Families used to worry about how to send their children to college. Now they worry about how to send them to day care.

In Indiana, the annual cost of day care for a child is generally more expensive than a year’s tuition at any of the state’s public universities. For many families, child care is not only their biggest expense, it’s their biggest worry.

It’s also in short supply. Of the estimated 675,000 Indiana children under 12 who need child care, there are licensed slots for only about 60,000—a mere 10 percent. Where are the other 90 percent? Many are cared for in unlicensed settings or by relatives. Some care for themselves.
Not exactly the stuff fairy tales are made of.

Unlicensed care does not necessarily mean poor care, but licensing does provide standards for health and safety. “All children have the same safety and education needs, whether they are in a licensed or an unlicensed situation,” says Judith Myers-Walls, a human development specialist in the Purdue Cooperative Extension Service. “Through training, we can bring unlicensed day care at least up to the same standards as licensed care, which covers the basics—space, health and safety, fire inspections, menus and first aid. Hopefully, we will encourage them to move even further and provide excellent environments for children.”

County Extension educators around the state are working to improve both the quality and quantity of care by helping providers meet licensing requirements and encouraging new providers to enter the field. Educators also are key players in community partnerships formed to address local child care issues.

By the numbers

Due in part to Extension’s efforts, there is licensed child care in each of Indiana’s 92 counties. Until recently, this wasn’t the case. Indiana’s rural areas, in particular, suffer from a lack of child care options.

Nearly a decade ago, Clinton County Extension educator Susan Tharp served on a local child care task force that resulted in the construction of a new
An alternative for teen parents

When Monroe County Extension educator Susan Berg answered the phone one day last winter, the voice at the other end said, “Sue, we need to talk.”

In many cases, this phrase is a signal for bad news. But this time, it was just the opposite. For Berg and Chuck Holloway—the voice at the other end of the phone—this conversation was the start of a joint effort that ultimately would make it easier for teen parents to stay in school.

Holloway is the principal of Aurora High School in Bloomington, an alternative high school for students who for one of any number of different reasons haven’t been successful in a traditional school environment. Aurora provides them with an alternative avenue to success. Several of the 75 students—both male and female—are teen parents.

“For teen parents, the biggest factor that affects attendance is day care,” says Holloway, who had long wanted to start a day care center at the four-year-old school. He found an ally in Berg, who had been working throughout the county on child care issues.

“In Monroe County, finding infant care is a real dilemma, especially for teen parents,” says Berg.

Berg and Holloway collaborated on the plans and together pitched the idea to the superintendent of schools. Holloway found grant money to fund both the center and its part-time director. The center opened last fall with space for four infants.

With an eye on the future, Holloway hopes the center can expand to include toddlers. “It’s a positive thing,” he says. “The teen mom and dad can be in school, and their babies are getting good care. It’s not that I want teen students having babies, but it happens. This gives them an opportunity to finish school and graduate.”

licensed center. Now she is part of another community-wide child care committee to reassess the county’s needs, given the changes in demographics that have occurred over the past 10 years.

To help pinpoint the issues, the committee brought in Purdue’s Center for Families for a needs assessment. “An assessment can identify an individual community’s child care needs,” says James Elicker, Purdue professor of child development and family studies, who led the research team. Elicker’s findings revealed a need for not only more child care, but more child care options.

“The committee is now addressing these child care issues,” says Tharp. The research will be pivotal in establishing a five-year plan, which may include a second child care center, this one near the city’s growing industrial park.

These types of community partnerships are proving that they can bring results. Adams County Extension educator Trisha Hockemeyer likewise has been involved in child care issues in her community. She’s a member of a committee whose efforts led to the county’s first licensed center. After attending one of Hockemeyer’s child care programs, a second licensed provider began offering evening child care for second-shift workers.

Family-friendly employers

With broad-based support from community movers and shakers often comes an emphasis on getting local businesses to “buy in” to child care.

“We’re currently trying to get businesses to help subsidize care,” says Hockemeyer.

“Businesses have an economic interest in child care, particularly firms that employ women and operate around the clock,” says Elicker. “Child care problems cause families a fair degree of stress and absenteeism. Communities can pool resources, collaborate in planning and offer tax breaks so no one company takes all the burden.”
It’s an idea that is gathering support in the halls of government, too. The Indiana Child Care Financing Initiative anted up more than $3 million in state money to support public-private sector partnerships that improve child care and boost business productivity.

**Provider resources**

One of the keys to increasing the number of providers and improving the quality of care is overcoming the “babysitter” stereotype.

“We have this idea that every woman knows how to take care of children,” says Myers-Walls. “Child care is not seen as a profession. As a society, we need to establish reasonable pay scales and make formal training available. We also need to educate parents about what to look for in quality child care. Often decisions about child care are based on cost and convenience rather than quality.”

While the number of children in Indiana who need day care is higher than the national average, the state is below the national average in hourly wages for child care workers. As a result, the field suffers from a higher than average turnover in employees.

