Eco-friendly crop plants

With a $3 million NSF grant, plant biologists are studying how legumes harvest their own nitrogen. The research could help make agriculture more environmentally friendly.
When the Nobel Prizes are awarded in Sweden every December, most Swedes stop what they’re doing to watch the live broadcast on television. And the next day every angle, from who wore or said what to more scholarly topics, is covered by the media—tabloids as well as daily newspapers. The ceremony is a very formal affair, not unlike a coronation. The king and queen preside over the event, which is held in the national opera house. And everyone, from spectators in the back row to the recipients on stage, is dressed to the gills.

You might say the American equivalent is the Academy Awards or perhaps the Super Bowl. To be sure, we have many awards and ceremonies for honoring entertainers and athletes, but our society just doesn’t value scholarly achievements in the same way. It’s unfortunate, because our academic stars are the people who will find solutions to our most pressing problems, not our movie stars and athletes.

Perhaps the only time academia gets a little spotlight in the U.S. is every spring, as colleges and universities nationwide hold commencement ceremonies. Of course most of these ceremonies aren’t broadcast on national television, but they may mean a few seconds on local airwaves. And there is a kind of pageantry, at least for graduates, faculty, and parents, as we proudly send a new group of graduates into the world.

Here at the College of Biological Sciences, commencement means a lot. You might say it’s our own version of the Nobel Prizes or the Academy Awards. Diplomas are not handed out by a king and queen; guests don’t wear tails; and there are no paparazzi waiting on the steps of Northrop Auditorium to snap photos of graduates. But it’s the most important day of the year for faculty, students, and their families. It’s also a time when we pause to take a look at where we’ve been and where we’re going.

This year, Bachelor of Science degrees will be awarded to 261 students. We’re very proud of this group of young men and women. Thirty are eligible to graduate with honors. Many have been accepted into competitive professional and graduate programs around the country. In addition to their studies, they have been active in faculty research laboratories and have found time for involvement in student government, music programs, varsity athletics, and service to refugees and inner-city children. Many have had enriching experiences through exchange programs in countries from Costa Rica to Denmark, Kenya to Japan. They represent our best efforts and hopes for the future of biology.

Added to that, we will present three Outstanding Alumni Awards, an honorary doctorate, and recognize several faculty members for distinguished teaching. You can read more about these awards and their recipients inside this issue.

I don’t know if any of our graduates will go on to win a Nobel Prize (or a Crafoord or Kyoto award for medicine). But I do know that they, along with other bright young people of their generation, will inherit responsibility for solving critical biological problems, from cancer and infectious diseases, to environmental threats, to feeding the world’s growing populations. They are truly deserving of our admiration and applause.

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Dean, College of Biological Sciences
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Frontiers
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CBS will offer a B.S. degree in Biology, Society, and the Environment beginning fall 2002. The interdisciplinary major combines training in biology with an examination of its relationship to society and the relevance of biology to social and environmental problems. Students may choose a theme to integrate their studies. Examples include the global environment; the ethics, economics, and politics of health care; biology and the U.S. government; and communicating biology to the public. Students and advisers will design a program drawing from courses offered throughout the University. This new option is offered jointly by CBS and the College of Liberal Arts and replaces the CLA B.A. degree in biology. For more information, contact John Beatty, program director, at 612-624-6749 or beatty@umn.edu.

CBS News

Good for the Earth, good for the economy

The College of Biological Sciences and Institute of Technology recently published a paper summarizing discussions and conclusions from the November, 2001 program “A Forum on a New Science and New Industry in Minnesota: Biocatalysis and its Synergy with Healthy Ecosystems.” The paper shows how biocatalysis (use of renewable resources and biological processes) can support the ecological health of the Earth and launch a profitable new industry for Minnesota. For a copy of the paper, call 612-624-7705.

Biodegradable products made by Cargill-Dow, Inc. from a polymer derived from corn are cited as an example of biocatalysis in the paper. The polymer, called PLA, was recently approved by the federal government as a new fiber, joining the ranks of cotton, rayon, and polyester.

Tom Soulen, who retires this spring, will end his tenure at the College of Biological Sciences with one of the U’s highest honors—the John Tate Award for Excellence in Undergraduate Advising. The award is given for sustained and substantial contributions to undergraduate advising.

Soulen, who earned B.A., M.S., and Ph.D. degrees at the University of Wisconsin, Madison, came to the University of Minnesota as an assistant professor of botany in 1964. He headed the plant biology department from 1985 to 1988, and has directed undergraduate studies since 1976. Previous honors for teaching include the Horace T. Morse–Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education (1991) and the Stanley Dagley–Samuel Kirkwood Undergraduate Education Award.

“Tom has had a huge impact on undergraduate programs during his 37 years here,” says Kate VandenBosch, head of plant biology. “Being new, I have benefited greatly from his knowledge and feel fortunate to have been his colleague. His value among longtime colleagues and students is reflected in many comments I’ve heard about his integrity, concern for quality education, and emphasis on putting the students’ needs first.”

Soulen says he doesn’t plan to vanish on the day he retires, but will still be on campus some, including several grandchildren who live in town, and will enjoy more time for reading, concerts, theater, and bird watching.

