Research for Your World

Building on a Tradition of Excellence ~ Part III

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C O N T E N T S

Flu fighters

You're not the only one bugged by cold and flu bugs. Researchers have been chasing the elusive viruses for years. The good news: They're catching up.

It's enough to make you sick. No matter how diligently you guard against them, the seasonal beasts of cold and flu still find a way to knock you flat and leave you sniffling.

If it's any consolation, cold and flu viruses — like all of the 2,700 viruses known to science — are elusive creatures to researchers as well. But UW-Madison scientists are making some promising advances in understanding how viruses attack the body, how they spread, and how they change into new forms.

"Everybody has the flu — it's part of the disease profile of the world," says Virginia Hinshaw, an influenza researcher and dean of the Graduate School. "But the virus keeps changing all the time. Anticipating those changes is the difficult part."

The virus is a genetic quick-change artist because it exists in many different hosts, such as birds, pigs, marine mammals, horses and, of course, people. When two of these viruses infect one host, the viruses "mix" their genes and create new strains. Such mixed viruses are a major threat to humans because they can cause worldwide epidemics.

Pigs are a particularly important "mixing vessel" for the flu, Hinshaw says. Pigs have their own viruses, but are readily infected with viruses from people and birds. Human immune systems have no defense against the new strains that arise from that mix. The swine flu epidemic of 1976 had the potential to be severe, but caused less harm than expected, she says.

Hinshaw is seeking innovative ways of blocking those virulent new strains. She is working with a technology called a "gene gun," a pneumatic device that shoots microscopic gold beads coated with genetic material. Those beads can actually implant a vaccine inside the cell, producing a swift and strong immune response. Hinshaw works with pigs and horses, but clinical trials using the gene gun with humans are under way elsewhere.

The DNA-based vaccine could provide an important life-long protection in farm animals, which can die in large numbers from flu epidemics. But by controlling it in animals, Hinshaw says, they are indirectly reducing the threat to people. "If you reduce the flu in pigs, you also reduce the level of genetic mixing that takes place," she says.

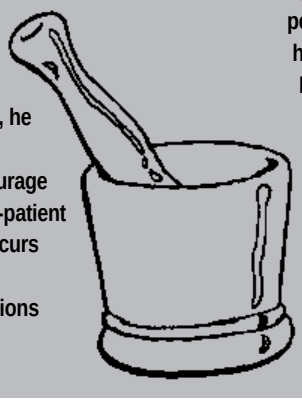
The flu is a more serious virus than one might imagine. Hinshaw says between 10,000 and 40,000 people in the United States die each year of complications from influenza, and the very young and very old are especially vulnerable. It's also the No. 1 cost to health care and lost productivity through sick days.

The challenges other viruses present are formidable. Consider the common cold virus. Biochemist Roland Rueckert says there are more than 100 rhinoviruses that cause the common cold, and those make up only one-third of all

Speak up to your pharmacist

Pharmacists are becoming more active players on the patient health care team, dispensing not just pills but essential information about drugs. As a result, researchers like Joseph Wiederholt are studying pharmacist-patient communication, known to ensure better health by helping patients manage their medication schedules. The UW School of Pharmacy associate professor has found that pharmacists and the environment in which they work are most important for communication.

"Pharmacists must recognize their role as counselors as well as patients' role as information seekers," he says. Pharmacies, he adds, should be designed to encourage direct pharmacist-patient contact, which occurs most often at the moment prescriptions are handed over.



No smoking, please

Despite overwhelming evidence that cigarettes shorten life, the age at which people start smoking continues to drop. To help kids withstand pressure to light up, Michael Pfau, professor of journalism and mass communication, has devised and successfully tested a preventive communication approach called "inoculation." The strategy presents adolescents with ways to refute pro-smoking arguments: "Smoking makes your breath stink," for example, or "It costs a lot of money."

Hinshaw's research is helping to bolster the immune system of pigs, which get sick even more than humans do. "Everybody has the flu — it's part of the disease profile of the world," she says. "But the virus keeps changing all the time. Anticipating those changes is the difficult part."

cold-causing viruses floating around. It's unlikely any one treatment would cover all these different forms, he says.

Rueckert describes viruses as machines with many moving parts. Drugs and vaccines are a kind of biological sabotage, jamming a virus' functions the way sand clogs gears in a clock.

A long-term virus research project has placed Rueckert's team on the trail of genetic leads. They are growing viruses in tissue cultures to find the proteins these viruses employ to grow and spread. Identifying these pathways of growth is the first step toward designing drugs that can shut down their spread, he says. Rueckert also is studying how viruses such as rhinovirus and polio are able to quickly develop resistance to drugs through genetic mutation.

In 1985, Rueckert was part of a team that produced a three-dimensional map of the surface of a common cold virus. The advance enabled researchers to actually see the shapes and surfaces where drugs can bind to the virus — an approach that ignited national interest in the concept of designing vaccines and drugs against other viruses, such as HIV.

The good news is that progress is being made: One drug in clinical tests works on 80 percent of all cold-causing rhinoviruses. And a new AIDS drug treatment is showing promise in inhibiting the final stage of the virus's reproduction.

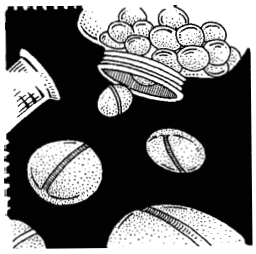
■ Early help for late talkers

Hearing babies speak their first recognizable word is enough to make most parents ecstatic. But others may fret over what is normal language development — especially if their child is a "late talker."

Collecting data on more than 800 children, UW psychologist Virginia Marchman has found perfectly normal variation in how much and how soon children use words. Funded by the UW Waisman Center and the National Institutes of Health, her research is helping to explain the difference between normal delays and early signs of trouble, giving parents peace of mind in knowing that many late talkers will be just fine.

Some children are late talkers because they process language differently, she says, but for others it may relate to a cognitive problem or hearing loss. The research could produce a better checklist to help pediatricians recognize language problems earlier — ideally at 18 months. When delays are caught at that age, most children catch up with proper intervention.

■ Research for YOUR HEALTH



The roots of depression

Imaging techniques are helping neuroscientists trace areas of the brain that may trigger clinical depression.

Parents suffering from depression may soon be able to have their children tested for the same disorder with the latest in non-invasive brain imaging techniques.

Researchers at UW-Madison already have found that the technology can provide the clearest picture yet of what happens in the brains of depressed people. They believe the scanners will eventually help clinicians identify people, particularly children, who may be at risk for depression. The UW group is among the few in the world to establish such a program.

"Identifying children susceptible to depression with these safe measures should allow us to treat symptoms before they develop into full-blown depression," says research leader Richard Davidson, a professor of psychology and psychiatry.

Davidson's team has adapted standard magnetic resonance imaging techniques to develop a machine that measures blood flow in different brain regions and a scanner that reveals metabolic activity. Both techniques can provide snapshots of brain structures that become activated when a person is exposed to emotion-evoking pictures.

In one experiment, researchers showed volunteers photographs of accident scenes and starving children as well as "neutral" photographs, allowing them to compare brain activity resulting from seeing both kinds of images.

"We found for the first time that the amygdala, a small structure located deep in the brain, clearly relates to emotional reaction in normal humans," says Davidson. When each of the study's six subjects were shown "emotional" pictures, their amygdalas were obviously activated.

But does the amygdala influence emotion in general or mainly negative emotions? Davidson next used a scanner to measure sugar metabolism, which correlates with blood flow, in various parts of the brain.

"We found amygdala metabolic activity related strongly to negative, but not positive feelings, as was suspected," he says. "Moreover, we were able to predict the severity of depression by the magnitude of amygdala activity."

In a third experiment, Davidson's groups used scans to determine the relationship between the amygdala and the medial prefrontal cortex, another region of the brain thought to play some role in emotions by inhibiting the amygdala. The study found that a portion of the left prefrontal cortex relates strongly to amygdala activity.

Armed with the knowledge that the two brain regions are closely linked, Davidson next looked for abnormalities in the two areas in depressed patients. He observed that in such patients, the prefrontal cortex does not clamp down on the amygdala as it normally should.

"This malfunction most likely leads to excessive amygdala activity, which then produces a cascade of changes that culminate in depression," he says.

Davidson says neuroscientists are especially excited about their new ability to see brain structures that play central roles in emotion, particularly the way parts of the brain interact.

Medicine with staying power

Drug manufacturers often face the challenge of getting medications to stay where they belong for extended periods of time. The task is even greater when a drug's target is the mouth, eye or another place in the body where it can be naturally washed away. Joseph Robinson, a pharmaceutics professor at the School of Pharmacy, has developed a water-soluble, bioadhesive gel that remains in place while it steadily dispenses a drug locally or throughout the body. Robinson's non-toxic compound has been used commercially for long-lasting contraceptives, enduring eye drops and mouth medications with staying power of up to 18 hours.

Getting smart about cancer diagnosis

A UW-Madison computer program may help doctors more accurately diagnose breast cancer. Computer scientist Olvi Mangasarian and surgeon William Wolberg teamed to refine the program, which uses artificial intelligence to develop a more precise diagnosis. The procedure uses just a tiny sample of cells, eliminating the need for a surgical biopsy. A patient's cell samples are compared against a base of hundreds of known cases stored in the computer. In 128 cases, the program diagnosed whether a mass was benign or malignant with 100 percent accuracy. It also holds promise for more accurate predictions of whether — and when — the cancer might recur.

A study of their own

Heart disease and cancer victimize women and men alike. Finally, researchers have turned attention to the effect of those diseases on women.

Think "heart disease" and the mental image that usually appears is that of a middle-aged male. But in Wisconsin — as in the rest of the nation — heart disease is also the leading killer of women. Yet virtually every new heart medication introduced in the last 25 years has been tested almost exclusively on men.

Unfortunately, the pattern of offering treatments to women based on studies limited to men goes well beyond heart disease. The Women's Health Initiative, the largest clinical trial ever undertaken in the United States, is profoundly changing that picture by enrolling women as research subjects to investigate several leading causes of female death and disability: heart disease, cancer and osteoporosis. UW Medical School, selected in September 1994 to be one of 40 sites nationwide for the groundbreaking study, now is among the top recruitment sites in the nation.

Sponsored by the National Institutes of Health, the study will provide answers to important questions women have asked for years: Does hormone replacement therapy reduce the risk of heart disease? Will a low-fat diet reduce breast cancer incidence? Will calcium supplements help prevent bone fractures and colorectal cancer? And, recently added to the study's agenda: Can estrogen help prevent or delay the onset of Alzheimer's disease?

Finding reliable answers to those questions will require enrolling more than 160,000 women nationwide: about 60,000 for controlled clinical trials and another 100,000 for an observational study of risk factors and disease. If the UW center's success is any indication, the study will tap a deep desire to help find answers too long unknown.

"We have women enrolled here in Madison from as far away as Duluth and Minocqua," notes Catherine Allen, epidemiologist at the medical school and principal investigator for the UW study with Douglas Laube, chief of obstetrics and gynecology. "I think that speaks to the willingness of women to take advantage of this opportunity to round out the research picture."

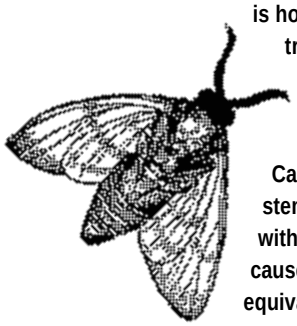
More than 1,800 women have enrolled in either the clinical trials or the observational study.

Study coordinators, based in Middleton, have traveled to small towns and big cities to spread the word and attract participants. One meeting last winter, organized by a parish nurse in Richland Center, attracted 35 women — despite temperatures that reached 20 degrees below zero.

The "memory study," which explores whether estrogen can prevent Alzheimer's disease, was added to the initiative this summer. Earlier studies have hinted that estrogen, naturally produced by women in their child-bearing years, may offer some protection against the debilitating disorder.

"This information is long overdue," says Allen. "I'm glad UW is part of this effort — and that Wisconsin women have shown their willingness to help."