Purdue Extension has become one of the state’s most visible providers of training for child care workers.

“Most people get into this business because they are nurturing, and they want to provide a service,” says Nancy Hunter, Extension educator in Boone County, who offers a series of workshops for new child care providers. “But they don’t spend a lot of time on the business part. To be effective for themselves and for parents, they have to operate as a business.”

Hunter also organizes an annual child care resource fair for providers that offers educational sessions. Other community service agencies set up booths to show how they can provide assistance, too.

Adams, Wells and Huntington counties put forth a combined effort to deliver a program called “Achieving High-Quality Child Care.” The series covers safety, record keeping, policies, food safety, nutrition, behavior, family communications, licensing, recognizing and reporting abuse, menu planning and immunizations. Participants take home a binder of the lessons for reference.

In addition to the myriad of programming around the state, Purdue Extension provides free newsletters, educational videos, packaged lesson plans and nutritional guides among its vast array of resource materials.

**Building a network**

A Child Care Network for providers that is part support group and part venue for continuing education meets monthly in Boone County. Darla Williams, a 17-year veteran of the child care business, approached Hunter with the idea two years ago. What started as a core of providers has grown into a thriving group now supported by grant funding.

“It’s a way to network with our peers and displace some of the isolation,” Williams says. “It’s good to have others you can turn to as a sounding board.” At any one meeting, the group can be found working on a range of projects from seasonal crafts to hands-on training with fire extinguishers.

The support the network receives from Purdue Extension and other community agencies helps ensure its success, Williams says. “It gives us a personal sense of satisfaction even though outward attitudes about our profession may be slow to change.”

**A matter of policy**

Public and private sector support is rallying. The statewide Step Ahead process provides a means for social service agencies to forge partnerships and dole out resources in ways that best meet the needs of a community. Through membership on local councils in each Indiana county, Extension educators can help direct funding, as well as collaborate with other community representatives on shared goals.

At the state level, the Center for Families, Purdue Extension and a host of other non-partisan educational groups provide information to Indiana legislators through Family Impact Seminars. These research-based educational sessions provide straight talk on family issues for legislators, legislative staff and other key decision-makers without the bias of lobbyists and special interest groups.

Are these efforts working? Are they enough? Part of the answer will come from Douglas Powell, Purdue professor of child development and family studies, who is evaluating the Indiana Child Care Financing Initiative. Powell is looking at the impact the initiative has had on child care financing and if the private-public partnerships have made a difference in the quality of child care.

For now, though, child care in Indiana is a work in progress, a story in which Purdue Extension is one of the main characters. It may not have a happy-ever-after ending, but, instead, one that is being rewritten daily across Indiana communities.
Solving the mystery of E. coli

by Chris Sigurdson
Alan Oglesby doesn’t like mysteries. That’s because he’s often the state’s principal investigator when people start thinking the reason they’re sick must be something they ate.

Oglesby is a communicable disease epidemiologist for the Indiana State Department of Health. Like a police detective, he depends on the recollections of victims and witnesses. What did they eat? Where did they get it? When did they know that something wasn’t right?

That was the case last May when 27 people in Johnson and Marion counties were confirmed with *Escherichia coli* O157:H7 food poisoning.

“The first cluster of four reports was unusual enough to prompt an alert to ER docs and physicians,” Oglesby recalls. The media had the story early on, and their reports helped flush out victims who hadn’t connected their distress with food poisoning. Staff from both county health departments helped take food histories from the victims and coincidence became conviction when all accounts led to a KFC restaurant in southern Indianapolis.

But what did they eat? “Statistical data pointed the finger at the coleslaw,” Oglesby says. After testing, he had the “smoking gun”—the genetic fingerprint of the *E. coli* in the slaw matched the *E. coli* found in the victims. It turned out that the restaurant had received unusually soiled cabbages from a substitute supplier. To make matters worse, employees were only removing outer
leaves and not washing the heads before shredding—a violation of company policy. “Usually lots of things have to go wrong before somebody gets sick,” Oglesby says.

**Tracing contamination**

Things appear to be going wrong more frequently. Although coleslaw would seem an unlikely host, E. coli O157:H7 seems to be turning up everywhere. There are more reports about it every day, either because there are more incidents or because we’re looking harder for it. Or both.

Called “Oh-one-five-seven,” it’s the virulent strain of an ordinarily innocuous bacterium found inside nearly every warm-blooded mammal.

Although O157 has been found in apple orchards, on alfalfa sprouts and strawberries, in hamburger patties, cups of coleslaw and glasses of tap water, cattle remain the only implicated source.

But why they get it is a mystery, too.

“I don’t think anybody knows for sure,” says John Patterson, a microbiologist in Purdue’s animal sciences department. “We suspect it’s an unusual recombinant, an independent combination of genes that did not occur in the parents. We know how the bacteria is transmitted. Excrement is involved; feed, water supply and nose-to-nose muzzling contact are all ways it can be passed from animal to animal.”