“Nothing glamorous,” he says, but with his wife, Marilynn, visiting about the same time we’re newly looking forward to having more chances to do the things we enjoy.”
Faculty achievements

Tony Starfield, ecology, evolution, and behavior; and Leslie Schiff, microbiology, are among 22 U of M faculty honored at the Distinguished Teaching Award ceremony on April 22. Starfield was recognized for his contributions to graduate education. A mathematical biologist in the Department of Ecology, Evolution, and Behavior, he teaches Decision Analysis and Modeling in Conservation Biology. Schiff, director of undergraduate studies in the Department of Microbiology, received the 2002 Horace T. Morse University of Minnesota Alumni Award for Outstanding Contributions to Undergraduate Education.

Bianca Conte-Fine was named one of two Distinguished Women Scholars for 2002 by the Office of University Women. Conte-Fine, a professor of biochemistry, molecular biology, and bio-physics, conducts basic research on autoimmune diseases. The award is co-sponsored by the Office of the Vice President for Research and Dean of the Graduate School, the Office for Multicultural and Academic Affairs.

Gary Nelsestuen, biochemistry, molecular biology, and biophysics, received an Outstanding Minnesota Inventor award from the Minnesota Intellectual Property Law Association. His design of an anti-clotting protein has been licensed to Eli Lilly as a treatment for septic shock. He has also designed an improved version of clotting factor Vlla that could potentially reduce treatment costs for hemophilia.

Pete Snustad, plant biology, and Michael Simmons, genetics, cell biology, and development, will publish the third edition of their textbook, “Principles of Genetics” in June. The book is in use worldwide as a standard text.

Professor David Tilman honored

David Tilman delivered a lecture on biodiversity at the Bell Museum in February to celebrate his appointment as McKnight Presidential Endowed Chair of Ecology. The lecture, titled “Biodiversity: Optimizing Ecosystem Services on a Human Dominated Earth,” focused on the importance of supporting ecosystems so they will continue to provide essential services such as clean air, water, and food—to meet needs of the Earth’s growing population. Tilman and his colleagues have demonstrated that biodiversity is key to healthy ecosystems. They co-edited a landmark 1997 book, “Principles of Biodiversity,” that is used in ecology courses worldwide.

In memoriam

Magnus Olson

Magnus Olson, emeritus professor of zoology, died March 2 at age 92. Born June 29, 1909 in Sor Fron, Gudbrandsdal, Norway, he immigrated to Minnesota with his parents, Ole and Elen Olson, in 1921. Olson earned his bachelor’s degree at St. Olaf College in 1932, and received his M.A. and Ph.D. degrees from the U of M in 1934 and 1936. He was a member of the zoology department from 1938 until his retirement in 1977, heading the department for 10 years. He was awarded the Horace T. Morse University of Minnesota Alumni Award for Outstanding Contributions to Undergraduate Education.

Olson is survived by Norma Moe Olson, his wife of 62 years, daughter Ellen Stannard, son Stephen Olson, two granddaughters and a great-granddaughter. Olson was a gentle man held in high regard by all who knew him and a talented illustrator, cartoonist and furniture builder. A memorial service was held at Prospect Park Community Methodist Church on Saturday, March 9.
Thomas Morley, who died on February 2 at age 85, was a quiet presence around the Biological Sciences Center, but one who was always keenly aware of his surroundings and worked tirelessly to preserve the natural environment. He enjoyed canoeing and was a generous contributor to the Friends of the Boundary Waters Wilderness.

Morley, a professor of plant biology, knew virtually everything there was to know about local and rare plants, including where to find them. During his University of Minnesota tenure, Morley developed an extensive firsthand knowledge of Minnesota’s native flora. He revised and updated Frederick Clements’ original Guide to Spring Flowers, which is now used as a standard text. With Gerald Ownbey he wrote Vascular Plants of Minnesota: A Checklist and Atlas, another seminal work for the state.

Morley made his name as a plant taxonomist, one who classifies plants according to their evolutionary relationships, but he may have made his greatest contributions by working with the Nature Conservancy to help protect plant habitats, says George Weiblen, an assistant professor of plant biology. “He was deeply concerned about climate change and the disappearance of rare plants and the arrivals of exotic plants,” Weiblen says.

A charter member of the Minnesota chapter of the Nature Conservancy, Morley served on its board during the 1970s. He was active in the Minnesota Native Plant Society. He advocated for protective measures on behalf of rare plants, including the eradication of buckthorn, a nonnative invasive plant, in natural areas of Minnesota.

Morley was born and raised in Berkeley, California. He was active in Boy Scouts, and loved to hike and camp in nearby mountains. During World War II, he was a civilian airplane mechanic.

After receiving bachelor’s, master’s, and doctoral degrees in botany from the University of California, Berkeley, Morley joined the University of Minnesota botany department (now plant biology) in fall 1949 to share in the teaching of taxonomy with Gerald Ownbey, who was then the herbarium curator. Morley was successful in helping recruit ecology professor Eville Gorham and other distinguished faculty, and he advised several graduate students who went on to successful careers in plant biology. He retired in 1987.

Memorials can be directed to the Lake Itasca Biological Station Futures Fund and should be made out to the University of Minnesota Foundation. Send to Janene Connelly, College of Biological Sciences, Room 123 Sturtevant Hall, 475 Gortner Avenue, St. Paul, MN 55108.
Imagine watching the evolution of the world through time-lapse photography. You’re not likely to see that on PBS any time soon, but something of the kind is going on in Claudia Schmidt-Dannert’s laboratory.

