Indiana Science and Engineering News

sponsored by the Science Education Foundation of Indiana

Autumn 2002

What is ISEN?

The purpose of *Indiana Science and Engineering News* is simply to create awareness about current advances in the State of Indiana to help promote interest in these subjects among students, teachers, parents and the general public. The focus will generally fit the K-16 level. Some articles and features will be specifically designed for younger students. All fields of science, mathematics, technology and engineering will be represented.

We are looking for articles of 500 to1500 words with one or two tables and figures (must be black and white). We welcome participation from schools, colleges, universities and companies. We are interested in news related to doing science and engineering, not news about fund raising, new buildings or academic programs, and we ask those who submit material to minimize the use of obscure jargon, or at very least, define it when used.

We want articles that create curiosity and have broad interest about science and engineering in Indiana and all the neat things we are doing here. Our thesis is that Indiana newspapers do not cover science well. For example, when was the last time a chemical structure or a mathematical expression appeared in an Indiana newspaper?

About SEFI: The Science Education Foundation of Indiana began in 1965, for the purpose of helping to organize science and engineering fairs throughout the state. SEFI sponsors travel of Indiana science fair winners to the Intel International Science and Engineering Fair, held each year in the late spring. In 2006, the Intel International Science and Engineering Fair will be held in Indianapolis which will be an opportunity to showcase Indiana. SEFI is broadening its franchise to include all aspects of science and engineering education and will play a leadership role with the many other professional groups in Indiana who have advancing education on their agenda. These include the Indiana Department of Education, Hoosier Association of Science Teachers, Inc. (HASTI), Indiana Health Industry Forum, the Indiana Academy of Sciences, the Girl Scouts and Boy Scouts and others.

More about SEFI can be found at **www.SEFI.org**.

Articles for consideration may be sent to Alice Schwind (*alice@bioanalytical.com*), Debra Robertson (*ddrobert@iupui.edu*), Pete Kissinger (*pete@bioanalytical.com*) or William Gilmore (*wkgilm@ameritech.net*).

Around the State

Indiana is blessed with wonderful interactive science museums where students (and parents, too) can have fun and learn something new with each visit. These are a great opportunity for school field trips, wonderful places to find ideas for science fair projects and can help families fill a dreary Saturday with delight.

Science Central in Fort Wayne
Indianapolis Children's Museum
Imagination Station in Lafayette
Celery Bog Nature Center in West Lafayette
Indiana State Museum in Indianapolis

33rd Annual HASTI Convention

Don't miss the 33rd Annual HASTI (Hoosier Association of Science Teachers, Inc.) Convention coming up February 18-21, 2003 at the Indiana Convention Center in Indianapolis. The convention theme is "Do More! Teach."

For complete information, visit *www.hasti.org/convention/convention.html*

Contents

A Matter of Opinion: Should we teach the scientific method?

In middle school it is common to introduce the so-called scientific method. We all remember the drill. First we form a hypothesis, then we do x and y. But is this how science and engineering actually work in practice? While there is some truth to this scheme overall, combining the approaches of various researchers over a period of many years, true innovation on the part of individual researchers and smaller groups of scientists and engineers rarely follows this scheme. The truth is that the process is far more serendipitous, involving a combination of old fashioned luck and curiosity. Students and teachers alike should see science and engineering as liberal arts. Both involve people—people who have emotions and egos, people who sometimes cheat, people who have fun and enjoy each other's company, people who are political and competitive. In other words, scientists and engineers are not so different from politicians, lawyers, salesmen, novelists and historians. In trying to pretend otherwise we regularly discourage people from technical fields by labeling them as more robotic than others, following some rote method.

In reality, new science is like a running back taking advantage of unexpected opportunity and weaving thorough a field of defenders in a manner not mapped out in advance. Pasteur believed that, "Chance favors the prepared mind." He was highly political and presented his innovations in a manner that would influence the largest number of people, sometimes leaving out inconvenient data. Think about such notions as the importance of insulin to diabetes, the discovery of penicillin, the discovery of Teflon and the role of lithium carbonate in treating manic depression. Think about the 100+ year history of aspirin as a drug or the development of the personal computer, cellular telephone, the microwave oven and the Internet.

I think it is very important that students consider the "scientific method", but it may be more important for them to understand that the vast majority of planned experiments simply don't work, and that substantial science and engineering advances more often come from unexpected results that cause a curious individual to follow an entirely new direction. I believe that historical examples of great scientific discoveries can help students see the humanity of those efforts and, hopefully, begin to see the fun in it all.

