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INSIDE THIS ISSUE:

FISHER SCIENCE EDUCATION

HEADLINE DISCOVERIES

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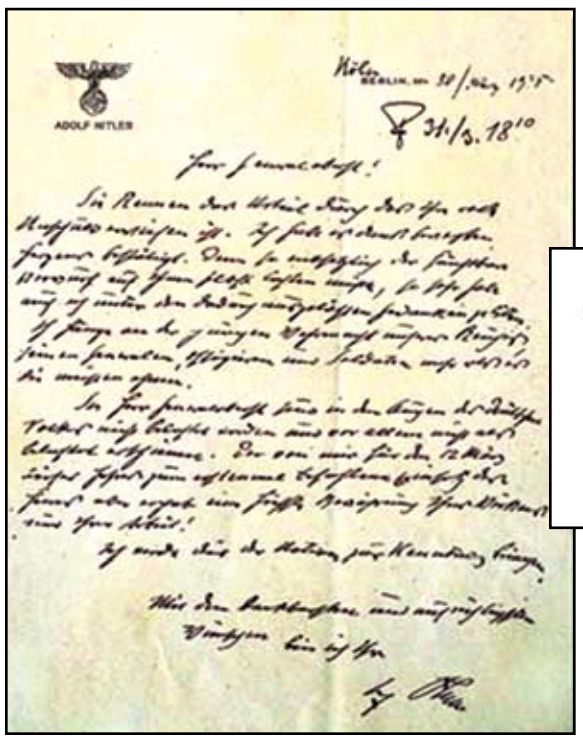
THE SCIENCE OF QUESTIONED DOCUMENTS



A Masterful Forgery

After being released from jail, Konrad Kujau hung up a satirical, handwritten letter from Adolf Hitler. In it, Hitler authorized Kujau to write his memoirs as a series of diaries. The letter, just like the 61 "lost" diaries Kujau claimed to possess, was a masterfully created forgery by Kujau.

When the diaries first came to light in 1978, some of the subject matter ran contrary to Nazi ideals and handwriting experts and historians openly doubted their validity. However, the few experts permitted to view the texts all came to the same conclusion—the handwriting matched other writings of Hitler's. The analysts who validated the work had not been wrong in their conclusion. As they all stated, the samples were written by the same person, their mistake came from the assumption that the exemplars were written by Hitler.

There are two types of documents used in handwriting analysis, exemplars and questioned documents. The exemplar can be collected from previous writings known to be authentic or written by a person identified as a suspect in an ongoing investigation. In the latter instance, the suspect transcribes dictated text using writing materials similar to that of the questioned document.

Analysts examine questioned documents, in this case the diaries, and compare them to exemplar documents to determine their authenticity. Typically, the more samples that an expert can have, the better the analysis will be. Kujau was able to skew the analysis because he manufactured and circulated fake paintings and Nazi memorabilia for years before creating the first of the diaries, thus providing a plethora of available "exemplar" samples that were also forged.

What the Experts Look For

At the start of a document comparison, the analyst identifies the form, arrangement, content, and line quality of both documents. Form refers to the proportion, slant, angles, lines, connections, and curves of each individual letter while arrangement refers to the spacing, alignment, formatting, and punctuation of the document as a whole. The content of a document will give clues that hint at the writer's level of education and intelligence from his use of spelling, phrasing, punctuation, and grammar. Finally, line quality refers to clues gleaned about the writer's physical style of writing based on the amount of pressure and type of writing instrument used.

Beyond comparing the letters and spacing, the paper and ink used can give criminologists even more clues. Examining electromagnetic wavelengths and filters, a UV/IR spectral comparison will reveal different inks, hidden erasures, and hesitation marks. Radiocarbon dating, x-ray analysis, thin-layer chromatography (TLC), and laser ablation test the elemental composition of the ink and paper.

With a library of recorded results, TLC is a cost-effective and simple method to determine what type of ink the questioned document was created with. However, TLC, unlike the other three methods, damages a small portion of the questioned document. Therefore, x-ray or laser analysis is used to determine a broader chemical breakdown and reveal additions or deletions to the original written text.

Only days before Kujau's forged Hitler diaries would be published in 1983, independent testing by West Germany's Federal Archives revealed that the paper, ink, and glue of the diaries contained additives that were only manufactured after World War II. The diaries were revealed, without question, as forgeries and when re-evaluated against authentic historical documents, the differences were obvious.

Types of Forgery

Most commonly, handwriting analysis in the courtroom involves document and signature forgeries. When reproducing someone else's handwriting, forgers use one of three methods: tracing, freehand copying, or mechanical placement.

Tracing is the most amateurish method. While anyone can use carbon copy paper or a light box, the lines typically do not exhibit the smooth flow of an original text or signature. Professional analyzers notice hesitation marks and unnatural pen lifts. Tracing is also easy to detect if there are multiple identical instances of the same signature or if the original signature is available. While handwriting is unique to an individual, the form of the letters is never identical, as would be seen with a tracing.

Freehand copying, which was Kujau's method, is harder to detect because it is practiced and smoother. A talented calligrapher may have practiced the forgery until he can adapt the handwriting into lengthy documents instead of just a signature. However, small traits in the arrangement and content are still present for an expert to identify.

Mechanical placement involves a device, such as a stamp or photocopy, to copy the original signature onto the document. Similar to tracing, this type of forgery is apparent when several identical signatures appear near one another.

Beyond Forgery

In cases involving ransom notes or threatening letters, handwriting analysis is typically behind-the-scenes work. When the case moves to court, the handwriting expert's analysis is rarely considered as viable, stand-alone evidence. Despite what you see on television or read in crime novels, getting the court system to recognize handwriting experts has been difficult for several reasons.

Firstly, unlike many forensics frontiers, handwriting analysis does not have a standardized educational degree from many colleges or universities. Ink and paper evaluation can be studied and taught as a science; but the skill of keen eyes and knowing what to look for often follows tutelage under previous experts. Organizations, such as the American Board of Forensic Document Examiners (ABFDE), formed in order to certify and vouch for an expert when he or she is called to testify.

Secondly, severe stress often masks typical handwriting habits in these types of questioned documents. Notes written by someone in an extreme emotional condition will have different slants, spacing, and pressure than samples collected from the same person at any other time. Similarly, in a letter that is knowingly sent to police, the writer often attempts to mask their letter formation. This may involve changing to printing instead of using cursive, or writing the letter with their non-dominant hand.

Lastly, and most significantly, handwriting analysis has some overlapping themes with graphology. Graphology claims to determine personality traits based on a person's handwriting sample. For example, when examining the writings of both Ted Bundy and Jeffery Dahmer, graphologists saw the same little break following a lower case "d". Many people with this handwriting trait are known to be able to rationalize any sort of action. While this may be helpful for psychologists, it does not make everyone with this trait a serial killer, and it is certainly not conclusive evidence to issue an arrest warrant.

The confusion comes because both handwriting analysts and graphologists examine documents and make assumptions based on the misspellings, grammatical choices, and word usage they contain. In the famous Unabomber case, a newly emerging type of analysis called forensic linguistics became the key to attaining a search warrant for suspect Ted Kaczynski.

The New Frontier of Linguistics

Over two decades, a mail bomber, known only as the Unabomber, killed three people and injured 29 with exploding packages. As the investigation progressed, family members of Ted Kaczynski recognized similarities between his writings and the Unabomber's Manifesto. When the FBI collected samples of Ted's writing their experts came to the same conclusion.

Many of the samples included unusual sentence structures such as "you can't eat your cake and have it, too," a convoluted version of the commonly used saying "you can't have your cake and eat it too." Ultimately, a judge agreed with the analysis and issued a search warrant for Kaczynski's cabin where agents discovered bomb-making materials.

The development of forensic linguistics as a resource for criminologists is indeed timely. With advances in technology, ransom notes and threats can be emailed, posted on the Internet, or even sent to a cell phone. Some technologies allow messages to be traced back to the original source, but the linguistics of the notes will help when the technology track is lost or ends. Plus, as society moves more towards electronic messaging as a primary means of communicating, linguists can give police more evidence to work with when there is no handwriting sample, ink, or paper to test.

By: AJ Rodgers

DIAN FOSSEY AND THE MOUNTAIN GORILLA

Dian Fossey graduated from San Jose State College with a major in occupational therapy, but her love of animals led her down the career path that made her famous.

In 1963, Fossey's career in primatology began when she showed up unannounced at Louis Leakey's dig in Olduvai Gorge. A tourist at that time (he charged her fourteen shillings to look around his camp), she failed to impress him. By 1966, however, Fossey's determination had persuaded Leakey to secure funds for her research of the mountain gorillas in the Virunga Volcanoes region of the Democratic Republic of Congo (then Zaire).

Fossey needed all the determination she could muster. An asthmatic smoker, Fossey struggled to adapt to the thin air of the Virunga camp's elevation. Her only human contact was with two African employees, whose language she did not speak. After a few days tutelage in studying large primates under Jane Goodall and field photographer Alan Root, Fossey was on her own professionally and personally.

Fossey's original goals were to study gorilla ecology, demography, and social organization. Despite the detached language describing these goals, Fossey's intensely involved, interactive approach to her study of the mountain gorillas earned her fame. She began her work by sneaking up to observe the gorillas. However, she soon abandoned this approach in favor of announcing her presence to them by imitating their vocalizations. Eventually, she managed to approach some groups as closely as thirty feet.

By 1967, political instability in the region drove her across the border to Rwanda, specifically to Volcanoes National Park. Because she situated her camp between Mt. Bisoke and Mt. Karisimbi, she called the place "Karisoke". Her observations began anew with the wary Rwandan gorilla population.

The gorillas of Karisoke gradually came to accept her presence among them. Here, one day in 1970, a male gorilla she called "Peanut" offered the first recorded friendly contact between human and gorilla when he touched her hand. Eventually, she developed a special fondness for a young male named "Digit."

Over time, Fossey noticed an increase in traps and snares in the area. While the animals of Volcanoes National Park were under protection legally, poaching worsened. At first, gorillas were incidental victims caught in traps meant for other creatures. However, poachers soon discovered a market for gorilla hands or heads for tourist trophies. Worse still, gorilla babies were captured for exhibition in zoos. Gorillas live in tightly bonded family units and will fight to the death for their offspring, so several adults died for each gorilla baby taken by poachers.

On New Year's Day, 1978, Fossey discovered the mutilated body of Digit, killed in the fight to save his family from poachers. His death compelled Fossey to begin a campaign against poaching using tactics she called "active conservation." She shot poachers' cattle that strayed onto park property and insisted that her students carry guns. She also encouraged rumors that she was a sorceress and would torture any poachers she caught. She even burned the houses of poachers.

Finally, in 1985, Dian Fossey was found murdered in her cabin in Karisoke. The crime remains unsolved, although the popular theory is that one or more poachers killed her. She was buried in the same cemetery where she had buried dead gorillas with an epitaph reading, "No one loved gorillas more." Today, Karisoke is a tourist destination, its fame as Fossey's camp prompting Rwanda to improve its policy toward conservation of the mountain gorilla. Her will stated that all her estate, including proceeds from the movie about her life, "*Gorillas in the Mist*," should go to the Digit Fund (today renamed "Dian Fossey Gorilla Fund International" in the USA) for antipoaching patrols.