Schmidt-Dannert is using what she calls “gene shuffling” or “evolution in a test tube” to speed up evolution and create metabolic pathways that produce new biomolecules for use as drugs and other products.

Although her approach is new in science, it’s a logical extension of what happens in nature. Microbes, plants, and animals produce a rich diversity of chemicals, some of which have been used as medicines for hundreds of years. Isolation and synthesis of chemicals for medicinal and other purposes has only been practiced during the past century. Natural biochemicals are a much better source for new drugs than manmade chemicals, she says, and using biotechnology is also much less complicated and cheaper than chemical methods.

In cells, she explains, biochemicals are created by an “assembly line” or metabolic pathway where enzymes trigger a series of chemical reactions. In nature, genes for these pathways recombine randomly over time to produce new characteristics or activities. But Schmidt-Dannert stirs them up in a test tube and places the new sequences into E. coli cells, which then produce new biomolecules.

“Like human siblings, each pathway gets a different shuffle, so the new molecules are similar but not identical.”

Because she is using genes for these pigments, the “newborn” biomolecules turn the E. coli bacteria a variety of shades of red, pink, yellow, and orange. She is also working with porphyrins, a biochemical that makes blood red and leaves green, and with terpenoids, a large biochemical family that includes cholesterol, plant oils, and taxol.

Dannert, who was named a young scientist to watch last year by U.S. News & World Report, came to the College of Biological Sciences a year ago from California Institute of Technology, where she was a visiting scientist for two years. She was drawn to CBS by the expertise of other faculty in the Division of Microbial Biochemistry, which complements her own skills and knowledge.

“The University of Minnesota is one of the few academic research institutions in the U.S. with a strong focus on microbial biochemistry,” Schmidt-Dannert says. “It has many well equipped research facilities and as one of the big research universities offers expertise in a variety of areas. Also, Minnesota appealed to me because of its people and nature.”

A native of Germany, Schmidt-Dannert earned a Ph.D. in biochemistry at the Technical University of Braunschweig, and headed the molecular biochemistry group at the University of Stuttgart for a few years. Since she arrived at the University of Minnesota, she has won a $1 million equipment grant from the National Science Foundation and a Packard Fellowship for Science and Engineering, which carries $625,000 in funding over five years.

—Nigga Board
If your mother used to tell you to eat your peas, she was in good company. Mothers around the world have long told their children to eat peas and related leguminous vegetables. Whether soybeans, cowpeas, lima, navy, or pinto beans, legumes are definitely an important food. They supply a third of humanity's dietary protein, plus high-quality oils and “phytochemicals” like isoflavones, which may promote heart health.

But did you know that legumes are also good for the environment? That’s because they have the unique ability to provide their own supply of nitrogen through a symbiotic relationship with soil microbes—a process called nitrogen fixation. Legumes grow root nodules that house the microbes, which reciprocate by making nitrogen. That’s significant because the use of nitrogen fertilizers in agriculture is creating a surplus of this nutrient in the environment that’s threatening the stability of the Earth’s ecosystems.

Recognizing the value of understanding nitrogen fixation, the National Science Foundation last year awarded researchers at the University of Minnesota and three other institutions nearly $6 million to study the genome of the barrel medic (Medicago truncatula), a close relative of alfalfa, as a model legume. Half of that amount, $3 million, was awarded to an intercollegiate team of six University of Minnesota researchers in the College of Biological Sciences, the College of Agricultural, Food and Environmental Sciences and the Academic Health Center.

Nevin Young, professor of plant biology and plant pathology, is coordinating the effort. Co-investigators are Kate VandenBosch, head of plant biology; Carroll Vance, agronomy and plant genetics; Deborah Samac, plant pathology; Stephen Gantt, plant biology; and Ernest Retzel, director of the Center for Computational Genomics and Bioinformatics.

One goal is to compile an inventory of the barrel medic's genes and how they work together to shape the plant's interactions with its symbiotic bacteria and pathogens. A second goal is to construct a detailed map of the plant's chromosomes and compare it to the maps of other legumes. The barrel medic, a plant native to the Mediterranean region, was chosen to represent legumes because its relatively small and simple genome makes it easier to work with than other legumes. Insights gained from this and a similar U of M project on soybean genomics will be translated to other economically important crops, leading to more efficient legume cultivation and a feed a growing population.

Each researcher will work on some aspect of how legume genes express themselves at different stages of development, under different conditions or in different plant tissues. For example, if an interesting gene is discovered in peas, the corresponding Medicago gene could be found and studied. Such cooperative interactions have already begun.

"Kate [VandenBosch] and others have identified genes specific to legumes," says Gantt. "Those genes may be involved in the process of nitrogen fixation or interactions with microbes. We’ll try to mutate some of those genes and determine plants that don't express them properly." Then, says Samac, "I will look at changes in the ways mutants interact with microbes to get an idea what the genes do."

Young’s lab has found a gene in Medicago that confers resistance to powdery mildew, an important fungal pathogen of peas. Some day, such findings could guide traditional breeding efforts to improve current crop lines. Alternatively, some crops may be genetically engineered with new genes for resistance or hardiness.

The interaction between Medicago and its bacterial partner, Rhizobium, will receive much attention, says Young. "This interaction teaches us about how
other organisms communicate," he says. "Similar types of communication occur betwen organisms living in symbiotic and host-mite relationships in diseases."

