Plant Biology News

COLLEGE OF BIOLOGICAL SCIENCES

Plant Biology Department **The Ohio State University** **Volume I – Spring, 2000**

Small Plant Plays Large Role

By Dr. Randy Scholl

The Arabidopsis Biological Resource Center (ABRC) cooperates with the Nottingham Arabidopsis Stock Centre (NASC) in England to collect, preserve, and distribute seed and DNA stocks of the genetic model plant Arabidopsis. This small plant offers many advantages for genetic and DNA studies, including a short life cycle, small quantity of DNA per cell, ease of introducing DNA, and prolific seed production.

Gene Exploration & Biotechnology Development.

Arabidopsis is closely related to vegetable plants such as cabbage and radish, and is also very similar to the crop plant rapeseed grown in the northern U.S. and Canada for its oil. Within the next year the complete DNA sequence of the chromosomes of Arabidopsis (consisting of 100 million individual units) will be determined. The genetic code of this species contains more than 20,000 genes. The availability of this important basic information, in conjunction with the plant's adaptability to extremely compact growth spaces, has placed Arabidopsis in the forefront of gene exploration and biotechnology development.

Recently, several large gene analysis projects (awarded by the National Science Foundation [NSF]) have been

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Dr. Randy Scholl, director of the Arabidopsis Biological Resource Center, and Dr. Luz Rivero observe the tiny dynamo of research: *Arabidopsis*.

Teaching, Research & Service: Biological Sciences Greenhouse Meets Many Needs

By Joan Leonard

What do a pregnant gorilla, a "century" plant and 1,100 visitors have in common? They were all served by the Ohio State Biological Sciences Greenhouse in 1999. Our activities ranged from Y2K preparation, computer system upgrades and expansion of the department's web site to maintaining established service programs.

Century Blooms. One of the highlights of the year was the spectacular blooming of the century plant, *Furcraea Selloa marginata*. The flower stalk alone reached a height of 24 feet!

Ice Cream & Pickles? A craving for banana leaves by a pregnant gorilla lead the Columbus Zoo to call upon the greenhouse on several occasions. The greenhouse was able to make the banana leaves available to the expectant gorilla whose baby was successfully delivered in early March, 1999.

Planting Seeds of Knowledge. Conservatory visits totaled nearly 1,100 in 1999. The majority of visitors were children who had the opportunity for a "hands on" experience to plant a small seedling or seeds that they could take home and grow. Corporate support providing plants and materials make possible this fun and educational experience.

OSU Hospitals Horticultural Therapy Program. The greenhouse provides plants and materials as well as project and curriculum consultation for the Occupational and Physical Therapy Department's horticultural therapy program. Among their projects, horticultural therapy patients make cuttings and

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Posing the Questions and Seeking the Answers

By Dr. Iris Meier

Dr. Iris Meier joined the OSU Plant Biology faculty in October, 1999.

Asking big questions and setting out to find the answers has lead me to a challenging and satisfying career in science. Where did my scientific curiosity begin? As an undergraduate biology student, I was fascinated by the thought that every single cell of an organism—whether a flowering plant or a human being—contains exactly the same number and kinds of genes. And yet the complexity and beauty of a living organism stems from the fact that it is made of vastly different cells, like the cells that form the eyes, skin, liver or brain—or the cells that form the roots, leaves, flowers, and fruit of a tree. I knew that what determines the character of a cell is that, of all its many genes, only a certain number get used or "expressed." For example, skin cells use the "skin genes" to make "skin proteins" which give the skin its special character and make it different from the eyes or the brain.

How Do They Do It?

It occurred to me that to accomplish this organisms must possess a vast, complex and precise system of regulating when and where to express their many genes. How do they do it? What are the signals that tell a cell which genes to "turn on" and which genes to "turn off" and when? How do the genes get to "see" the signals? How do they respond? Big questions. And when my teachers didn't have the answers, I decided that I wanted to be part of the large number of scientists who set out to answer them.

Switch On/Switch Off. As a graduate student, I studied how a simple microorganism, the soil bacterium *Escherichia coli*, manages to switch off and on a single gene: When the bacteria are exposed to the antibiotic tetracycline, they switch on the gene that fights off the drug. When they were not exposed, they saved energy by keeping it switched off. I learned that it required the activity of a specific protein, the TET repressor, to accomplish this. In the absence of tetracycline, the TET repressor sits tightly on the control region of the gene, and thereby blocks its expression. When tetracycline enters the cell, the drug binds to the TET repressor, changes its conformation, and makes it "fall off" the gene. The gene is then expressed and tetracycline fought off.