By: Lisa Jancarik

A timely examination of the state of the Earth's ecosystems and the ways humans influence the natural habitats on our planet.

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THE MOUNTAIN GORILLA

When Dian Fossey began her research in 1966, the mountain gorilla was already under threat, with a population in Volcanoes National Park estimated at only 480. Today, the Virunga population she studied is estimated to be around 320.

Mountain gorillas live in family units led by one or two adult males called "silverbacks." These families include younger males, adult females and juveniles. The dominant male fathers most of the offspring in the group.

Females can become mothers at around age 10. They carry a pregnancy for eight and a half months, and then raise the juveniles to about age four.

Adult males can weigh in at 400 pounds, with females reaching about 200 pounds. Newborn gorillas, however, weigh only about four and half pounds.

Gorillas eat mostly plants. Adult gorillas can consume 60 pounds of vegetation per day.

ANIMALS WITH ACCENTS?

It is well known that throughout the United States people have regional accents depending on what part of the country they are from. This is also true of other countries around the world. These regional accents are also known as dialects. According to Webster's Dictionary a dialect is defined as a "regional variety of language distinguished by features of vocabulary, grammar, and pronunciation from other regional varieties and constituting together with them a single language." For example, the English language is the most commonly spoken language in the United States, but based on where an individual resides, the English language sounds differently. A good instance of this would be if a person has a "drawl" in his/her pronunciation it would be assumed that the person resided in the Southern part of the U.S. based on American English accents. But are dialects only subject to humans? Could other animals also have accents?

Accents Under Water

Findings in a new study show that certain species of whales sing in different dialects depending on where they are from. With underwater microphones called autonomous hydrophones, researchers recorded various clicks, pulses, and calls of blue whales throughout the Pacific Ocean. Based on where the whales were from, each population sounded different. Blue whales from regions around Antarctica sounded different than whales recorded near Chile. The same was found in blue whales that resided off the U.S. coast of the Pacific Ocean versus those living further west in the Pacific Ocean. Whales located in the Eastern Pacific use low-pitched pulse sounds, trailed by a tone. Populations from different areas of the Pacific use different combinations of pulses, tones, and pitches. Some would say that these findings could be regional accents. However, researchers do not know why blue whales living in different areas of the world sound differently. They are not sure if it is linked to genetics, tied to a regional dialect, or if the different combinations of sounds come from confused young whales that have not completely learned the intricacies of communicating.

Field observations of killer whales off the Pacific Coast have found that dialects also seem to be present in this species. Scientists have discovered that not only are groups of killer whales differentiated based on morphology, feeding behavior and genetics; they are also separated by different calls. Whale biologists from British Columbia conducted field studies in the waters surrounding Vancouver Island. They can identify whether a killer whale resides in the north or south, what clan they belong to, and which pod they are a member of based on the whale's sounds. It has also been determined that killer whales reflect their genetic relationships through dialect. Basically meaning that the more similar the dialect, the closer the whales are related. Through combined field study and genetic analysis, biologists believe that dialects serve to help groups of killer whales identify each other. This function may help organize pod movements and maintain the integrity of the pod. It is also suggested that these dialects prevent killer whales from mating with others that are too genetically similar.

To hear examples of killer whale dialects visit **http://www.zoology.ubc.ca/~ford.**

Accents in the Air

Ornithologists have known for a number of years that birds sing with regional dialects. Birds are considered to be one of the most complex communicators in the animal kingdom. Some species are pre-programmed with songs they know from birth, others learn them from their elders, like a child learning to speak. Scientists have observed that birds can identify a neighbor or a stranger by individual differences in their songs. Astonishingly, some birds are even bilingual. These birds sing both the local song and a second dialect that they seemingly learned from migrating birds passing through.

Regional accents are usually dictated by the habitat the bird population lives in. If a population of robins resided in a thick forest containing a large amount of vegetation their songs would be measured at a louder amplification and a higher, longer pitch so they can hear each other. Robins living in a suburban area with less vegetation 50 miles away would have lower, softer pitched and shorter songs because there is not as much vegetation for the sound to penetrate through.

In the world of birds there are believed to be two main functions for song, defending a territory and attracting a mate. Hence, in most circumstances the male bird of the species is the one who does most of the singing.

Female birds rarely sing. However, researchers in Australia have discovered that female whipbirds sing the same songs as their male counterparts, but with regional accents. Researchers recorded the song's number of syllables, the length of the first syllable, the highest and lowest frequency of the last syllable, the time between these frequency extremes and other characteristics of 112 birds residing in 16 different populations. For the female birds, the vast majority showed variations in dialect on each of the recordings. Surprisingly, the male songs were nearly identical regardless of their location. Some researchers believe that female whipbirds may have regional accents to somehow coordinate reproductive activities. It is still left to be determined why the male songs are so similar.

Accents in the Pasture

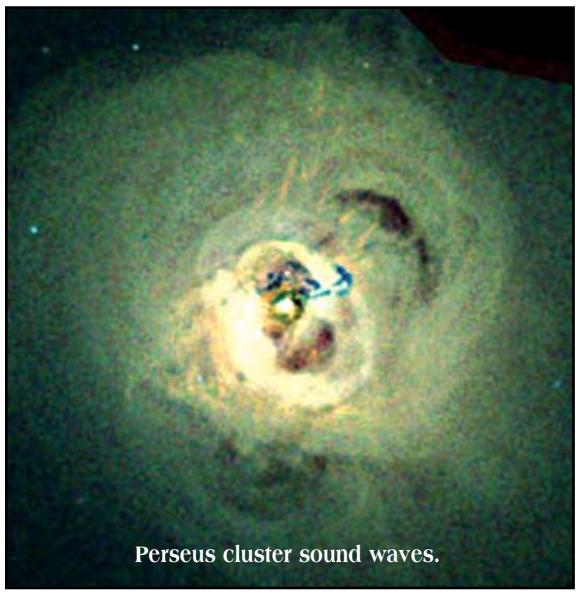
Can it also be possible that cows have different moos depending on where they live? Some dairy farmers have claimed that they are noticing a slight difference in their cows' mooing based on where they come from. There have been no field studies proving this farmer hypothesis, but some linguistic experts say that it is possible. They believe that the variation in mooing could be from herd influence. Since regional accents can be well attested to birds and whales, the same could also be true for cows.

Accents All Around

From a Texan's southern drawl to a Scotsman's brogue, all accents are adopted from one's parents or peers when learning to communicate. In essence the same can now be said for certain species of animals. Does this suggest that a dog's bark in Texas can have a longer drawl versus another dog's bark in New York? Not exactly. It is safe to say, however, that an animal's habitat, environment, and coexisting population may have a noticeable effect on "pronunciation" in the animal kingdom.

By: Jennie Culver

SPACE NOISE: THE PERSEUS CLUSTER AS A COSMIC SUBWOOFER



Perseus cluster sound waves.

Time Out for Physics: Sound Is a Pressure Wave

Sound travels only through a medium, like air or water. This is because the excited jostling of the atoms in a particular medium is what transmits sound. Although the medium as a whole doesn't move much, the waves of excitement pass through the atoms that make up that medium. These waves are called "pressure waves" (fans doing "the wave" in a stadium are mimicking particles through which a pressure wave is traveling). The atoms in the air get jostled by the sound of vibrating vocal cords, for example. No medium, no sound.

If space is mostly empty of atoms to excite, then it should be a pretty quiet place. Any sounds occurring in space would require a tremendous amount of energy for the transmission of sound through atoms that are extremely far apart. What about galaxies and other concentrations of matter in space? In theory, sound can exist wherever there is matter. The Chandra X-Ray Observatory has discovered evidence of sound in other parts of the universe. Specifically, the activity in the Perseus galaxy cluster seems to tie into the idea of sound as a pressure wave.

The Perseus Cluster Structure

Galaxy clusters are the largest structures in the universe, and the Perseus galaxy cluster, some 250 million light years away from Earth, is among the brightest clusters visible to the Chandra Observatory. The Perseus cluster owes its brightness to the disc of gases heated to millions of degrees within it. At those temperatures, the gases glow visibly on X-ray images.

At the center of the cluster's disc of gases, a super massive black hole belches jets of plasma (electrically charged gas) perpendicular to the disc at regular intervals, roughly once every 10 million years. The reason for these emissions is poorly understood, but the jets leave bubbles of expanding plasma. The bubbles create pressure waves in the glowing gases like ripples from a stone thrown into a pond. Images from Chandra show pressure waves from Perseus' cavities rippling through the glowing hot gases of the Perseus cluster.

Energy from the plasma bubbles should dissipate quickly, cooling them down rapidly, but that doesn't happen in Perseus. Chandra's X-ray images suggest instead that the energy in the sound waves is sufficient to keep the plasma bubbles heated. Preventing the plasma from cooling prevents the matter within it from condensing into new stars.

Pitch-Perfect Perseus

Not only does the Perseus cluster have sound, it produces a note that can be measured in terms of a musical scale. A musical note has a regular frequency, and the cavities erupting from the Perseus black hole occur regularly, too. Each cavity corresponds to one sound wave, so their regular creation creates a frequency like that of a musical note. The sound emitted by the Perseus activity has been calculated to 57 octaves below B flat above middle C.

Researchers arrived at this conclusion by measuring the distance between the ripples in the glowing hot gases of the Perseus cluster and using the speed of sound to calculate frequency at about one cycle per 300 million million seconds (about one jet of plasma belched every 10 million years). An octave corresponds to a factor of 2 in frequency. Therefore, a frequency of one cycle per 300 million million seconds is about 257 times lower than 475 cycles per second, or the frequency of B-flat above middle C. The lowest note audible to the human ear is about 20 cycles per second.

The air of Earth's atmosphere is invisible to the human eye, so sounds moving through Earth's atmosphere are invisible, too. If atmospheric gases on Earth were visible in the optical spectrum, then one could do the same kind of calculations by watching a cell phone ring that astronomers did for the Perseus cluster.

About the Chandra Space Telescope

The Chandra X-Ray Observatory is the most powerful x-ray telescope ever created, at about one billion times more powerful than the first x-ray telescope built a little over thirty years earlier. In fact, it could read a one-centimeter newspaper headline at a distance of half a mile away or the letters of a stop sign from 12 miles away.

NASA deployed the Chandra Space Observatory from the space shuttle Columbia in 1999. It was the largest payload ever carried by the space shuttle. The Chandra X-Ray Observatory orbits Earth from 200 times higher than the Hubble Space Telescope. Each time it completes an orbit, it has traveled nearly one third the distance between Earth and the moon.