Gantt, a molecular biologist, will investigate the function of the root nodules after they form. Much is already known about this unique cooperative arrangement, including the chemical used by Rhizobium as its "calling card." But plenty remains to be learned about the role of specific genes.

If Medicago is to serve as a model of the legume family, its relation to other legumes must be understood, says Young. To that end, he is pursuing the evolutionary history of Medicago by comparing gene "families" and similarities in organization on chromosomes. He hopes to reconstruct the genetic character of the common ancestor(s) of legumes that lived 50 or 100 million years ago.

The task of sorting through the massive data on DNA sequences and organizing them into genes, mapping the genes, and determining their functions can be done only with bioinformaticist Retzel and his associates. Using sophisticated computer algorithms, he compares raw DNA sequences to sequences of known genes to get an idea of their function. DNA sequences are mapped to chromosomes by finding overlapping parts and fitting them together as one would fit overlapping text on scraps of newspaper to reproduce the original page.

With 160,000 Medicago DNA sequences to deal with, the logistical challenges are formidable. But Retzel also has ways of visualizing the data that not only make relationships among DNA sequences visible, but indicate the strength, and therefore reliability, of matches and comparisons. All the data will be made public through publications and in Web databases.

If the project seems huge, it is. "The major objective is to inventory as many genes as possible to generate a resource for anyone interested in legume biology," says VandenBosch. "We want to get as many cards on the table as we can."

"We hope to find ways to put together agricultural systems that are more environmentally friendly," says Young. "We're constantly aware that this matters for the environment, nutrition, and quality of life issues. It really has an impact."

—Deane Morrison
If you’ve ever been to Cedar Creek Natural History Area, you know why there’s so much pride surrounding the celebration of its 60th anniversary this September. Cedar Creek’s nine square miles of preserved bogs, fields, and forests—a microcosm of North American biological heritage—is where modern ecosystem theory was launched in the early 1940s and continues to thrive today.

Located just 35 miles north of the Twin Cities, Cedar Creek is situated at the convergence of three vast North American ecosystems: hardwood forests, evergreens, and prairies. And within its boundaries there is a wealth of natural features and species, including a rare black spruce bog, a white cedar forest, never-plowed prairies surrounded by oak savannas, and a mile-wide lake.

“There is no place with comparable biological diversity so close to the Twin Cities,” says Clarence Lehman, associate director of CCNHA and chief planner for the celebration. Cedar Creek began to generate excitement when it was spotted from the air in April of 1930 by botany professor William Cooper, who visited the area on foot that summer. Cooper later worked with the Minnesota Academy of Sciences to acquire and preserve the land. One of the most vocal supporters was academy president Cora Corniea, who bought up parcels totaling hundreds of acres and then persuaded local farmers to give or bequeath bog lands to the academy. In 1940, the academy began formal planning to preserve the area and transfer it into the care of the University. And in December, 1942, the academy and the University signed an agreement specifying that the University use the area for natural history research and education.

Over the past 60 years, the University has more than kept its promise. Raymond Lindeman, one of the first University scientists to conduct research at Cedar Creek, in 1942 published a landmark study in Ecology on energy and nutrient cycling in Cedar Bog Lake, titled “The Trophic Dynamic Concept in Ecology,” it is the basis for modern theories about energy flow among plant and animal species within ecosystems.

Sadly, Lindeman, whose health was frail, died the year of publication—only one year after he received his doctorate in zoology. Although he never saw the science he founded develop, his legacy lives on. Today, Cedar Creek is a living laboratory for scientists around the world, including David Tilman, McKnight Presidential Endowed Chair in Ecology, who is a leader in his field. Tilman is celebrating another anniversary—the 20th year of the Long-Term Ecology Research Project, which is funded by the National Science Foundation. Over the past two decades Tilman and colleagues have conducted a series of field experiments to test how our planet’s ecosystems function.

One of that key findings is that a plot of land with many species is more...
tive and resistant to drought, pests, and other stressors than a comparable plot with only a few species. That’s an important discovery because excess nitrogen in the environment is reducing biodiversity worldwide. Although nitrogen is an essential plant nutrient, too much of it allows a few species to take over, which crowds out and weakens ecosystems.

Because of this and other discoveries, Tilman has become one of the most influential ecologists in the world and Cedar Creek, one of the most well-known ecology “laboratories.” According to Essential Science Indicators, Tilman was the most cited environmental author of the decade for 1990-2000. He and his colleagues continue to conduct field experiments at Cedar Creek to learn more about the value of biodiversity and the global consequences of declining biodiversity.

Cedar Creek is also known as the place where telemetry, or radio-tracking, was developed to study animal behavior. In the early 1960s John Testa, then Cedar Creek director, and engineering professor Larry Kuechle used a small transmitter to track movement of deer within the preserve. The transmitter, placed around the animal’s neck, relayed signals via 100-foot towers to computers at the station. The information showed each deer’s home range and movement patterns within that range.

As electronics grew more sophisticated and compact, the technology was adapted for tracking a variety of animals around the globe, including big game in African wildlife parks, whales, dolphins and sharks, seals in the Antarctic, birds, and even bumblebees. The method is used for measuring environmental parameters from oceans to rain forest canopies as well as tracking behavior.

