Indiana Science and Engineering News

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Spring 2004

Let's celebrate laboratory animals for all they've done for us!

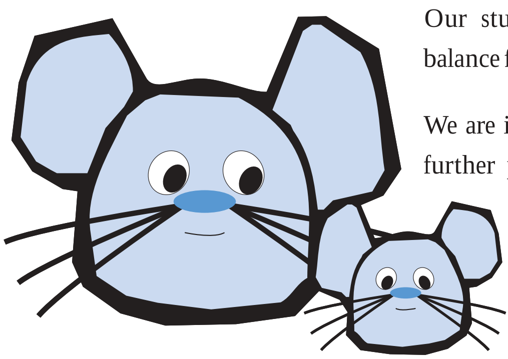
Every day several billion of us (10^9) benefit from what has been learned by studying our fellow mammalian species. If astronauts from another galaxy were to visit, they would find that we are not so different in our genetic material from mice, rats, pigs and the like. This can be seen by noting our basic body parts such as a heart, two kidneys, one liver, two lungs, a nose, eyes and so on.

What was learned from dogs 80 years ago has helped millions of diabetics. Mice are great pals when it comes to understanding cancer. Rats have been wonderful companions for research on central nervous system diseases such as Parkinson's, Alzheimer's, depression, stroke and schizophrenia. Pigs are marvelous friends to those with cardiovascular disease and much more. I never pass up the opportunity to quote Winston Churchill who said, "I like pigs. Dogs look up to us. Cats look down on us. And pigs treat us as equals."

When medical research is introduced to students their immediate reaction is that animals are too cute to participate in learning about new medicines. I explain that over 97% of animals used in research are rodents, and every single one of them was born only for this purpose. Were they not helping us understand new medicines, they'd not exist at all. Likewise, few chickens would exist were they not purpose-bred to lay eggs and provide food.

It is also important to understand that we develop medicines not just for people, but also to benefit other animals such as dogs, cats and farm animals. Veterinary medicine is important. We want our pets to be as healthy as they can possibly be. The research mice help our cats. I'm not sure the mice would want to know they are helping cats, a natural enemy, but nevertheless, this is how science works.

Laboratory animals are given great respect today. They are used in the smallest possible numbers and are treated in the best way possible to minimize any pain or suffering that can come from some research. They return the favor by helping to limit the pain and suffering of humans. Overall, it is a reasonable exchange. In the final stages of the process, humans also participate in research, and some medicines tested on humans are later used to benefit animals. Our students should be taught to understand this balance from an early age.



We are in a life sciences revolution. Opportunities for further progress abound, and the seventh graders of today are the scientists, biomedical engineers and research physicians of tomorrow.

By Pete Kissinger, BASi

Science Fair News

Science fair projects are great! Students learn about planning, scheduling, finding and using resources, as well as building a tolerance for failure. In other words, participants get a taste of what it's like to do science in the real world!

On April 3, the Kokomo Campus of Indiana University hosted the 2004 State Science and Engineering Fair. Eighty-six students in grades 6 through 12 participated. Check out *www.sefi.org* for a list of this year's winners.

In May, 26 students will represent Indiana at the Intel International Science and Engineering Fair in Portland, Oregon. This is the world's largest pre-college science fair, where more than 1,200 young science pioneers will be competing for $3 million in awards and scholarships.

It's more than a WOW! High school student winners from science fairs in all 50 states and from more than 40 countries around the globe will converge and merge their brain cells in the toughest, most prestigious science competition in the world. These kid-scientists are smart: almost one-fifth of them apply for patents on the work they produce!

Get ready, Hoosier kids, because in 2006 the Intel International Science and Engineering Fair will take place in Indianapolis!

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Bioengineer, 82, Still Working to Improve Lives

Burn victims today heal with fewer scars, heart patients exercise with greater confidence, athletes and aging baby boomers can have their ligaments and tendons restored almost like new thanks, in large part, to an 82-year-old bioengineer who isn't about to retire.

Leslie Geddes, Purdue University's Showalter Distinguished Professor Emeritus of Bioengineering, officially retired in 1991, but he still comes to work every day around 5 a.m., teaches a course at 7:30 and has three ongoing research projects, one of which is funded by the National Institutes of Health. "Doing research is like peeling an onion," said Geddes, who has written more than 700 scholarly articles and taught 2,000 biomedical engineers. "You are crying as you are tearing away the layers of ignorance. And you finally get down to the truth, the center of the onion, after all those layers of ignorance you've peeled away."