So often, the advances we all enjoy every day arise from the following equation:

An Unexpected Result + A Curious Person + Enthusiasm for Going In A New Direction + The Freedom To Do So = Amazing Revelations

I remember as a youth my mother bringing me books like *Microbe Hunters* by Paul DeKruif. Biographies of Alexander Graham Bell, Thomas Edison and Michael Faraday were scattered about our house and I read them along with those of John Paul Jones, Lord Nelson, George Washington and Napoleon. I was unable to distinguish the military campaigns from the scientific campaigns. Both involved enthusiastic people preparing for, and then taking advantage of, opportunity. I still like that concept! There is no clear pattern that fits all. Many ways of doing things can work. *(Pete Kissinger, pete@bioanalytical.com)*

Electrochemistry is Everywhere

It's never too early for students to think about electrochemistry. What is it? In electrochemistry, electrically charged atoms or molecules move. Those molecules may also be created or even destroyed by taking away the electrical charge. The most important point is that chemical energy can be converted into electrical energy and vice versa. It is easy to get lost in the details and jargon and therefore lose sight of the big picture.

We all know that chemical energy can be converted into heat and light when we burn wood and light a candle. It is a lot of fun to think about all the ways we encounter energy conversion. Electrical energy converted into light energy and into heat energy is a process happening all around us. Light bulbs and electric stoves are great examples. When a football player runs, chemical energy is converted into mechanical energy. The conversion of chemical energy into electrical energy happens wherever there is a battery. A flashlight, a cellular phone, a laptop computer, a digital watch, an electrical toy, a portable drill and a CD player are a few examples. We use a battery to start our car, converting chemical energy into electrical energy and then into mechanical energy using a motor. Once the car has been started, we use chemical energy to make heat and then mechanical energy, a little of which we use to recharge that same battery by taking electrical energy and converting it into chemical energy stored in the battery.

Yes, electrochemistry goes both ways: chemistry into electricity, and electricity into chemistry. An English gentleman named Michael Faraday helped make some sense of this. He had a great year in 1834, and many other scientists have contributed along the way. We still do not understand all the details. Many things about electrochemistry remain fascinating to study.

Electrochemistry happens all around us, and even in us. When we process thoughts or feel pain, charged chemicals (ions) move to provide electrical signals which race about circuits (neurons) throughout our bodies. Students beginning to learn science should understand that physics, chemistry and biology are not distinctly different topics; they are mixed together to understand nature.

Often scientists create names to define their interests. Electrochemists study electricity and chemistry. Bioelectrochemists study this subject in biological systems. Photoelectrochemists explore how light can be involved. Corrosion electrochemists study how electrochemical events corrode our automobiles, our pipes and our ships to make rust. Physical electrochemists focus on details at the surfaces of metals. Organic electrochemists like to study the electrochemical events with organic chemicals, for example, chemicals found in petroleum. As time goes on, more specialized branches of science and engineering are created by combining subjects. There are food chemists, nuclear physicists, biomedical engineers, plant geneticists, computer engineers, forensic anthropologists and many more. One of these jobs might be fun for you. You might even define your own special combination. There is a lot we don't know yet. Join us to help discover nature's secrets.

One final thought: Without electrochemistry there could be no life. *(Pete Kissinger, pete@bioanalytical.com)*

Purdue Extension Offers Materials for Tree Education

Oak, maple, birch and sycamore are familiar tree names, but many people can't identify these trees while walking through a forest. To help residents learn about Indiana trees and why the leaves on many are beginning to radiate bright red and orange, Purdue University Extension has developed educational materials on trees.

The compact disc "Trees of Indiana" is a graphical identification guide designed for an expert or an amateur. Included on the CD are photographs and detailed descriptions of Indiana's native trees and 16 introduced species. In addition to the 1,000 photographs, information about the leaves, buds, twigs, flowers, fruit, bark, habitat and form for each tree is available. The CD was co-authored by Sally Weeks, Purdue dendrology laboratory manager, and George Parker, Purdue professor of forestry. "Fourth- and ninth-grade students across the state make leaf collections every fall, and this unique product will aid them in producing a leaf collection," Weeks said.

The "Trees of Indiana" CD is an educational tool that provides information on Indiana trees. It can be purchased through the Purdue Media Distribution Center. (Purdue Agricultural Communications graphic)

The "Trees of Indiana" CD is available for $25; a 20 percent discount is available for purchases of 10 or more. The package "Why Leaves Change Color" is part of the 4-H Youth Science Series. It features a short video created by William Chaney, professor of tree physiology. Designed for teachers, other materials in the packet include an educational guide containing six student activities, a news release and fact sheet discussing color change in leaves, and a color transparency for classroom use. The cost is $9.95. Both packets are available from the Purdue Media Distribution Center by calling 888-398-4636 or via email at *media.order@purdue.edu*. "Trees of Indiana" is publication CD-FNR-1, and "Why Leaves Change Color" is publication YSS-1.

Teacher's Resource Center

The Teacher's Resource Center (TRC) at IUPUI provides classroom kits to schools and youth-focused organizations in Indianapolis and the contiguous counties at no cost to teachers, schools, or students. Ninety-one (91) self-contained kits include lesson plans and classroom activities designed to foster an interest in math and science and to encourage today's students to become tomorrow's scientists. Each lesson is correlated to the Indiana Academic Standards for K-12 in math and science and is delivered to teachers and youth development professionals. Last year, more than 21,000 students in Central Indiana utilized these innovative hands-on kits.

