

 The Beginnings: 1965-1978

Anton Lang

Since its inception in the early 1950s, the Division of Biology and Medicine (DBM) of the Atomic Energy Commission considered research with plants essential to its mission. However, it became clear that the plant research programs of AEC (and elsewhere) were lagging behind those in other scientific areas. In 1959, a select committee of plant biologists was convened to re-view the plant research programs supported by DBM. It concluded that plant sciences in the United States were not in a healthy state and that the obvious deficiencies noted in DBM's program would be difficult to overcome because they were a reflection of the general situation. The committee recommended that on-site programs, for example at Brookhaven National Laboratory, should be expanded and that a new, broadly based program should be initiated at one or more universities where student interest in plant research could be fostered. A second ad hoc committee was convened in the fall of 1961 to deal with the latter recommendation.

In addition to concurring with the finding that a university-based program was needed, the second group also established guidelines for the selection of a university where an interdisciplinary research and training program in the plant sciences should be established by AEC. The committee suggested that the university selected should (a) have a demonstrated interest in plant sciences and radiation biology and a strong graduate program; (b) be closely associated with a land grant college; (c) not have rigidly established departmental lines which would tend to restrict cooperative projects; (d) be willing to grant academic tenure appointments to senior staff; and several other administrative criteria. The recommendations for establishing a university-based program that would be firmly integrated with the rest of the university and the criteria for its selection were endorsed by the standing Advisory Committee of DBM in the summer of 1962.

Staff members of the Division subsequently identified and evaluated 42 universities for their breadth and depth in plant sciences and reduced the number of institutions to fifteen. After further study, four of these—the Universities of Illinois, Minnesota and Wisconsin, and Michigan State University—were selected for site visits. On the basis of these visits, during which extensive discussions were held with faculty members and administrators, Michigan State University was considered to have best met all criteria and was invited to submit a proposal. DBM determined that the proposal by Michigan State University was scientifically sound. The recommendation for initiating a multidisciplinary research and training program in the plant sciences relevant to AEC interests was approved by the Commissioners of the AEC and later by the Congressional Joint Committee on Atomic Energy. Based on this, the necessary funds were allocated to this program within the AEC budget, and a contract between AEC and the University was signed on March 6, 1964.

The contract provided for a comprehensive research program in plant biology and related education and training at the graduate and postgraduate levels. The program was to draw strongly on related disciplines such as biochemistry, biophysics, genetics, microbiology, and others, as the need might be determined; it also provided for the construction of a building to house the new facility. Over the past years, other centers for plant research have been created, e.g., the Complex Carbohydrate Center at the University of Georgia,

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Athens, and the Plant Gene Expression Center of the U.S.D.A. at the University of California-Berkeley at Albany. However, it is only fair to recognize that AEC was the first agency to take a major step in this direction.

After the signing of the contract, plans for the Laboratory building were developed and its construction started. Lloyd Wilson, Assistant Professor in the Botany and Plant Pathology Department, was placed in charge of administrative work, which included supervising the building's construction, hiring of some supporting personnel, and purchase of general equipment and supplies. It was thanks to these activities that the PRL's new faculty members could start their research work virtually immediately upon their arrival in East Lansing. I was appointed Director of the MSU-AEC Plant Research Laboratory (PRL) on May 1, 1965, and the first seven faculty members as well as the first graduate students and postdoctoral research associates arrived in 1964–65. Many of the students and research associates came with the new faculty members from their previous locations. When I arrived, the PRL Building was still largely a hole in the ground, and the Laboratory was housed in the Biochemistry Building. However, in July, 1966, we were able to move across the street into our own quarters. The full complement of the faculty, 12 apart from the Director, was reached in 1969, with joint appointments in the Departments of Botany and Plant Pathology, Biochemistry, and Biophysics; later appointments were with the Departments of Crop and Soil Sciences and Microbiology and Public Health.

Klaus Raschke, who later joined the PRL faculty, presented the first PRL seminar on October 11, 1965. In addition to a major weekly seminar series, which mostly features outside speakers, another, more informal series devoted mainly for reports on the Laboratory's own current research, was started later. The first PRL Annual Report appeared in 1967, summarizing research done in 1965-66; the Report has since been published every year to inform interested scientists and institutions of the Laboratory's work.