A heart disease caught on the fly



What can we possibly learn about the human heart from fruit flies? Thanks to the insects, UW Medical School's Gail Robertson is hot on the trail of potential new treatments for cardiac arrhythmias, heartbeat irregularities that kill 250,000 Americans yearly.

Robertson's work at the Cardiovascular Research Center stems from earlier studies on flies with nerve cell electrical abnormalities caused by a mutated gene. The human equivalent causes "long-QT syndrome," a form of heart arrhythmia. She recently showed that the gene makes a particular ion channel, a structure that regulates the heart's rhythm by controlling the flow of charged particles in and out of cells. Knowing that the mutations causing long-QT syndrome disrupt the channels, she hopes her studies of how the channels work will lend insights to the disease.

Robertson, assistant professor of physiology, expects her investigations will also improve understanding of other ion channels, some of which may underlie other unresolved human diseases such as epilepsy.

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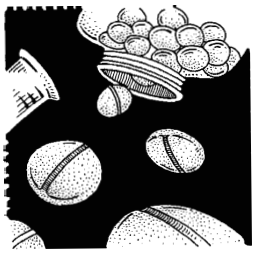
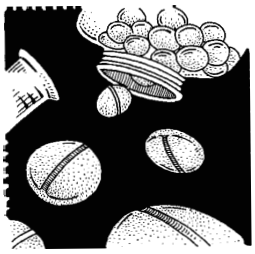


Research that brings relief

Comprehensive Cancer Center researchers focus their work on the cancer patient, not necessarily the cancer itself.

■ **Research for YOUR HEALTH**



As a nurse, Donna McCarthy was puzzled by the anorexia and weight loss that often weaken cancer patients, complicating their treatment and making them miserable. The standard clinical approach — using food supplements to boost protein and calorie intake and maintain weight — frequently fails.

This perplexing phenomenon drew McCarthy out of the clinic and into the laboratory, where her experiments reveal the way the body regulates food intake and responds to cancer.

McCarthy is one of a trio of faculty in the School of Nursing who conduct research as a part of the nationally recognized UW Comprehensive Cancer Center. Their focus is "the person who has the disease or is at risk to develop it, rather than the disease process itself," says researcher Sandra Ward.

McCarthy's laboratory studies, for example, may partly explain why cancer patients struggle to overcome nutritional deficits. While studying rats with tumors, she found that the rats' body systems made them eat less, even when food supplements were used to boost their calorie or protein intake. She will next explore whether cancer patients have the same response when they receive food supplements.

"Patients often incorrectly believe that 'good patients' don't complain about pain or that they'll become addicted to pain relievers."

Ward and Diane Lauver are testing whether accurate health information effectively presented translates into better outcomes. A key project addresses patient's misconceptions about pain and its appropriate management — beliefs that often interfere with patients' ability to seek and receive pain relief.

Up to 90 percent of patients with advanced cancer, Ward says, have moderate to severe pain that could be controlled with medication. "In many instances, however, cancer pain is not adequately managed," she says. "Patients often incorrectly believe that 'good patients' don't complain about pain or that they'll become addicted to pain relievers."

In a study of adults with advanced cancer, Ward's research team is testing a system she devised to give patients accurate information about medication addiction, tolerance and related issues, and teach them to cope with side effects. Pain and symptoms reported by these patients will be compared with reports from a separate group of patients.

One of Lauver's lead projects seeks to identify messages nurses can use to persuade women to have mammograms. The project continues several years of study by Lauver of women's early cancer-detection and care-seeking behavior.

"Early detection of breast cancer is critical to control the disease, but many women don't engage in breast cancer screening as often as recommended," Lauver says. "We don't know yet what specific aspects of messages promote breast cancer screening behaviors most effectively and how these messages are effective."

In Lauver's study, older cancer-free women are randomly assigned to one of three study groups: those receiving oral and printed information about screening recommendations; those receiving the screening information as well as information about feelings, beliefs and costs regarding screening; and a control group to whom no messages are given. Each group is being evaluated to determine which intervention leads to increased screening.

Old and loving it

The nation's elderly are by and large happy and remarkably resilient in the face of the problems of aging. UW researchers want to know why.

■ **Research for YOUR FAMILY**

Psychologist Carol Ryff finds an interesting pattern in our perceptions of aging: Young people have the most negative views of growing old, while people over 55 give it the highest marks.

Which begs the question: Why do we assume that aging is automatically a breeding ground for unhappiness?

Ryff, director of UW-Madison's Institute on Aging, leads a research effort to discover why, in the face of the physical, social and emotional setbacks of old age, many elderly people still show a remarkable resilience. A growing body of research shows that many elderly people are able to bounce back from a litany of problems — many of them coming all at once — and remain mentally healthy and positive.

"What we want to know is: Who doesn't get done in by all the negatives, and why?" Ryff says. "The answer is in learning about the protective factors that insulate people from life's difficulties."

"If we don't study the positive side of health, all we will be able to do is treat people for disease after the fact. There is a large preventive goal with our approach."

Depression, a significant and well-studied problem in the elderly, often is triggered by chronic health problems, loss of loved ones or the waning of a clear purpose in life. But Ryff and a team of researchers argue that it is not enough to study the problem; the absence of a problem may be just as revealing.

"If we don't study the positive side of health, all we will be able to do is treat people after the fact," she says. "There is a large preventive goal with our approach."

The prevention comes from learning more about the "protective factors" in the elderly. Ryff says those can be expressed in four distinct categories:

• Psychological resources. People develop different coping strategies in dealing with stress and illness that help alleviate long-term depression. These are teachable skills that may translate to better prevention and treatment of depression.

• Social resources. The network of personal and institutional support available to the elderly, from family and friends to community opportunities.

• Socio-demographic issues. A person's income level, education, social class and level of health care access all play a role in long-term mental and physical health.

• Biological resources. Biology and health are very clearly linked to the mind. Several UW researchers are studying physiological responses to stress and how the mind can actually teach the body to reduce stress and illness.

Two current Institute on Aging studies strive to look at all four of these measures together. Both are long-term studies of how and why people, in the face of accumulating adversity, have either negative or positive staying power.

"We are trying to map the pileup of bad stress in people's lives, as well as the positive, protective experiences," Ryff says. "We will monitor people's health records over the same period. By the end, we think we will be able to predict who will get sick and who will stay well based on what we know about their 'protective profile.'"

Another just-completed study illustrates Ryff's case. Marsha Seltzer, a Waisman Center researcher and social work professor, studied mothers who, for most of their adult lives, cared for a child with mental retardation. Her hypothesis was that these women would be exhausted and show more signs of aging and stress than their peers. She found the opposite: The lifelong care of a child had hidden emotional benefits for the mother that translated into better-than-average health.

In safe hands

Rest assured, parents: A national study shows that child care itself does not harm a mother's bond with her child.

The massive movement in recent decades toward alternative forms of child care in American families has generated an unsettling question: Does the use of child care itself affect children's attachments to their mothers?

The answer is no, according to a national study that included Deborah Vandell, professor of educational psychology and the Wisconsin Center for Education Research. Vandell is one of 25 researchers in the study, supported by the National Institute of Child Health and Human Development.

The study has followed more than 1,300 families in 10 locales around the nation since 1991. So far it has focused on various child-care arrangements in the first 15 months of life, including father care, grandparent care, care by a nonrelative in the child's home, family day care and center-based care.

If the mother's interaction with her infant is sensitive, then the child is likely to develop a secure relationship with her, regardless of child-care arrangements.

Vandell and colleagues found that nonmaternal child care by itself does not constitute a threat to the security of the infant-mother bond: If the mother's interaction with her infant is sensitive, then the child is likely to develop a secure relationship with her, regardless of child-care arrangements.

On the other hand, the study showed evidence that child care can add to the risks already inherent in maternal insensitivity. That is, when mothers are relatively insensitive and unresponsive to the needs of their infants, child-care conditions can exacerbate those troubled relationships. Those conditions include child care that is of poor quality, changes frequently or extends beyond 10 hours a week.

To assess the security of infants' attachment to their mothers, Vandell and the other investigators used a laboratory measure known as the "strange situation" procedure. It is designed to expose infants — at age 15 months, in this case — to mild stress by separating them from their mothers for a few minutes. Secure infants reestablish positive contact with their mothers following these brief separations, while insecure infants either ignore and avoid their mother or are not reassured by her return.

The study also confirmed that higher-quality child care comes with smaller groups of children, more adults per child and more sensitive caregivers. Those factors give children great stimulation and attention. Ranked lowest by those criteria were child-care centers, and ranked highest were care by fathers or relatives or by a caregiver in the home.

Next up for Vandell and the study: an examination of children's bonds to their mothers at 3 years old, as well as their cognitive and language development, physical development, health, behavior and relationships with peers.

Helping children succeed

Why do some children succeed, while others fail? Answers to that question have come recently from a study of 1,700 children conducted over 21 years by Robert Haveman, professor of economics, and Barbara Wolfe, director of the Institute for Research on Poverty.

They determined which parental decisions are likely to have the greatest impact on children. Among their findings:

• The positive effect of a working mother is surprisingly powerful. When a mother works, the probability of her children dropping out of high school falls significantly.

• Children who spend more years in a single-parent family finish fewer years of school, as do children who experience more household moves.

• Holding other factors constant, the education level of parents is strongly associated with their childrens' achievement.

Quality time

A baby's birth is one of life's most rewarding passages, but parental leaves sometimes pass too quickly than is healthy. A study of nearly 600 women by UW psychologist Janet Hyde and colleagues found that too-short maternity leaves pose psychological stress for mothers. Short leaves, of six weeks or less, can interact with other problems new mothers face, leading to more depression than those who take 12 weeks or more. A similar study found that new dads, on average, take under five days of leave, though they'd like to take more. That number, Hyde says, could be improved with more supportive employment policies.

Dog's best friend

Thanks to hip-replacement surgery techniques originally perfected for humans, Rover can roll over.

Innovative minds are making life better for man's best friend. Researchers at the School of Veterinary Medicine are now adapting surgical techniques used for humans to treat dogs afflicted with hip dysplasia, a condition that can lead to lameness and a crippling, painful arthritis for family pets.

Typical signs of dysplasia include lameness after exercising, less tolerance for exercising, reduced muscle mass in the rear limbs and decreased ability to extend the hip joint. The disorder most often afflicts larger breeds such as Labrador retrievers, golden retrievers and German Shepherds.

The work of veterinary surgeon Paul Manley is offering a second chance to dogs like Chess, a German Shepherd and best friend of Kathie Huncosky of Green Bay. Last year, when Chess started having trouble climbing stairs, Huncosky made an appointment to have her euthanized. "I had another dog before Chess, and I had to put her down because of dysplasia," Huncosky remembers. "I knew what was coming, and a lot of tears were shed. I didn't want to see her suffer."

But after learning about the work being done at UW-Madison, Huncosky decided to see if surgery was an option for Chess. After total hip replacement surgery, Chess is as rambunctious as ever.

Modeling his techniques after those used on humans, Manley has developed ways to relieve dysplasia with total hip replacement or creation of a false joint. Approximately 90 percent of dogs experiencing total hip replacement surgery will return to full function, he says. Surgery also can be performed on younger dogs to head off dysplasia.

Approximately 90 percent of dogs who undergo hip replacement surgery at UW-Madison's Veterinary Medicine school return to full function.

Procedures average $1,000 to $2,000, which, considering the success rate, some consider a bargain. Says Huncosky of Chess, "She's my family, and I would definitely do it all over again."

Work and home: A tug-of-war

Balancing the demands of work and family life could make the average working parent both happier and healthier, say UW-Madison family experts.

A research team led by Hamilton McCubbin, dean of the School of Family Resources and Consumer Sciences, has identified stresses at work and at home that can increase health risks for working parents. The exhaustive study collected information over six years from 1,300 employees of a national insurance company. It found those with the highest health risks generally had the biggest pileups of work and family stresses.