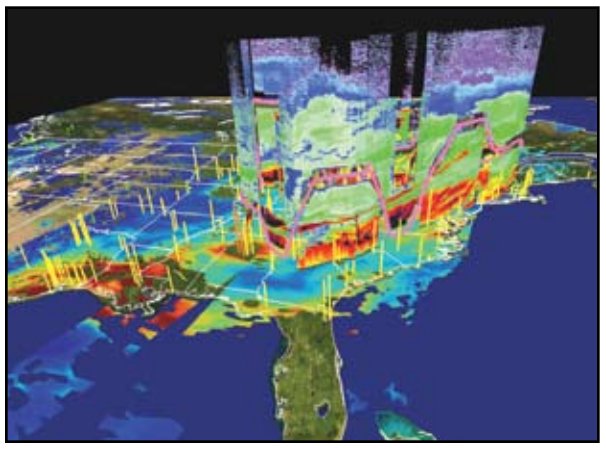
By: Lisa Jancarik

The Math Part

10 million years between cavities = (1 x 107 years) (365 days/year) (24 hours/day) (60 min./hour) (60 sec./min.) = 3.15 x 1013 seconds (or, about 300 million million seconds, the estimate used in the article)

This makes the frequency of cavities from the black hole 1/3.15 x 1013 seconds. The frequency of B flat above middle C = 1/475 seconds

3.15 x 1013 divided by 475 equals 6.63 x 1010, roughly 257. Because an octave corresponds to a factor of 2 in frequency, the black hole's note is 57 octaves below B flat above middle C (remember, the larger the number of seconds between cycles, the lower the note).



GLOBAL PSYCHIC?

Imagine if it were possible to forecast next winter's weather in the summer, or foresee the pattern of the North American monsoon? This type of foreshadowing may be possible within the next decade.

On February 16, 2005, a plan that will revolutionize the understanding of the Earth and how it works was set into motion. Sixty-one countries came together to create a 10-year implementation plan for a Global Earth Observation System of Systems (GEOSS). This emerging global network is visualized as a giant national and international cooperative effort to bring together comprehensive and sustained Earth observations and information. GEOSS will be seen as providing the necessary information that will help guide decisions and actions to benefit the health of humankind and the global environment.

The Plan

At this moment in time, there are thousands of Earth observation systems around the world collecting different types of data, but most of these systems are isolated. Earth observation systems currently collect data to estimate crop yields, detect earthquakes, forecast droughts, predict floods, and monitor air and water quality. This new endeavor seeks to link those systems together into a global network so that all information would be available instantaneously to all countries. An informal group of senior political officials from all participating countries and organizations, named the Group on Earth Observations (GEO), was formed to embark on this global effort. GEO was called upon to develop a "Framework Document" that outlines a more comprehensive report to describe how the GEOSS would work.

Predicting Natural Disasters

On December 26, 2005, Indian Ocean tsunamis took tens of thousands of lives. There was no tsunami alert system in place in the Indian Ocean. Thailand and other affected countries criticized the United States National Oceanic and Atmosphere Administration (NOAA) by saying that more should have been done to raise the alarm of a tsunami warning. Officials from the NOAA stated that no proper system was in place for the countries affected to receive a suitable warning to avert the disaster in time. However, the Pacific Tsunami Warning Center in Hawaii detected the earthquake that triggered the fatal waves. If the GEOSS system was in place, it might have prevented such a huge loss of life.

Satellites can help save lives and protect property from natural disasters. For instance, Geostationary Operational Environmental Satellites (GOES) are used across the Western Hemisphere to detect and monitor forest fires. These satellites are highly sensitive. A blaze can be detected within 15 minutes of igniting. With GEOSS other satellites could be incorporated to extend fire-alert coverage globally.

Global Benefits of GEOSS

According to the GEOSS 10-year implementation plan created by the GEO, this "system of systems" will help the delivery of the following benefits to the international community.

- Decrease the loss of life and property caused by natural and human-related disasters
- Improve weather information, forecasting, and warning
- Understand environmental issues affecting human health
- Improve the management of energy resources
- Comprehend, assess, predict, mitigate, and adapt to climate variability
- Aid water resource management by providing a clearer understanding of the water cycle
- Better management and protection of terrestrial, coastal, and marine ecosystems
- Recognize, monitor, and conserve biodiversity

Local Benefits

Want to see how the GEOSS will affect you? The U.S. Environmental Protection Agency (EPA) has posted a map of the United States on its Web site: **http://www.epa.gov/geoss/whereyoulive.html.** Just click on your state and a list of benefits for your region will appear. Below are a few examples from states across the country.

Pennsylvania

- Aid in storm and hurricane preparation by using satellite data, weather models, Doppler radar, and other information, thereby reducing impacts of natural disasters.
- Facilitate response to and clean-up efforts for flooding by providing residents and officials better information on flooding, road loss, and extent of property damage.
- Help emergency responders pinpoint the location of technological accidents and oil spills, like the spill that occurred at the Heinz Wildlife Refuge in Philadelphia several years ago. Water monitoring and satellite imagery can help clean-up crews respond faster and avoid hazards as they work.

Texas

- Help expand the ability to track and model natural disasters (such as hurricanes and storms). Through Earth observations, Florida can also have near real-time monitoring that will improve storm and hurricane forecasts and help to dramatically reduce the cost of damage to property and loss of human life.
- Benefit agriculture by monitoring rates of fertilizer application, field fertility, and plant diseases; thereby, making sustainable agriculture more manageable for both large and small scale farmers.
- Pinpoint beach areas impacted by coastal erosion, weather, and environmental pollutants.

California

- Provide better information to decision-makers and the public about the potential for earthquakes, including near real-time updates on the extent of potential danger and damage.
- Enable us to predict how changing environmental conditions, including sea currents, affect the whereabouts and numbers of fish and marine resources.
- Integrate satellite images and water quality models that will help pinpoint beach areas impacted by environmental pollutants such as harmful aquatic blooms and oil spills.

GEOSS strives to make 21st century technology as integrated as the planet it observes. Supporters of the GEOSS firmly believe that the health and well being of the human species is directly correlated to the health and well being of the planet. Once the scientific dots are connected, the world will have a better understanding of the links between environment and health.

By: Jennie Culver

A CLOSER LOOK AT SNOW

The Journey of a Flake

With cloud temperatures at or below the freezing level and enough moisture in the air, ice crystals freeze around a spec of dirt or other particle and begin to form into a snowflake. As the water molecules bond together the complex crystal patterns of a snowflake are born.

As snow crystals fall through the atmosphere, they develop characteristic deformities that reveal the weather conditions they encountered on their journey to Earth's surface. Snow crystals pass through fogs of super-cooled water droplets that attach themselves and freeze. Depending on the atmospheric conditions, snow crystals may acquire only a few droplet blemishes and remain recognizable as a needle or dendrite. Others may be fully encased in a lumpy coat of tiny, frozen water droplets.

Once the snow lands, fluctuating temperatures, pressures, air currents, and sunlight cause a metamorphosis in their structure. Snow crystals partially melt, refreeze and even fuse with neighboring crystals to create transfigured crystals that can look like miniature flowers or a tiny bunch of grapes.

One type of transfigured crystal is of particular interest to scientists because it has been associated with avalanches. When the temperature of a snow pack's surface is significantly lower than the snow underneath it, ice from the inner levels sublimes, meaning it changes directly into vapor without melting first. The resulting vapor refreezes on overlying crystals and over a period of time it produces large, blocky crystals called depth hoar. The formation of depth hoar makes the snow pack unstable and more likely to shift. Ski resorts and other areas known for avalanche activity have learned how to monitor snow packs for the formation of this dangerous layer so they can close-off areas that are at risk.

Accidental Science

In December 1993, William Wergin and Eric Erbe of the U.S. Department of Agriculture's Electron Microscopy Unit were anxious to run a newly configured, custom-built, low-temperature scanning electron microscope (LTSEM) through its paces. Designed to keep samples chilled to -320 degrees Fahrenheit, the LTSEM can flash-freeze nematodes and other insects found in soil samples then magnify the frozen organisms for study. The samples give the scientists insight into the behavior of these tiny creatures, helping them to study how they interact with crop plants.

Finding themselves without nematodes to freeze, Wergin and Erbe decided to test it out on the snowflakes falling outside their lab. They chose a copper plate as their sample medium, holding it out for the falling snow to stick to. They brought the crystals they collected to the microscope and were astonished by the images their new toy captured.

Spreading the Word About Snow

They shared their snowflake images with a visiting colleague who realized how valuable this up-close inspection could be for research on winter snow packs. As word of the images spread, other researchers soon began calling to request Wergin and Erbe's assistance with studies of ice and snow structure. Wergin retired from the USDA, but still devotes some of his time to snow research. Erbe went on to develop procedures for collecting and preserving snow crystals.

Erbe now uses a copper plate coated with a common laboratory adhesive to freeze and collect better snow crystal samples. The plates are then placed in a Styrofoam container with liquid nitrogen before being transferred to cryogenic storage that can keep them intact for a decade or more. Erbe also developed a method for coating the crystals with a layer of platinum less than a millionth of an inch thick to greatly enhance the images captured by the LTSEM. He and Wergin have imaged snow crystals across the country from Maryland to Alaska and have provided a stunning glimpse into the secret life of snow.

In addition to representatives from the six typical snow crystal categories (see sidebar) their innovative methods have captured the truly complex nature of these crystals and the water that forms them. Their images have given scientists new insight into the formation of depth hoar and its contribution to avalanches. In the future, it might also provide a new way of studying acid snow and air pollution by revealing, under extreme magnification, airborne particles trapped inside the crystals.

By: Janice Campbell

SIX BASIC CATEGORIES OF SNOWFLAKES

STAR—Formed at two temperatures: -2°C and -15°C; Among the most common type of snowflake; May stick together to form large flakes, largest ever reported was 8 x 11" in Bratsk, Siberia in 1971

DENDRITE—Formed in brutally cold temperatures, -20° to -25°C; Need high level of moisture present in the atmosphere, 3-D stars with branches growing on more than a single plane

COLUMNS —Formed at a wide temperature range of -15° to -25°C; Produced when the atmosphere is dryer; Small, dense columnar form

PLATE—Formed at -10° to -20°C, The beginning of a star but lacks enough moisture to fully develop; Low atmospheric water vapor doesn't allow them to grow the delicate arms of a star

NEEDLES—Formed at between -5° and -10°C; Usually form when the ground is at or near freezing; Produce dense, stiff snow pack that can lead to an avalanche under certain conditions

COLUMN CAPPED WITH PLATES—Composite flakes formed when a snow crystal passes through different temperature and moisture zones as it is falling to the ground; Columns form first at the higher, dryer regions of a cloud; Combine with star crystals as they fall through lower and wetter clouds

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WE'RE ALL PRODIGIES?

No peeking at the answer. No pencil, paper or calculator. Now, add 747 and 365—quickly. Whoops, sorry, there's the buzzer.

If you couldn't do that mental calculation almost instantly, you're in good company. Not many of us can do rapid mental arithmetic. But suppose you were presented with two sets of objects—say, 747 tiny squares and 365 tiny squares—and asked to say which set has more objects? "Piece of cake," you're likely to say. Now, let's split those 365 squares into sets of 200 and 165 squares, and place them next to the set of 747 squares. Can you say whether the largest set has more objects than the two smaller sets combined? Can you do the same if you're shown each of the sets separately?