Kit of The Month: *Crime Lab Chemistry (GEMS)* Challenged to determine which of several black pens was used to write a ransom note, students learn and use paper chromatography as they explore the concepts of solubility, pigments, and separation of mixtures. Several mystery scenarios with intriguing characters are suggested. In a special "Going Further" activity, students use "candy chromatography" to solve an additional mystery. Many teachers have created their own mystery scenarios, sometimes involving themselves and/or the principal as suspects.

Time: Two 35- to 45-minute sessions plus follow-up sessions.

Grade Levels: 4-8, can be adapted for 2nd and 3rd grades.

Subject Areas: Chemistry (chromatography, separating mixtures, pigments, solubility)

To reserve a math/science kit or to find out more, visit our website at *www.cln.iupui.edu*, click on Community Outreach, then select Teacher's Resource Center. Your one-stop shopping for free use of math and science kits plus a new Kit of The Month! *(Linda Stein, 317-274-9840)*

Purdue to Study Making Biofuel from Corn Residue

After the massive combines sweep millions of acres of corn in the fall and remove the kernels, what is left are millions of tons of stalks, cobs, husks and leaves of the corn plants. Although this leftover material, called corn stover, provides nutrients for the soil and prevents erosion, it also has the potential for a new use: making ethanol.

Purdue University scientists say they believe they can put some of this corn stover to use as a fuel for automobile engines by converting it to ethanol. Ethanol can be used to boost octane and reduce engine knock, and it also can be blended with gasoline to make an environmentally friendly fuel. Currently ethanol can only be made in industrial quantities from starch extracted from corn kernels.

However, Michael Ladisch, distinguished professor of agricultural and biological engineering, and biomedical engineering, together with colleague Nancy Ho, research molecular biologist, have developed a pretreatment process that can also convert the fiber left over when the starch is processed out of the corn kernel. The process uses genetically engineered yeast developed by Ho.

Now Ladisch says the process is ready for development with corn stover. Corn stover fiber is different from the fiber found in the kernel. However, both materials contain cellulose, which can be converted into sugars which can then be fermented into ethanol.

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Biofuel from corn residue, continued

The research is being conducted in Purdue's Laboratory of Renewable Resources Engineering (LORRE, pronounced "Lori"), an integrative center for biotechnology and engineering.

To aid this next step in ethanol research, the Indiana Department of Commerce has given LORRE an $80,000 grant to modify the process. Pilot-scale testing of the new process will be conducted at the Williams Bio-Energy facility in Pekin, Ill.

Making fuel from the corn stover could benefit Indiana's economic development, says Indiana Lt. Gov. Joe Kernan. "Finding ways to produce ethanol more efficiently by using our own agricultural resources is important to Indiana's economy," he says. "This grant promotes this goal while helping Indiana take a leadership position in the critical biotech industry."

Ladisch says developing a process that uses existing industrial equipment is a key to getting the technology accepted by the ethanol industry. "Then this process has the potential to greatly increase the amount of ethanol that will be produced from non-grain sources," he says.

To enhance the process, Jonathan Wilker, assistant professor of chemistry, and Nathan Mosier, a graduate student, are in the process of developing new catalysts that mimic organic enzymes which convert cellulose into sugars that can be fermented into ethanol.

In addition to the work being done at Purdue, scientists at Williams Bio-Energy, the National Renewable Energy Laboratory and the U.S. Department of Agriculture's National Center for Agricultural Utilization Research are working with the Purdue scientists to adapt the process to commercial production.

The need for ethanol is increasing. Ethanol can be used in automobile engines as a replacement for methyl tertiary butyl ether (MTBE), which is a chemical derived from petroleum that is used to boost octane levels in gasoline. MTBE itself was a replacement for tetraethyl lead, but like the lead compound, scientists have found MTBE causes environmental damage, and the U.S. Environmental Protection Agency is phasing out its use.

According to the Renewable Fuels Association, in 2001 the United States made a record 1.77 billion gallons of ethanol. But the U.S. Department of Energy's National Renewable Energy Laboratory estimates that converting one-third of the nation's corn stover to ethanol could produce an additional 5 billion to 8 billion gallons of ethanol, enough to have a significant effect on the amount of petroleum used in this country.

Nationally, about 244 million tons of corn stover is produced each year; more than 22 million tons are produced annually in Indiana. Finding a market for corn stover could mean $10 more per acre for farmers, according to the National Renewable Energy Laboratory.

Purdue is a national leader in developing new technologies to enhance the production of ethanol. One such process, developed by Ladisch, uses modified ground corn grits to remove water from ethanol. This environmentally friendly, low-cost technique replaces methods that use chemicals such as benzene or cyclohexane. The Purdue-developed method is being used in the United States by companies such as Archer Daniels Midland and by other companies around the world.