But when scientists have gone looking, the incidence of infected cattle is so rare that a herd that has been a confirmed source of O157 may have only one carrier steer per every 10. Even then, the bacteria may only be present in small amounts, hiding in the lymph nodes or building small populations in the intestine.

Most of the beef-carried infections have been traced back to contamination during slaughter and processing. But the bacteria also becomes a risk to humans when the steer or cow is excreting or “shedding” the bacteria, and the manure is used for fertilizer.

A number of factors can prompt shedding, most of which are linked to animal stress, Patterson says. “Shipping, fasting and commingling of cattle, which produce social order stress, all can decrease the normal digestive process that would reduce pathogens.”

For humans, even a little bit can be fatal.

“Some reports say it only takes 10 cells for an infection versus the millions it takes for some other pathogenic strains of E. coli,” Patterson says.

“It only takes a few to start secreting toxins that tear into the intestinal wall,” says Richard Linton, a food safety specialist with the Purdue Cooperative Extension Service. “The toxins act like miniature PacMans through the intestines and once it gets into the blood, it has access to all the organs.” Most people will notice bloody diarrhea and stomach cramps that disappear after a few days, if they’re fortunate.

Those whose bodies aren’t strong enough to stand up to the microbe are the unlucky ones. Some people develop more severe complications like hemolytic uremic syndrome (HUS), which affects the kidneys and blood clotting system. HUS is more common in the very young and elderly, for whom it can be fatal. Antibiotics don’t seem to help much, and letting the bacteria run its course seems to be the primary treatment.

“There’s no true cure. Your body has to take care of it, and some have a harder time than others,” Linton says. “That’s why the United States got serious about food safety. Kids died.”

**Farm gate to dinner plate**

It’s the first bacterium to be classified as an adulterant, Linton says. “Bacteria are inherent in raw meat; it’s natural. But O157 is so deadly that any contaminated product must be cooked or destroyed.”

E. coli contamination already has meant changes in how some food products are produced or sold. Since O157 can survive in refrigerated and highly acidic foods, foods that depend on preservation methods other than heat can be carriers. Apple cider, for instance, relies on its high acidity to keep most microbes in check, but that won’t work on apples that pick up O157 after dropping in manure-fertilized fields. Now, cider must either be pasteurized or festooned with consumer warnings.

Since E. coli is extremely heat sensitive, cooking destroys the strain. “The guidelines recommend cooking ground beef to an internal temperature of 160 F,” Linton says. Any temperature above 140 will kill it, given enough time to reach the center, but undercooked internal temperatures around 105 degrees will let a population of E. coli double every 15 to 20 minutes.

But the new national emphasis to make food safer from field to fork means more research attention has been turned to stopping O157 at the point of origin and the point of purchase, in addition to the point of preparation.

The national food safety priority, combined with the new state-funded, state-of-the-art Purdue Food Science building, helped Purdue Agriculture earn a $1 million federal food safety engineering program that Linton will be closely involved with.

Linton has several projects under way that use physical and chemical methods of...
Bad bug popping up all over

People might start to feel like they’re being ambushed by a bad bacteria. For a bug that starts out in beef cattle, E. coli O157:H7 bacteria show up in a growing number of implausible places. Centers for Disease Control and Prevention experts estimate E. coli O157:H7 infections may be double what they originally estimated, going from 20,000 cases to 40,000 a year. About 200 people die each year from kidney failure brought on by the ravaging bacteria that they’re catching from a lengthening list of sources.

While beef products remain the primary source of infection, the bad bacteria has shown up in some unlikely places, according to Peter Feng, a research microbiologist with the Food and Drug Administration in Washington, D.C. and a former postdoctoral fellow in molecular biology at Purdue. Several foodborne outbreaks of serotype O157:H7 have implicated unique and seemingly unlikely vehicles of infection, among them fruits, salad vegetables, yogurt and water.

- In fall 1991, an outbreak of O157:H7 that affected 23 persons was traced to the consumption of fresh-pressed apple cider. Although the E. coli in the cider was never fully established, it was suspected that unwashed “dropped” apples had been contaminated by cow manure.

- The first waterborne outbreak associated with the pathogen occurred in Missouri in 1989, according to Feng. Of the more than 240 people infected, 32 were hospitalized and four died. Contaminated drinking water also was implicated in an Alpine, Wy., outbreak last summer that sickened 159 people, with no fatalities.

- Last June, 26 kids were infected after coming in contact with fecal material in a children’s wading pool at a Georgia water park. A 2-year-old girl died.

- A 1993 outbreak in an Oregon restaurant was apparently caused by ingredients from a salad bar, which were most likely cross-contaminated by meat products during preparation.

- An outbreak in the United Kingdom in 1991 that infected 16 persons, 11 of them children, was traced to the consumption of yogurt. Although pasteurized milk is safe, raw milk also has caused outbreaks. A dairy in Wisconsin admitted to using small amounts of raw milk to make contaminated curds, which was implicated in 30 illnesses.