A number of scientists, using tests like these on children and adults, are adding to the increasing body of research which indicates that children acquire a sense for "large numerosities" well in advance of the ability to count or use language. In fact, our brains may well be "wired" with systems for estimating amounts and even doing arithmetic, according to Elizabeth Spelke, a Harvard psychologist. Her work, along with the discoveries of other scientists, seems to indicate that infants—and even some animals—have a built-in "sense of number" existing well before the advent of formal math lessons.

Spelke's research is specifically designed to learn what innate capabilities children show that can help them to learn math once they enter school. Her premise is that formal learning can take advantage of systems that are already present in the brain; and her goal is to define those systems, discover their workings and see how they coalesce into mathematical thought. Knowing these skills, teachers will be better able to make use of them to teach math more effectively.

Seeing Numbers As Symbols

Spelke's research team has designed a number of experiments to demonstrate that preschool children, without any training in arithmetic, are able to estimate quantities of things and even add large numbers. Doing basic arithmetic requires that a child grasp the concept that numbers are symbols to be used in all sorts of ways. The same numerical symbol—such as "9"—can represent the street address of your house, the number of frogs in your collection, or the number of brownies left over from a dozen after your mid-day snack. Understanding the abstract concept of numeric symbols is one thing that distinguishes humans from other animals. Among animals, only humans can calculate precisely how many of a thing you have when you add 24 and 41, regardless of what objects these symbols refer to.

In recent experiments. Spelke and her coworkers tested their premises with five experiments, in which computers rapidly flashed sets of animated dots before a group of preschool kids, in sets numbering from 10 to 58.

Experiment 1 showed two sets of dots, one red and one blue, to a group of 5 year olds. Even though each set was displayed separately, and flashed on the screen too rapidly to be counted, the subjects usually determined which was the larger set—despite the fact that the dots were sized differently and were displayed in different patterns on the screens.

Experiment 2 was a bit more complex: the children were presented with a set of blue dots, then a second set of blue dots, and finally a set of red dots. They were still able to determine whether there were more blue dots or red dots, considering all together. This suggested to the researchers that the children could actually add and compare amounts.

Experiments 3 and 4 added the sense of hearing to the mix. The children compared a set of dots on the screen to a set of tones in experiment three; and in the fourth experiment, two sets of dots of the same color and a single set of tones were used. In both experiments, the children were consistently able to choose the largest groupings.

Experiment 5 replaced dots and tones with simple word problems, similar to the comparisons in experiment two. For example, what if you have 8 marbles; your Dad gives you 10 more marbles; and your friend has 25 marbles. Who has the most marbles, you or your friend? Given the question in this form, the children were not able to give the correct answer, even though they could pick the right answer when the problem was presented as a series of dots.

Considering the results of these experiments, Spelke and her team arrived at the conclusion that a child's innate number sense is independent of the child's language ability. And in fact, studies with adults show that we use different parts of our brains in doing arithmetical operations, such as basic addition, compared to visual estimation of quantity, as in comparing those sets of dots.

The Steps Toward Building Math Proficiency

Research by Spelke and others shows that the basic mental capabilities for learning math—the "building blocks"—seem to be part of kids' mental equipment well before they're of school age. And yet, Spelke says, elementary arithmetic is still tough going for almost all children. Reason: the brain must learn how to make that innate sense of number work in tandem with its language ability and other symbolic skills, in order to acquire true proficiency in mathematics.

Nevertheless, Spelke's research holds out hope: indications are that kids may be better equipped for certain kinds of math than they believe themselves to be. And it appears that, when teachers involve students in thinking about numbers—that is, numbers without specific numeric symbols—they're able to comprehend quite a lot.

And even though proficiency in math means numerous classes, plenty of homework and steady application, Spelke says, the end result is well worth all the hard work required. Because, she points out, our world today could not function without math: our measurements, our science, our technology, our very understanding of the world depends on mathematics.

By: Ray Schafer

"SUPER MOUSE" PROVIDES CLUES TO POTENTIAL CANCER TREATMENT

A team of scientists at the Comprehensive Cancer Center of Wake Forest University may have stumbled across some vital information that could lead to future gene or drug therapies for the treatment and possible prevention of cancer. The researchers, led by biochemist Zheng Cui, owe their most recent discovery to one very special mouse.

The Mouse that Wouldn't Die

It all started seven years ago, during a routine, ongoing cancer study. Dr. Cui and his colleagues were injecting mice with a virulent type of cancer cell that forms highly aggressive cancers in all strains of lab mice. The resulting death rate of the injected mice was 100 percent.

Upon injecting the cells, the scientists routinely observed a large, rapidly growing tumor causing the abdomen to completely fill with fluid within two weeks. Soon after, the cancer progressed by metastasizing into the liver, kidneys, pancreas, lungs, stomach, and intestines. The experiment continued predictably until one day, something unusual happened. One male mouse did not die.

A Colony of Cancer-Fighting Mice

Assuming that he had made an error, Cui injected the mouse again with a million times the lethal dose. Still, the mouse remained free of the cancer and did not die. Dr. Cui was fascinated with this anomaly, and he began breeding the mouse. Developing a large colony of mice, Cui studied the offspring and made a groundbreaking observation--the resistance to cancer was carried on, proving this to be a genetic trait.

Further, when the cancer-resistant mice were bred with normal partners, about half of their offspring were resistant to cancer cells, indicating that the genetic protection is dominant and is most likely due to a change in one gene. According to Cui, "The resistance appears to be caused by just one gene, or a cluster of closely related genes." The cancer-fighting trait continued to be passed down, for at least seven generations.

Another interesting observation was that the cancer-killing ability of the mice was highly consistent with different types of cancer. So it appeared that somehow the mice were able to recognize something in common to all cancer cell lines. "The power of this resistance seems to be unlimited," said Cui. "You can give them many, many tumor cells and the mice get rid of them."

Clues to a Cure

Intrigued by this new colony of cancer-resistant creatures, Dr. Cui and his team of researchers took the study one step further and injected white blood cells from the anti-cancer mice into their nonresistant siblings. Incredibly, the injected mice became resistant as well, fighting off induced cancer in just weeks, or avoiding it entirely.

A sample group of human volunteers revealed that 10 to 15 percent had similar, super cancer-fighting white blood cells. This could explain why certain individuals never get cancer and why others' tumors seem to spontaneously regress. Moving forward to the next obvious step, Dr. Cui has proposed that we inject these individuals' white blood cells into cancer patients to see if their immunity is transferred.

Some oncologists suggest that while Cui's mice are genetically uniform, humans have distinct DNA differences and would run a deadly risk of the donated cells attacking their host. Dr. Cui believes these problems could be overcome, as they have for other types of transplants.

Spontaneous Regression

Physicians have known for many years that in rare cases, cancers can mysteriously clear up of their own accord, without treatment. This is referred to as "spontaneous regression," and no satisfactory explanations for this phenomenon have ever been put forward. In fact, because such cases are so rare, many scientists have dismissed the phenomenon as either mistaken diagnosis or fiction. Dr. Cui's new research is the first to suggest that there is indeed a reason for spontaneous regression, and that it is genetic.

In the case of the mice, it appears that their age played a factor in how quickly the cancer was resisted, with the cancer-fighting trait declining as the mice aged. Six-week-old mice appeared to resist the cancer immediately when injected with the cells, displaying complete resistance. However, the older mice were more likely to first develop cancer and then experience the spontaneous regression, with the cancer rapidly disappearing within 24 hours. In any case, after fighting off the disease, the mice became completely healthy and immediately resumed all normal activities, including mating. Dr. Cui comments, "They are healthy, cancer-free and have a normal lifespan."

So How Do They Do It?

An in-depth investigation of the mice revealed that when their immune systems identified cancer cells, their bodies launched a massive attack of white blood cells to kill the budding tumor. Scientists say that this demonstrates the importance of the immune system in the fight to stop cancer from developing. It might also explain why some people, despite repeated exposure to cancer-causing agents (such as tobacco use) never develop lung cancer. With this in mind, Dr. Cui suggests that a previously unknown immune response could be responsible for the spontaneous regression seen in the mice.

Hope for the Future

One major puzzle that remains to be solved is how the "super mice" actually detect the cancer cells in the first place. Dr. Cui speculates that some sort of diffusible factor from the tumor may reveal the deadly cells.

Cui's mouse colony, now containing over 700 mice, is kept exclusively at Wake Forest. The original "super mouse" remained healthy and cancer-free, eventually dying of old age after a normal lifespan. Hopefully the clues that he provided will someday lead to a break in the continuing search for a cure for cancer.

By: Joe Giacobello

GROWING NEW BODY ORGANS: FROM SCIENCE FICTION TO REALITY

Since ancient times man has attempted to replace or remedy body parts lost to trauma or disease in order to improve the quality of life for survivors. The oldest known splint unearthed by archaeologists dates from the fifth Egyptian Dynasty (2750-2625 B.C.). A prosthetic copper and wood leg dating from 300 B.C. was unearthed in Italy in 1858.

More recently, medical advances in the 1950s heralded implantation of the first pacemaker as well as the first successful living-related kidney transplant. In 1962, the first successful replantation surgery was performed to reattach a severed limb and restore limited function and feeling. Since then, transplant of major organs, including kidneys, pancreas, livers, hearts, and lungs, from nonrelated donors (called allografts) has advanced to become a realistic life-saving alternative for patients.

Medical advances in transplantation have been so successful that the demand for organs far exceeds availability. In fact, as of January 2007 nearly 95,000 patients were on the waiting list for organ transplants according the United Network for Organ Sharing. The number of organs donated each year is only about one-quarter of what's needed and many of these transplants may fail due to organ rejection.

Tissue Engineering: The Foundation for Custom-Built Organs

Now ground-breaking advances in tissue engineering may change the future outlook for organ transplantation. Researchers have already mastered techniques to grow simpler body parts. Skin has been grown to heal leg ulcers and as grafts for severe burn victims. Bone has been engineered to repair breaks or correct defects. In the not-too-distant future, doctors may be able to replace injured or diseased organs or body parts with new ones actually grown from a patient's own cells (called an autograft). Such a ready-made solution would alleviate the organ shortage and offer a rejection rate of zero.

This fantastic concept, which a generation ago seemed possible only on the pages of a science fiction novel, is now becoming a reality. Years of pain-staking, interdisciplinary medical, molecular and cell biology, and bioengineering research have developed the framework for potentially growing body parts.

Based on a model of the organ, researchers build or mold a three-dimensional scaffold from biodegradable materials such as polymers or collagen. This porous frame is seeded with a patient's tissue cells, which infiltrate the structure as they multiply. As cells proliferate in the shape of the organ, the scaffold disintegrates. The lab-grown organ would then be implanted in the patient and a blood supply established to nourish it. If initial success with this concept is any indication, a revolution in the science of transplantation may begin in our lifetime

Cutting-Edge Research Shows Potential for Organ Genesis

One of the researchers at the forefront of replacement organ research is Dr. Anthony Atala, a pediatric urologist at Wake Forest University in North Carolina. He successfully grew the first functional, lab-grown animal bladder and has grown and implanted urethras in humans. Building upon Atala's research, Dr. Alan Retik at Children's Hospital in Boston, Massachusetts, removed a piece of bladder tissue from seven spina bifida patients ranging in age from 4 to 19 in April 2006. These tissue sections were grown in the lab and then layered on a three-dimensional mold shaped like a bladder. After several weeks, the newly grown bladder was then implanted and connected to the patients' original bladders.