Nancy Ho developed a type of genetically modified yeast that can convert sugars other than glucose, which is made from corn starch, into ethanol. When other materials, such as corn stover, tree leaves, grass clippings or wood chips are broken down, they produce other sugars, such as pentoses and hexoses. Ho's yeast converts these sugars to ethanol, too. In 1998, R&D Magazine selected this breakthrough as one of the top 100 significant research developments of that year. (*Steve Tally, 765-494-9809, tally@aes.purdue.edu)*

Sources

Michael Ladisch, 765-494-7022, *ladisch@ecn.purdue.edu*
Jeff Harris, IN Dept. of Commerce, 317-232-2464
Ty Graves, IN Dept. of Commerce, 317-232-8873
Robert Nielsen, 765-494-4802, *rnielsen@purdue.edu;*
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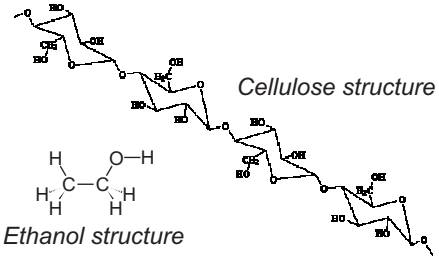
Ag Communications

Beth Forbes, *bforbes@aes.purdue.edu*; 765-494-2722; *www.agriculture.purdue.edu/AgComm/public/agnews*



Properties of Green Tea and Soy Antioxidants

Many natural products are advertised as having beneficial health benefits. A large number of these claims have been made on the basis of anecdotal evidence. Because so many people are interested in using herbal products for maintaining health as well as for treating disease, the National Institutes of Health (NIH) established six centers around the country to investigate these products in rigorous scientific studies. The goal is to determine which products are beneficial and which are not. One of these NIH Botanical Centers is at Purdue University. The Purdue Center is a collaborative effort of a number of institutions including the University of Alabama, Rutgers University and BASi (Bioanalytical Systems), and it focuses on age-related diseases. BASi contributes core support to the Center in the areas of analytical chemistry and in vivo testing.

One of the projects BASi is working on is determining whether green tea is beneficial in preventing obesity and Type II diabetes. Obesity and Type II diabetes have become major problems. There are 16 million diabetics in the United States, and over 90 percent of these have Type II diabetes which results from obesity. In the past, Type II diabetes was largely a problem in older people, but with the change in lifestyle and increasing obesity in young people, Type II diabetes is now seen in children as young as eight years old. Green tea contains a number

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of compounds called catechins, which are antioxidants and have been shown to be beneficial in preventing cancer. It was thought that these catechins might also be effective in reducing food intake and preventing obesity and diabetes.

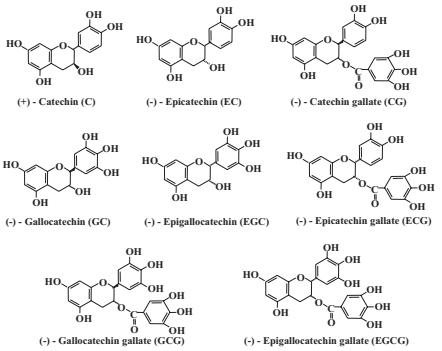
Any treatment that would reduce food intake and weight gain could be beneficial in reducing obesity and delaying or preventing diabetes. Some drugs previously used to reduce weight were found to have dangerous side effects and were withdrawn from the market. Green tea has been reported to be beneficial in reducing weight gain. Since it has been consumed for centuries without any known ill effects it is probably safe. One of the missions of the Botanical Center is to determine whether herbal products are safe and effective. It is thought that the catechins in green tea are responsible for its beneficial effects. The chemical structures of these catechins are shown in **F1**. These compounds can be studied using an analytical method called liquid chromatography. **F2** shows chromatograms of the catechins and an extract of green tea. At BASi we have been studying green tea to determine if it is effective in preventing obesity and diabetes. To do this study we used Zucker diabetic rats which naturally become obese and diabetic. (The Zucker diabetic rat was developed at the Indiana University-Purdue University Medical Center in Indianapolis to aid in the study of diabetes.) These animal models of disease are very useful in developing treatments for diseases. The life span of a rat is only two years, so when we study the effect of a treatment we see the results in a few months. If humans were studied, it would take decades to see the same effects.

To determine if green tea could reduce weight gain and prevent diabetes in Zucker rats, we started giving them a green tea extract at seven weeks old, the age at which they first start to become obese and develop diabetes. We did a dose response test; that is, we gave three different groups of rats three different amounts of green tea extract to see if the higher dose would be more effective. We also had a control group of Zucker rats that received no green tea. In addition, we compared these rats to another group of rats which does not become obese or diabetic. We gave the rats green tea for five weeks and measured how much food they ate and how much weight they gained. We also measured their glucose levels. People who are diabetic measure their blood glucose every day by pricking their fingers and using a meter to measure the glucose in their blood. Since rats are much smaller than humans, it is not possible to take as much blood from the rats. So instead of measuring the glucose in their blood, we measured the glucose in their interstitial fluid. (Interstitial fluid is the fluid between the cells.) A special device called an ultrafiltrate probe is placed under the skin and the interstitial fluid can be withdrawn painlessly to measure glucose.