- Person-to-person contamination happens, too. Daycare centers have been rocked by multiple outbreaks that were tracked back to sandboxes and modeling clay. People who change diapers also are at risk, both of catching the bug and spreading it.

bacterial destruction. Although pork has yet to be implicated as a source of O157, Linton thinks it’s only a matter of time. He and Purdue animal scientist David Gerrard have been experimenting with using ultraviolet light to reduce salmonella and E. coli contamination on pork carcasses. Early results show that hitting the carcass with a dose of UV light could act as a surface microbial agent, killing most of the exposed bacteria.

Small apple cider producers, who can’t afford the pasteurization equipment the government says they need, may be heartened by a new method that kills bacteria without heat. Linton and fellow food scientists John Floros and Lise Dock have found an effective combination of preservatives and an acidifier that can make cider safer. “We hope to make it easy and affordable,” Linton says of the experimental method. “A producer could drop this little seltzer pill in, let it sit, then you’re good to go.”

Linton also is testing machines that use ozone to destroy bugs just before the plate leaves the kitchen. Batches of food are placed in machines that surround it with ozone, a form of oxygen that bacteria can’t tolerate. If deemed effective, the manufacturer soon could have processor, restaurant and home models on the market.

Researchers also are looking at feeding protocols to cut down target bacterial populations, as well as ways to reduce animal stress to prevent bacterial population explosions and shedding. “With this particular organism, we need to reduce the risk at the source,” Linton says. “Animal well-being becomes human well-being.”

Patterson is working to find some ways to prevent bad bacteria and promote the good ones in pigs and cattle. Called “competitive exclusion,” the good bacteria, which could actually produce vitamins rather than toxins, would inhibit bad bacteria by competing for space in the intestine, stimulating the steer’s immune system and snatching up nutrients. “Think of it as bacteria wars,” Patterson says.

But the adjustments may go deeper than just animal feed, says Mike Boehlje, a Purdue agricultural economist.

“Food safety is going to be one of the majors forces for changing the way we farm,” says Boehlje, who travels the country telling business leaders and bankers what’s probably in store for production agriculture.

He points out other segments of the industry that have found their own market-driven methods for getting the quality they want, whether it’s bacteria-free beef or perfect potatoes. “Frito-Lay used to buy their potatoes from 900 growers. Now they buy from 60, and I think we all know that the demand for chips didn’t go down.”

What happened was Frito Lay tightened up its requirements, and 60 saw the writing on the wall.

The lesson for livestock producers, he says, is that new trace-back procedures may make cattle processors very picky. “You have to wonder what the 840 growers who aren’t selling to Frito Lay are doing.”

Agricultures
The Oct. 29, 1998, launch of the Space Shuttle Discovery carried the hopes and dreams of Americans everywhere, embodied in 77-year-old astronaut, politician and hero John Glenn.

It also carried the hopes and dreams of Rick Vierling.

Aboard Discovery was Vierling’s experiment that tests a gene delivery process designed to insert new genetic material into soybean plants. It was one of 83 experiments conducted during the mission.

Vierling, director of the Indiana Crop Improvement Association’s Genetics Program and a part-time agronomy professor at Purdue, and Steven Goldman, a University of Toledo biologist, had been preparing the experiment for space flight for six months. Vierling approached NASA’s Commercialization Center in Madison, Wisc., in February, 1997, hoping for a shuttle flight sometime in 2000.

In January, 1998, NASA decided the experiment had enough promise to bump it up on the timeline. Vierling’s experiment was listed on the manifest for STS-95—Glenn’s historic return to space.

But the new schedule gave Vierling and Goldman less than six months to get the experiment approved and in a format that would allow the payload specialist (Glenn) enough time for training.

“We had to do two years’ worth of research in six months to meet NASA’s deadline,” Vierling says. “I didn’t know the federal government could move that fast! It really put me under the gun. I had planned on 18 to 20 months to get the background information so that we could correctly design the experiment.”

The actual launch of the shuttle was a momentary respite from the rigorous schedule Vierling had endured for the previous six months.

Glenn performed Vierling’s experiment on Nov. 1, sometime after 10 p.m. Back on
the ground, NASA woke Vierling and relayed the good news: the experiment had gone off without a hitch.

“How many people can say an American hero and former U.S. senator acted as their lab technician in space?” asks Vierling. “John Glenn performing my experiment came as a complete shock to me. If I had written a scenario myself, it would not have been this good.”

The experiment sent 1,000 soybean seedlings into space, each wrapped in wet paper rolls. Each soybean had been injured so that when it grows, it becomes susceptible to the bacteria that causes knobby plant tumor, crown gall.

In the microgravity of space, Vierling hopes the bacteria can more easily reach the injured area of the soybeans. On earth, the gene transfer process transforms one plant for every 1,000 attempts. If researchers are able to increase the gene transfer success rate, well, the sky won’t even be the limit.