Because these bladders were grown from the patients' own tissue, they experienced no rejection and required no anti-rejection medication. While the patients still require catheters to void, their quality of life has improved dramatically. They no longer experience incontinence, are more socially accepted especially in school, and are less at risk of kidney failure commonly experienced by spina bifida patients.

David Humes at the University of Michigan is working on a complex engineering challenge to develop a bioartificial kidney. Currently patients with kidney disease are treated with dialysis to remove wastes from their blood. While effective, the process doesn't selectively remove just toxins from the blood; it also separates needed sugars and salts. Humes has constructed an external blood-filtering device that functions like a dialysis machine but uses human cellular parts. His apparatus first removes wastes from the blood and then routes the cleansed blood through a series of fishing-line-sized tubes lined with kidney cells. As the blood passes through these tubes, sugars and salts are re-absorbed by the blood. The kidney cells in the tubes also manufacture cytokines, or proteins that stimulate the immune system, and help to prevent bacterial infections in patients. The process has been successfully tested on dogs and Humes hopes to receive approval to begin human testing.

At the Carolina Medical Center, bioengineer Craig Halberstadt has been growing breast tissue that may one day replace saline implants. Halberstadt uses a scaffold made of sodium alginate, a seaweed-derived substance often used as an ice cream thickener, with an attached peptide that makes the structure "vascular friendly." He seeds the structure with fat cells, which disintegrate the scaffold as they proliferate. When the new tissue is implanted in the body, it is infiltrated by blood vessels and nutrients. The technique has been successful in rats and Halberstadt has great expectations for success in humans.

In Canada, researchers Francois Auger and Lucie Germain have constructed corneas using layers of human cells grown in the lab. Auger and Germain bypassed scaffolding altogether by coaxing cells to produce their own collagen. Australian researchers have grown beating heart tissue in the laboratory and pancreas cells that secrete insulin.

Researchers and bioengineers worldwide are working to grow more than twenty different tissues and organs, including hearts and blood vessels. They truly foresee a day when transplant patients will be able to grow their own lifesaving medical miracle.

By: Mary Rose Thomas-Glaser

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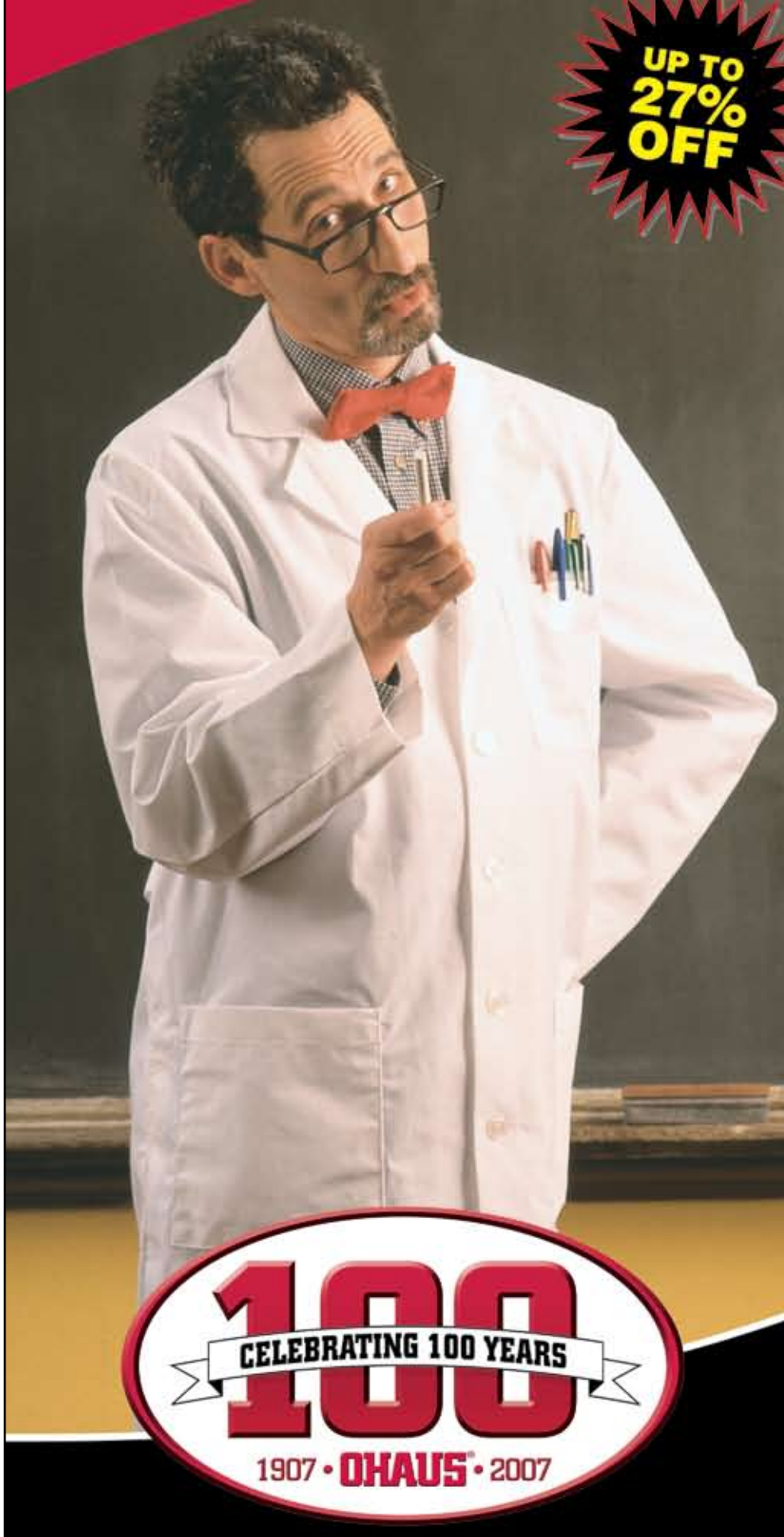
Balances and Scales for Education



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WHEN ATOMS COLLIDE

In November of 2007, the first low-energy test run of the Large Hadron Collider (LHC) will take place. The event will keep the international physicists community glued to their seats. The LHC will claim the title of the world's biggest particle accelerator and shift the focus of the physics world away from the United States for the first time in almost 50 years.

The LHC is designed to smash protons traveling at 99.999,999% of the speed of light into each other. Two beams of protons rotating counter to each other are expected to produce proton-proton collisions at 7 TeV (tera electron volts) per beam. One electron volt (eV) is the energy transferred to an electron by accelerating it through one volt of electric potential difference. A tera electron volt is 1,000,000,000,000 or 1012 electron Volts. These subatomic collisions are theorized to produce conditions that resemble what happened to our universe in the fractions of a second after the big bang occurred.

Located on the outskirts of Geneva, Switzerland, the LHC is being constructed in a circular tunnel that's 16.78 miles (27km) in circumference and between 164 and 574 feet (50-175m) underground. The first high-energy collisions are planned for 2008 and scientists hope to have the initial results not long after.

Very small science in a big tube

In the early 20th century, scientists uncovered the structure of the atom, which led to the later discovery of the subatomic particles that make up an atom, the proton, neutron, and electron. Further research and eventual experimentation with "atom smashers" or particle accelerators gave scientists their first glimpses of the incredibly complex subatomic structure of atoms.

Using particle accelerators, scientists were able to take a subatomic particle, smash it into an atom, and analyze the resulting particles and radiation emitted from the violent collision. As bigger accelerators with higher energy beams were built, even more particles were found. Most of these exist for less than one billionth of a second, but some combine to form composite particles that are more stable. Scientists were able to use the data collected from accelerators to create a standard model of the atom and identify which particles are associated with the forces that hold atoms together and which are not.

You're probably unaware that you have a miniature version of a particle accelerator on your desk right now. The cathode ray tube in your computer monitor functions in much the same way as an accelerator. Electrons from cathode are accelerated and have their direction of travel changed using electromagnets in a vacuum, then they smash into phosphor molecules on the inside of the screen, resulting in a spot of light or pixel.

Anatomy of an accelerator

In general, all accelerators have the same basic parts. A particle source provides the particles for the collisions, which travel through a vacuum inside a copper tube. Klystrons create the waves on which the particles ride and electromagnets keep them confined to the narrow beam traveling through the vacuum. Targets are introduced for the particles to collide with and detectors record and analyze the particles and radiation resulting from the collision. Vacuum systems keep the entire tube free of air and dust while cooling systems remove the heat generated by the electromagnets. Computers are used to analyze the data collected from the collisions. For the safety of the operators and the public, the system is shielded to contain the radiation generated. Closed-circuit television and radiation detectors allow scientists to monitor conditions before, during, and after collisions. Storage rings are used to store particle beams when they are not in use. Finally, an electrical power system and separate computer system are necessary to provide power and process control for the entire device.

There are two basic types of particle accelerators: linear and circular. Invented in 1929, circular accelerators were the first type to be developed. They accelerate particles in a vacuum through a circular path made of copper. The particles ride on Klystron waves and the magnetic field is boosted incrementally so that each time the particle beam passes through the field, it is further accelerated. Once the particles are at the desired energy level, a target is introduced into the path of the beam near the detectors. When the beam hits the target, the detectors record the subatomic particles and radiation released.

Linear accelerators do much of the same thing, except the particles travel down a long, straight copper path instead of a circular one. The target is placed at the end of the tunnel with a host of detectors to record the collision. These machines are huge and are housed underground. For example the Stanford Linear Accelerator Center (SLAC) in California is about 1.8 miles (3km) long.

The ILC, the next biggest thing

America's scientists have also been hard at work exploring technologies that will support the construction of the biggest particle accelerator yet, the International Linear Collider (ILC) that will create collisions between particles traveling at near the speed of light. In April of 2006, a group of U.S. scientists and business leaders proposed a multibillion-dollar project to build the 19-mile-long linear collider.

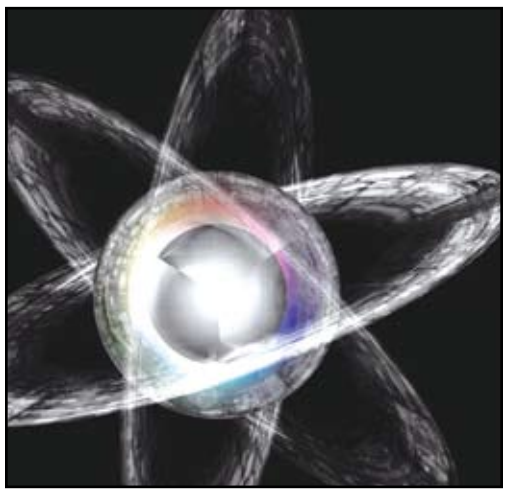
The ILC will be capable of smashing together the smallest particles of an atom, giving scientists important clues to questions about the structure of dark matter, the possible existence of extra dimensions in the universe, and the fundamental nature of matter, energy, space, and time.