"Contrary to the popular literature, health risks can increase from pressures at home as well as at work," McCubbin says. "The family and the work place actually compete for a person's time, commitment and dedication. Working parents can't handle both easily."

But the research does find ways working parents can achieve a healthy balance. In the work place, employees need strong supervisor support, group problem-solving approaches and an infusion of new challenges. And in the home, good communication is a must. "If the family environment is more incendiary and combative, it puts the employee in double jeopardy," he says.

Research for YOUR FAMILY

The garbage man

A UW researcher and colleagues look at what we throw away — and how we throw it — to figure out ways to make better recycled products.

Communities across Wisconsin may benefit from UW-Madison research that has literally gone to waste. Agricultural economist John Strasma and his students study garbage, and they're finding ways to help local governments cut the cost of waste disposal and recycling programs.

Consider, for example, a recent study of plastic bottle recycling, funded by a grant from the Wisconsin Recycling Market Development Board. Whether they contain milk, soda or detergent, plastic bottles are made of valuable polymers that could easily be melted down and turned into new containers.

They could, that is, if not for a common contaminant: their own caps. Plastic bottle caps, rings and even labels are made of different kinds of plastic. Separating them often requires costly manual labor, but failing to do so strips recycled plastic of most of its usefulness and value.

"If you have several types of plastic polymers mixed up, then all you can do is make things like low-grade plastic lumber, and since there's lots of raw material for that, it doesn't bring much money," says Strasma. "But if you can single out a particular polymer, then industry is willing and able to pay a great deal for it."

The researchers have found that most bottle caps can be made from the same kind of plastic as their bottles. That would require a change in the way the packaging industry produces most tops, but Strasma says the industry is willing to listen. And he says UW-Madison may help coordinate an industry-wide standard for plastic caps.

Such small details play a big part in making recycling work, especially for taxpayers. State-mandated municipal recycling programs are never likely to operate in the black, according to Strasma. Their main goal is to keep materials out of landfills. But stronger recycling markets can help underwrite a larger share of the equipment and labor that curbside pickup programs require.

"The end purposes are to try to lower the cost of recycling collection and processing and increase the amount of money that municipalities get for running recycling programs by producing a consistent plastic," Strasma says.

But in another recent study, Strasma found that Wisconsin municipalities themselves could do more to strengthen recycling markets. State law requires all public offices to purchase paper with a minimum recycled content and strongly encourages efforts to buy other recycled materials. Funded by the Wisconsin Recycling Market Development Board, the study found two-thirds of the government entities surveyed abide by the state law. As for the rest, a small number were unwilling to comply, but most simply had not yet heard about the requirement.

Farming's natural solutions

Halfway through a 12-year study, scientists and cooperating farmers are finding that replacing chemicals with intensive management practices can improve both farm profitability and environmental quality. The study addresses the concerns of Wisconsin dairy farmers and those who raise grain crops.

Developed by scientists in the College of Agricultural and Life Sciences, experts in organic agriculture from the Michael Fields Agricultural Institute in East Troy, Wisconsin, UW-Extension agents and farmers, the study encourages broad community involvement in the quest for a prosperous and environmentally sound agricultural sector. Sites are located in Columbia and Walworth counties.

Early results are encouraging. For example, the cash grain system that relies on a three-year crop rotation, legume crops for nitrogen and mechanical weed control is as productive — and more profitable — than one that uses chemical fertilizer and pesticides to grow corn year after year. Groundwater quality is improving at the Walworth County site, which has a shallow groundwater table.

Water watchdogs

Although groundwater is an abundant resource in Wisconsin, it can be easily contaminated. Through its program of proactive research, the Wisconsin Water Resources Center focuses on technical and regulatory ways to keep the state's groundwater clean.

The center has helped guide efforts to control the potentially hazardous flow of atrazine, a pesticide used in corn production, into the water supply. Studies from the center have identified atrazine and its four toxic metabolites in groundwater and traced their flow. In response to potential health threats, the state has restricted atrazine use, and in some areas has banned it entirely.

Pesticides: Missing the point

Are our fears about the health effects of pesticides in our food justified? One UW researcher shows why the answer may be no.

UW-Madison toxicologist Michael Pariza says the public may have overblown fears about the cancer risks of pesticides.

Many scientists are divided on the human health impact of pesticide use. But Pariza, a national expert on food safety, argues that many pesticides, when used properly, present minuscule health risks and may ultimately protect us from greater risks.

"We're not poisoning our food by having a minute quantity of pesticide in it any more than we're poisoning our water by adding tiny amounts of chlorine."

An insect called a corn borer illustrates Pariza's point. When it gets into stressed corn crops, it carries the spores that produce aflatoxin, a powerful natural carcinogen — ultimately stronger than the pesticides that control the insect, he says.

Virtually all foods contain traces of carcinogenic substances, many of them from natural sources. Although these typically are not health threats to humans, Pariza says they may pose a higher risk in the long run than any traces of pesticide residue on foods.

Pariza, director of UW-Madison's Food Research Institute, has argued to lawmakers that comparing risks makes more sense than a total ban of pesticides. "We're not poisoning our food by having a minute quantity of pesticide in it any more than we're poisoning our water by adding tiny amounts of chlorine to protect us from cholera," he says.

Pariza favors a rethinking of the federal Delaney Clause, enacted in 1958, which prohibits the use of food additives that cause cancer. That was expanded in 1987 to include pesticides. But Pariza questions the measures used to assess a substance's possible risk. Many of the substances covered by the Delaney Clause are not powerful carcinogens, he says, and only produce cancer in lab animals at levels hundreds of times higher than humans would ever ingest.

Instead, Pariza says efforts should focus on other food-safety threats unrelated to natural or synthetic chemicals. An estimated 12.5 million food-associated illnesses occur each year in the United States, at a health cost of $8.5 billion. The vast majority are from infectious agents, like salmonella bacteria, hepatitis A virus, and a variety of parasites — all of which are controllable.

Pariza has co-authored treatises on the safety of food enzymes and bio-engineered food products that are models for Food and Drug Administration policies. Most recently, he served on the National Research Council's committee on "Carcinogens and Anti-Carcinogens in the Human Diet."

Invisible killers

Marty Kanarek makes his living tracking down deadly killers, but his suspects are quite unusual — they can't answer questions and most aren't visible to the naked eye. Kanarek, professor of preventive medicine and environmental studies, explores indoor air pollution and how it affects health. Some of the pollutants most harmful to humans, he says, are found in the inner spaces of our homes, office buildings and other workplaces. Those airborne pollutants are small particulates from tobacco smoke; formaldehyde and other organic substances; carbon monoxide; nitrogen dioxide; microbes; fungi and spores.

In collaboration with the U.S. Environmental Protection Agency, Kanarek has studied lead levels in inner-city Milwaukee homes. The findings: Some indoor dust and air is contaminated with lead from old paint and old leaded gasoline tracked in from soil, and that contamination negatively affects children's health, IQ levels and behavior.

Kanarek has also co-authored a book for building managers and others in the building trades that explains how to avoid the most harmful contaminants. Homeowners, he says, can purchase inexpensive kits that detect contaminants, or they can turn to their local utilities and health departments for help. Good ventilation and source elimination or control, he adds, are the best tactics for ending the threat.

Research for

YOUR ENVIRONMENT

In the eye of a data hurricane

UW space scientists were among the first to start collecting weather information from space. Now they're leading efforts to make sense of it all.

■ **Research for**
YOUR ENVIRONMENT

It only makes sense that researchers at the UW-Madison Space Science and Engineering Center would be pioneers in weather technology. The idea of visualizing weather — translating a flood of weather data into more easily understandable pictures and images — was essentially born there.

Two inspirations of the late Verner Suomi, founder of the SSEC, paved the way for visualizing the atmosphere. His spin-scan camera, developed in the 1960s, enabled scientists to collect myriad new forms of weather data, such as cloud height and growth rates, rainfall location and amounts, and the extent of atmospheric pollution. Suomi's development a decade later of the Man computer Interactive Data Access System (McIDAS) gave scientists a powerful system to organize the stream of weather data they were now receiving from space.

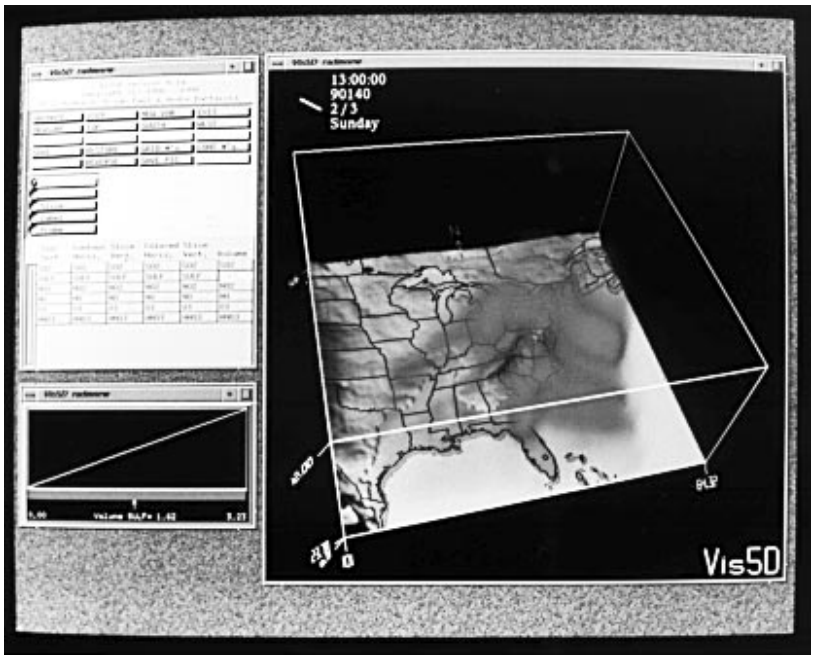
Using McIDAS and spin-scan data, SSEC researchers continue to extend the boundaries of weather research with innovative applications of satellite data.

Hurricane research has become a prominent focus at SSEC. Christopher Velden and colleagues are developing new ways to analyze satellite data to improve hurricane forecast predictions. They find that images of water vapor can reveal previously undetectable features in air flow, which ultimately influence the motion and path of tropical cyclones and hurricanes. The results are making predictions of a hurricane's path more precise and warnings more effective.

Elaine Prins and Paul Menzel are focusing satellite eyes on Amazonia, to study the effects of rain forest burning on climate and ecology. The studies provide detailed information on smoke transport and the location, size and average temperature of fires. The Amazon area's richness in animal and plant life is especially vulnerable to damage from fire.

And thanks to the work of SSEC researcher Bill Hibbard and his team in developing visualization software, scientists can now view and interact with their data in five dimensions. The software, called Vis5D, helps scientists understand very large sets of data, containing billions of numbers, by turning numbers into pictures. The software is currently in use at the U.S. Environmental Protection Agency, which uses the program to track pollutants in acid rain and form pictures of pollution over urban areas. Vis5D is also used to examine sea-surface temperatures and to analyze the dynamic processes of severe thunderstorms.

The software is provided, as are the satellite images received by SSEC's rooftop antennas, free over the Internet.



Vis5D helps scientists understand very large sets of data, containing billions of numbers, by turning numbers into pictures.

Extracurricular or just extra?

How much work and extracurricular activity can your child take on before they begin to interfere with classwork? A professor provides a few clues.

As every parent knows, teenagers lead busy lives. Many may hold part-time jobs flipping burgers or waiting tables. Others spend countless hours each week at football practice, drama rehearsal or student-government meetings. Their schedules seem to leave little room for homework. And that leads parents to wonder: Are all these activities hurting my child's schoolwork?

Research by a UW-Madison professor indicates that parents may be asking the wrong question. They should instead be concerned about what *kind* of activity their teens are engaged in — and how much time they devote to it.

Brad Brown, a professor of educational psychology, bases his conclusions on surveys and focus-group discussions with 20,000 teenagers and hundreds of parents in Wisconsin and California. The three-year study examined such topics as students' attitudes toward school, relationships with peers, and after-school activities.