“If this works, it will affect everybody,” Vierling says. One of the first applications could be an arthritis vaccine for humans,
Vierling says. “We have the genes and the vectors in the lab right now, ready to go. We just have to get them into the soybeans. The pinchpoint is the transformation to soybeans. If we can increase the transformation rate, it will open up a whole new era for soybeans.”

After returning from space, Vierling’s beans were grown into plants at the University of Toledo greenhouse. The seeds will be harvested late this spring and returned to Purdue. Vierling and his staff will then determine the success of the experiment.

That is where the final frontier of space becomes critical.

“The bacteria we are using is mobile, it swims,” Vierling explains. “We know from previous experiments in space that it is much easier to move in microgravity. The bacteria should be able to move much easier in space.”

Vierling had some difficulty just getting the bacteria on board the Discovery’s mid-deck locker. Commercial airlines would not let him ship certain chemicals and the bacteria to the Kennedy Space Center.

“No genetically modified organisms are allowed on planes,” Vierling says. “People get nervous when you talk about genetically modified bacteria, even if it is a naturally occurring plant pest, not a human pathogen.”

Undaunted, Vierling rented a van, loaded his family and experiment on board, and headed south.

“Since we had to load the shuttle 36 hours prior to liftoff, we had to do a lot of experimentation with individual bacteria colonies on their growth rate,” Vierling says. “We had to estimate how much we needed to put in the culture so that it would be the right proportion when it came time for Glenn to do the experiment in space.”

Vierling found that they needed to put more bacteria in the culture than originally planned. A late night call to a NASA toxicologist in Houston gained the necessary approval to alter the concentration level of a second chemical, just prior to loading. All of this added up to a 19-hour day for Vierling and Goldman. “We were definitely busy,” Vierling says.

Given the short amount of preparation and the lack of available background information, Vierling says he is cautiously optimistic about the experiment results.

“Something like this has never been performed in microgravity,” he says. “There isn’t a wealth of background information for us to go to and say this may happen or this might not happen. We’re basically flying blind. Things may not go as we expect, so we can’t get too excited yet.”

But Vierling hopes that this chance of a lifetime will pave the way for more experiments on board future shuttle flights. “If this shows some positive results, I would hope that I could have an experiment a year on board the shuttle.”
At the Kennedy Space Center in Florida, the space shuttle doesn’t go up until NASA knows where its exhaust will come down.

NASA engineers have authority to scrub a launch if conditions aren’t right—a weighty responsibility that requires a great deal of confidence in the computer-based geographic information system (GIS) they use.

Bernie Engel, a Purdue University agricultural engineer, helped develop the GIS system for the National Aeronautics and Space Administration.

“Right next to the launch area is Merritt Island National Wildlife Refuge, which is visited by more than a million people a year,” says Engel. “NASA is very careful about not messing up, not letting harmful deposits accumulate there, as well as protecting the people who come to watch the launch.”

A few hours after a shuttle goes up, spent fuel from the solid rocket boosters falls back down. Much of what falls is an acid cloud—in concentrations low enough that it won’t hurt spectators, but high enough that repeated launches could alter the local environment, which is home to more than 20 threatened or endangered species. NASA monitors the deposits and limits the number of launches from each pad to prevent environmental damage.

For years, NASA has used a computer model to figure out where deposits may fall. But three years ago, during a six-month sabbatical to study environmental issues at Kennedy Space Center in Florida, Engel noticed that NASA engineers were using photocopied maps to plot their estimates. One of the pioneers in GIS technology, Engel convinced them to move to a GIS computerized mapping system.

With GIS, researchers can pull together data on weather, land use, topography and wildlife into one computer system. With all the data integrated, launch personnel easily can estimate how a change in something like wind velocity or launch location will affect where the acid cloud will fall. Also, GIS computer maps of data are more accurate than the paper ones that NASA had been using.

“Distance estimates made using the paper system could easily be off by thousands of feet,” Engel says. “GIS gives a better estimate of where the hydrochloric acid cloud will fall and removes some of the chance for human error.”

GIS is utilized continuously during the 8-10 hours prior to the launch by using data gathered from weather balloons to predict where the cloud will land. This information is then intersected with the location of buildings, visitors and wildlife. “After the launch, the acid cloud is mapped to test the accuracy of the software,” Engel says.

Burton Summerfield, pollution control officer for Kennedy Space Center, pushed to make the change as soon as he saw the advantages of Engel’s suggestions. Engel helped set up the new system, which NASA has used for the last year and a half.

“Bernie has taken our existing model and integrated it to allow for better prediction of the environmental effects,” says Ross Hinkle, chief scientist for Dynamac International Inc., a company that contracts with NASA for life science support. “We can get almost instant feedback on what the environmental effects might be.”

NASA still calls on Engel when it needs help tweaking the system. In fact, engineers for the space agency called him in October as they prepared to send Discovery into orbit.

“Just when I was teaching my Purdue GIS class about GIS programming,” Engel says, “they called and said they needed help with the same issues the class was studying.”