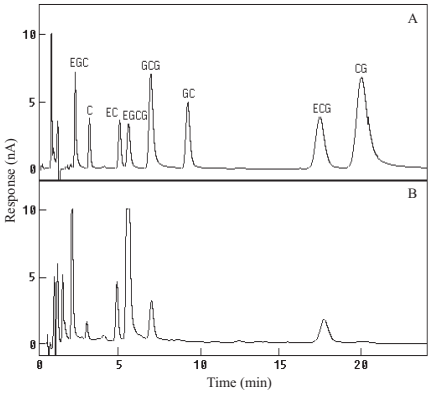
What the study showed was that the rats given green tea ate a little less than the obese rats that were not fed green tea. They also gained a little less weight and their glucose was a little lower. However, even with the green tea they ate more, were heavier and had higher glucose levels than the normal lean rats. Therefore, it must be concluded that green tea alone is not sufficient to reduce appetite and prevent obesity and diabetes.

Another service BASi performs for the Botanical Center is providing analytical support. BASi was originally founded to build analytical instruments, and over the years the company has developed many very sensitive analytical methods used to analyze chemicals present in the human body in small amounts. These can be naturally occurring (endogenous) substances or chemicals coming from the outside (exogenous) in the form of drugs or in food. BASi uses these skills to help the Botanical Center scientists analyze compounds from plants. One of the Botanical Center groups is trying to determine whether the isoflavones in soy products can help prevent osteoporosis. BASi is working on an analytical method to determine isoflavones both in the dosing material and in the blood. To do this, samples are first put through a liquid chromatograph which separates the complex mixture into its individual components. These components are then put into a mass spectrometer to identify them.

With the information gained from these studies, consumers and physicians will have a better understanding of the health benefits available from botanical products. *(Elsa Janle, ejanle@bioanalytical.com)*



F1. Catechins found in green tea are thought to be beneficial.



F2. Liquid chromatograms of catechins (above) and green tea extract (below).

Zucker diabetic rats are fed green tea to determine if it will decrease their weight gain, appetite and improve their diabetes.

Bringing the Ocean to Evansville

Whether it is *Ace Ventura*, *Jaws*, *Flipper* or *Free Willy*, most people learn about marine life from movies or taking a summer vacation to a beach. However, sitting in your living room watching a Blockbuster movie or sunbathing on a populated beach does not provide a hands-on experience about what the marine environment has to offer. Therefore, at the University of Evansville, we have brought the beach and ocean to our students.

Marine biology in the Midwest? How? Why? Where? These are the usual responses I receive when I discuss what I teach and research in Indiana—marine biology. Here are the answers. *How?* By teaching lecture classes in Indiana and taking week-long field trips to the Gulf of Mexico where students collect live marine animals and bring them back to Indiana. *Why?* Because Indiana students are interested in marine animals and marine environments; they are exciting and unfamiliar. *Where?* At both the Gulf Coast Research Laboratory and at the University of Evansville in classrooms and in the biology department's new marine research laboratory. We use the animals collected in the field to conduct research studies back in Evansville. Very exciting and very "do-able."

However, since the ocean is approximately 15 hours away, using natural seawater to maintain these animals back in Evansville is not possible. Thus, we must use artificial seawater, and the artificial seawater used to fill aquariums must be ideal. It is created by removing harmful chemicals such as ammonia (NH_3) and nitrate (NO_3^{-1}), and adding such beneficial chemicals as calcium (Ca^{+2}) and magnesium (Mg^{+2}). Understanding the chemistry and properties of saltwater insures proper maintenance of marine aquariums and environmental conditions and, in turn, will ensure the prosperity of many marine organisms.

The Who I am a professor in the biology department. My interests are in marine biology and I especially like working with crabs and shrimp. You may eat them; I study them. Erin Ball, a junior at the University of Evansville, approached me last summer and asked if she could work with me on a marine biology project. Erin and I knew we wanted to study marine chemistry; our project focus found us.

The First Problem: Available Information Erin and I discovered that background information on the major elements and components of saltwater, as well as on marine chemistry testing techniques, was sparse. There were no sources available (including textbooks, websites, and marine aquarium hobbyists books) that had complied saltwater nutrient information in terms of importance, ideal concentrations, and nutrient impact on a variety of marine life, including fish, crustaceans, non-coral invertebrates, anemones, and corals.

The Second Problem: Variable Mixes and Prices We learned there are several types of artificial saltwater mixes and those vary substantially in price and availability. Several local pet stores sell pre-made saltwater at varying prices, all claiming their water is "the best" and made from the "best salt in the world." Also, these pet stores have marine saltwater systems that house the organisms they sell to the public, and the quality of the water housing these animals directly impacts the likelihood the animals will survive after being sold. By the term *quality*, we are referring to the nutrient levels in the saltwater mixes.