I have quite often been asked about my “philosophy” in setting up and directing the PRL. The answer may be disappointing since my approach was a very pragmatic one, although it obviously had to be based on some guiding ideas. I will not deal here with the mechanics of the directorship—the actual administrative needs and challenges and the representation of the unit vis-à-vis the higher administration and the scientific community. These are similar in any position of this type and rather self-evident. The only somewhat unusual feature in the case of the PRL is that the Director has to keep two administrations, that of MSU and that of the granting agency in Washington (AEC / ERDA / DOE), happy. The unique challenges to any director who is to develop a research unit “from scratch” are to block out a program, find the people to staff it, and provide optimal facilities and environment so the staff can devote itself full-time to research and training. Once this is achieved, the Director has to monitor the performance closely, seeking to improve it further in the face of a rapidly developing and changing field, recognizing accomplishments, but also recognizing and correcting weaknesses and deficiencies in the program.

Regarding the PRL's research program, it would have been futile to try to cover all aspects and areas of experimental plant biology: selection was necessary and was guided by several considerations. One was to have a balance of work on general biological problems, to be conducted with plants, and work on specifically “planty” phenomena. Plants, animals and microorganisms share many common features: the genetic

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code and how it is “read”, many properties of cell structure and function, certain aspects of development, like the formation of some patterns. On the other hand, both plants and animals have features of their own, with no analogy in the opposite kingdom. It is generally known that only plants (and a few microorganisms) can convert inorganic into organic matter, thus providing the basis for virtually all life on earth (except perhaps some simple microorganisms that have learned to derive the energy needed for their life from inorganic reactions). But there are other striking differences, too. Animals are developmentally “closed” systems; their organs are all laid down early in development, including reproductive organs, none being added later in life. Plants are “open” systems; they keep adding organs, both identical and novel ones. For example, the reproductive organs (flowers) are initiated quite late in the life of many higher plants. Cells of plants are surrounded by walls and grow mainly by uptake of water into special organelles, the central vacuoles. Plants and animals also differ in some general aspects of hormonal regulation, animals possessing numerous hormones with mostly highly specialized activities, while plants manage with a much smaller set of hormones, which participate in the regulation of numerous different processes. Another very important difference between the two types of organisms is their relation to the environment: animals can, at least within limits and temporarily, escape their environment; plants have to cope with theirs “on site.” I considered it important that the research program of the PRL reflected these different aspects of plant biology. Of the first projects, or in AEC term “tasks”, that were created, some focused on problems specific to plants, such as cell growth and its regulation by plant hormones, cell wall structure and composition, and the physiology of flower formation; others addressed general biological problems, such as the regulation of enzyme formation during development and cellular and genetic aspects of hormone action. Of course, this classification of projects was not intended to form rigid dividing lines. On the contrary, most of the projects in one of these categories included elements of the other, and projects in either category included studies on the effects of environmental factors (light, temperature) on the phenomena studied.

Regarding staffing, my prime “philosophy” was to find the right people based on a firm conviction of mine that progress in basic sciences is made by individuals: persons whose work was already clearly at the cutting edge of their problem area or, in the case of younger scientists, persons showing the promise of attaining this stature. The precise type of problem or problems they were studying was of secondary importance as long as it fitted the overall program of the Laboratory. Three corollaries were: The appointees should be able to convey their own enthusiasm for research to their younger coworkers; there should be some overlap in their research activities to ensure a common language; and they should have a broad, non-possessive attitude towards research, being willing to share ideas and undertake cooperative work. These characteristics, especially the second and third, were considered essential to make the unit’s program more than the mere sum of its component projects or tasks.

By the fall of 1965, the following faculty members had arrived at the PRL: Phil Filner (Assistant Professor of Biochemistry) from Caltech; Hans Kende (Associate Professor of Botany) from the Negev Institute of Arid Zone Research, Beersheba, Israel; Derek Lamport (Research Assistant Professor) from the Research Institute for Advanced Studies (RIAS) in Baltimore; John Scandalios (Research Assistant Professor) from the University of Hawaii; Joe Varner (Professor of Biochemistry) from RIAS in Baltimore; Peter Wolk (Assistant Professor of Botany) from Caltech; and Jan Zeevaart (Associate Professor of Botany) from McMaster University in Hamilton, Canada.

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Left to right: Phil Filner, Peter Wolk, Joe Varner, Jan Zeevaart, John Scandalios, Hans Kende, Anton Lang, Lloyd Wilson, Derek Lamport. June 1966

Later additions or replacements were: in 1966, Rainer Hertel (Research Assistant Professor) from the University of Cologne, Germany; in 1967, Michael Jost (Assistant Professor of Botany) from Northwestern University; Alfred Haug (Associate Professor of Biophysics) from Caltech; Klaus Raschke (Professor of Botany) from the University of Giessen, