of the most common sources of bioluminescence, are also easily grown in the lab. Cultures and growth media can be readily obtained, and dinos require no more care than the average houseplant. Since their light production is on a strict day/night cycle, or circadian rhythm, studies must be performed in a darkened room during their night phase. Both mechanical (shaking) and chemical (10% acetic acid or vinegar) stimulation will produce a bioluminescent reaction that can be viewed under a microscope. Since the bioluminescence produced by a dinoflagellate indicates its overall health, scientists often use these plants to examine the harmful effects of toxins on the environment.

## A Bright Future

Studies of bioluminescence have applications in many fields, including genetics, medicine, ecology, and biotechnology. Inserting a jellyfish gene into an African butterfly is helping scientists at the State University of New York (SUNY) study how genes control development. Bioluminescent ATP assays are used to identify bacterial contamination in wounds and tissues; ecologists use bioluminescent tests to assess bacterial contamination of drinking water. Life scientists use the luciferin-luciferase reaction extensively due to its extremely high sensitivity and nonhazardous nature. Some of the applications include the detection of calcium in live cells or tissues, ELISA, and high-throughput drug screening. And while researchers continue to find new species of glowing creatures in the ocean depths, others work above the surface to seek new and exciting ways to unlock the potential of bioluminescence.

# LOCATING THE FUTURE OF GPS TECHNOLOGY

Since its introduction to civilian and commercial use, the global positioning system (GPS) has been adapted for use in cars, cell phones, and on camping trips. The average GPS receiver uses between four and eight satellites and includes key landmarks and road maps. However, as GPS readings are used more frequently in geophysics research, the receivers need to be able to communicate with more satellites and calculate more accurate readings.

## Get your GPS bearings

The system currently consists of 24 satellites that orbit 11,000 miles above the Earth. In Colorado, a master controlling station works with five monitoring stations around the world to keep the satellites moving in a grid-like fashion.

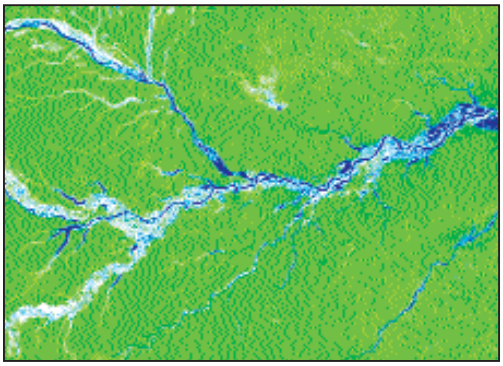
A GPS receiver needs to locate at least four satellites before it pinpoints a location and relays any further information. Since the satellites work on "line of sight," most receivers are used outdoors.

## Squeezing water from bedrock?

Geophysics is the study of the Earth by quantitative physical properties. As GPS receivers become more accurate, geophysicists are including these recordings in their research. However, ground-based receivers are reporting yearly oscillations in altitude.

These oscillations were typically a maximum of one half inch, but researchers were not definitive about what was causing them. The minor fluctuations were sometimes attributed to ocean tides or the Earth's electromagnetic field and until 1994, no reliable pattern was apparent in the oscillations.

Geophysicist Michael Bevis was studying a lake in Chile when he noticed GPS readings that suggested the ground rose and fell with the addition or removal of water. Comparing this to other reported oscillations, he and fellow researchers theorized that the Earth's crust is elastic. This theory would suggest that the highest GPS variations would be found near the Amazon River.



*Composite radar mosaics show flooding patterns of the Amazon River. Blue areas designate a constant river path. White overlay depicts areas that are flooded annually during the rainy season. Image was composed as part of the Global Rainforest Mapping Project.*

The Amazon River carries more water than the Mississippi, Nile, and Yangtze Rivers combined. It contributes approximately 20% of the world's freshwater discharge into the ocean and has a flood basin roughly the size of Texas. Bevis went to where the Amazon meets the Rio Negro in Manaus, Brazil to test the crustial elasticity theory.

He had expected to see an inch of variability. Instead, he recorded a three-inch difference between the rainy and dry seasons. With colleague Doug Alsdorf, they came up with a very simple approach called the "bathtub model," which assumes that the water level rises and falls uniformly.

Using this model for GPS records in Manaus from 1995 to 2003, their research team discovered the bedrock rose and fell in a pattern that coincided with the annual flooding. While there is still plenty of comparative research to be done, Bevis and Alsdorf are attempting to assess the ramifications of their discovery. Most significantly, it opens the possibility of scientists being able to calculate the amount of freshwater available in a river system.

Calculating bedrock's elasticity could help predict serious flooding and droughts. This type of global water monitoring is currently underway with the Water Elevation Recovery (WatER) mission. Alsdorf leads the American branch in their effort to measure water levels every eight days using radar and satellite information.

## The next natural disaster detector

Another factor to affect the accuracy of a GPS receiver comes from the Earth's ionosphere. The signal traveling from satellite to receiver can be delayed while traveling through this solar-radiated ionic field. Most receivers are limited to eight satellites and ignore satellites closest to the horizon where the signal would have the greatest delay.