Brown and his colleagues discovered that once they earn their driver's licenses, most teenagers go to work. Three-quarters of the seniors in the study, and two-thirds of the juniors, held a part-time job at some point during the school year.

But that news isn't necessarily bad. "We found that students who work 10 hours a week or less actually do better in school than peers who don't work at all," says Brown. "They have higher grade-point averages, are more attentive to their schooling, and have lower rates of delinquent activity."

Yet once teenagers begin to work 15 hours a week or more, the picture changes dramatically: Those students perform more poorly in school than their peers without part-time jobs.

"Kids already spend 35 hours a week just going to school. If they work 15 or 20 or even 30 hours a week on top of that, how will they find time for homework?" he says.

Brown and his colleagues learned that students who participated in extracurricular activities such as sports, clubs and performing groups did better in school than those who didn't. There's a catch, though: When the researchers controlled for other factors, the advantage disappeared. Explains Brown: "The kids who choose to go out for extracurriculars tend to be the ones who already earn good grades. They were doing well in school even before they signed up for the extracurriculars."

Generally, though, Brown believes extracurricular activities are a good way for teenagers to spend their time. The only exceptions are those groups and teams that discourage kids from doing their best academically. For instance, does the coach refuse to let athletes miss practice in order to study for a test? Are the other teenagers participating in the club more interested in parties than in school? If the answer to these questions is yes, parents may want their child to find a different activity.

Homework: a family affair

The more involved parents are with their children's education, the better the kids do in school, a UW-Madison researcher has found. But, says Brad Brown, a professor of educational psychology, the type of involvement that's appropriate may change through the years. For instance, if a teenager won't accept mom's help with homework, she may need to ask the school to assign a tutor instead. And if a teen thinks it's not "cool" for dad to show up at school for parents' night, perhaps he can become active in the school as a mentor. Either way, parents demonstrate a commitment to education — and kids notice.

Sacrificing convention for invention

Linus Pauling used tinker toys to visualize DNA. Mozart composed complete symphonies in his mind before putting them on paper. Some say this ability to use analogs and imagery is the essence of creativity.

UW-Madison education researchers are exploring how best to encourage creativity in students. "We've applied that research by urging education majors to ask their future students open-ended questions, without a 'right' answer," says Robert Clasen, emeritus professor of educational psychology.

More than 100 teachers have finished UW-Madison master's degrees emphasizing gifted education. With new Wisconsin laws that require schools to provide appropriate gifted education, Clasen thinks more students than ever will be "finding solutions to problems in ways we never imagined."

■ Research for YOUR SCHOOL

2 + 2 = reality

Put away the slide rules. Get out the hang gliders. The new math is coming to a school near you.

■ **Research for YOUR SCHOOL**

The difference between traditional mathematics education and a new math curriculum for middle schools developed at UW-Madison is the difference between frozen and fluid, between isolation and collaboration, between math as lock-step rules and math as a dynamic way of thinking.

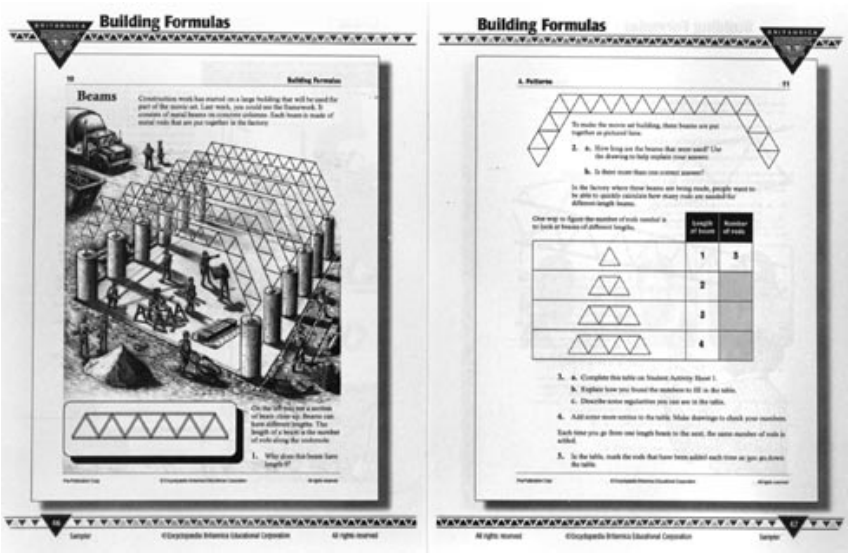
The curriculum's name, "Mathematics in Context" (MIC), is apt. It pulls mathematics from its backwater mooring in rote, work-at-your-desk exercises and moves it into the mainstream context of modern life. Some examples:

• Students explore geometric concepts involving angle through calculating how far a hang glider will fly from various heights at various angles of descent.

• To learn algebraic concepts, they devise a formula to help a movie set designer calculate how many metal rods are needed for different-length beams.

• In statistics, students construct systems of classifying pottery unearthed by an archaeologist.

During these exercises, students often answer questions together, sharing their problem-solving strategies instead of hunching over their desks and working alone.



By putting mathematics in real-life context, the MIC workbook (above) allows students to reinvent math.

MIC, being published by Encyclopaedia Britannica, was produced by researchers at the university's Wisconsin Center for Education Research (WCER) and curriculum designers at the Freudenthal Institute in the Netherlands.

Coordinating the project was Thomas Romberg, director of WCER's School Mathematics and Science Achievement Center, who is considered the preeminent leader of a widespread reform movement aimed at changing the way mathematics is taught in the United States.

Why the Dutch connection? "The Dutch have been doing 'realistic' math education for years," says Romberg, "so we invited them to work with us."

Going Dutch made sense to Romberg. "In international comparisons of student mathematics achievement," he says, "the Dutch students generally rank first or second in the world and are significantly better than American students."

In the Netherlands, extensive comparisons have been made between students in "realistic" programs and those in traditional programs. The "realistic" students outperformed the others on 11 of 29 criteria and were comparable on 17 others.

Romberg's center worked with the Dutch designers to produce a curriculum suitable for American middle schools, then tested the concept in school districts around the nation.

The Dutch-American team made sure that cooperative investigation was a prominent feature of MIC. "If students have an opportunity to reinvent a mathematical idea together," says Romberg, "they're more likely to remember it because they discovered on their own why it was needed."

The designers also made the curriculum depart from the traditional by building on and pushing beyond the fundamental skills learned in early levels. "In the past, middle school mathematics has been basically a review and extension of arithmetic," says Romberg.

"But MIC incorporates such material as using the ideas underlying statistics and probability, drawing inferences from graphs and spreadsheets, and exploring transformational geometry [turning an object to view it from different angles]," he says. To introduce algebraic concepts, MIC challenges students with problems involving variables.

Overall, says Romberg, the strength of the curriculum is the way it recognizes the interconnectedness of mathematical ideas and weaves those ideas into real-life situations.

Work schedules that work

Employees love flexible work schedules and benefits. Now, thanks to new research on the productivity of those arrangements, companies can, too.

Just a few years ago, for a company to experiment with an alternative work schedule, such as a four-day, 40-hour week, was a stab in the dark — enough to give a human resources director the heebie-jeebies.

But now the process of trying an alternative to the eight-hour day is less confusing and more likely to succeed because of research by a UW-Madison business professor.

Research by Randy Dunham and his colleagues helps managers satisfy employee demands for autonomy, independence and flexibility. The team is also helping managers meet company objectives by offering guidelines on how to:

- evaluate alternative work schedules before choosing one to try;

The bottom-line: Flexible benefits lead to increased employee satisfaction, especially when the company communicates the plan clearly to employees as an aid in making choices.

- design, administer and score a survey of employee opinions to help managers anticipate likely employee reactions to various alternative schedules once they would begin (using a set of measures devised by Dunham); and
- implement and monitor new schedules to maximize the chances for success.

Arrangements such as compressed work weeks, flextime and permanent part-time employment aren't as rare in the workplace as you might think: The number of full-time production and service workers with other than eight-hours-a-day schedules increased from 15.9 percent in 1985 to 18.2 percent in 1991.

Findings such as these have been compiled into a book titled *Alternative Work Schedules*, the result of collaboration among Dunham and three other business researchers around the country.

Dunham also has done research on flexible or "cafeteria-style" benefits, which allow an employee to choose from a variety of benefits or varying levels of benefits up to a certain cost limit.

The bottom-line finding: Flexible benefits lead to increased employee satisfaction, especially when the company communicates the plan clearly to employees as an aid in making choices.

Another piece of Dunham's research has looked at shift-work schedules, which affect about one-fourth of the American work force. He studied a police department's switch from an eight-hour-day schedule to a 12-hour day with four days on and four off. He and a colleague discovered that the new schedule allowed the workers to better harmonize their non-work activities with family and community rhythms.

Managers have appreciated the real-world connection of Dunham's research. In fact, the Society of Human Resources Management gave Dunham the Yoder-Heneman Best Personnel Research of the Year award — not once, but twice — for his studies.

Time quest

Fourteen Midwest manufacturing firms are learning how they can reduce lead time by 75-95 percent while improving product quality and reducing costs, thanks to a study conducted by the College of Engineering Center for Quick Response Manufacturing.

The center's findings suggest that firms should pay more attention to factors such as set-up, order processing and down time — which can make up more than 90 percent of the time from order to product completion — in organizing work time. Researchers also have demonstrated the time and efficiency gains of work cells — where products with similar manufacturing operations are produced in a "cell" consisting of all the necessary machines and staffed by multi-skilled workers. At nine of the firms studied, it was found that a cellular production system could slice lead time by as much as 80 percent, in addition to providing such benefits as reducing scrap rates.

The study also found that a key factor in saving work time was a willingness on the part of a company's management to invest in training, education and production capacity, and to give employees responsibility and authority.

Research for YOUR JOB

A helping hand for hands

A new battery of easy and painless tests may help spot workers at risk for serious hand injuries.

■ **Research for YOUR JOB**

Industrial engineering professor Robert Radwin wants to save workers' hands.

Much of Radwin's research concentrates on understanding and preventing hand injuries in the workplace. His studies have led to the development of new biomedical instruments to detect hand injuries and ergonomic improvements in the design and use of industrial hand tools.

Radwin's current work hopes to identify workers at risk of serious and costly injuries. Working with UW-Madison clinical scientist Arthur Rodriquez, Radwin is developing medical instruments to improve the detection of carpal tunnel syndrome. The numbing pain of carpal tunnel — caused by an entrapment of the median nerve in the wrist — is a common complaint of computer users, but it is also prevalent among workers who perform repetitive tasks.

Radwin says new computer tests to detect carpal tunnel syndrome are "simple to administer and painless."

"If a problem is detected early on, an ergonomics and medical intervention can be taken to prevent a long-term problem from occurring," Radwin says. "Currently, most screening tests for carpal tunnel syndrome are not very specific, accurate or practical for routinely monitoring workers. In fact, there are none that are very good at all."

The clinical test for carpal tunnel syndrome — called electromyography — is expensive and time consuming. It must be performed by a physician and its effects range from unpleasant to outright painful. In short, not many people would be willing to take it with the kind of frequency required for early detection of repetitive motion injuries.

Radwin and his graduate students have developed two early detection instruments that are no more difficult to administer than a common hearing test. Just as workers in a loud factory receive periodic hearing checkups, workers who are exposed to vibrations, forceful exertions, stressful postures and repetitive motions can be tested regularly using the new method.

In one test, subjects use their hands to feel for a small crack in a smooth metal plate. As the crack is enlarged by computer — from one tenth of a micron to several millimeters wide — workers run their fingers over the plate, responding when they detect the gap. Because carpal tunnel syndrome dulls touch, sufferers tend to feel only the wider gaps.

The other test is a simple video game that is controlled by squeezing bars together. "The patients we tested who have carpal tunnel syndrome use a lot more force than the people who don't have carpal tunnel syndrome symptoms and nerve-conduction deficits," Radwin explains. That's because the median nerve tells your brain how hard you are squeezing and sends motor signals to the muscles in your fingers. "If there's an injury to the median nerve, that transmission of the nerve signals may be impaired," he says.