But there’s more to celebrate than the history of Cedar Creek. As a training ground for the next generation of ecologists, its future is equally promising. Each summer 50 or more ecology students work research internships, learning about field study techniques and how to conduct research. The program concludes with a symposium where students present research projects. Several have published papers in journals or made presentations at national meetings.

“Ecology is no longer just a pure science, but has worldwide relevance to the future of our planet,” says Lehman. “We at Cedar Creek are committed to safeguarding that future.”

—Peggy Board

You’re invited to Cedar Creek’s 60th Anniversary party.

Saturday, September 21

1:00 p.m. Commemorative Program, Refreshments, and History Display
2:30 to 5:00 p.m. Tours, Research Update, Radio-Tracking Demonstration, Children’s Nature Adventure.

For further information, contact Emily Johnston at 612-624-4770 or ejohnsto@cbs.umn.edu
hat if dust mites ran your household? That's kind of the way it works in lakes. Minute algae, bacteria, crustaceans, and other creatures do most of the work—capturing energy from the sun, providing food for other living things, and recovering nutrients from waste. To know how a healthy lake functions—and how to heal an ailing one—we need to understand the little living things that play a big role in freshwater ecosystems.

To understand freshwater ecosystems, scientists begin with the smallest members of these communities. Zooplankton, algae, bacteria, and other little living things play big roles in lakes and other bodies of water.

Cruising for copepods

Most people who cruise Lake Superior with a fish finder are anglers in pursuit of the Big One. When Robert Megard goes out with his Lowrance X-16 Echosounder, he's looking for the Tiny Ones. A professor of ecology, Megard is exploring the relationship between water temperature and distribution of copepods—aphid-sized animals that are a key source of food for many of the fish that inhabit the great lake.

In the past, scientists studying the distribution of copepods and other zooplankton—small creatures suspended in bodies of water—have been limited to lowering fine-screened nets into the water at various locations and depths, then counting what comes up. Wanting more accurate measurements than this tedious and relatively imprecise process provides, Megard began a dozen years ago to explore the use of high-frequency sonar to map populations.

He’s had great success. Combining sonar data on copepod distribution with water temperature measurements beamed down from earth-orbiting satellites, he’s been able to prove that the two are closely linked with each of the three species he’s studying favoring a slightly different temperature range.

The results have allowed Megard to ponder potential impacts of global warming on the Lake Superior ecosystem. The species that prefer cooler water would become less abundant, he predicts, while the smallest of the three—“a much poorer food morsel for a hungry fish”—would prevail. “So there’ll be a major shift in the abundance and proportion of the major species,” he says.

Divided chemicals

Lake Superior is the subject of study for other researchers in the Department of Ecology, Evolution, and Behavior as well. Among them is department head Robert Sterner.

“Lake Superior holds 10 percent of the world’s fresh water, and we know so little about it,” Sterner says. He’s doing his share to change that with a long-term study of physical and biological traits at several sites along the North Shore. He and graduate student Tanya Smutka are also looking at the influence of trace metals (such as aluminum and zinc) on phytoplankton—the tiny plants zooplankton graze on.

These studies have practical implications for those who monitor and regulate pollution, manage fish, and so on. But the real appeal to Sterner is what they say about how life-sustaining chemicals are divided among living things and their nonliving environment, the effect that allocation has on species distribution—and, conversely, the effect of...
species distribution on which chemicals end up where.

“What gets me up in the morning is the understanding that different organisms are made of different chemical recipes, and having different chemical signatures, shapes their ecology,” Sterner says.

Sterner and others in the department are studying the concept, known as ecological stoichiometry, at a variety of levels, from glass beakers to entire lakes. Last summer he led a study of key nutrient distribution in six very different lake districts in Minnesota, Iowa, Michigan, North Dakota, and South Dakota. Data he gathered is providing a clearer picture of how factors such as phosphorus and light combine to fuel aquatic ecosystems.

Graduate student Rebecca Forman is using water-filled tubes to look at how zooplankton move in response to the presence of phytoplankton with varying phosphorus contents.

“There’s been a lot of work on how they react to food quantity, light, temperature,” Forman explains. “I’m studying their migratory response relative to food quality.” The results, she says, may shed light on migratory patterns observed in zooplankton in nature—important to understanding lake life.

Love handles

Small as they are, zooplankton are sea monsters compared to James Cotner’s study subjects. Holder of the Moos Chair in Limnology, Cotner focuses on bacteria. It would take about 100 million bacteria to equal the weight of a single copepod. But don’t underestimate their significance. They also are responsible for the bulk of the metabolic processes in lakes.

“It doesn’t take a brain surgeon to figure out that, because they are so abundant and their metabolism is so high, they have a huge impact in terms of carbon cycling and nutrient cycling on our planet,” Cotner says.

The nature and extent of that impact is the focus of much of Cotner’s current research. In lower Lake Michigan, he’s found that, although bacterial decomposers remain active during winter, they tend to let organic matter build up—much as Minnesotans tend to put on a few pounds during the cold season.

The results—soon to be published in a paper titled “Love Handles in Aquatic Ecosystem”—is a large sequestration of carbon in winter, followed by a release during summer months.

In other studies, Cotner is looking at how bacteria affect the movement of mercury out of lake sediments in northern Minnesota. He’s also assessing the bacterial role in the accumulation of PCBs in trout and other predators in Lake Superior. In both instances, the bacteria seem to play a large role in moving the pollutant into the food web, which eventually includes humans.