In fact, Engel’s students use the same GIS programming to design class projects. And with NASA as a model, what better example of practical application could there be?
“It is not the answer that enlightens, but the question.”

- Eugene Ionesco, playwright
Papers rattle in the lecture hall as students jot down notes. Feet shuffle. The professor describes oxidation-reduction reactions. Students ask a few questions, then go home to study their textbooks and prepare for the test on Friday.

This is a part of learning that we’re all familiar with—but there is more to education than lectures, textbooks and tests. And Purdue Agriculture professors are trying to make sure that their undergraduate students “get it.”

“Textbooks are full of answers—and it’s important to know some of them,” says Karl Brandt, associate dean and director of academic programs for Purdue Agriculture. “But it’s also important to know how to ask a good question that leads you someplace new. That’s what you do in a research experience.”

Together with the faculty, Brandt is making sure students learn how to ask good questions rather than just give answers. During the past 10 years, 46 undergraduate and high school students have coauthored research papers with Purdue Agriculture professors. It’s the kind of opportunity that Brandt would like to provide every School of Agriculture student.

Each year, he offers grants that encourage faculty to work with undergraduates in laboratory settings. “I think it’s a very good thing, even if students don’t plan a career in science,” he says. “Every citizen needs to have an understanding of the process of discovery. From time to time, it helps us to understand why what we once thought we understood, turns out not to be true.”
Ryan McCarthy, Megan Sullivan and Jessie Keith are just three students who’ve gone beyond textbooks to ask questions in the lab.

“How do plants produce lignin?”

Ryan McCarthy couldn’t wait to get into a research lab.

“That was one reason I came to Purdue,” says the biochemistry major. He worked hard, did well in classes—and made it a point to see Karl Brandt.

“Dr. Brandt told me to talk to Klaus Herrmann, who offered me work in his laboratory the summer after my sophomore year,” McCarthy says. “I’ve worked there every semester and every summer since then.”

McCarthy’s asking how, why and when plants produce lignin. The answers to these questions someday could help plant breeders produce plants that are more useful to farmers, vegetable producers or foresters. But right now, he is reaping the benefits, learning things he’ll use later.

“There has been a common theme running through my research since the beginning,” he says. “I’ve been studying amino acid biosynthesis. I’m specifically studying an enzyme in the pathway that bacteria and plants use to produce aromatic amino acids.” The enzyme he studies is key in the production of lignin, compounds that stiffen plant stems and protect them from decay.

“All the techniques that we use in the lab are ones that are used across the board—like recombinant DNA technology and basic enzyme analysis,” he says. In the process, McCarthy’s gaining a set of skills that he plans to use when he leaves Purdue to pursue a career combining research and medical school.

“My goal is to study the disease process in humans,” he says. “These types of techniques allow us to manipulate genes, to figure out what’s going on, and then, hopefully, learn how to fix problems.”

Megan Sullivan is asking questions about water quality at the man-made wetland that collects run-off at Purdue’s Kampen Golf Course.

“It’s more interesting than classes in that I get to decide more of what I want to do,” says Sullivan, an agricultural and biological engineering major. “Right now, I’m getting a lot of background information and talking to people from across campus. Then, I’ll be out doing field work.”

Field work for Sullivan means sampling the water that runs off the golf course into a series of filtering ponds. She’s trying to discover just what makes the constructed wetland work.

“I’ll be looking mostly at microbial action in the constructed wetland, looking
at the variability and testing it to see how effective the system is in different seasons,” she says. “I’ll see where microbial activity is most concentrated and then try to find out if that’s cleaning out the nitrates.”

Sullivan hopes her work will help her get into graduate school. Of that, her advisor, assistant professor Rabi Mohtar, has no doubt. Like Karl Brandt, Mohtar’s sold on the benefits of undergraduate research, and not just to put on a graduate school application.

“Energetic students need an experience where they’re not limited by the formats of a classroom and textbook,” Mohtar says. “They need to be able to explore.”

Sullivan also hopes the experience eventually will help her land a job with an organization like the Environmental Protection Agency, Indiana Department of Environmental Management or Natural Resources Conservation Service.

“I want to work directly with farmers to improve water quality and to stop erosion,” she says. “Eventually, I might like to work in consulting, then get a Ph.D. and become a professor.”

Megan Sullivan and agricultural and biological engineering professor Rabi Mohtar: Their research takes them to Purdue’s Kampen Golf Course to discover how wetlands work.

“What waxes protect hostas from pests?”

Horticulture major Jessie Keith asked herself and her advisor, assistant professor Matthew Jenks, how she could best prepare for a career in public horticulture.

“After graduate school, I’m interested in being a curator of plant collections in a public garden,” Keith says. “These days, curators are doing more research.”

Keith had signed up for a course in public horticulture without really considering lab work. Jenks convinced her to spend the time researching a problem that was eating away at the hosta industry.

“Hostas are popular perennials today,” Keith says, “and hosta buffs are complaining that they’re having a bigger and bigger problem with foliar nematodes.” Nematodes and slugs chew up and destroy hostas.