Dr. Geddes was honored for turning discoveries into medical miracles as well as jobs for Indiana when he received Purdue University's Outstanding Commercialization Award in January. The award recognizes his 30 patents, many now licensed by Indiana companies. "Thanks in part to Professor Geddes, Indiana is now a national leader in biomedical industries," said Purdue President Martin C. Jischke.

Among Geddes' team's many accomplishments are: an automated miniature defibrillator (a device that jolts the heart with electricity during a heart attack) small enough to implant inside a person; a pacemaker that automatically increases a person's heart rate during exercise; a portable electrocardiograph that patients use to monitor the electrical patterns of their own hearts; and a miniature cuff that fits over the pinky-size limbs of premature infants to measure blood pressure, heart and respiratory rate and the amount of oxygen in the blood.

His latest innovation is a device that tells medical personnel whether they are properly administering cardiopulmonary resuscitation, in which force is applied to the patient's chest to get the heart pumping. The device is placed on the patient's forehead and produces a high-pitched whistling sound that indicates whether the proper amount of force is being applied to the chest.

Geddes feels his biggest achievement by far was leading the team that discovered SIS. The researchers were surprised to discover during the early 1980s that grafts of this material acted as scaffolds that enabled the body to regenerate tissue damaged by injury or disease. The scaffold-like grafts disappeared and were replaced by the body's own tissue. Surgeons have used the material to treat more than 175,000 patients so far.

Leslie Geddes, Professor Emeritus of Bioengineering, and doctoral candidate Rebecca Roeder, test a device they invented that uses optical techniques to measure the vital signs of premature infants.

Purdue file photo/Vincent Walter

SIS was discovered by accident. The researchers originally were looking for a way to avoid lung transplants by using tissue from the small intestine to deliver oxygen to the blood. When the small intestine proved impractical for that purpose, researchers studied whether tubes made from the small intestine could be used to replace damaged arteries. But enzymes in the intestine digested the sutures when the tubes were sewn in place. "Then one of our team members scraped off the lining, which has the digestive enzymes in it, and he stripped off the smooth muscle layer so it was a tube of collagen," Geddes said. Research revealed that this stripped-down version of the small intestine enabled animals to regenerate a new artery in place of the graft. "That was a stunner," said Geddes. Subsequent experiments showed the same results for various parts of the body, including tendons, the urinary bladder, the heart muscle and a covering of the brain called the dura, which is damaged in head injuries.

The discovery changed how the medical community viewed prosthetic replacements. "Prior to SIS, prosthetic materials were only manmade things," Geddes said. "You put them in and they stay the same for the life of the subject. SIS undergoes a series of changes and becomes host tissue, so this required a complete rethinking of the meaning of the word prosthesis."

Two Indiana companies, Cook Biotech, created in West Lafayette's Purdue Research Park as a result of SIS's discovery, and DePuy Orthopaedics in Warsaw, have used the material for a wide variety of surgical applications over the past decade. DePuy recently received FDA clearance to expand use of the implant for all the tendons of the shoulder's rotator cuff. Nearly 300,000 rotator cuff surgeries are performed in the nation every year, and sales of the implant are expected to increase as a result of the expanded approval. Cook uses SIS for non-orthopedic applications, including treatment of hernias, chronic wounds and burns, repairing the brain's dura covering, and creating a "sling" that repositions a woman's bladder to treat incontinence.

"A gal lost part of her nose in an accident and was so disfigured she wouldn't go outside," Geddes said. "They reconstructed her nose with SIS and you can't tell she had an injury. A kid in Bloomington had a gunshot wound to his foot. They patched the wound with SIS and you can hardly tell the difference now."

A key factor in Geddes' success has been his diverse education — bachelor's and master's degrees in electrical engineering and a doctoral degree in physiology. He is a multifaceted person and an excellent teacher, able to translate what are sometimes fairly complex physiologic principles, like blood pressure, into very understandable terms.

Source: Purdue University News Service
By Emil Venere, venere@purdue.edu

Racing To Victory - The Technology Behind the Scenes

Every year toward the end of May, Indianapolis is bustling with spectators young and old who come to watch an auto race called the Indy 500. This spectacular event has been called the largest one-day sporting event in the world.