The Objectives of our research study were to: 1) determine the essential nutrients in saltwater that impact a variety of marine life, 2) determine if high-priced salt mixes are better quality than lower-priced salt mixes, 3) determine if pre-made water (more expensive per gallon) is better quality than customer-made mixes (less expensive per gallon), 4) determine if pet store waters vary in quality, and 5) determine if the water in which animals live at pet stores promotes their long-term survival. The overall purpose of this project was to determine the most cost-effective way to obtain healthy seawater and insure that future research conducted at UE will not be impacted by poor water quality.

How We Did It We determined that 17 nutrient levels such as calcium (Ca^{+2}), nitrate (NO_3^{-1}), nitrite (NO_2^{-1}) and iodine (I^{-1}) are biologically important or harmful to marine animals and should be tested regularly. Then we investigated why these nutrient levels vary and the consequences if they vary; we compiled this information in a chart. Next, we used laboratory-grade marine chemical tests to evaluate pre-made and pre-established pet store waters and UE tank waters. Waters and nutrient levels were tested several times, in random order, at the same time of day. By the terms *quality*, *pre-made* and *pre-established*, we were referring to the nutrient levels in saltwater mixes, saltwater made by pet stores that never housed live animals, and saltwater that animals have occupied for a minimum of one month, respectively. Tested waters were ranked from best to worst in each of the 17 nutrient levels.

Our Results and Findings We compiled nutrient information and impacts on marine life (see **T1** for a shortened table of five nutrients). We also ranked UE's water and each pet store's water quality (pre-made and pre-established) for each nutrient (the lower the ranking the better quality the water). The water used at the UE had the highest quality pre-made and pre-established waters. Pet store water varied substantially in quality and without variation over time. Stores that sold saltwater at higher prices did not have better quality water. The water used to house marine organisms was much lower quality than needed to increase survival rates of the marine life. Saltwater mixes did vary in quality; however, buffer and calcium (Ca^{+2}) supplement additions were required with all saltwater mixes.

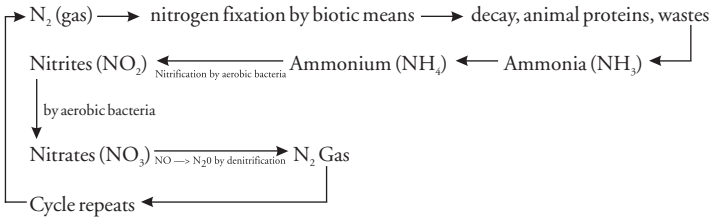
Our Conclusions This research provides information about the best environmental conditions to house marine organisms, ranging from fish to crustaceans, anemones and corals. Regarding pet store saltwater for sale: 1) higher prices do not mean higher quality water, 2) waters used to house marine organisms are usually poor quality, and 3) salt mixes vary in quality and quantity of the seventeen important saltwater nutrients. The information obtained in this study will be beneficial to the biology department, interested students and faculty. Our research should: 1) spare others countless hours of library and internet searching, 2) make this essential information easily accessible and understandable, 3) assure that nutrient information and its impacts on marine life are accurate and complete, and 4) most important of all, insure that the marine animals collected in the field will survive for months when brought back to UE.

So, marine biology in the Midwest? You betcha!!! *(Jennifer L. Wortham, Assistant Professor of Biology, University of Evansville)*

Facing page: **T1.** A sample of the chart complied on the seventeen important nutrients in saltwater. This table lists the importance of five nutrients.