Both devices are now being introduced to some workplaces, using employees as volunteers.

In tests at UW Hospital and Clinics, both devices fared well at detecting known carpal tunnel syndrome sufferers, identified using electromyography. What isn't yet clear is whether the tests will help health care professionals ferret out the syndrome in its infancy.

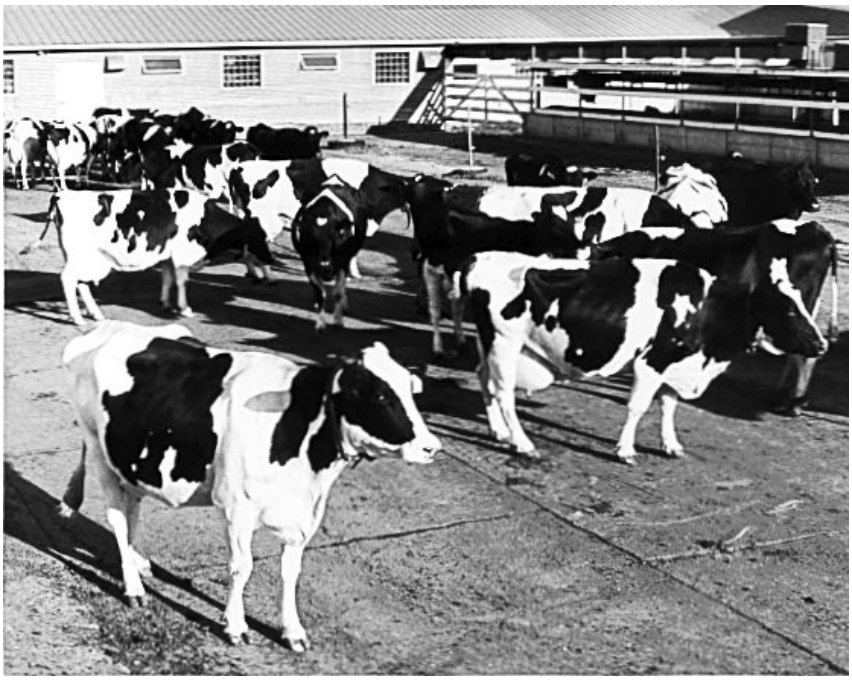
For farmers: Help making hay

Dairy researchers harness their work — from recommended cow diets to optimal barn ventilation — to help farmers beat problems and turn profits.

Two Rivers dairy farmers Paul and Robert Tulachka hadn't seen anything like it before. Over a two-year span, more than a dozen cows had died on their 100-cow farm, and dozens more had fallen ill.

Milk production was down. Some of their animals were suffering. The losses were getting serious — as much as $100,000 over that time.

"We didn't know what was happening," remembers Robert Tulachka. "All the signs that were supposed to be there weren't there."



"About half the dairies we work with are experiencing severe financial problems. When we're able to turn some of these farms around, it's really gratifying."

The farm's veterinarian sought the assistance of a UW-Madison veterinary medicine professor, Kenneth Nordlund. The call led to a site visit from the veterinary medicine school's Food Animal Production Medicine program — and to the end of the mystery on the Tulachka farm.

Nordlund's team ran through a checklist of medical tests on the cows and reviewed the nutritional content of their feed. They found the culprit: a condition called subacute rumen acidosis, the product of too much grain in the herd's diet.

Tulachka says it "would have been very hard to recover" if the problem hadn't been corrected, but they haven't lost a single cow to illness since taking steps to improve their feed mix.

The Food Animal Production Medicine program, run out of the School of Veterinary Medicine, has conducted as many as 80 such farm visits a year since its inception in 1989, offering farmers a combination of trouble-shooting and the latest in research knowledge.

Veterinary science on farms is going beyond the traditional "barn calls" to treat the occasional sick cow, says veterinary medicine professor Gary Oetzel. The production medicine approach emphasizes total herd management, which can help prevent common problems like infectious disease before they start.

The program's computer-assisted analysis of herd records can identify trends that might be sapping a farm's profit margin. Researchers run laboratory tests of feed ingredients to ensure the herd is getting the nutrients for optimal milk production. They can find environmental problems, such as poor barn ventilation, that can jeopardize the herd's health.

"When you get into the nitty-gritty details during a herd investigation, you find issues that farmers have not considered before," Oetzel says.

Subacute rumen acidosis is a good example. Excess acidity in the cow's system is caused by too much high-energy grain and too little forage food. This condition was poorly understood only a decade ago, but the UW program has become a leading source for diagnostic methods on this silent killer.

"On the economic side, we're working on improving the marginal returns for farms," Oetzel says. "About half the dairies we work with are experiencing severe financial problems. When we're able to turn some of these farms around, it's really gratifying."

Superveggies and wonderfruit

UW food researchers are working to make your corn sweeter, your carrots healthier, and your cranberries cranberrier. Now please pass the orange cucumber.

If you could steer a squeaky-wheeled grocery cart through the advances of UW-Madison food research, the produce section would be a must-stop.

Scientists here have helped create more succulent sweet corn; bigger and redder cranberries; carrots enriched with added beta-carotene; and tomatoes with extra sweetness. You might even find an orange cucumber.

Through a mix of old-fashioned plant breeding and modern biotechnology, researchers are solving agricultural problems for Wisconsin farmers and improving what ends up on the supper table.

Take the work of horticulturist Philipp Simon. He specializes in boosting the nutritional content in carrots by adding beta-carotene, an important source of vitamin A. The health benefits of beta-carotene, the pigment that makes carrots orange, include reducing cancer risk and high blood pressure. Children deficient in vitamin A are more susceptible to measles and mumps.

Simon's "Beta III" carrot gives consumers more of what makes carrots healthy. Developed by breeding regular Midwestern carrots with high beta-carotene varieties from Asia, Simon was able to triple the total beta carotene content. The Beta III is slated for trials in vitamin A-deficient parts of the world.

Sweet corn slathered in butter — one of the finer indulgences of summer — is a research obsession for Bill Tracy. The agronomist has developed 15 varieties, some of which are used commercially in Wisconsin. Many have improved flavor and tenderness.

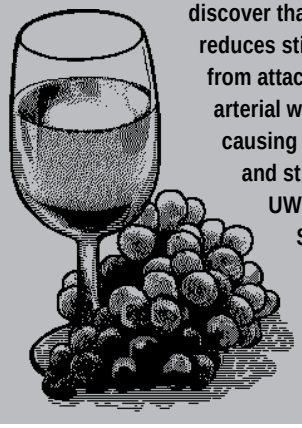
"Flavor is my top concern," says Tracy, a self-described "sweet corn chauvinist" who covets the vegetable above all others. "If we don't care about flavor, we might as well grow field corn."

Tracy's varieties also can be planted earlier in the season, to meet the high consumer demand for early-summer sweet corn. His ultimate goal is to develop sweet corn that can be planted as early as field corn, a full month ahead of schedule. One project has him cross-breeding sweet corn with a corn that's native to the frigid high altitudes in Mexico.

Another up-and-coming crop research project concerns cranberries, of which Wisconsin is a top producer. Horticulturist Brent McCown says state farmers have a shorter growing season than their counterparts in the Northeast, and consequently, cranberries here are typically smaller and have less color intensity. McCown selectively breeds plants for a shorter growing season that are better suited for central and northern Wisconsin.

McCown uses biotechnology to give cranberry plants a natural defense against insects — a development that could almost eliminate the need for insecticide treatments. He has successfully introduced a gene from Bacillus thuringiensis — Bt for short — into the genetic makeup of plants that could provide insect resistance over the life of the plant.

You can drink to that



In 1974, then-doctoral candidate John D. Folts was the first to discover that aspirin reduces sticky platelets from attaching to arterial walls and causing heart attacks and strokes. Now a UW Medical School professor of medicine, Folts has found that certain vitamin-like substances called flavonoids may do an even better job of preventing coronary thrombosis.

Using a model he developed that duplicates how blood flows through narrowed arteries, Folts has found that flavonoids in some fruits and vegetables, red wine, purple grape juice, dark beer and black tea have an anti-clogging effect that in some cases exceeds that of aspirin. But flavonoids go a step further: They're also potent anti-oxidants that soak up hazardous oxygen molecules and help keep "bad" cholesterol from damaging arterial walls.

Folts, whose findings have been supported by several recent clinical studies, is currently studying which of the 4,000 flavonoids are the most protective and the dietary sources of those flavonoids.

McCown says their process for Bt-altering plants, patented by the Wisconsin Alumni Research Foundation, shows promise in the second year of field tests.

"We have farmers ready to replant as soon as these are available to reduce their reliance on chemicals," McCown says.

Biotechnology is bearing fruit on other fronts as well. Botanist Thomas Sharkey worked with the California company Calgene to test a tomato with higher sugar content that would be better for canning. The tomato uses genes from sweet corn to produce the extra sugar. Sharkey helped perfect an approach that not only produced 10 percent higher sugar content, but 50 percent higher per-acre yield.

On a more fundamental level, two UW-Madison botanists made a genetic discovery that could one day lead to fruits and veggies with a longer shelf-life in the refrigerator. Anthony Bleecker and Eric Schaller found the first hormone receptor responsible for aging and ripening in plants, a process that governs everything from bananas turning brown to flowers shedding their petals. Plants may one day be engineered to ripen more slowly, which could reduce huge losses of spoiled food crops.

But what about those orange cucumbers? That's another creation of Phil Simon, who enhanced the beta-carotene content in cucumbers through selective breeding. It's not meant to be a freak of nature, he says. Cucumbers with more beta-carotene could offer a sustainable vitamin A source in developing countries, where deficiencies still causes blindness in children.

"Consumer acceptance of an orange cucumber would probably take some time — not to mention courage," Simon says.

Bleecker (right) and Schaller found a hormone in tomatoes and other fruits and vegetables that controls rotting, which may help botanists breed food that stays fresh longer.

■ On the track of a meat menace

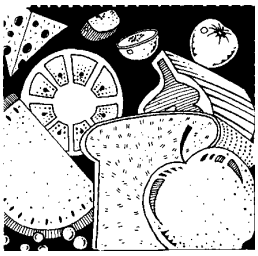
It's made people ill, grabbed national headlines and shaken public confidence in the food industry. But microbiologists at UW's Food Research Institute are tracking E. coli (known to scientists as E. coli O157:H7) from the barnyard to the meat case.

Charles Kaspar, John Luchansky and USDA researcher Jack Shere are surveying Wisconsin farms to find how the pathogen hides and how it travels. The information will help them develop ways farmers can reduce or eliminate E. coli from their herds.

The researchers found the bacterium in calves on five of the 70 farms they surveyed. On two farms, they found it in water tanks. Animals carrying E. coli shared the same housing or water, occupied pens previously containing infected animals, or were housed nearby barns or pens with infected animals. The findings suggest that the bacterium can be transmitted directly among animals within a herd or indirectly through areas contaminated by infected animals.

Researchers Kaspar, Luchansky and Eric Johnson also have studied survival and destruction of E. coli in fermented sausage — such as salami and pepperoni — and have identified several methods of fermentation, curing or heating that help manufacturers make a safe meat product.

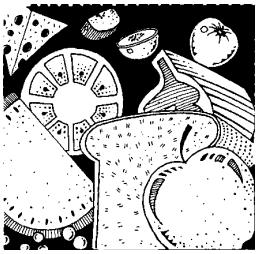
■ Research for YOUR FOOD



Eat less, live longer

Watching a group of dieting monkeys head toward an active and healthy old age, one scientist says there's a lesson for humans.

■ **Research for YOUR FOOD**



There's a better path to old age and Joe Kemnitz knows the way.

For Kemnitz, a UW-Madison primatologist, and his collaborators, the way to a healthy, active old age is being illuminated by 30 rhesus macaques, monkeys whose special diet promises fundamental insight into the process of aging.

By probing the connection between diet and how our bodies change with time, the Wisconsin scientists will establish a baseline for understanding the relationship between food, how much we eat, and the very process of growing old. That knowledge will underpin new methods for medical intervention — both dietary and pharmacological — that have the potential to help us enjoy a healthier, happier old age.