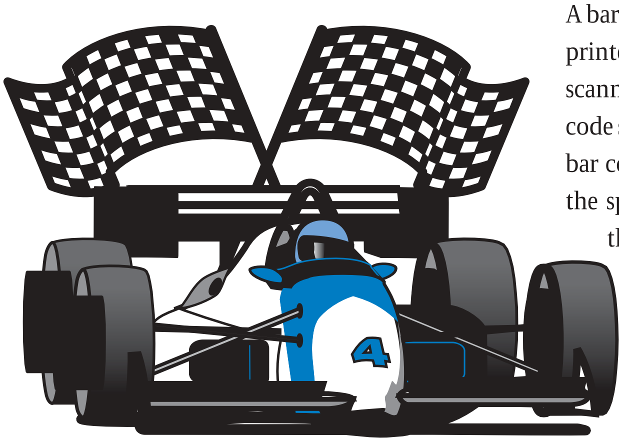
Before the race, many people are busy behind the scenes. The grounds are full of activity as the racing teams arrive to hone their cars and practice for the big race day.

One of the most important components of the racecar is the tire. All Indy race tires are Firestone Firehawks, which are composed of well-guarded formulas that belong exclusively to Bridgestone/Firestone North American Tire, LLC, a subsidiary of the Bridgestone Corporation, the world's largest tire and rubber company.

The Firestone Racing program began in 1909 when company founder Harvey Firestone recognized the research and marketing value of auto racing. Firestone provided tires to Ray Harroun, the winner of the first Indianapolis 500 race in 1911. Since that race, 52 drivers have driven into Victory Lane on Firestone tires.

Bar Code Technology Behind the Scenes

Long before race day, a semitruck full of race tires arrives at the track. Each tire comes with its own special serial number molded into the rubber sides. That number appears in numerical form and also in a special code called a *bar code*.



Almost everyone has been to a supermarket or a Wal-Mart and has seen the bar coded UPC (United Product Code) labels being scanned at the check-out counter. Have you ever wondered how they work, and wondered what the codes are actually used for?

How Bar Code Technology Works

A bar code is a series of lines and spaces that depict letters or numbers, much like the Morse Code is a series of dots and dashes that represent words.

While it is sometimes difficult for the human eye to read the small lines, it is easy for a machine. In fact, the machine reads the lines with almost 100% accuracy!

Why not count the tires by hand and write the serial numbers on a clipboard? This method has been used successfully in the past, but when you consider that it takes only a second or two for a bar code scanner to collect information that would take a human a few minutes to collect, and it reads and records the information with 100% accuracy, it is clear that the automatic process saves a lot of time and money.

Barcode Symbology

Currently there are more than 400 symbologies, or bar code languages, in use. Most have a set pattern to the way they are constructed.

A bar code can be printed using virtually any printer. The bar code symbologies are scanned and "read" with a device called a bar code scanner. When a scanner is pointed at a bar code, the laser light is reflected back by the spaces between the bars and is read by the bar code reader located inside the same device. The electronic signal is then sent to the computer, and the computer translates the code back into words or numbers. The information is stored in a database within the PC for future use.

How are bar codes used in auto racing?

The following process takes place as the race tires are loaded and handled before, during and after a race:

1. The tires are scanned when they are loaded into semitrailers at the warehouse.

2. They are scanned at the racetrack as they are distributed to the race teams.

3. They are scanned when they are returned after the race.

4. They are scanned when the truck returns to the warehouse.

Each team is allowed many sets of tires—some are for practice, some for rain, and some are for hot, dry weather. Weather conditions strongly dictate what tire is used when. Many accidents have occurred when the temperature is cold and the tires are not warmed up sufficiently. The rubber is soft and the tires are smooth, meaning that the tires have to be warm and pliable in order to grip the track and not slide on the corners. Perhaps you have seen the drivers warm up their tires by weaving back and forth on the track before the race starts.

It is important to scan the same tires each time they are moved because every tire has to be accounted for at all times. A report can be printed showing who or what team has the tire, what time they took it, the location it went to, and even what condition the tire was in.

You can find case studies of other industry solutions at ***www.astconsulting.com***.