While the LHC in Geneva will gather data that will provide excellent clues to the puzzles of the universe, it will take the more exact measurements generated by the ILC to really give scientists all the information they need to fully answer them. For example, if the LHC proves the existence of a theoretical particle, the ILC will be needed to determine how the particle functions.

An international effort

Even though the ILC won't be built until sometime after 2010, the international physics community is already discussing how the program should work and where it should be located. An international panel called the Funding Agencies for the Linear Collider will decide where the ILC will go. American scientists are already meeting to discuss how to promote the United States as the best location for the accelerator. In addition to revealing some of the deepest secrets of the universe, the ambitious physics experiments would draw the most talented scientists from all over the world and may help to spark children's interest in pursuing scientific careers. American physicists are unanimous in wanting the United States to maintin their superpower status in the physics world and they are passionately pursuing the ILC project as a way to ensure that we will maintain that status for many years to come.

By: Janice Campbell



For more information on the LHC and ILC projects, visit:

http://lhc-machine-outreach.web.cern.ch/lhc-machine-outreach

http://ilc.fnal.gov

ROCKIN' THROUGH TIME

Imagine blindfolding a geologist and paleontologist, then dropping them off at an unknown road construction site. What could they tell you about their unknown location?

Examining the road signs and digging equipment, they could tell you about the natives' language and access to technology. Counting the layers of road indicates the road's age. Varying thicknesses in those layers reveal what type of transportation the natives used. The drainage method and road materials (cobblestone, brick, concrete, or asphalt) speak volumes about climatic conditions of the area.

Now, move those same scientists from the relatively small area of the construction site and place them into a canyon with hundreds of layers to examine. New, yet similar, sets of questions arise.

Where Did the Layers Come From?

Rock layers (or strata) are formed from sedimentary or igneous rocks being deposited by wind, water, or tectonic activity over great spans of time. As the methods in which the layers are deposited change, different mineral and chemical factors change the color and composition of the layer being formed.

Large portions of the Earth were covered in water millions of years ago. In some areas, tectonic activity trapped large pockets of salt water as it moved the ground. In other areas, severe electrical storms formed lakes with low oxygen isotopes in the empty craters of volcanoes. Both of these lakes would create mud as they settled. However, the types of mud are different.

As our planet shifted and erupted, extreme weather conditions moved new debris and deposited each layer on top of the older ones. Strata formed by ocean or atmospheric current are uniform and widespread—stretching for miles. Oppositely, stream currents or irregular wind patterns formed smaller, irregular structures.

Either way, rock stratification was only created horizontally. When geologists view diagonal or vertical strata, they see the impact of the Earth's crust folding and faulting.

What Carved the Rocks?

Erosion. The same wind and water that helped to create rock stratification also wore it down.

Water and ice deal damage as they move—picking up sediment and moving it downstream. Fast-moving water, as with a river, cuts the surface quickly (geologically speaking) to expose the stratification that had formed over the years. In the water's response to gravity, it will search out the fastest path downward. It will travel over and through the softest rock it can find—sometimes turning sharply and doubling back on itself.

When trapped on all sides by hard rock, water creates ponds and lakes. But don't let that fool you. Groundwater, though much slower, seeps down and out from the lake bottom. As it comes in contact with softer rocks, it erodes and weakens the sides of the lake. Once enough material has been weakened, a rockslide opens a new river path. This can often result in waterfalls.

Although just as damaging, wind erosion often takes longer than water. Wind removes small particles and throws them against other surfaces. In order for wind to be a constant source of erosion, the area has to have little to no plant life to act as a buffer.

Weathering can also have an effect on the planet's surface. Unlike erosion, which uses movement to shape rock quickly, weathering changes the planet's surface through heat and pressure. These changes are slower and can hide the stratification from view.

Who Was Here Before Us?

Sometimes, as plant and animal life developed and died, biological material would get compressed within the rock layers. Whether sucked into deep mud or quickly covered with loose debris, these remains were protected from the natural weathering and bacteria decay processes. More rock debris covered the remains (bones or shells) and hardened into its own layer of the ground.

Over time, groundwater found this soft, organic material and slowly disintegrated it. The hard, rigid rocks around it remained intact to preserve a natural mold of what had once been.

These fossils can be found throughout many levels of rock stratification. Sometimes the patterns of seashells and aquatic life are found in dry, desert areas. These kind of contrary discoveries support theories of a wet, watery history.

When geologists found sea animal fossils in the Himalayas, they theorized that a sub-continent (now know as India) crashed into the Asian continent, pushing the mountain up and stranded this ocean life 5000 feet above sea level.

Fossils become more and more rare as the geologist digs deeper. These rocks pre-date life. The oldest rock samples have been radiometricly dated to 3.8 billion years ago. Some minerals within that rock are believed to be 4.2 billion years old.

So What Are They Looking For?

The obvious fossils and Earth-formation questions aside, there is a lot of useful information that can be guessed at by a geologist. Some geologists might hope to study and catalog every square foot of ground. This, however, is impossible. When asked about the best places to dig for gold or oil or diamonds, the scientist is forced to look at some visible stratification and make a good guess.

When looking for coal, its important to know what areas had been dense swamplands years and years ago. One vertical foot of coal comes from ten vertical feet of peat being compacted, heated, and decayed over long periods of time.

Patterns in some rock stratification can hint at long-term climate patterns. This information can help inform local authorities of heavy storm or periods of drought.

Understanding the ground structures is key before beginning new house or building development. If the upper strata levels are tilted or diagonal, it could indicate an active surface. Such shifting can affect a building's foundation in fewer than 10 years.

In light of all that geologists can glean from stratification, bringing one to your road construction site isn't such a bad idea. Rock stratification has gone on for millions of years, and Mother Nature might think that your concrete road is just a new strata. If you build on softer rocks (like limestone), they'll compact and disintegrate over a quicker time period than if you build on a harder base, which may be just down the road.

By: AJ Rodgers

CORAL REEFS: THE OCEAN'S RAINBOWS

Did you ever stop to wonder why coral reefs are so colorful? Marine biologists are now asking that very question, and their answers might surprise you. The diverse and vibrant colors of the reef and its inhabitants serve many purposes. The shallow depth and clarity of the water in some parts of the reef allow for sunlight to penetrate and this permits visual communication among the different species that inhabit the reef. It is thought that fish might see in the UV spectrum of light, so fish may have markings that the human eye cannot visualize. It is this visual communication that plays the major role in why the reef is so colorful.

Communication

Color communication describes the role color plays in the communication between animals of the same and different species. There are many theories that try to explain the main role color plays in marine animal communication on the reef. Sexual selection, warnings, camouflage, and intra-species communication are a few of the predominate explanations for the color diversity and vibrancy on the reef. Each one of these theories could explain why the coral reef is so colorful, more likely it is a combination of all of them.

Sexual Selection

When animals reach sexual maturity they often need ways to impress their mates. Many marine species have evolved ways to attract the opposite sex such as colorful markings, flashing light displays or larger fins. We can observe the same thing on land with birds such as cardinals; the male cardinal is bright red, while the female is a brownish red color. Can you guess who is trying to impress whom? The sexual selection theory suggests that color enhancements in one sex entices the opposite sex into mating, usually the female selects the best (in this case, most colorful) male. While some fish seem to display this type of color selection the prevailing theories seem to suggest color plays another more important role.

Warnings

Color can serve as a warning signal to other animals. Above water we observe this in the brightly colored monarch butterfly, its vibrant orange signals to birds "I taste bad." It seems unlikely that red would be an effective warning color for fish because red has a long wavelength that cannot travel far underwater so it's not seen as a real warning color in marine life. However, the red/black pattern of the puffer fish, along with its puffed out appearance (which makes it look larger to potential predators), warns of its toxic taste. The warning theory suggests that color indicates to other animals that they will be hurt if they eat the brightly colored animal.

Camouflage

The brightly colored, bold-looking fish of the reef may seem poorly camouflaged to us, however, to the many predators of the deep, their brilliant color patterns blend in with the reef's coloring, making it hard to differentiate the fish from the reef. The bold black and white stripes of the zebra on the savannah, at first glance, don't seem to offer much camouflage either, but, when a herd of zebra are running against the background of high grass, it is difficult for a lion to distinguish where one zebra ends and the next begins. The camouflage theory proposes animals are brightly colored to blend in with their surroundings and thus avoid predatory animals.

Intra-Species Communication

More scientists are looking into how fish recognize their own species among a wide variety of fish found in and around the coral reef. Some scientists speculate that the bright, bold patterns are actually identification markings, so the fish can recognize each other and ensure that they are mating within their own species. It was recently discovered that bacteria send chemical signals to help recognize other bacteria of the same species in the same area. This exciting research helps us to understand the animal world, because even at the microscopic level, it is important for organisms to identify each other. The intra-species communication theory proposes that the patterns help to identify members of the same species.

The World's Reefs in Danger

The ocean's reefs are facing dramatic changes like bleaching, thought to be due to a rise in ocean temperatures, that scientists are now linking to global warming. Coral polyps that are stressed by heat or radiation from the sun, pollution or global warming lose their color, causing a whiting or bleaching effect. Other damage can be caused by severe storms, overfishing, increased marine tourism and the introduction of non-indigenous species to the reef. When we visit coral reefs we must remember to look but not touch, and never anchor on a reef.

What You Can Do to Save Our Reefs

The first step is awareness, then you must educate yourself and others. There are many Web sites where you can get more information about the health and importance of coral reefs. You can get involved today by organizing a beach cleanup or volunteering. If you are land-locked but still conscientious, you can help by conserving water and planting trees to reduce runoff, and writing to your congressperson. Urge them to take action to protect our coral reefs, stop pollution and over-fishing in our oceans, and take steps to reverse global warming. Then tell a friend what you have learned to increase awareness about this valuable and beautiful natural resource.

By: Karen L. Lew

EMPTY OCEANS: THE THREAT OF OVERFISHING

Living Off the Seas

An armada of diverse organizations agrees that overfishing is a global threat demanding immediate action. These include the United Nations, Ocean Conservancy, Monterey Bay Aquarium, Environment Main, Greenpeace, and many others.

Empirical evidence supports their claims. Overfishing has been cited as the cause for the collapse of commercial fishing in California (sardines in the 1950s) and Peru (anchovies in 1970). The Ocean Conservancy cites overfishing for depleting the stock of another popular table fish, the Gulf of Mexico's red snapper, to just 3% of historic levels.

Overfishing has economic and environmental consequences. Let's examine each.

Fishing is big business. One in five people on Earth depend on seafood as their primary source of protein. In the United States, commercial fishing employs more than 250,000 workers. Sport fishing—charters and bait shops and related businesses—accounts for another 350,000 jobs and $30 billion in annual revenue.