To combat this phenomenon, dual-frequency receivers can "read" the ionic density and estimate how many electrons were encountered. Using software designed to record these specific electron columns, researchers can monitor fluctuations in the ionosphere to possibly predict severe natural disturbances on Earth.

At least, that's what Project Warn is attempting to do. Created by the Arthur C. Clark Foundation after the devastation of the Indian Ocean tsunami, they believe that combining international communication and IT technology can predict severe disasters earlier and at less cost than current methods.

Underwater earthquakes create tsunamis but monitoring seismographic readings alone has led to 75% false alarms for tsunami warnings. Currently, advanced sensors monitor the seafloor and use buoys to relay seismographic disturbances via satellite. These sensors are relatively close to the shoreline and only provide a few minutes of warning to evacuate. Considering the size of the wave can vary greatly; this may not be enough time for people to get far enough inland to safety.

Tsunamis have a vertical displacement along with the earthquake. This displacement continues beyond the water's edge into the troposphere and ionosphere. Nonstop monitoring of the ionosphere would display these disturbances and the ripple effect that follows.

Project Warn is proposing to engage middle and high schools and provide them with receivers that could monitor up to 12 satellites at a time. These schools would have their GPS running constantly without disrupting current science and computer studies. Teachers would have the necessary resources to inform students about the study so that when an ionic oscillation occurs, students would be able to actively participate in the research.

The theory is beginning to be tested in the Asian Pacific region. If successful, it would not only increase the time of warning, but could be applied to other natural and man-made disasters that disrupt the ionosphere.

VIDEO REVIEW


## Discovery School: *Nanotechnology*

Enlightening DVD explores the ever-shrinking advancements brought about by nanotechnology. Students will get to see this technology in action with the doctors and specialists who are developing it.

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DVD FEATURES:

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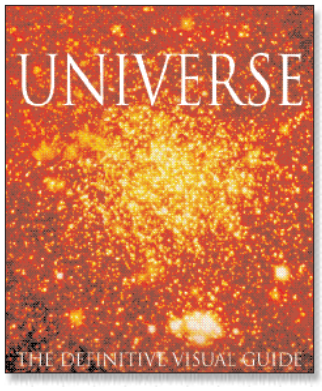
- Standards link that highlights correlations to national education standards
- Teacher's Resources such as a guide to using multimedia in the classroom

Program Time: 30 min.
Grades 6-12


# Reference that s Out of This World!

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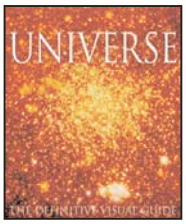
BOOK REVIEW




## Universe
## The Definitive Visual Guide

***DK Publishing, hardcover, 2005, 512 pages***

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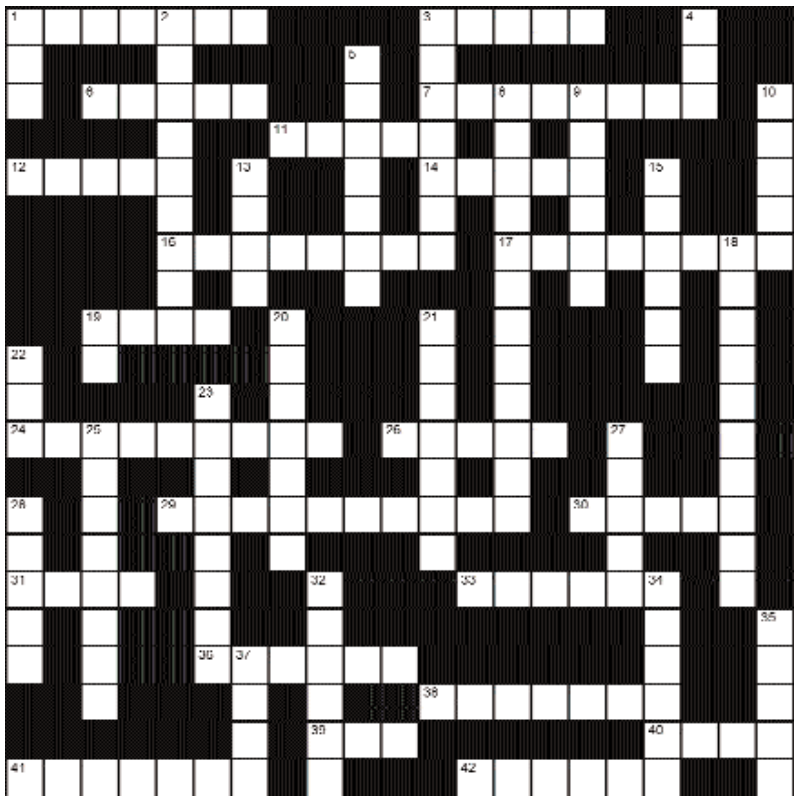

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