Higher Organisms. Learning how a simple organism can switch on and off a single gene fueled the next question: How about higher organisms, how about multiple genes in different organs? In my effort to learn more, I moved on as a postdoctoral researcher, first at the Max Planck Institute in Cologne, Germany and later at the University of California at Berkeley. I chose plants as the model system for a complex higher organism. Over the years I have studied how genes in plants get turned on and off in response to attack by pathogens, by light, and by the signals of the specific organ in which the genes are expressed. I have learned that in higher organisms genes rarely respond to a single protein, like the *Escherichia coli* gene, but that they are capable of integrating the information of a large number of signals, the sum of which will determine their on/off state. While this system is wonderful for the organism, providing the large amount of variability necessary, it is also frustrating for the researcher. It is often very difficult and time consuming to unravel all the different signals that speak to a plant or human gene.

Even Bigger Questions. During the past few years prior to coming to OSU, I was a senior research scientist at the Dupont Company, and an assistant professor at the University of Hamburg in Germany. I have begun to ask whether there are any more global, large-scale mechanisms that act on many genes of a cell at the same time. And it seems that this is indeed the case. Presently, my lab studies the mechanisms by which chromatin, the sum of all the genes of a cell, is organized in a three-dimensional fashion, and if and how this organization is involved in determining the expression of genes. We have found specific plant proteins that might be involved in attaching chromatin to the rim of the nucleus, and we are in the process of determining how this specific "shelving" of genes might influence their expression.

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Chairman's Corner

With this issue we inaugurate the first Department of Plant Biology Newsletter. The last two years have brought many changes to the Department. In late 1998 the Department of Plant Biology began a major reorganization of its teaching and research missions. In this issue we highlight some of these changes. As will be evident from the following articles, our teaching and research efforts emphasize new and emerging areas of the experimental plant sciences including cell biology, molecular genetics, physiology, and biochemistry. The research and teaching interests of **Dr. Iris Meier** and **Dr. David Somers,** two new faculty members who are highlighted in this issue, exemplify some of the new programs in plant cell and molecular biology. With the reorganization, the Department also has become the home of the **Arabidopsis Biological Resource Center (ABRC),** an internationally recognized center for plant genetic resources. The activities of the ABRC are described in an article written by **Dr. Randy Scholl**, Director of the ABRC. Faculty and staff commitments to our undergraduate Plant Biology majors and to the nearby community also continue to grow and change. Some of these initiatives are highlighted in the articles focusing on the Plant Biology Undergraduate Student Organization written by **Dr. Jennifer Smith**, and the Plant Biology Greenhouse, written by **Ms. Joan Leonard.**

This year also marks the 25th anniversary of the **Waller Seminar Series** The Waller Seminar Series was established to honor the late Dr. A. E. Waller, a faculty member of the Department. Each year the Plant Biology graduate students host an outstanding speaker in the plant sciences for two days of informal discussions and seminars. Many of the past speakers are members of the National Academy of Sciences and regard the invitation has a highlight of their year. At this writing the schedule for the Waller Lecture has not been finalized. Please see our web site for updates and details as they become available. We invite you to attend the Waller Seminar Series on the occasion of the 25th anniversary.

We hope you find the newsletter interesting and informative. Please contact us with your comments. We can be reached through our web site www.biosci.ohio-state.edu/~plantbio/plantbio.html or by phone at 614-292-8952.

Thank you for your interest in the Department.

Richard T. Sayre, Chair

Dr. Joe Colasanti of PGEC in Albany, CA spoke at the March 2, 2000 Plant Biology Colloquium. His presentation was entitled, "Long distance signals that cause flowering – Analysis of the maize *indeterminate* gene."

Timing is Everything

By Dr. David Somers

Years ago, as a Master's student of ecology in Canada, I worked in the High Arctic studying the control of leaf senescence and dormancy in willow. At that latitude summer is very short—about 2 months—and the sun is up continuously. There was still snow on the ground upon our arrival in late June and we didn't see our first sunset until the third week in August. It was just a little dip below the horizon and then back up again. But by then all of the plants had finished growing and flowering, and most had leaves turning yellow. How did they know that winter was approaching without any cue from the environment, like changing daylength, that plants in the temperate zones use?

Tick Tock. My research today, many years later, involves the study of a timing mechanism in plants that would seem to have no place in the land of the midnight sun. This *circadian* clock is found in almost all organisms and controls many events in plants and animals with a nearly 24 hour rhythm. Since day length is set by the rotation of the earth, sunrise and sunset are very regular and predictable events in most places on the planet. This means that processes that need to happen at about the same time every day, like photosynthesis, could benefit from *anticipating* the optimum time for their occurrence. This is where a timer, like the circadian clock, can be useful. For example, even before the sun rises, the machinery and enzymes necessary for photosynthesis can be assembled so that with the first rays of light the plant can immediately begin to harvest the energy of the sun.