Large-scale commercial fishing dates to the 1950s and has operated relatively unencumbered by government regulation, especially on the open seas outside national territorial waters. Modern high-tech fishing vessels are literally seagoing factories with collection, processing, packing and freezing operations inside the hull. Outfitted with sophisticated sonar and casting nets up to two miles in circumference, a trawler can haul in and store a 50-ton catch. Studies estimate that today's global commercial fleet has twice the fishing capacity of the ocean's ability to sustain its fish populations.

This increased capacity combined with unrestricted fishing eventually spells doom for the fish. Once a species dwindles to the point that it is no longer commercially viable, related business falls with devastating impact; the collapse of Newfoundland's cod industry in 1992 cost 40,000 jobs. Resourceful fishermen adapt by targeting other species. Monkfish and shark, for years considered undesirable, are now hunted and marketed as table fare.

Scientists estimate that unchecked overfishing will have devastating and possibly irreversible effects not only for the economy, but for the planet as a whole.

A Threat to The Planet

Overfishing upsets the ecological balance of the oceans. Every sea creature exists in the food chain as predator, prey, and/or scavenger. Many popular table species like tuna, swordfish and halibut are top predators. When their numbers are unnaturally depleted, other species replace them, but biodiversity—the number of different species in an ecosystem—is adversely affected. Loss of biodiversity reduces the ocean's ability to produce seafood, resist diseases, filter out pollutants, and rebound from stresses.

Overfishing wreaks havoc beyond the fish stocks. Trawlers gouge the ocean floor, upsetting bottom-dwelling plants and invertebrates. Fishing nets claim unintended victims like dolphins, sea turtles, birds, and undesirable fish, called by-catch.

Coastal areas that rely on tourism are concerned about the long-term quality of their waters. But the vitality of the oceans extends beyond sandy white beaches to the deepest, most remote seas. The negative effects of overfishing aren't necessarily apparent every day; like a chronic disease, the damage manifests itself over time.

Time For Action

Alarmed about the impact of overfishing, governments are taking action to preserve the oceans, including imposing catch limits, no-go zones, and devising better management practices.

California established a network of marine refuges covering 200 square miles from south of San Francisco to Santa Barbara—opening in 2007.

Florida banned all fishing in a 46-square-mile zone 70 miles west of Key West within the Dry Tortugas National Park, creating the largest marine reserve in the continental U.S.

In January 2007, the Louisiana Wildlife and Fisheries Commission banned shrimping in a portion of its offshore waters to preserve white shrimp populations.

Also in 2007, the U.S. Congress introduced HR-21, called Oceans-21, a bill aimed at developing a comprehensive national oceans policy, and principles for management of America's coasts, oceans, the Great Lakes, and their resources.

Recreational fishermen have criticized certain restrictions, claiming that commercial fishing vessels are the real problem, not sport fishermen. But governments believe that such measures are critical to ensure species survival.

Hope For Recovery

As grim as this sounds, scientists say that the situation is reversible. Marine ecosystems can recover as long as they remain biodiverse. With proper management of fishing zones, stocks can recover over time. The key is to curtail harvesting of threatened species and to allow them to restore their numbers.

What Can You Do?

As a consumer, you can make smart choices without sacrificing your taste for seafood. Look for products bearing the blue label of the Marine Stewardship Council, an independent nonprofit organization that certifies seafood from well-managed, sustainable fisheries. Or look to Web sites such as Monterey Bay Aquarium's Seafood Guide **(mbayaq.org)** indicating which species are viable and which are overharvested.

To learn more about overfishing, do an Internet search on the word, and see what you find. It's a complex issue without an easy answer—one that will require cooperation and planning between governments, environmental groups and industry to ensure that the bounty of the seas survives for future generations.

By: Dan Skantar

ARE THE MOON AND THE SUN THE SAME SIZE? THEY LOOKED IT THIS MORNING!

Teacher! Teacher! What's happening here?

This morning, the moon was still out after sunrise, and when looked at, it appeared to be the exact same size as the sun! Let's explain this phenomenon, demonstrate it to a class, and even propose and test a hypothesis about it.

Students should first be encouraged to suggest a number of hypotheses. This will probably range from atmospheric aberrations, angle of the sun or moon to each other, relative distance to each other, and many others.

A classroom camera can help!

Document cameras, particularly flexible necked cameras, have two primary uses in a teaching classroom. The most obvious is that they can be used for "show and tell," and will do it better than a traditional overhead projector because the native three-dimensional object is shown with no need for transparencies or other preliminary manipulation—put the object under the camera, and voilá! Students see a projected image.

An even more important use of cameras in the classroom is helping students to be 'on task' by showing the whole class, with the camera substituting for their eye, exactly what hands-on exercise or experiment the teacher wants done. The 'Apparent Object' exercise is a great example of this!

The Apparent Object Exercise

Supplies:

- Various sizes of Styrofoam (or other material) balls
- Brightly colored plate with a larger diameter than the balls
- Tape measures **(HS40507)**, meter sticks **(HS40626)** or string.

The good use of a camera will assist in getting the students organized and help them understand what they should be looking for during the experiment. With the camera on the teacher should first focus on the plate 'sun' and then project the image of the 'sun' on the screen. The teacher then walks in front of the camera and moves the ball until the point is found where everyone in the class agrees that the ball ('moon') and plate ('sun') appear to be the same diameter.

Holding this point steady, have student assistants measure the distance between the camera lens and the ball the teacher is holding, and then the distance from the camera lens to plate ('sun') on the wall.

By demonstrating the experiment using a camera, the student teams gain a clearer understanding of how to make their own observations and measurements. Now they too can explain why the sun and moon appeared to be the same size.

Student Experiment

First place the colored paper plate on the wall. The plate represents the 'sun', and the balls will represent the 'moon'.

Students, working in pairs, will try to find the exact point where the diameter of the ball and the plate appear to be the same to the fixed observer. To do this, one student looks at the plate, while the other student moves the ball in their line of view until the plate and ball seem to be the same diameter to the observer.

Students now measure the distance between the observer's eye and the 'moon' and also the distance from the observer to the 'sun'.

A simple ratio of the distance from observer to object A, the distance to object B, must equal the ratio of the diameters of the two observed objects.

$$\frac{\text{Distance to 'moon'}}{\text{Distance to 'sun'}} = \frac{\text{Diameter of 'moon'}}{\text{Diameter of the 'sun'}}$$

This can also be used as an algebra or applied mathematics exercise by not letting the students measure one of the vectors, either one of the diameters or one of the distances, and having them calculate this from knowledge of the values of the other three vectors.

Having the students try various diameter 'moons' can also validate or allow testing of the fact that the relationship of size and distance is in fact true and verifiable.

Incidentally, the ultimate answer is that the sun is approximately 400 times as large as the moon, and the distance of the moon to the earth is approximately 1/400 the distance of the earth to the sun, therefore, two very different-sized objects appear to be the same size to the observer!

Ken-A-Vision makes a number of flexible-necked cameras that work well for a variety of applications in the classroom, including this "Apparent Object" problem. The software that comes with the cameras allows the user to take single pictures, time lapse sequences, time lapse movies, and movies. Additionally, the newest version of Applied Vision (3.), available spring of 2007, will allow two cameras to operate simultaneously, giving the classroom user even more flexibility and options.

HS67919

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Calcium Carbide is placed in a cylinder containing water. A reaction occurs producing acetylene gas bubbles. A plastic tube from a chlorine gas generator is placed in the cylinder. As the bubbles of acetylene and chlorine collide, flashes of light are produced.

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SAFETY

Read all MSDSs for the chemicals before proceeding.

Standard Laboratory safety precautions should be taken, including eye-protection (safety goggles) and appropriate personal protection gear, including an apron or lab coat and chemical gloves.

Run experiment under a fume hood. Use care in handling the chlorine gas generator. Chlorine gas is poisonous.

CHEMICALS

- 5% Sodium Hypochlorite 250mL
- 1.0 N Hydrochloric Acid Solution 30mL
- 10g Calcium Carbide

OTHER MATERIALS REQUIRED

- 500mL Graduated Cylinder **(HS63460)**
- 250mL Side arm flask **(HS76108A)**
- Rubber stopper for the 250mL flask **(HS50080L)**
- Plastic tubing **(HS376086)**

PROCEDURE

1. Set up a gas generator using a 250mL side arm flask with plastic tubing attached to it.
2. Place about 400mL of water in the 500mL cylinder. Place the tubing from the gas generator in the cylinder and secure it so it stays near the bottom of the cylinder.
3. Charge the gas generator with 50mL of the Sodium Hypochlorite solution and about 5-10mL of hydrochloric acid solution. Stopper the flask and swirl quickly to mix.
4. Drop a few pieces of Calcium Carbide into the cylinder.
5. Watch as the bubbles of the two gases collide.

Acetylene contains a high energy C-C triple bond. When this bond is broken by the reaction with Chlorine, a great deal of energy is rapidly released, causing explosions under water.

DISPOSAL

Allow all of the calcium carbide to react. The solutions can be safely disposed of by pouring down the drain with running water if local regulations permit.

MENTO "MAGIC"

OBJECTIVE

- To explore conservation of matter.
- To explore how changing the amount of a reactant can influence the rate of a reaction and the amount of product.

EQUIPMENT

- Five 250mL Erlenmeyer flasks or 20 oz. plastic water bottles (labeled 1, 2, 3, and 4) **(HS76106D)**
- Four Balloons
- 0.01g Adventure Pro Balance from Ohaus **(HS67066)**
- Cold Diet Coke (the colder the better)
- Mentos
- Stopwatch or clock with second hand **(HS90208)**
- String and a meter stick **(HS40625)**

PROCEDURE

1. Weigh 1 balloon and record its mass. Place one Mento inside the balloon, press Tare on the balance, and record the mass of the Mento. Zero the balance.
2. Weigh Erlenmeyer flask #1. Pour 150mL of Diet Coke into the flask. Press Tare and record the mass. Zero the balance.
3. Add the mass of the balloon, the Mento, the flask and the Diet Coke and record the sum.
4. Carefully pull the end of the balloon over the mouth of the flask. Do not let the Mento fall into the flask. Place the flask on the balance. Compare the mass on the balance to your mass from step 3.
5. Gently "plop" the Mento into the Diet Coke. Time the reaction. Swirl the flask to mix if needed. Record your observations.
6. Take a piece of string and place it around the balloon to get a "rough circumference" in centimeters. Record your value.
7. Repeat steps one through seven using 2, 3, 4, and 5 Mentos.
8. Record the mass after five minutes have passed.
9. Using an Excel spreadsheet, graph the relationship between Number of Mentos and Time of Reaction. Also, graph the relationship between Number of Mentos and Rough Circumference of the Balloon.