Seven years ago, Kemnitz and his colleagues at the Wisconsin Regional Primate Research Center embarked on an ambitious study. The question was simple: If we provide a healthy, balanced diet, but fewer calories, can we extend life span and improve the quality of life in old age?

The question was simple: If we provide a healthy, balanced diet, but fewer calories, can we extend life span and improve the quality of life in old age?

The study of the animals on a restricted diet — and a control group allowed to eat freely — is far from over. But the initial results support a growing body of evidence that life span can be extended and killers of the elderly, such as diabetes, can be held at bay through dietary intervention.

The results, which Kemnitz calls a "backbone of knowledge," will lead to new approaches to treating and averting the complications of old age in humans.

Issues of aging and the elderly are urgent as America's elderly population continues to balloon. Not only will there be many more elderly within the next 30 years as baby boomers mature, but improvements in medicine, diet, public health, education and income levels are helping people live longer. By the year 2020, one-fourth of Americans will be older than 60, and the average life expectancy will be 82 for women and 74 for men.

The Wisconsin primate study focuses on two groups of middle-aged monkeys that are nearly identical except for diet. One group is allowed to eat freely while the other is provided a diet with 30 percent fewer calories than the control group.

The study is exploring how diet influences physiological functions such as metabolic rate, vision, immune function, physical activity and glucose tolerance.

In terms of aging, rhesus monkeys are a lot like people, says Kemnitz. They get the same diseases, and as the study progresses and the animals enter the stage of life where the visible signs of aging begin, they will provide a novel window into the process of growing old.

"They are in a phase of life now where we would expect age-related diseases to emerge," says Kemnitz. "In fact, four of the animals in the control group have impaired glucose tolerance and one of those has developed full-blown diabetes and requires daily insulin therapy. None of the food-restricted animals are showing glucose regulatory problems."

A guiltless cheese?

Low-fat cheeses are often just as low on taste. But with the help of UW dairy research, a low-fat, high-flavor Cheddar is on the horizon.

Cheesemakers know that the customer is always right, and many of today's health-conscious consumers want lower-fat cheeses that offer full flavor.

No problem — just make cheese from skim milk, right? Wrong. The chemistry of cheese doesn't work that way. Drastically reducing the fat can have disastrous results: bad-tasting cheese with texture ranging from hard and rubbery to soft and pasty.

By tweaking the timing and modifying parts of the cheesemaking procedure, UW dairy researchers are coming up with ways to make low-fat cheese that retains most of the taste of its more sinful cousin.

Milkfat, milk proteins, cheese cultures and aging time interact to produce the rich flavors and textures of good cheese. Today, a good 25-percent reduced-fat Cheddar approximates the taste of mild full-fat Cheddar. But cutting the fat content even more — such as by 50 percent — poses a challenge, explains Mark Johnson, senior scientist at the Center for Dairy Research. The more fat you take out, the trickier the cheese chemistry gets. Some of the so-called "non-fat cheese" sold today barely resembles cheese, he says.

Johnson and colleague Carol Chen have developed a recipe for 50-percent reduced-fat Cheddar that holds its own in side-by-side comparisons with full-fat Cheddar. The recipe tweaks the timing and modifies parts of the cheesemaking procedure, but requires no special equipment. Any cheesemaker making full-fat Cheddar cheese should be able to use it, they say.

Consumer response to reduced-fat Cheddar right now is lukewarm, Chen says. People are buying it, but that's because a trip down the grocery aisle doesn't provide a side-by-side taste test with full-fat Cheddar. When compared with its full-fat counterpart, Chen says, reduced-fat Cheddar is missing true Cheddar flavor and has off-flavors.

"We think our reduced-fat Cheddar can stand up to mild to medium full-fat Cheddar in side-by-side comparisons," Chen says.

In fact, their reduced-fat cheese passed muster with a tough bunch of cheese tasters in the Food Science Department's Sensory Analysis Lab. And when tested on an even tougher group — visitors to the World Dairy Expo — common comments likened it to aged Cheddar, and tasters wanted to know where to buy it.

To introduce people to high-quality reduced-fat cheese, Chen and Johnson plan to sell this Cheddar at the Babcock Hall Dairy Store on the UW campus. The cheese should have a nine-month shelf life or better, say the researchers. As it ages, it will develop a balanced Cheddar flavor, rather than the off-flavors of some reduced-fat cheeses.

Taking a molecular approach to cheese flavor, food microbiologist Jim Steele is identifying the enzymes that generate Cheddar flavor compounds. These enzymes are produced by bacteria in starter cultures — the mixes of microbes that commence the cheesemaking process. Certain strains of bacteria can speed flavor development and reduce bitterness. Using molecular biology techniques, Steele creates a derivative of the original strain that lacks one enzyme. By comparing the original strain with the derivative, he learns whether that enzyme affects flavor development.

In another study, Steele has removed genes from a good mozzarella starter organism and put them into a good Cheddar starter. In the resulting starter, the enzyme that helps eliminate bitterness is 100 times more prevalent — an important finding for producing reduced-fat Cheddar.

Great Lakes miracle

In 30 years, an active program of lake management has turned Lake Michigan from a black hole to one of the Midwest's favorite fishing holes.

The thousands of anglers who plumb the depths of Lake Michigan on summer mornings in search of monster coho, steelhead and chinook are enjoying some of the nation's best salmon and trout fishing.

They may not know, however, they are also enjoying the fruits of a "modern management miracle."

That's how UW-Madison zoologist and Great Lakes expert James Kitchell views the incredible comeback of sport fishing in Lake Michigan — a comeback which he helps maintain through research.

"We went from zero — absolute zero — in the value of recreation for Lake Michigan to an overwhelming success," he says. "In coastal communities, the lake used to be their back door, where they threw their junk. That perspective has now rotated 180 degrees."

Lake cities like Racine, Port Washington, Sheboygan, Two Rivers and Algoma all have sparkling new marinas packed with boats, and local motels are filled with anglers from across the Midwest. Wisconsin is only one part of the booming Lake Michigan sport fishery, which generates nearly $1 billion per year in regional economic activity.

It didn't exist 30 years ago. The lake was an ecological disaster, Kitchell says. By the early 1960s, native lake trout had all but vanished due to overfishing and the widespread invasion of parasitic sea lamprey. With predatory fish gone, populations of forage fish like the alewife exploded. During summer, millions of fish washed up on the lakeshore.

The introduction of hatchery-raised trout and salmon helped lead the coastal turnaround. Stocking of up to 15 million salmon per year since the 1970s has created a healthy sport fishery and helped restore the predator-prey balance in the lake.

But without constant research and management, the lake could easily sink to its past degraded conditions. Through the UW-Madison Sea Grant Institute, Kitchell and other researchers are developing new computer-analysis tools to help managers maintain the best stocking and parasite-control practices.

Kitchell's computer models create a total "energy budget" for the predators, which tells managers how many sport fish the available forage fish base can sustain. It can help managers make predictions and stock the appropriate species to create predatory fish populations without over-taxing the lake's available food.

It's a delicate balance, Kitchell says. In 1989, the culmination of years of salmon overstocking led to another massive summer fish kill — except this time, it was salmon that succumbed to disease, weakened by a lack of food.

With computer models that estimate the

Home, shop, home

Who *isn't* delighted to have catalogs arrive in the mail?

Steve Deller, associate professor of agricultural and applied economics and a community development specialist who studies trends in retailing, says catalogs please both consumers and businesses. "Catalogs offer a real service to dual wage-earners and single parents," he says. "A lot of people simply don't have time to go to the store nowadays, and most mail-order companies have excellent return policies, so shopping through the mail is both easy and convenient."

For businesses, especially those in rural areas, mail order offers an expedient, attractive marketing option. "Some businesses have one simple product that they offer through the mail. I remember one family out East that made gourmet jellies and marketed them through a catalog," he says.

Meanwhile, both shoppers and businesses are discovering retailing opportunities on the Internet, particularly through the World Wide Web. Deller's studies suggest that electronic shopping will grow even more rapidly than mail order. "Mailing costs are going up, and it's relatively easy to look at a catalog on computer and place your order online," he says.

Building strong bones

Women lose an average of 1/2 to 1 percent of their bone density each year after about age 35, leading many to serious problems with osteoporosis in later life. But in an ongoing study involving 120 women, Everett Smith, UW professor of preventive medicine, found that a diet and exercise program could help most women between 35 and 60 improve their overall fitness and muscle tone and maintain bone mass.

Now Smith is examining the genetic controls that direct bone growth. One element of the research includes testing whether certain drugs effectively promote bone growth. The result could well be drug therapy for healthier bones as we age.

"We went from zero — absolute zero — in the value of receation for Lake Michigan to an overwhelming success."

impact of stocking practices, Kitchell says fish managers can avoid these costly shocks on the food chain.

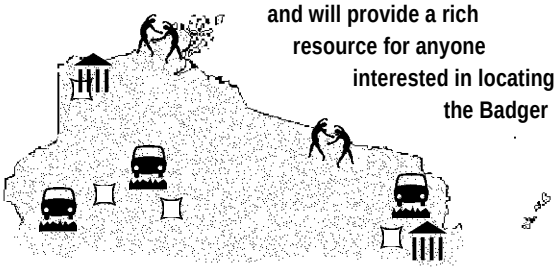
Kitchell's group also is working to find the best population balance between sport fish and native lake trout, which are less desirable to anglers but important in bringing a natural balance to the lake. Another long-term goal is to reduce reliance on hatchery-raised fish, since they are vulnerable to disease and boom-and-bust cycles.

Finally, Kitchell and others constantly monitor the control and spread of exotic species such as the sea lamprey, the main culprit in the collapse of the Great Lakes fisheries. Without continuous control of the parasite, he says, the Great Lakes' resurgent fishery could not exist.

■ Wisconsin culture: A road trip

Wisconsin, we know, has abundant cultural and historical heritage. But now, with the help of a new map constructed by UW-Madison geographers, we can find that heritage at a glance.

The map, three years in the making, will roll off the presses this fall at the University of Wisconsin Press and will provide a rich resource for anyone interested in locating the Badger State's trove of important cultural sites. The map identifies not only culturally diverse regions like southwestern Wisconsin's "driftless area," but also serves as a convenient chart for finding sites of historic, ethnic, archeological, architectural, literary, musical and artistic importance, says David Woodward, the UW-Madison professor of geography who initiated and guides the project.



In addition, a light-shaded relief background will help display the variation of Wisconsin's land forms. In short, the map promises an in-depth tour of Wisconsin's heritage and the landscape that helped define it.

■ Research for YOUR LEISURE

Bring on the potholes

Neither rain nor road rut will slow down new bicycles engineered with space-age materials.

■ **Research for YOUR LEISURE**

Mountain bikers pedal the path of most resistance, always searching for the ultimate ride on trails snarled with rocks, ruts, roots and ravines.

Bike manufacturers rise to the challenge of this hard-driving bunch with featherweight composite frames and suspension systems that would rival your father's Buick. But there remains an Achilles heel: Bicycle rims, it seems, are most prone to buckling under off-road punishment.

Bicycle rims reinforced with boron carbide will allow riders to tackle even the most pothole-infested streets.

UW mechanical engineer Terry Richard and the late materials scientist Frank Worzala, who died in August, have been on the trail of new materials to help mountain bike rims withstand the onslaught. The duo teamed recently with TREK Bicycle Company of Waterloo, Wis., the nation's top mountain bike manufacturer, to look at improving the strength and performance of off-road rims — without inflating the cost.

They found a good candidate by blending a composite of 80 percent aluminum and 20 percent boron carbide, the same super-tough material the Department of Defense uses for helicopter components. "This turned out to have considerably better properties than all the other components we tested," Worzala said. "It has very high strength and high modulus."

A material's modulus is essentially its stiffness. Standard aluminum rims, while lightweight, have a low modulus. Bolstering the aluminum rims with boron carbide roughly doubled the stiffness of standard rims, Worzala said.