“They’re fundamental to a lot of what goes on in lakes and food webs in general,” Cotner says. “That’s my soap box.”

— Mary K. Huf
At this instant, somewhere in your body, a strand of chromosomal DNA is breaking clean in two. In another cell, the tightly wound DNA double helix is coming apart and unwinding. But not to worry. Both events happen more often than you might think in the rich and complex life of a chromosome, as do DNA repair and replication.

Given the dynamic character of the average chromosome, it’s no wonder four members of the Department of Biochemistry, Molecular Biology and Biophysics faculty have devoted themselves to unlocking its secrets. Taken together, their work gives a glimpse into how DNA and chromosomes manage—and sometimes fail—to perform the brutally exacting tasks evolution has ordained for them.

A chromosome exists for one purpose: to have its genes “read,” or transcribed. But the cellular machinery that transcribes genetic messages can’t just float up to a chromosome and go to work, says assistant professor Julio Herrera. Chromosomes are more than simply naked DNA; instead, the DNA winds around regularly spaced complexes of proteins called histones, like a string winding around a series of balls. These structures, called nucleosomes, protect DNA, but they also make it hard to get at and transcribe.

“The fact that you limit access to DNA by the nucleosome structure implies a regulatory function for it,” Herrera says. “I’m interested in transcriptional regulation and how the DNA-histone structure is involved.”

In eukaryotes, prying DNA loose from its associated histones is accomplished by molecular “crowbars” composed of large multiprotein complexes. These complexes contain enzymes that chemically modify histones, breaking their grip on DNA. Herrera studies various components of these enzyme complexes in order to understand how they work and how they might be modified to fine-tune their function. For example, drugs that keep the enzyme active may also keep their target genes open and working. And, when the target gene is one that suppresses tumors in humans, this could open another target for antineoplastic (cancer) treatment, Herrera says.

When a cell is getting ready to divide, it must make a copy of its DNA so each daughter cell will have a complete set of genes. The DNA double helix unwinds, and an enzyme, DNA polymerase, uses each of the two separated strands as a template to reconstruct the other strand. The process starts at particular locations, called origins, along the chromosome, and assistant professor Anja-Katrin Bielinsky wants to know how they work. She knows that when replication is about to begin, a complex of proteins—an origin recognition complex, or ORC—attaches to the origin.
"The ORC probably helps to recruit DNA polymerase, and presumably also the enzyme that unwinds the helix," she says.

In both yeast and people, some origins also are the sites where factors that trigger DNA transcription bind. "Origins function better when they have transcription factor binding," Bielinsky explains. "Julio [Herrera] and I look at the structure of these sites. The goal is to understand how binding sites for the ORC or transcription factors contribute to the initiation of DNA replication."

Bielinsky says that a better understanding of origins may one day help in the fight against cancer. In most cancer cells, the ability to turn off DNA replication has been lost, and this commits the cells to endless rounds of division. Disrupting the function of origins could short-circuit this deadly loop.

"We think it's because DNA-PK protects not only broken chromosomes, but the ends of normal chromosomes, and keeps them from fusing to other chromosomes in an attempt to repair themselves," he says. His work has implications for many diseases, including some of the immune system, which must routinely break and rearrange chromosomes to create new antibody genes.

In most cancer cells, the ability to turn off DNA replication has been lost, and this commits the cells to endless rounds of division. Disrupting the function of origins could short-circuit this deadly loop.

"When the strands come together to get repaired, they cross," he says. "The same thing happens in crossing over." In the phenomenon of "crossing over," maternal and paternal chromosomes exchange parts just before the cell divides on its way to producing an egg or sperm cell. Such exchanges result in new combinations of genes.

Whether the chromosomes fragment with their original partners or some new ones, several proteins help bring it about. Livingston has found differences in the functioning of one such protein, depending on whether the process is taking place in cells of the germ line and sperm line or other cells. He is examining its role, as well as those of related proteins, because they play an important role in cancer. But even more, "because I just want to understand how double-stranded breaks are repaired," he says.

This brief sketch barely scratches the surface of these four researchers’ work. The care of chromosomes involves an army of proteins and other factors, and sorting it all out takes a huge effort. But with obvious enthusiasm and dedication, Livingston, Herrera, Bielinsky and Hendrickson are staking out their places in the grand adventure.

—Deane Morrison
Ruth Shuman, biotech entrepreneur

Entrepreneur Ruth Shuman has been described by colleagues as a scientist at heart who is making it in the world of business. Her Plymouth-based company, Gentra Systems, Inc., employs 80 workers to develop and manufacture kits for DNA and RNA purification. Lauded by industry publications for its innovative products and increasing market share, Gentra’s high-tech venture has its roots in Shuman’s experience at the University, where she earned a B.S. in animal science and an M.S. and Ph.D. in genetics.

Gentra now sells its kits in 37 countries and expects the market to grow rapidly in the coming years. Helping the company grow is Shuman’s friend and colleague Ellen Heath, Gentra’s vice president of research and development. Heath also earned a Ph.D. in genetics at the University, where she and Shuman first met as graduate students.

The College of Biological Sciences has an important role to play in the field of genetics, says Shuman. “CBS has been involved in molecular biology from its beginning and that basic research has been the foundation for research that is being done today,” she says.

This spring, Shuman will share her perspective with the newly minted graduates of CBS when she delivers the College’s commencement speech—a fitting way to launch the class of 2002 on its own path to discovery.