DISCUSSION

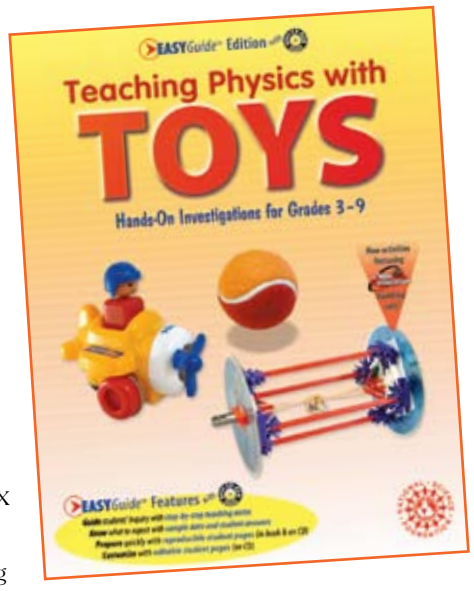
1. Compare your masses from step 3.
   Were your values the same?
   Why?
   Did you expect this?
2. What did you find out about the reaction time and the amount of gas produced as you increased the number of Mentos.

HS67066

HS76106D

HS90208

Submitted by: Chemistry Teacher Cheri Faley, Heritage High School, Loudoun County Schools, Leesburg, VA



TEACHING PHYSICS WITH TOYS

Newly revised manual transforms learning into fun! A new introductory text rationalizes why toys make excellent teaching tools before discussing how to use K'NEX kits for a variety of experiments. Each of the twenty-two projects have detailed, step-by-step teaching notes listing the time and materials required, key topics, any safety precautions, and how the experiment relates to national standards.

Each experiment builds on previous experiments. This tiered learning process introduces new concepts gradually. To further encourage scientific thinking, students participate in the experiment planning and graphing.

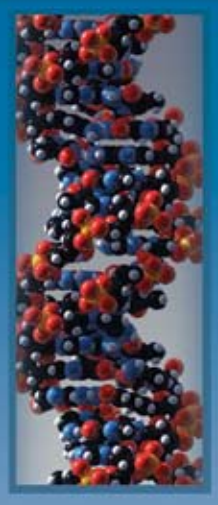
The accompanying CD-ROM creates reproducible and customizable student worksheets, templates, and graphing masters. This manual encourages imagination and experimentation into the learning process. Hands-on investigations explore physics topics such as inertia, kinetic energy, and the laws of motion fun.

Experiments use K'NEX kits, as well as some common everyday items, to build levers, pulleys, balances, crank fans, tops, cars, and more. Grades 3-9. 336 pages.

HS94284 $27.95

BOOK REVIEW

K'NEX Education



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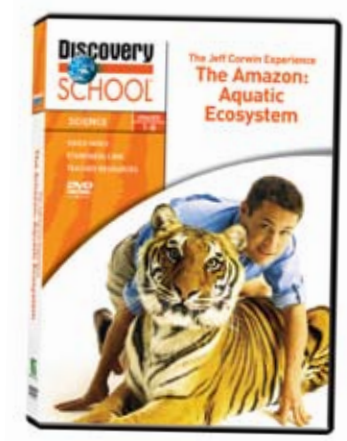


JEFF CORWIN: COASTAL ECOSYSTEM VHS VIDEOS AND DVDS

Join Jeff Corwin as he marvels at some of the most fascinating animals ever to prowl, crawl, slither, and swim across our planet. Each program profiles the plants, animals, and climatic features of a distinctive ecosystem and investigates conservation efforts that will protect and preserve these areas for future generations.

Jeff travels the immense landmass of Brazil, hundreds of miles away from its famous beaches and bustling cities, in the Pantanal. This region is the largest system of wetlands in the world and its inhabitants are masters of this lush and perilous world.

From there, he travels to the most impressive river system in the world, the Amazon. The exotic and beautiful creatures have a natural history that can help to determine the health of the Amazon ecosystem.

Continuing north, Jeff travels to central America. On a secluded beach in Costa Rica, your students can witness thousands of sea turtles come ashore to lay their eggs. Along the way, encounter a troop of Capuchin Monkeys, a venomous Bushmaster serpent, a Silky Anteater, dolphins, whales, and frogs.

Finally, we return home to the United States. In the backwoods and bayous of southern Louisiana, encounter black bears, armadillos, and rattlesnakes, as well as swamp creatures like the cottonmouth, a rare white alligator, and the elusive alligator snapping turtle.

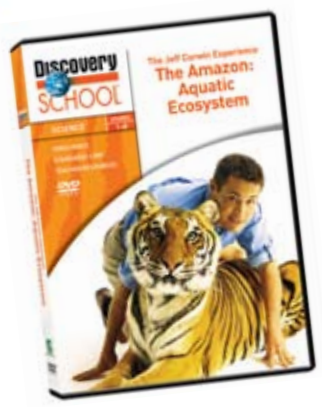
Clear, crisp images keep students involved while they learn. Each video has a running time of 45 minutes.

VIDEO REVIEW

Discovery SCHOOL™

VISIT EXOTIC PLACES AND LEARN ABOUT COASTAL ECOSYSTEMS

Brought to you by Discovery School, these popular videos travel with Jeff Corwin as he shows your students the importance of wet ecosystems. From rivers to swamps to wetlands, Jeff will reveal the life in these areas and its importance within the cycle of life. Running time: 45 min.



Jeff Corwin: Coastal Ecosystems

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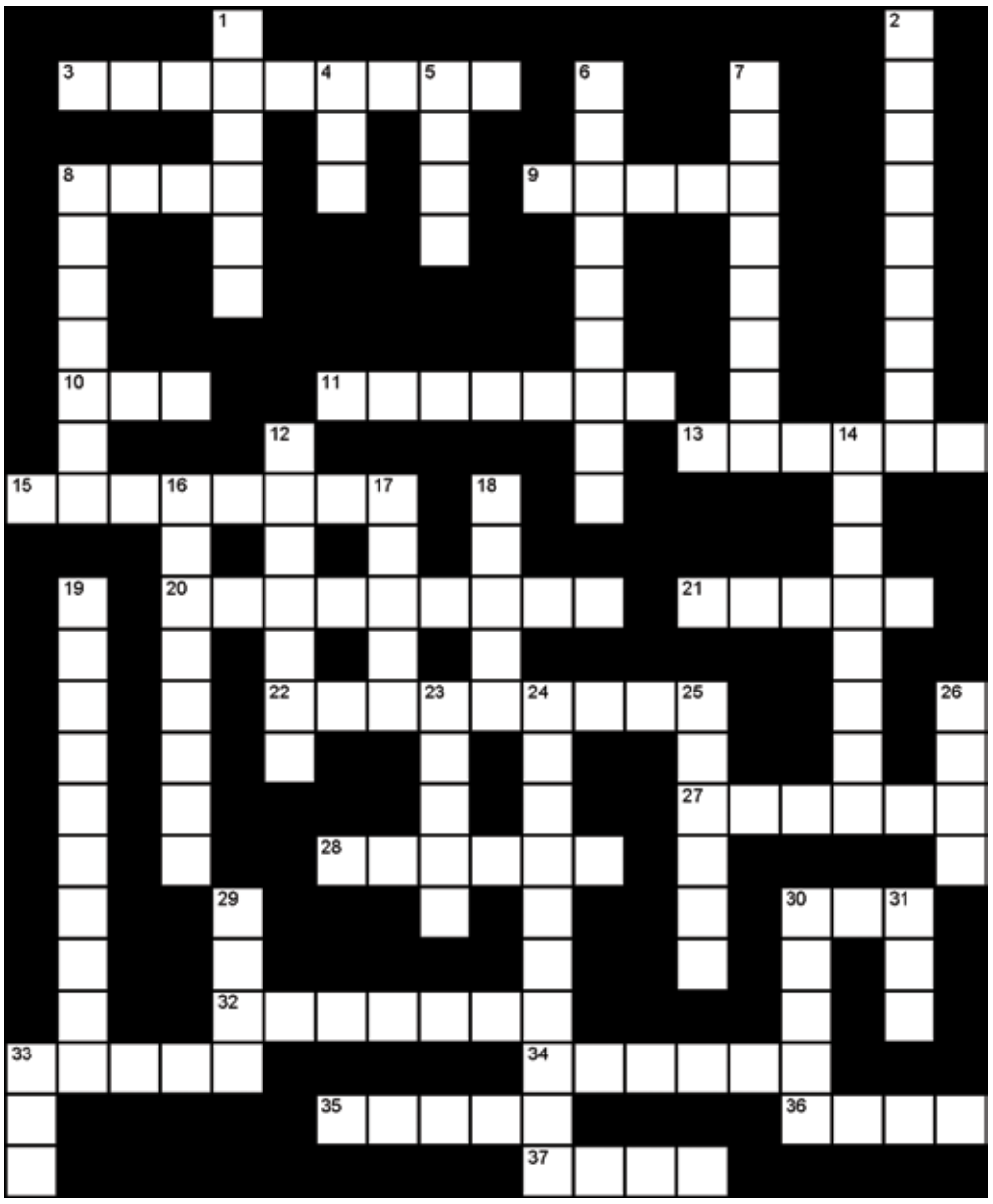
CROSSWORD PUZZLE



Answers can be found at www.fisheredu.com in the Literature section.

Across

3. A transplant of a patient's own tissue (p. 9)
8. Possible accent in the pasture (p. 3)
9. One of the six basic categories of snow (p. 6)
10. International Linear Collider, abbr. (p. 12)
11. Galaxy cluster with sound rippling through hot gases (p. 4)
13. Started Fossey on work with the mountain gorilla (p. 2)
15. Female bird singer (p. 3)
20. A transplanted organ or tissue from a genetically unrelated family member (p. 9)
21. Research animal with immunity to cancer (p. 8)
22. Proteins that stimulate the immune system (p. 9)
27. Karisoke Camp location (p. 2)
28. Home of the Amazon (p. 19)
30. Large Hadron Collider, abbr. (p. 12)
32. Effect of wind and water on rock (p. 13)
33. Emerging global network that will revolutionize the understanding of the Earth and how it works (p. 5)
34. Corresponds to a factor of 2 in frequency (p. 4)
35. Famous forger (p. 1)
36. Possible inate learning ability (p. 7)
37. Ice crystals frozen around a spec of dirt (p. 6)

Down

1. Made first friendly physical contact with a mountain gorilla (p. 2)
2. Source of plasma jets in the Perseus cluster (p. 4)
4. One of two colors used in math proficiency research (p. 7)
5. One of four components of handwriting analysis (p.1)
6. Some birds are even ____ (p. 3)
7. Kind of wave that transmits sound (p. 4)
8. Farmed seafood that's safe for consumption (p. 15)
12. An accent (p. 3)
14. Microwave generator (p. 12)
16. Illegal hunting targeted by Fossey's campaign of "active conservation" (p. 2)
17. Fossey's favorite gorilla (p. 2)
18. Marine animal in threat from overfishing (p. 15)
19. Disguise from predators or prey (p. 14)
23. Marine biologist's interest (p. 14)
24. Originating and living or occurring naturally in an area or environment (p. 14)
25. Layers (p. 13)
26. Chandra telescope type (p. 4)
29. Satellites that are used across the Western Hemisphere to detect and monitor forest fires (p. 5)
30. Low-temperature scanning electron microscope (p. 6)
31. Scientist who discovered a cancer-proof mouse (p. 8)
33. Informal group of political officials from participating countries and organizations (p. 5)