Some varieties of the plant get eaten up more than others. Keith analyzes the natural wax coating on hosta leaves, looking for a clue to the resistance some plants show.

“Hostas produce many different wax types,” she says. “We’re trying to find out what wax types help resist the pests.”

Keith and Jenks also plan to genetically transform some hosta plants in the laboratory—to move genes for wax production from Arabidopsis thaliana, a plant in the mustard family, into hostas. By watching how hostas react to the new gene, they will learn more about wax production and how they might use genes to improve pest resistance in hostas.

Keith doubts she’ll find all the answers to the problem before she graduates this spring, but that makes the opportunity to pursue the question no less valuable.

“This is the first experience that I’ve had with research in a real situation,” she says. “It should help me get into graduate school. And the thought of going into graduate school and getting thrown into research for the first time was scary. This gives me time to acclimate to that.”

Jenks sees additional value in the undergraduate research experience. “It’s one of the most effective teaching tools we’ve got,” he says. “Students identify a problem, develop a hypothesis, set up experiments to test their hypothesis, collect data, and write up what they’ve done and seen. It teaches scientific method—one of the most important concepts in science.”
“Can there be a place on earth where things are upside down, where the trees grow downwards, and the rain, hail, and snow fall upward? The mad idea that the earth is round is the cause of this imbecile legend.”

— Lactantius Firmianus, tutor, 3rd Century A.D.
Early teachers had a small amount of information and tried, with obvious errors, to produce a view of what the world looked like. The maps of that era were equally off target, with misshapen or missing continents and dire warnings about the dangers that existed in the unknown waters.

Although the concept of the world they came up with is comical now, their ideas of how the world worked were quite reasonable at the time, given the information that they had.

The story of the ancient mapmakers is somewhat like that of the life sciences—biology, medicine and agriculture—for the past 100 years. Just as 16th-century explorers Columbus, Magellan and Cortez brought rapid change to the understanding of the Earth, a new field of biology promises to bring great strides to the understanding of living organisms. The new area of study focuses on an understanding of the genes of living organisms, first by mapping out the structure of all of the individual genes of the organisms, and then by figuring out what all of those thousands of genes actually do. This new revolution in life sciences is called genomics.

The first step

“It’s quite a change to think that any of this is possible,” says Jeff Bennetzen, Purdue professor of biology. “Five years ago, we wouldn’t have even thought about doing these experiments.” However, new laboratory techniques have been developed that allow scientists to make discoveries that seemed impossible just a few years ago.

In traditional genetics, scientists would take a genetic trait that they were interested in, such as resistance to a particular disease, and spend sometimes years looking for the particular gene that caused, or coded, for that trait. (They did this by comparing the genes of an organism that had the trait with those that did not.) In the new world of genomics, however, scientists take the opposite approach. Now they are working to map out the structure of all of the genes of an organism, then going back and assigning functions to each of those genes.

The genomics revolution has been spurred, in part, by new automated machines that can quickly determine the structure of genes. “Before, it might have taken us two years to determine the structure of one particular genome,” Bennetzen says. “Now we expect to do the same region in a couple of weeks.”
Working out the structure of genes is just the first step in the genomics revolution. “The science of genomics as it exists today is still a science of discovery to identify new genes,” says Randy Woodson, director of the Office of Agricultural Research Programs at Purdue. “And then, the real science will begin, in my opinion, because the real science is identifying what these genes do.”

Bennetzen says that when scientists understand all of the genes of an organism, and what each of them does, scientists will have a near complete understanding of how the organism works. “That’s it. That’s biology. That’s why genomics is such a big, blossoming field. Now, we can understand an organism comprehensively. Of course, there are a lot of organisms out there. In the end, what genomics has as its goal is to understand all of the genes in all of the organisms on the planet.”

The idea that we may know all of the genes of all of the organisms on the planet may seem absurd. But, 15th-century mapmakers would have thought the idea of topographical maps for every continent, island and speck of land equally as absurd. But biologists have an easier task before them in making maps of all living organisms than that faced by early cartographers, because, as surprising as it sounds to a non-scientist, the genes of nearly all living organisms are almost identical.

**Viva la difference**

Although the external differences are not subtle, most creatures are very much alike in their genetic codes. Humans and chimpanzees differ by less than one percent in their genes, for example.

“Oh on the surface it would appear that cows and humans are very different,” Woodson explains. “Yet, when one examines the genes that make up a cow, generally, the same gene, or a version of it, is present in humans. The differences are very slight. Take corn and tomatoes as another example. They’re very different plants, but they have a lot in common genetically.”

The reason for this similarity, Bennetzen says, is that nature doesn’t like reinventing the wheel. “Creation of new genes is very rare, maybe happening only a few times in tens of millions of years,” he says.