Bernice Folz, software design pioneer

Even while she was earning her Ph.D. in biology from the University, trekking through bogs at Cedar Creek to study biological iron oxidation, Bernice Folz nursed a growing interest in computer science. “The broader the education you have, the better prepared you are for the workaday world,” says Folz, whose interest in biology arose from a desire to pursue applied math.

By the time she earned her doctorate in 1973, Folz had already earned an M.S. in business and mathematics and had worked as a systems design engineer for IBM in Milwaukee. She went on to work as a manager at UNIVAC before returning to academia to teach software engineering at St. Thomas University. By 1984, when Folz founded St. Thomas’ innovative graduate program in software design and development, she had long been considered a leader in the field.

Today, the program is among the largest of its kind anywhere in the world. Known for its responsiveness to changing business and technological climates, it draws 500 students each year, most of whom work full-time in related fields. Folz has fostered a global perspective, leading trips to meet with software engineers in India, China, and Cuba. Thanks in part to contacts Folz has made during her travels, 45 percent of the students now enrolled in the St. Thomas program are from foreign countries.
Franklyn Prendergast exemplifies excellence at all levels of research, teaching, and service. “He is a true star among our graduates,” says David Bernlohr, Head

Born in Jamaica, Prendergast earned a medical degree from the University of the West Indies in 1968, and continued his education at Oxford University as a Rhodes Scholar, earning a master’s degree in physiology. Thereafter, he was a resident in internal medicine at the Mayo Clinic and finally a graduate student of Mayo/University of Minnesota. After earning a Ph.D. in Biochemistry from the University of Minnesota in 1977, Prendergast joined the faculty of the Mayo Medical School. Since then, he has served in numerous faculty and administrative positions, including Director of Biochemistry, Director of the Mayo Clinic Cancer Center, Member of the Mayo Rochester Board of Governors, and Member of the Mayo Foundation Board of Trustees. Prendergast has also been very active nationally, with numerous National Institutes of Health assignments and service on a variety of scientific advisory boards and boards of directors. He currently academic appointment is Edmond and Marion Guggenheim Professor of Biochemistry and Molecular Biology and Director of the Mayo Clinic Cancer Center.

As a researcher, Prendergast has made notable contributions in applying fluorescence spectroscopy to the study of protein structure and dynamics, linkages between optical and magnetic spectroscopy, and protein-lipid interactions.

Prendergast also earns high praise for personal qualities. “On a personal level, he is a delight to be with,” says Leonard Banaszak, Dietrich Professor of Biochemistry. “He is a warm, friendly individual who wears his success well hidden.”

“As a minority scientist he has influenced countless students as a role model and mentor,” Bernlohr adds. “He is a tireless worker on behalf of students of color.”

For Regents Professor Emeritus Margaret B. Davis, the most thrilling fossil discoveries lie not in the skeleton of the mighty T. Rex but in humble grains of pollen. By focusing her efforts on the tiniest of fossils, Davis’ groundbreaking research helped a generation of scientists to unlock the secrets of sweeping ecological change.

By examining the fossil record of pollen, Davis pioneered a method for reconstructing the species composition and distribution of ancient plants. She tracked migration and routes of the tree species that spread across the landscape after glacial retreat. She shed new light on the role of disease and disturbance in forest dynamics. And—in a discovery that impacts one of the most pressing issues in contemporary ecology—Davis showed how changing climates cause shifts in the geographical ranges of plant species. Today, this work is considered a vital component in efforts to predict the effects of global warming.

As the world wakes up to the sociological, economic, and political implications of ecological damage, over-exploitation of natural resources, and human-induced climatic change, Margaret Davis’ work, and that with the she has influenced the world over, takes on a new kind of importance,” says Dr. D. Walker of the Australian National University’s Institute of Advanced Studies.

When Davis came to head the University’s Department of Ecology, Evolution, and Behavior in 1976, no one could have predicted the impact her work would have today, not only in science but also on the University. During her years of leadership in the college, Davis is credited with recruiting top faculty and serving as a distinguished teacher and role model. In recognition of these achievements, she has been awarded an honorary Doctor of Science degree.

Franklyn Prendergast, researcher and role model

Franklyn Prendergast

Margaret Davis, groundbreaking paleoecologist

Margaret Davis

—Jennifer Anne
I’d like to volunteer, but I don’t have a lot of time.” This is a common dilemma for many CBS Alumni. We have the perfect solutions—the CBS Career Fair, CBS at the State Fair, and the Alumni Speakers bureau.

This year for the first time, CBS alumni helped out at CBS Career Fair. They were such a hit we’re already thinking about next year. We’re hoping you’ll mark your calendars and plan to join us on February 28, 2003 for this volunteer opportunity. Whether you’re available for the entire day or just one hour over your lunch, this is the perfect opportunity for you to share your experiences with undergraduates and coach them about resumes, job-search strategies, careers, and life after college.

CBS is hosting a booth at the Minnesota State Fair from August 22 through September 2, 2002. Volunteers are needed to staff the booth in three-hour shifts from 9:00 a.m. until 9:00 p.m. Each volunteer will get free admission to the fair, a T-shirt, and the opportunity to interact with the community and be an ambassador for CBS and the U of M.