Nutrient	Ideal Level	Causes for higher levels	Causes for lower levels	Treatments	Consequences	Effects on Fish	Effects on Crustaceans and Non-Coral Invertebrates	Effects on Corals
Ammonia (NH_3) [A]	Less than .25mg/L normally want level at 0	NH_3 levels increase as pH[B] levels decrease. If detectable, aquarium may be new and hasn't fully undergone a nitrogen cycle, or something is decaying. Over feeding the animals can also cause levels to be high.	Levels dependent on pH. Keeping pH levels high helps to ensure low levels of NH_3. Also, feeding proper amounts and making sure the tank has cycled (to insure that helpful bacteria have been properly established) will make sure levels are low.	Increased levels of CO_2 lead to increased pH which leads to decreased NH_3 levels--thus increasing the rate of photosynthesis. Have a good filter. High levels can be caused by overcrowding. Do not overfeed. Change water often.	Stimulates algae growth on rocks, can cause organismal health problems.	High levels can cause diseases in fish and destroy healthy fins. Toxic in high amounts (causes death) Ammonia poisoning is evidenced in fish by a decrease in feeding (appetite), loss of color, and increased rate of respiration.	High levels harmful – they put stress on animals, damage gill tissue, and lower resistance to disease; toxic in high amounts.	High levels harmful – they put stress on corals and lower resistance to disease.
Calcium (Ca^{+2})	Seawater: 380-480mg/L (425-450ppm) Most aquariums: 350-500mg/L Ideal: above 400, closer to 500mg/L	Adding too much of a calcium supplements will result in "snowy" precipitation which will cause alkalinity to drop and make further calcium additions difficult [1].	No recent additions of calcium, hard corals and coralline algae deplete calcium, also low levels of Mg can cause low levels of Ca. Low specific gravity (1.021) dilutes concentration of Ca.	Add Ca buffers, add $Ca(OH)_2$ also called kalkwasser[J] slowly (it can raise pH if added too quickly)[ii] it helps to neutralize acids (nitrates) and remove phosphates. $CaCl_2$ can be added, but it can interfere with the Na-Cl balance. Is used to buffer acids, thus Ca levels decrease as pH levels decrease. Mg must be present in the water to keep Ca available	pH and alkalinity (want alkalinity to be high) are directly effected by Ca levels. Inadequate levels of Ca can cause organismal development problems.	Low levels can cause poor fish growth, can also make it harder for fish to respond to changes in water temperature, alkalinity and pH.	Used by crustaceans, snails, clams, mollusks, etc. for shell/ exoskeleton building. Low levels cause decreased development in crustaceans.	Primary building block of corals, clams, calcareous algae, etc. Inadequate levels can cause them to waste away and die. Low levels stop or retard growth of coral and coralline algae.
Dissolved Oxygen [C] (DO)	ideal: less than 5.5ppm	During the daytime levels rise due to photosynthesis. Using pure oxygen can also cause high levels.	Lots of algae[iii], poor circulation, too many animals, temperature too high, night respiration [D].	Lower temperature, decrease number of animals in tank, increase circulation (by use of power heads, aerators, airstones, etc.), add live plants (for oxygen production through photosynthesis), and increase circulation[iv].	Animal physiological complications.	Low levels interfere with respiration. High levels cause tissue problems.	Low levels of oxygen cause respiration problems.	Too much or too little is harmful to coral—causes respiration problems.
Phosphate (PO_4^{-3})[v]	less than .1ppm (or .1mg/L) [vi]	Adding too much food (especially liquid supplements), food decaying in the tank, salt mixes, tap water, activated carbon with phosphates in it. Silica can cause a false positive test result. Phosphate is a byproduct of fish and invertebrate metabolism (thus more animals = more phosphate).	Want levels to be low (ideally 0).	Adding herbivorous snails or fish to tank, using a protein skimmer or airlift, adding $Ca(OH)_2$ (kalkwasser) can cause phosphate to precipitate out. At higher pH (8.2-8.5) phosphates are insoluble, when pH drops they become soluble and available for use by algae. Washing food after thawing decreases phosphates.	High levels can cause algae blooms[vii]. Phosphate removes Ca and Mg from the water makes them unavailable to organisms.	Can negatively affect health of organisms. Non toxic to fish, but leads to hair algae growth which harms fish.	Can negatively affect health of organisms by removing Ca/Mg from the water and making it unavailable for exoskeleton growth.	High levels interfere with calcification[E] of corals and coralline algae. Also increased algae growth covers coral and inhibits photosynthesis.
Silicate (Si)	Ideally should be below detection.	Tap water, salt mixes, substrate and decaying organic matter. Also can be water insoluble at higher pH. Use of silica sand or low grade sea salts which contain Si supplements. deO unit not working properly. Diatoms[viii] secrete silica in their houses. Decreased pH causes increased Si.	Silicate remover added, use of special Si filter. Low levels wanted,	Add Si remover, add algae eating snails, clean glass off then siphon out dirty water, use limestone or gravel, use filter which has little or no Si supplements.	High levels can cause algae growth and diatom blooms -- brown haze on glass and rocks.	Can cause increased diatom growth, when diatoms die there is a greater number of dead and decaying matter which causes increased levels of nitrate which harms fish and decreases oxygen levels (because bacteria use O_2 to breakdown dead diatoms). This leaves less oxygen in the water for organisms (see statement in crustacean column).	Lower oxygen levels in water can interfere with respiration process in organisms.	Important in the formation of sponge skeletons. Diatoms block light, decreasing the rate of photosynthesis and production of oxygen. They also grow on coral causing decreased coral growth and sometimes death.

A. Nitrogen Cycle: *Nitrogen fixation:* transferring nitrogen from a mostly unusable form (N_2 gas) into usable forms such as NH_3. *Denitrification:* converting nitrogen back to the gas form by the respiration of anaerobic bacteria.



B. pH: Usual range 1-14 (1-<7 = acid; 7 = neutral; >7-14 = basic)

C. Photosynthesis (Basic Equation): $CO_2 + H_2O \xrightarrow[\text{sun energy + chlorophyll}]{} \text{Organic Matter} + O_2$

D. Respiration (Basic Equation): Organic Matter (i.e. glucose) + $O_2 \xrightarrow[\text{chemical energy (ATP)}]{} CO_2 + H_2O$

E. Calcification: The deposition of calcium salts (i.e. $CaCO_3$) in tissue. Corals are formed by polyps living in a $CaCO_3$ shell/skeleton that the polyp secretes itself.As this calcium carbonate ($CaCO_3$) is laid down in the coral tissue, the coral will usually increase its growth rate, development, reproduction, and be generally healthier.