Richard is continuing to work with TREK to produce rim sections that can later be tested by the company's fleet of riders. But another UW-Madison innovation is being adopted by the company, solving a different problem: braking in rain-slicked conditions.

Adding a ceramic-metal composite to rim surfaces, through a plasma-coating process, produced better stopping power in wet conditions, the researchers found. TREK recently began marketing ceramic-coated rims, but the surfaces are brittle and crack easily. Worzala said their innovation — adding 20 percent nickel and chrome to the ceramic — helped the material bond more strongly to the rim. TREK is planning to market the improved rims soon.

A third project will help manufacturers produce better, cleaner welds on rims through a laser-welding technique, which eliminates the need to machine away excess metal from conventional flash welds.

In addition to TREK, the researchers formed partnerships with two Wisconsin companies, Laser Machining Inc. of Somerset and Thermal Spray Technologies of Sun Prairie.

Beyond building university-industry partnerships, Richard says the knowledge gained is of larger importance to material scientists. "By working with several companies on a common project, we are able to apply our knowledge of new materials to applications beyond a single industry," he says. "What we're doing in a larger sense is improving existing concepts by using advanced materials."

Into the great unknown

Advances in medicine, energy and technology can often be the unexpected results of basic research.

■ **Research for YOUR DREAMS**

When Hector DeLuca began studying vitamin D 30 years ago, treating disease seemed a distant goal. His research team was after something more basic: How does this unusual vitamin work in the body?

The UW-Madison biochemist's discoveries changed what everyone thought they knew about vitamin D, and a whole gallery of unexpected new uses availed themselves to science.

DeLuca's work led to more than 150 U.S. patents for life-enhancing drugs, including treatments for osteoporosis and a number of bone, muscle and skin diseases. New analogs of the active vitamin D compound are now being developed for the treatment of multiple sclerosis and cancer.

The vitamin D story provides a clear example of why universities conduct basic research: Without first answering fundamental questions, the information for cures and treatments would not be available.

"If you look at the modern miracles of medicine," DeLuca says, "virtually all of them have come from basic science. Penicillin is a perfect example. It wasn't discovered because we were trying to cure infectious disease. It was discovered because researchers were trying to figure out why molds inhibit the growth of bacteria. The pursuit of that led to the discovery of compounds that are enormously useful."

Basic research — the quest to understand all the natural phenomena around us, from particle physics to the human genome — is big business at UW-Madison. About 90 percent of the $370-million-plus research enterprise here is considered basic research.

There are literally thousands of basic research projects under way. They include exploring the molecular rules that govern limb formation; using supercomputers to map engine combustion; using magnetic resonance imaging to locate emotional activity in the brain; and studying genes that control fruit ripening and flowers wilting.

Basic research can thrill scientists with unexpected results. DeLuca says his work "went against the dogma of the time" by showing that vitamin D had to be modified into entirely new compounds before it performed in the body. When they traced its path in animal models, they found it would disappear. The kidneys convert the vitamin into an entirely new, active compound.

"It became immediately apparent," DeLuca says, "that these would be useful compounds in the treatment of disease."

But basic research takes time — often lots of time — before the benefits start to make themselves evident. Fusion is an example of a complex scientific problem that may take another 30 to 40 years to reach large-scale use. But researchers keep their eyes on the prize: providing a cheap, safe and nearly limitless supply of energy for the world.

Physics professor and fusion researcher Stewart Prager admits he was attracted in part by the "save-the-world" implications of fusion. But he is also driven by the theoretical challenges it poses. He works with one of three UW-Madison experiments in fusion research, which attract about $6 million in federal funds.

Fusion is the equivalent of "producing a miniature sun here on earth," Prager says. It involves creating a plasma — an electrically charged gas, similar to lightning — which can reach a heat of 100 million degrees. Unlike nuclear power, fusion does not pose the risk of meltdown. Fusion plants could run on natural elements found in sea water, giving it almost limitless potential.

But the research has proven more difficult than scientists imagined. Fusion researchers in the 1950s believed they would see fusion power plants in their lifetime. Even though great progress has been made, Prager says fusion research has reached a kind of "mid-life crisis." Its federal funding was cut by one-third last year, from $336 million to $244 million.

Fusion is federal research personified, he says, since its goals are long-term and it probes a fundamental question. State or private funding sources could not support such a giant enterprise, he says, which must be made a national priority to survive.

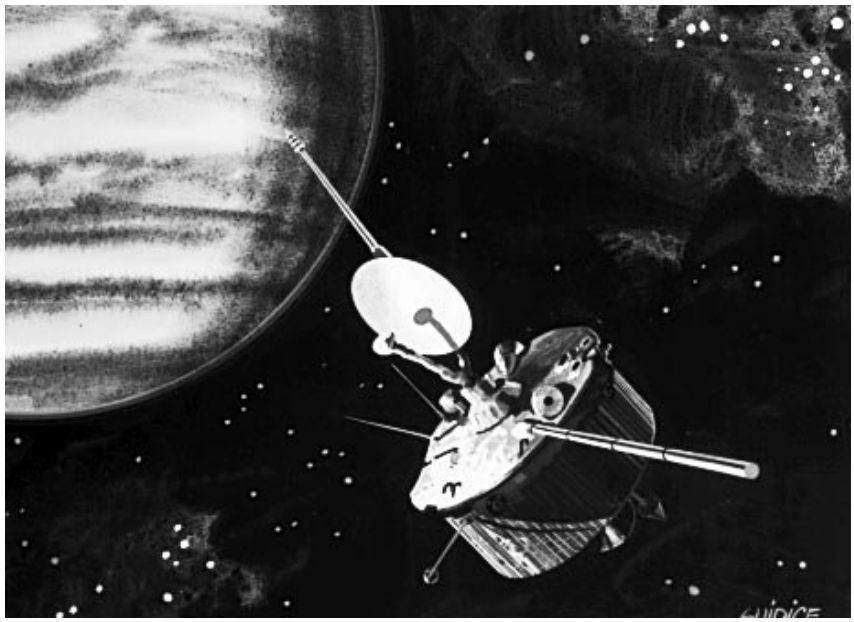
"I think we will see fusion power in our lifetime. It's inevitable," Prager says. "It will start to have greater urgency as we have more knowledge about depletion of oil and the polluting effects of fossil fuels."

■ Islands in the sky

Dwarf galaxies have stood star-to-star with celestial thugs for more than a billion years. Astrophysicists want to know what's holding them together.

In the vast universe of astronomy, small is increasingly beautiful.

For decades, astronomers have trained telescopes on the sky in search of the big and the flashy: black holes, distant quasars and giant spiral-shaped galaxies. Now, however, an ordinary and long-neglected piece of the universe — the humble dwarf galaxy — promises rich insights into our place in the cosmos.



Where we see black sky, astonomers see mass — but what's tipping the scales?

"These common and durable galaxies are the cosmic equivalent of rocks," says John "Jay" Gallagher III, a professor of astronomy and a current explorer of miniature galaxies. "There are 10 times as many dwarf galaxies as giants, but for the most part they've been ignored."

These galaxies, which contain just a million or so stars, have become important because they seem to be jam-packed with dark matter, the hypothesized missing mass of the universe.

Astrophysicists have long been trying to account for the chunk of the universe's supposed mass that does not exist as stars, planets or other directly detectable phenomena. In dwarf galaxies, they might have found it. "The smallest ones seem to be absolutely loaded with dark matter," says Gallagher.

Because dwarf galaxies have so few stars, they could easily be ripped apart by the gravitational pull of nearby giant galaxies, such as our own Milky Way, around which orbits a constellation of dwarf galaxies. But something, says Gallagher, is holding them together, and recent observations by Wisconsin astronomers and others point to dark matter as the celestial glue whose gravity keeps the small galaxies intact.

Dwarf galaxies pose another puzzle: They apparently are very old, but they seem to have changed little over billions of years.

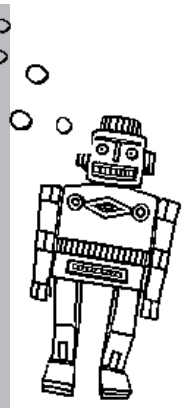
"We call it the Hollywood effect," says UW-Madison astronomer Eric M. Wilcots, another scholar of dwarf galaxies. One idea, he says, is that the early universe may have been dominated by these small galaxies and, all of a sudden, many of them coalesced to form more familiar giant galaxies, such as the Milky Way.

If that's the case, it would be like finding a cosmic time capsule in our backyard. Astronomers hope it holds answers to the questions of the earliest moments of the cosmos.

■ 20,000 volts under the sea

Scientists may soon be able to plunge deeper into the ocean's secrets without putting human divers at risk. UW-Madison electrical engineer and computer scientist Vladimir Lumelsky is developing robots with a sensory "skin" to help them navigate a collision-free course through the deep blue and come back with images of deep-sea caves, sunken ships and other outer-limits locales.

Lumelsky uses an emerging technology called "sensor-based motion planning," which places thousands of light-emitting sensors on a robot's surface that instantly detect obstacles. The technology could lead to machines that can make decisions in all sorts of uncontrolled environments, including offices, households, hospitals and construction sites.



Now you see it

Engineers have long known they could make materials stronger if they could get a good look at their atomic structure. Now they can.

In high-tech materials, the action is down at the atomic level. At that scale, the problem is not always making materials, but knowing what you've made.

Enter the three-dimensional atom probe (3DAP) microscope being developed by Tom Kelly, professor of materials science and engineering. The 3DAP is able to make atomic-scale maps of the position and identity of millions of atoms. There are just a handful of these microscopes in the world at this point.

"Companies and researchers developing new materials need much more precise information about how improvements are made and performance is enhanced."

Kelly has specialized in making a very high-speed 3DAP that will ultimately record 1 million atoms per second. Just how much faster is that than current methods? To study material containing 1 billion atoms, over a distance of about one micrometer, takes more than a year. Kelly's 3DAP would only take about 17 minutes. That's a quantum leap for the study of many critical materials, says Kelly.

The 3DAP will play a role in greatly improving the development and manufacture of a number of high-tech materials. For example, it will help design and create stronger structural metals like steels and aluminum alloys. "Companies and researchers developing new materials need much more precise information about how improvements are made and performance is enhanced," Kelly says.

One could liken current methods to a nearly hit-and-miss proposition — "You can make changes in the process which improve the material, but you don't have any way of knowing why it improved," Kelly says. That makes further improvements more difficult to predict and make. "But if you can see the interface more sharply, at the atomic level, you can see what's better. You may find that what you've done is the best so far achieved — but not necessarily the best there could be."

Other types of scientific studies will find 3DAP a revolutionary tool as well. For example, scientists (including Sue Babcock, assistant professor of materials science and engineering) are studying why impurities in materials often segregate to form a weak point, potentially leading to failures in the high-strength metals and ceramics that make up bridges or aircraft. Other researchers are anxious to get a look at very small-scale nucleation and growth phenomena. "It has not been possible to study these kinds of processes down towards the atomic scale which is where everything is happening," says Kelly.

The 3DAP has already produced three-dimensional images. The development team, which includes both graduate and undergraduate students, has almost completed installation of a new stage called the Local Electrode Atom Probe (LEAP), which will make it much easier to analyze planar structures like semi-conductors. LEAP will also make it much easier to achieve the high pulsing rates 3DAP needs to see that revolutionary million atoms per second.

Wings to grow

Working with a common fruit fly, biologists have discovered a single gene responsible for growing wings — and the means to direct it to grow wing tissue from eye sockets, legs, antennae, and virtually any other body appendage.

The discovery promises key insight into how genes in animals, including humans, direct limb formation, says Sean B. Carroll of the UW-Madison's Howard Hughes Medical Institute.

While the finding has no immediate application, it may lead to the prevention of the genetic miscommunication that causes birth defects.

"We've clearly got our hands on one of the crucial genes," says Carroll. "It will enable us to get into the guts of the system" that controls limb formation.

That system, he says, probably arose several hundred million years ago in a distant ancestor of both flies and humans. The system is apparently conserved today in both insects and vertebrates.