The new Alumni Speakers Bureau needs alums willing to speak to CBS students about their careers. Volunteers are needed for monthly programs. You can choose to serve on a panel or give an individual presentation.

If you’re interested in any of these volunteer opportunities please contact Emily Johnston at ejohnsto@cbs.umn.edu or (612) 624-4770.

Phil Lawonn (B.S. 1997 Microbiology) volunteers time at the CBS Career Fair.

When you think about what makes the College of Biological Sciences and the University of Minnesota great institutions, what comes to mind? Perhaps it’s the dedication of an inspiring professor, the reputation of a great department, the impact of cutting-edge research, the memory of an educational opportunity that you experienced, or the relationships you formed as a student. Whatever triggers that feeling for you, a gift to CBS will help ensure that future students will be able to share a similar experience.

Last fiscal year, approximately 600 alumni and friends made a financial investment in the College of Biological Sciences students, programs, and faculty. Even small gifts, when combined with others, can make a tremendous difference. For example, alumni and friends who designated their individual gifts to CBS scholarships last year provided twenty-three $1000 awards.

Here are some other examples of how small gifts can help.

$60 covers the materials for students pay for each biology lab course.

$125 covers registration for a student to attend the National Conference on Undergraduate Research to present their research.

$180 covers the average cost per credit for an in-state student.

$350 covers the average cost of books for a semester.

$500 provides a modest scholarship.

$5000 provides a significant annual scholarship.

$5000 provides a highly competitive scholarship.

$5000 provides a meaningful annual scholarship.

Your gift, small or large, enables the College to recruit and retain talented students who may consider attending other institutions. Gifts also strengthen our programs and enable the College to make strides in strategic areas.

Consider establishing a legacy gift in a named endowment. Become a donor to the College through Campaign Minnesota by contacting Janene Connelly at 612-624-7496 (connely@cbs.umn.edu) or Paul Germscheid at 612-624-3752 (pgermsch@cbs.umn.edu). To list your name in the CBS Annual Honor Roll, published in the September issue, we must receive your gift before June 30, 2002. Every gift of cash, credit card, stock, etc., is valued, put to good use, and is very much appreciated.
Welcome to the new BSAS Board Members

Meet the new members of your Biological Sciences Alumni Society board.

Jennifer Seffernick (Ph.D. 1997, M.S. 1982) is pursuing a master’s degree in transcultural nursing at Augsburg College. An associate professor at Augsburg, she will serve on the Board of Directors, French 4.0 Committee, and AAAS, serving in various capacities, including co-chair of the AAAS.

Jeff Carpenter (Ph.D. Cell and Developmental Biology, 2001) is working on the biochemistry and development of the University of Minnesota. He is interested in working with the Board as an active member.

Kip Thacker (B.S. 1976, M.S. 1982) was involved in the biology research program at the University of Minnesota. He was recently appointed as the Head of the Biology Department, and plans to work on the BSAS Mentor Program.

Would you like to submit an Alumni Note?

Folks who have graduated from the University of Minnesota are invited to submit Alumni Notes for future issues of Frontiers.

1. Web submission: visit www.alumniforeum.com and click on “Submit an Alumni Note.”
2. E-mail Alumni Relations Coordinator, Emily Johnston, at ejohnsto@cbs.umn.edu.
3. Mail a written update to College of Biological Sciences, 125 Biophysics Hall, 1450 Gortner Ave, St. Paul, MN 55101.
Career Fair draws 700 students

More than 700 students from CBS, other U of M colleges, local colleges, and area high schools attended the CBS Career Fair on March 1 at the McNamara Alumni Center. Exhibitors included U of M graduate and professional programs, private companies such as Gentra Systems, H & D Systems, Proctor Environmental Consultants, and Peterson Environmental Consultants. Other participants were the Science Museum of Minnesota, Wildlife Rehabilitation Center, Student Conservation Association, U.S. Army Corps of Engineers, U.S. Army Health Care Recruiting, Anoka County Parks, and Hennepin County Medical Center.

UPCOMING EVENTS

All-College Picnic
May 10, 2002, 12:00 - 3:00 p.m., lawn in front of Snyder Hall. Alumni, faculty, staff, and students welcome. Contact: Lija Greenseid at 612-625-7705 or lgreenseid@umn.edu

Commencement
May 18, 2002, 11:00 a.m., Northrop Auditorium. Dr. Ruth Shuman, former and President of Gentra Systems, speaker. Contact: Student Services at 612-624-9717

Rock Around the Block UMAA 2002 Celebration
June 4, 2002, 5:30 p.m., Gateway Plaza. Dinner, live music, entertainment, and plaza grand opening. Tickets are $42 for UMAA members, $57 for nonmembers, and $21 for students.

St. Paul Saints Game
June 27, 5:30 p.m., Intel Center. All-CBS events are free to CBS students and faculty. Family fun for the whole team.

Cedar Creek 60th Anniversary Event
September 21, 2002, 1:30 - 5:30 p.m.
Commemorative program, refreshments, history display, tours, children's nature adventure

CBS at the State Fair
September 21-25, 2002, 1:30 - 9:00 p.m.
Commemorative exhibit in the University of Minnesota building

Second Annual Homecoming Picnic
October 11, 2002, 4:00 - 8:00 p.m., food, prizes, games, hayride around St. Paul campus.

Contact Emily Johnston at 612-624-4770 or ejohnston@umn.edu for information about any of the above events.

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