Scientists call this similarity “genetic conservation.” Once nature finds something that works, it sticks with it, even if the organisms are strikingly different. Twenty or 30 percent of the genes in a human may be the same as the genes in a single-celled organism, such as *E. coli* or an amoeba, because these genes are necessary for any living organism. Likewise, the same gene might be found in both humans and mice but not in corn, which would indicate that that particular gene is necessary for mammals but not for plants.

Nature takes this genetic conservation to some unexpected extremes. The eyes of the octopus and the human are created from different tissues when the body is an embryo, yet scientists have discovered that the eyes in both creatures are coded for by the same genes.

“Twenty years ago, if you had told a biologist that the eyes of a human and an octopus arise from the action of the same gene, he would have thought you were being ridiculous,” Bennetzen says.

“It’s these slight differences in gene structure and function that determine the amazing diversity in organisms,” Woodson says. “The science of genomics will begin to unravel this mystery, opening up untold opportunities for the application of genetic technology to crop and livestock production, as well as to human health.”

Agronomist John Axtell says that it is these similarities that are changing the way scientists look at organisms. “We’re all pretty much alike, but it’s the differences that make the world interesting,” he says with a smile.

### Making maps of plants

Genetic conservation goes beyond just having certain genes in common, though. In the past few years, plant scientists have discovered that if they determine the location of a gene for a specific trait in one plant, another plant in the same family is likely to have the gene in the same place.

Plant scientists have discovered that if they determine the location of a gene for a specific trait in one plant, that another plant in the same family is likely to have the gene in the same place.
For biologists, this will mean that many organisms they used to study genetics in the past are no longer acceptable models. “For years, the two best cytogenic tools for looking at genes were corn and the fruit fly Drosophila, because they both have very large chromosomes,” Axtell says. “Now, all of that extra DNA that made those so useful is a liability. Instead, researchers have gone to work with other organisms that have smaller genomes, such as rice. I’ve been interested in the genetics of sorghum for many years, but I often worked with corn, because the chromosomes of sorghum were so small you’d go blind looking at them. Now, the smaller set of genes makes it much easier to find things at the molecular level.”

Axtell predicts that this use of genomics will greatly speed the development of improved varieties of many crop plants. “All cereals are members of the grass family, and they are all closely related,” he says. “They obviously have a lot of similarity in their origin. Now, all of the technology developed in one cereal will work for all cereals.”

This is especially true for minor cereals that are very important in Third World countries, Axtell says. These minor crops don’t offer financial incentives for large seed companies to develop improved lines, but better genetics may help prevent famine in some of these countries. “For example, tef is a grain that is a staple for millions of people in Africa. We can now take our knowledge of cereals, such as wheat, rice, and corn, and apply that information to tef, which is genetically unknown.”

New Purdue centers

At Purdue, the focus in the field of genomics is on the application of genomics to agriculture. “This winter, Purdue advertised for seven positions in agricultural genomics in five departments,” Woodson says. “That’s an unusually large number of new positions in one area.”

Gene sequencing is the first step in genomics, and Purdue is constructing a major genomic instrumentation facility for high-throughput gene sequencing. This facility received a $1 million grant in seed money from the National Science Foundation, and it will be directed by Bennetzen, one of the nation’s leading experts in structural genomics.

Purdue also received a $2.2 million grant from the National Science Foundation to establish a plant stress research center. The center, which will be directed by Purdue horticulture professors Ray Bressan and Michael Hasegawa, will use the techniques of genomics to locate genes that help plants withstand stresses, such as drought, heat, cold and poor nutrition.

Bressan and Hasegawa have been working on genetic responses to stresses in plants for several years, but this new funding will allow that work to greatly expand. “They’re using an approach called EST, or Expressed Sequence Tags,” Woodson says. “They take a plant that is resistant to a certain stress and one that is susceptible to that stress, then they compare the genes of the two plants to see what the resistant plant has done to overcome this stress. They can then take the genes and put them into the sensitive plant to see if they are able to transfer this resistance trait to other plants.”

According to Woodson, environmental stresses such as heat, cold and drought are the major factors that reduce crop yields. “In the Midwest, we don’t always worry about having plants that are drought resistant, but farmers spend a certain part of every year praying for rain. If you had plants that could withstand drought better, you could put marginal land into full production.”

These new centers promise to change the way life science research is done at Purdue. “This is not a fad. It’s the best way to do biology,” Bennetzen says. “When molecular cloning came on the scene, there were people in biology who said, ‘It’s a fad.’ Now, everybody does molecular biology; nobody is called a molecular biologist anymore, because it has become a part of every biologist’s tool kit. In five years, genomics will be the same way. We expect to see everyone in life sciences move into the field to a degree.”

And, although the sequencing of genes of important organisms is obviously a finite activity, Woodson says that Purdue has a long-term commitment to genomics. “The science of genomics isn’t going to be over tomorrow,” he says. “There will be a five- to 10-year period of intense activity, especially in the sequencing of genes. At that point, we will have come full circle and be back to a point where physiology, biochemistry and other sciences will be needed to understand the functions of the genes and how these processes work.”