By Diane Newcum,
Advanced Software Technology

Chemist 'Mussels' in on Secrets of Natural Adhesives

Purdue University scientists have found the glue that saltwater mussels use to affix themselves to rocks is a subject worth sticking to, both for pure scientific interest and for potential applications in medicine and industry. Jonathan Wilker and his research group have discovered that the formation of mussel adhesive requires iron, a metal never before found in such a biological function. While the discovery is valuable for its scientific merit, it also could impact the market as well, leading to surgical adhesives, rustproof coatings and anti-fouling paints to defeat barnacle adhesion.

"These animals appear to use iron in a way that has never been seen before," said Wilker, an assistant professor of chemistry in Purdue's School of Science. "Research based on materials like this one could open up new branches of adhesives research, helping us to do things such as develop new surgical procedures and prevent barnacles from sticking to ships."

Mussels stick to objects such as rocks, pilings and each other. Up close, it is easy to see the dozens of tiny filaments—often referred to as its beard—that stretch from a mussel, attaching it to its home turf. A mussel has an organ called a "foot" that it extends, attaching each filament to a stationary object with a tiny dab of glue. The foot then repeats the process until it is secure enough to resist the pull of tides, currents and predators. "It takes about five minutes for a mussel to make an adhesive plaque, and it uses 20 or more such plaques to anchor itself," Wilker said. "A mussel can easily establish itself overnight."

Jonathan Wilker of the Purdue University Chemistry Department examines a group of saltwater mussels. *Purdue News Service photo:David Umberger*

Key to the mussel's tenacity is the plaque, or glue, that holds these filaments in place, and it is the chemistry of this glue that Wilker and his fellow researchers are studying. Metals such as iron are usually needed only in trace quantities for life, but Wilker's research has demonstrated a novel role for metals—biomaterial formation.

"This is the first time a transition metal has been found to be essential for the formation of an amorphous biological material," he said. "We will be exploring other organisms that produce materials such as barnacles, kelp and oysters to see if there is a common theme in the synthesis of biological materials."

Wilker first became interested in this subject while on break from academic work, pursuing one of his favorite hobbies—scuba diving. "I was looking at mussels and barnacles while diving and wondered how they stick," he said. "I checked the literature for an answer and saw that many of the details for these processes were not known."

This simple question of how mussels stick turned into a research project that has occupied him since August of 1999. His work has uncovered a new aspect of bioadhesives, most of which are based upon proteins.

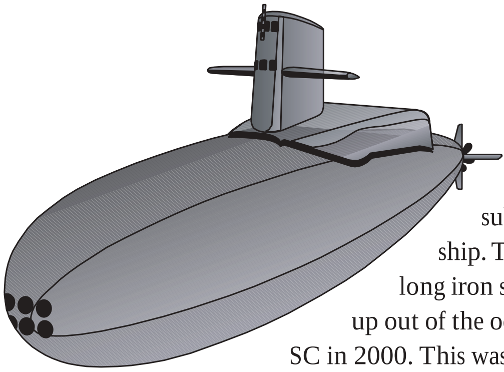
"The mixture we extract from mussels has a consistency similar to gelatin," Wilker said. "When we add iron, the mussel proteins cross-link or 'cure' and the material hardens. Other bioavailable metal ions do not appear to bring about this cross-linking. Our spectroscopic experiments show how this iron binds the proteins for cross-linking, turning them into glue."

Mussels obtain iron by filtering it directly from their surrounding water. As with other bivalves such as oysters and scallops, mussels obtain all the nutrients they need in this fashion. Wilker said that mussels can affix themselves to nearly any surface, including Teflon, the same substance used to make non-stick coatings for frying pans.

"This material's ability to adhere to many surfaces and its biological origin may make it useful in medical applications," Wilker said. "This glue could be modified for use in wound closure, nerve reconstruction, or when one might need a scaffold upon which to grow cells and build new tissue."