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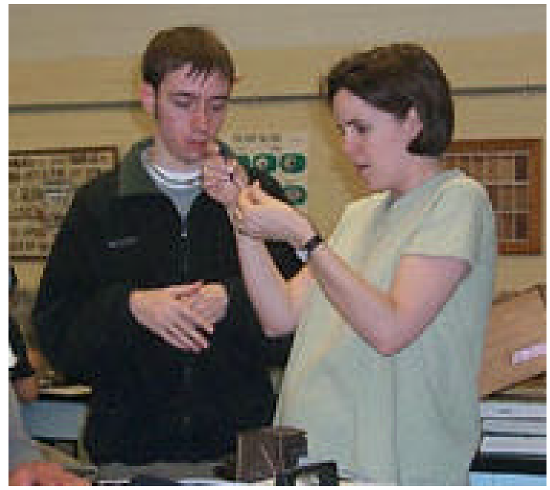
Focus on Undergrads

By Dr. Jennifer Smith

During the past several months, I have been acting as the advisor to the undergraduate majors in the department. In addition to assisting students in developing their course schedules, I have also been working at ways in which to open up new lines of communication between the faculty of this department and the Plant Biology Majors who take their classes. A few times each quarter the undergraduates have been gathering for social events and informal meetings. In addition, the department has been making special efforts to include these students in weekly departmental colloquia, research opportunities and the annual departmental symposium. The response has been positive from the students, many of whom are interested in learning more about future career opportunities and attending graduate schools.

Growing Opportunities. At present the department has 14 declared majors, many of whom are in their final year or two of undergraduate studies. Some of these students are currently applying to graduate schools for such programs as pharmacy and biochemistry, and many are participating in independent research projects mentored by faculty in the department. There also have been a number of students who have expressed a desire to declare a Plant Biology major after taking introductory courses. With these new students, we hope to expand the base of majors in our department, creating a group of students who are more interactive with faculty, more involved in independent research projects, and who ultimately will become the next generation of plant biologists.



Top: Dr. Jennifer Smith works with a student participating in Plant Biology 101. **Bottom:** Students take advantage of frequent opportunities to use the greenhouse as a classroom.

Posing the Questions *from page 2*

I have been fortunate to have both a top-quality industrial research lab and the presence of an excellent and fearless graduate student in my lab. It was this graduate student who, late one night, was the first person to “see” the chromatin-binding protein attached to the nuclear rim as a result of his own experiment. This graduate student has now moved on to become a postdoctoral researcher in a lab in Germany. Scientific curiosity inspires yet another career.

Part of the Solution. Having decided that an academic career would be more satisfying than an industrial one, I joined Ohio State University’s Plant Biology Department in fall, 1999. I was attracted to OSU by the active and dynamic Plant Biotechnology Center and its commitment to growth in the areas of plant biotechnology, plant molecular biology and large-scale genomic research. I am planning to establish a research program that will allow further investigation of the questions being asked throughout the world and to teach some of what I have learned over the years to the next generation of potential scientists.

Possibilities. There is something I have learned that I would like to share with today’s students: it is possible to choose a career in basic science, driven by curiosity and by an awe about the natural world, and to combine it with an attempt to aid in the solving of some of the problems of today’s societies. The present involvement in using the knowledge gained about plant gene organization to improve the technologies of making safe and healthy genetically engineered crop plants is a good example of science having an impact on everyday life.

Outside the lab, I have studied Tai Chi for 7 years, love outdoor pursuits such as hiking, backpacking and swimming, and I am an avid reader.

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And at the end of the day, synthesis of the light-harvesting complex can be reduced and then completely turned off before the sun sets.

Dr. Dave Somers is involved in the study of a timing mechanism—or circadian clock—in plants.

Fast Forward. My lab is involved in searching for the molecular components that constitute the circadian clock in plants. We know from research in other systems that the clock, in part, is made up of events and molecules that alternate between the cytoplasm and the nucleus of the cell. Proteins in the cytoplasm enter the nucleus and turn off the very genes that are responsible for their own synthesis, in addition to others. But over time these proteins are degraded and their production can start up again, renewing the cycle of synthesis and repression. Although this process is simple in concept, just how the cell ends up with a nearly 24 hour cycle is still a big mystery, especially since the clock keeps running even in constant light or dark. We have recently identified a protein that seems to be involved in the destruction of some of these cycling components and are in the process of trying to identify what these factors are. By working backwards, from knowing how the molecules are degraded, we hope to identify and position all the components of the circadian clock in plants.