Research for YOUR DREAMS

Mixed media

The lines between broadcast, cable and the World Wide Web are blurring. That may signal the coming of the ultimate couch potato experience.

■ Research for YOUR DREAMS

Watching a televised baseball game one afternoon, you've just seen your favorite Milwaukee Brewer rip a three-run homer into the seats of County Stadium. You're curious about his batting average, so you flip from the game to the Brewer Web page. Seeing he's batting an astounding .380 with 10 homers in July, you decide to post a message on major-league baseball's official Web page, urging he be named player of the month. Satisfied, you click back to the game just in time for the ninth inning.

The idea of surfing the World Wide Web on television may be closer than you think. Barry Orton, a UW-Madison communications professor in the Division of Continuing Studies and a national telecommunications expert, says television-based Internet access is just one exciting prospect around the corner for a technology that's already exploding.

Industry types call it convergence: a variety of crossover developments among the television, telephone, cable, computer and entertainment industries. Orton says the latest round of federal deregulation has created a ripe environment for this kind of media crosswiring.

What's on the tube? Soon the Web will be, allowing your television to surf the Web's many guides to TV surfing.

"Convergence was originally talked about as the 500-channel cable universe, which would look a lot like cable now with more channels," he says. "But the Internet model is a lot more exciting. The user is in control of an infinite number of options. It will completely change the idea of mediated, controlled information."

For people who — like Orton and other UW researchers — have developed research and teaching expertise on the Internet, predicting its future may be less exciting than jumping on-line right now. Orton teaches courses on Internet applications to business and academic groups and says present users are watching the technology reach critical mass.

The band width is opening up and modems are moving faster, allowing quality video to be transmitted on the Web. Nearly every major corporation now sports a World Wide Web address to promote itself. Thousands of individuals have satiated their egos with Web pages promoting special interests. Access to education and health care has moved from institutions to living rooms.

Orton says the Internet will certainly change the way we do business, from Web-based shopping to telecommuting. Employees no longer have to be attached to the office to be productive, when they can send documents by e-mail or assemble a work group from home.

We will also see the emergence of a new form of digital currency, allowing us to make transactions and do our banking over the Internet. Orton says the banking industry is currently looking at no less than 10 digital-cash schemes that would allow secure bank transactions via electronic mail.

Things happen at a breakneck pace on the Web, Orton says. The guiding principle seems to be that if people want it, it will happen. One example is using stationary video on Web pages, Orton says. That started a couple years ago with a popular lark called "The Amazing Fish Cam." A guy set up a video camera in front of his fish tank, and sent the image out on his Web page.

It's gone from a joke to a useful service overnight, Orton says. Now, services in several metropolitan areas offer commuters video traffic reports on the Web, with live footage of the most congested sections of interstate.

Perhaps the biggest lingering effect of the Internet, Orton says, is the empowerment it offers people to get involved. People can participate in government and politics in untold ways. A search for Web pages on presidential candidates, Orton says, will produce 10 "unofficial" pages supporting or attacking Bill Clinton and Bob Dole, right next to the freshly scrubbed "official" documents.

"The fact that there's anarchy out there — and you can put out practically anything you want — allows people to be part of things," Orton says. "There's word of mouth on the Net, and 30,000 people a day will find you if you have something interesting to say. It's a blossoming of personal expression, the likes of which we've never seen before."

Q&A

A by-the-numbers look at the factors that make UW-Madison's research enterprise run smoothly.

How much research goes on at UW-Madison?

At any one time, 9,500 research projects are underway at UW-Madison, involving members of the faculty and academic staff, as well as graduate and undergraduate students. While many faculty members receive grants to conduct research, countless others carry on research projects without the aid of grant money.

How much money does UW-Madison receive from external sources for research?

In 1994-95, UW-Madison received $471 million in extramural support — which includes grants from federal and nonfederal sources for all university functions. Of that support, $372.6 million was awarded explicitly for research.

How much money does UW-Madison spend on research?

In 1994-95, UW-Madison spent $369.5 million on research projects. It ranks third nationally among all universities in terms of research expenditures.

How is money from a grant spent?

How grant money is used is specified in each grant, but in general most goes to hire and pay a research team and fund the supplies necessary for the project. A portion of most grants is devoted to research overhead, which includes costs such as utilities and building maintenance and depreciation that the university incurs with research.

How much research funding comes from the federal government?

Nearly $300 million in awards for research came from federal sources in 1994-95. Grants from four federal agencies — Health & Human Services, the National Science Foundation and the departments of Defense and Energy — comprised more than 75 percent of that sum. Health & Human Services accounted for the largest portion, awarding 621 grants worth more than $141 million. *(see graph, next page)*

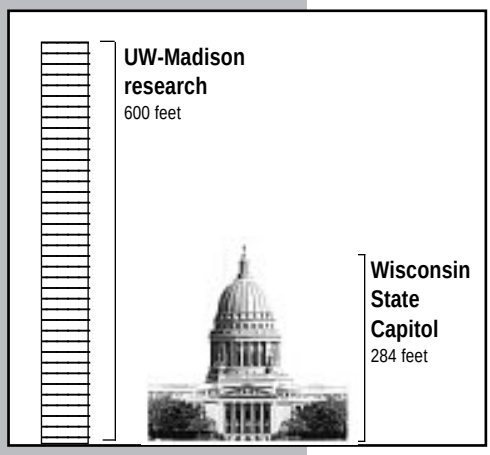
What role does the state play in funding research?

Revenue from the state of Wisconsin plays a vital role in funding all programs at UW-Madison, including research. In the 1997-98 budget, 10 percent of UW-Madison's research allocations come from state general program revenue, totaling $47 million. During the past two decades, the state's share of general program revenue funding has declined. Of the state's research allocations for 1997-98, 46 percent are targeted for the College of Agricultural & Life Sciences.

How competitive is the funding environment?

Competition for grant money is quite fierce. Although UW-Madison is generally very successful in winning grants, nationally only one of every 10 grant applications wins funding.

Towering research



If UW-Madison were to put on paper all the research-related activities faculty and students undertake in a single year, the paper would stack to more than twice the height of the State Capitol.

Q&A *(continued)*

What UW-Madison schools receive the most funding for research?

Three schools — the Medical School, Letters & Sciences and the Graduate School — received more than two-thirds of the research grant money awarded to UW-Madison in 1994-95. *(see graph, facing page)*

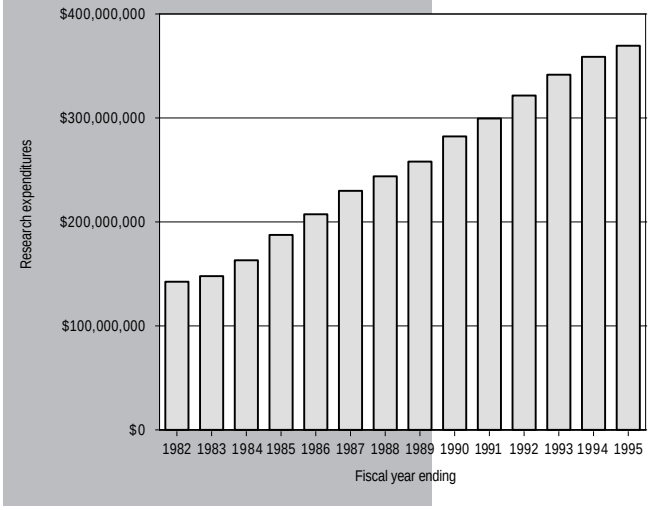
What departments receive the most grant money for research?

The department that received the most research grant money was the Engineering Experimental Station, which received more than $33 million. The departments of physics and medicine were the next largest grant winners, receiving more than $16 million each.

Do all areas of the university receive grant money?

The bulk of funding for research is awarded to projects in the biological or physical sciences, but studies in the social sciences and humanities also win research funding. Of federal money granted for research, 43 percent was awarded to projects in the biological sciences, 46 percent was awarded to projects in the physical sciences, and 11 percent was awarded to projects in the social sciences. Of research grant money from nonfederal sources, 54 percent of grants went to biological sciences, 27 percent went to physical sciences, 17 percent went to social sciences, and 2 percent went to humanities.

UW-Madison research spending



How much money is awarded in a typical grant?

Research grant awards can range from very small — less than $10,000 — to very large — $1 million or more. In 1994-95, 66 faculty members received grants of $1 million or more, but the average grant was much smaller. In particular, nonfederal research grants tend to be small; 31 percent of nonfederal grants received by UW-Madison in 1994-95 carried awards of less than $10,000. Federal research grants, on the other hand, can be quite large: 69 percent of federal grants awarded to UW-Madison in 1994-95 were for more than $100,000. The largest grant received by a UW-Madison researcher in that time was a federal grant worth $11.5 million.

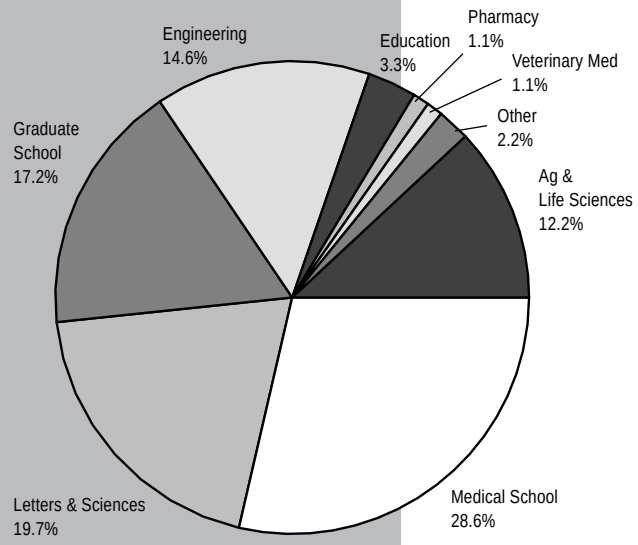
How much has UW-Madison's research enterprise grown in recent years?

In 1984-85, UW-Madison spent $187 million on research projects. Ten years later, the amount of money UW-Madison spends on research has nearly doubled, accounting for more than $369 million in 1994-95. *(see graph, above)*

Has funding for research remained stable over recent years?

Between 1989-90 and 1994-95, awards for research increased by 10 percent a year. In 1995-96, funding dropped significantly. From 1989-90 to 1994-95, federal awards for research increased by more than 13 percent a year, while nonfederal research awards increased by 4 percent per year; both sources have been suspectible to annual fluctuations.

Research grants by school/college



How does UW-Madison ensure that its work is applied to the real world?

UW-Madison's office of University-Industry Relations acts as a matchmaker between researchers and business, finding industry partners for faculty researchers, and vice versa. Researchers also maintain close connections with industry and community through collaborative research projects and participation on numerous boards and committees. Currently, faculty are serving as members of 18 industrial consortia.

UW-Madison also plays a role in helping companies using university research get started in business. More than 60 companies can trace their roots to UW-Madison; many have started as a direct result of patented UW-Madison advances. At the UW's 700,000-square-foot University Research Park, 63 companies, employing 1,800, benefit from UW-Madison collaboration.

How much income does UW-Madison get from the application of research?

The Wisconsin Alumni Research Foundation has obtained more than 800 U.S. patents for UW-Madison work since 1925. The applications of those patents have brought more than $342 million to the university over that time. In 1995, WARF received more than $12 million from UW-Madison patents, making it the country's fifth largest producer of patent income. The income received by WARF is rechanneled into UW-Madison research following federal guidelines.

How do students participate in university research?

Among the most valuable returns of UW-Madison research is its contribution to the university's teaching mission. Undergraduate, graduate and professional students reap benefits from faculty research through better-informed classroom and laboratory presentations. UW-Madison also devotes significant resources to fostering student involvement with research. The Hilldale Fellowship program, for example, enables approximately 100 undergraduate students each year to work with faculty on a research project of their own design. Some 2,300 students participate as research assistants, working directly with faculty as members of research teams in order to fulfill graduate-degree requirements.

Federal research grants by agency