Another potential application could be in rustproof coatings, often used in outdoor settings such as the exteriors of buildings and cars. "There are coatings on the market made from polymers, but none

Interesting and Fun Web Sites



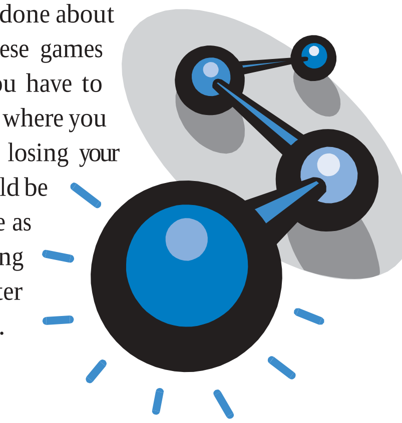
www.hunley.org is about the first submarine ever to sink a ship. The Hunley, a 40-foot-long iron submarine was hauled up out of the ocean near Charleston, SC in 2000. This was a submarine with no motor — eight men cranked the propeller shaft by hand. It sank 140 years ago, in February 1864. The story is fascinating. A team of scientists and archeologists are working on preservation. The challenge now is to stop corrosion of the iron. This web site explores and explains such issues as buoyancy, how to get fresh air under water, how to navigate when you can't see anything at all and why cars rust. It also shows how slow technology is to develop. The next ship to be sunk by a submarine was in 1914, 50 years after the Hunley. The crew of the Hunley was found inside and they were buried with full military honors in April 2004, 140 years late. May they rest in peace.

http://chemistry.org/kids is sponsored by the American Chemical Society (ACS). It is specifically aimed at students K-8. There are some good links and even interviews. The ACS has a lot of material for teachers, students and parents, too. Chemistry is fun! Everyone who studies it comes out a winner.

Want to learn how to build a hot air balloon using birthday candles? Check out **www.overflite.com**.

www.mathcounts.org is a national effort to help improve math skills for middle school students. It's kind of like a spelling bee for math — fun and thought-provoking. Many students are frightened by math or don't understand how it is relevant to them. Few consider it fun, but it can be fun for those who give it a chance. There is an Indiana program at **www.mathcountsindiana.org**.

http://science.education.nih.gov is a wonderful, colorful site for teachers, parents and kids alike. The Life Works section has information on over 100 life science and health careers. Life sciences are important. Jobs in health and medical sciences now represent 15% of our total economy and are expected to grow rapidly over the next 10 years. Those kids who become life scientists will be able to afford an even bigger/faster computer, and the game will become protein structures, clinical trials, studies of how the brain works and what can be done about diabetes and arthritis. In these games the results are important. You have to play to win. Science is a game where you remain a kid forever, never losing your curiosity to explore. This would be a good site for kids to explore as they take a break from playing on-line shoot-'em-up computer games with instant messaging.



are ideal," Wilker said. "By using this glue to coat surfaces, we may have a natural rust-proofing compound."

Further research also could reveal a less environmentally damaging way to keep barnacles and mussels from attaching themselves to ship hulls, where they increase drag and reduce sailing speeds. "Copper-based paints are often used on ship bottoms to kill barnacles in their larval state and prevent them from attaching," Wilker said. "But this use of copper-based anti-fouling paints has harmed the marine ecosystem. Copper concentrations in most harbors are through the roof nowadays. Obviously this is a major environmental problem, and in the future we might be in a position to help solve it."

Wilker said he is excited to work in such a fascinating area of research early in his career, one that could possibly yield so many benefits. "We may be able to take parts of this glue and use them to make materials that have controlled electronic, magnetic or optical properties," he said. "Mussel glues have provided insights on new aspects of materials design. This research lies at a point where chemistry, biology, engineering and materials science intersect, and that's exciting."

This research was sponsored in part by a National Science Foundation CAREER Award, the Arnold and Mabel Beckman Foundation, the Alfred P. Sloan Foundation and the Purdue Research Foundation.

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No More Cavities?

A few years ago, Dr. George K. Stookey, Distinguished Professor Emeritus at the Indiana University School of Dentistry, thought he saw something promising in a technology under development in Amsterdam. Dutch researchers using a laser light scattering technique appeared to be able to spot potential cavities much earlier — possibly years earlier — than is possible in conventional dental exams, even when they include X-rays.

Even under the best of circumstances today, a cavity is already halfway through the tooth's enamel by the time it is detected. The new technology, using a laser to provide an intense light source, measures reflectance that indicates very early cavity development — weak spots in tooth enamel that will develop into cavities if not treated.

Dr. Stookey has received grants from the 21st Century Research and Technology Fund and the National Institutes of Health to explore and refine the Dutch technology and make it widely available in dental practices. This technology represents a breakthrough in dental treatment, and thanks to Dr. Stookey's perseverance and early support from the 21st Century Fund, the new technology should be available to dental practices soon. *By Kelly Streepy, 21st Century Fund*

Dr. George K. Stookey