In the Glow. This work began about four years ago at the Scripps Research Institute in San Diego. There I started in the lab of Dr. Steve Kay with a small, weedy plant called mouse-eared cress that has become a genetic model for studying plant development and physiology. His group had developed a novel way of seeing into the inner workings of the clock without having to destroy or disrupt any cells in the plant. It involves using the enzyme from the firefly that is responsible for making them glow. This protein, luciferase, can be put into plants under the control of the circadian clock. In this way, we can make luminescent plants that glow with a 24 hour rhythm. Using a very sensitive camera, we then monitor mutations in the plant that affect the pace of the clock. In this way, we were able to identify the gene that changed the degradation rate of a component of the clock, since that mutation caused the pacemaker to run about three hours slower than normal. This has been a very powerful way of watching the clock in action, and has been applied to fruit flies to make a very different kind of "firefly!"

Studying Life. It's these kinds of innovations that help make and keep science interesting. Finding out about how the world is put together and functions as a whole is what drives many people to pursue a path in science, but coming up with a new way of answering questions is a key part of the process. This is because novel techniques allow novel questions; ways of asking not possible before, and this is how we discover new knowledge. With numerous new technologies developing, many which marry biology with computer science, there has never been a better time to study life.

Life and Times. My own interest in science began with high school physics, moved through the study of field biology and plant ecology, and has settled on the circadian biology of plants. For some time I combined my enjoyment of the natural world, through hiking and birding, with my scientific curiosity. Carrying spectrometers and gas analyzers to within 1000 miles of the North Pole, I was able to ask the questions I posed at the beginning, while enjoying the spectacle of High Arctic fox, muskox and vast numbers of birds breeding on the lush green tundra. Since that time, though my research venue has moved indoors, the topics have not moved as far apart as I might have thought.

Time Marches On. So how *do* plants in the Far North know when winter approaches? The answer to this question seems to turn on knowing when they first begin growing that season. There seems to be a timer that starts with the beginning of growth, soon after the snow melts from around a given plant. That plant then grows for about 40 days, after which it begins to shut down for the season, dropping its leaves. So plants that start early in the year, finish early, and ones that emerge later from the snow grow a bit longer, but all grow for only about 40 days. But when plants from both locations are moved to controlled conditions back in the lab, all can still respond to shortening photoperiod and drop their leaves early, just like the willows "down south." So there still seems to be a circadian clock in these plants, but it is overridden by the special circumstances of the High Arctic. Perhaps someday we'll be able to apply to their distant cousins in the north what we are learning from a small weed here in my Ohio lab.

ABRC *from page 1*

initiated using Arabidopsis as the subject. The investigators hope to be able to determine the functions of all plant genes. Information obtained from these studies will be used to develop improved crop plants and extend our understanding of cellular processes in plants and animals.

Serving the Worldwide Scientific Community. The ABRC maintains a diverse and expanding array of stocks used by scientists participating in the gene analysis initiatives and other basic and applied research. The Resource Center serves scientists at academic and private institutions around the world. Seed stocks are maintained, including 800 mutant lines, genetic mapping populations and 50,000+ genetically modified lines for gene cloning. The DNA stocks available from the Center include characterized clones of genes, clones for chromosomal mapping, 40,000 randomly selected and sequenced cDNA clones (copied from RNA; termed ESTs), clones used for the Arabidopsis DNA sequencing effort, and DNA isolated from genetically modified plants. In the past year, ABRC distributed 40,000+ samples of seeds and 100,000+ DNA clones to 1,800 researchers on all continents. Information on all ABRC stocks can be found in the AIMS database and the ABRC electronic catalog at http://aims.cse.msu.edu/aims/. The ABRC home page (http://www.biosci. ohio-state.edu/~plantbio/ Facilities/abrc/ABRCHOME.htm) also contains information about the Center and its personnel. ABRC is supported by an NSF grant.

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Greenhouse *from page 1*

do transplanting for the plants that are used in the Plants for Patients program. This program, in Maternal-Fetal Medicine, delivers plants to long-term stay patients transferred to OSU from outlying areas.

Plant Rescue Center. The greenhouse continues its service to the U.S. Fish and Wildlife Service. As a Plant Rescue Center, the greenhouse cares for plants confiscated by the U.S. Department of Agriculture due to noncompliance with import/export requirements under the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

A tranquil scene invites visitors to pause while touring the **Biological Sciences Greenhouse.** 1,100 people visited the conservatory in 1999.