1. Ca^{2+} from $Ca(OH)_2$ is used by animals for calcification. OH^- from $Ca(OH)_2$ combines with CO_2 to form bicarbonate ($HCO3^-$) which is used in buffering pH.
2. $Ca(OH)_2$ has a pH of 12 and is caustic. DO NOT let it touch skin. DANGER!!
3. Poor water circulation may cause algae growth.
4. Oxygen levels are dependent on temperature, specific gravity, and atmospheric conditions. Also oxygen dissolves more readily in lower temperatures.
5. Want minimum input into system and maximum output. Phosphates are BAD for saltwater tanks.
6. Note most tests only test for inorganic (orthophosphates), thus it is possible to have high levels of organic phosphates which do not show up on a test. Phosphate levels less than 1mg/L limit hair algae growth.
7. Algae growth is caused by increased evaporation, phosphates, or city water. Use of an ammonia-based glass cleaner can trigger an algae bloom. To prevent this, use water without phosphates or silicates in it. Phosphates = hair algae = BAD!
8. Diatoms are microscopic marine life that live in a “glass house” made of silicate. Diatom blooms resemble brown algae.

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15th Annual Indiana Science and Engineering Fair

To Be Held April 4, 2003 in Indianapolis

The 15th annual Indiana Science and Engineering Fair, sponsored by the Science Education Foundation of Indiana, Inc., will be held in downtown Indianapolis, on April 4, 2003 in Union Station and the adjoining Crowne Plaza Hotel. Students who were winners at regional science fairs throughout Indiana will compete for more than 200 prizes and scholarships. The one-day event will include science fair exhibits, judging the student research in each exhibit, and an award ceremony. Special functions and speakers are being planned to encourage students to pursue opportunities in science, engineering and technology, to attend Indiana universities and colleges, and to practice their careers in the state.

Sixty high school and 36 junior high (middle) school students will compete. They will have been selected at 12 regional fairs where they were judged on their research done in schools where such work is encouraged and programs are available. The competing students' teachers and many parents will also attend. Special effort is being made this year to attract middle school students into research, since students that age typically are beginning to think about careers. Also, the need for elevating science education in Indiana schools and helping students connect with positions that will become available in the Indiana workforce are goals of the Indiana Science and Engineering Fair.

The science fair process is recognized for showcasing student research done in the K-12 school years, where students identify issues, write a hypothesis, design a research project, and then collect and analyze the data. Often students work with mentors or use laboratories where special equipment is available. The student research will be professionally judged by working scientists, teachers and university professors. Many students active in science fairs earn valuable prizes and scholarships, in addition to winning recognition for their school systems.

The science fair projects will be judged according to criteria from Science Service, the national organization regulating the worldwide system of student research. The Science Education Foundation of Indiana, Inc. is a not-for-profit foundation working to enhance science education in the Indiana K-12 schools by encouraging student research and other careers in technical areas. *(Dr. William Gilmore, Executive Director, 317-733-0692, wkgilm@ameritech.net)*

For more information: **www.sefi.org**

Art and Science Come Together

At IUPUI, 21st century scientific tools are being used to examine whether a famous 15th century artist or one of his assistants completed a well-known painting now held at the Indianapolis Museum of Art. Two faculty members in the geology department in the Purdue School of Science at IUPUI and a staff member in the Digital Electron Microscopy Facility at the IU School of Dentistry conducted a scientific analysis of Giovanni Bellini's *Madonna and Child with Saint John*, painted about 1500.

As museum staff prepared to clean and restore the 500-year-old work, they asked Gary Rosenberg, a geology professor with whom they have worked for many years, to examine tiny samples of pigment and ground taken from the painting. Rosenberg teaches a course on art and geology, recognizing that there are important relationships between things like landscape art and man's understanding of the structure of the earth, between earth materials and their use as art materials.

For their analysis of the pigment samples, Rosenberg, along with Keewook Yi of the School of Dentistry and Jeffrey Swope of the geology department, employed two sophisticated devices. An X-ray diffractometer was used to determine the crystalline structure of the pigment. Every solid material has a unique crystal structure, and the diffractometer provides the equivalent of a fingerprint. Then an electron microprobe was used to determine the concentration of different elements in the samples.

Their analysis gave two clues to the artist's identity. One showed that the gypsum ground on which the pigment was applied appears to be of the type used by artists in 15th century Venice. The other showed that the natural ultramarine blue pigment used was very pure. Such materials were very costly and used sparingly, something Bellini would have reserved for his use alone and not for one of his assistants.

The analysis of Bellini's work is ongoing. *(Source: IUPUI Partnerships)*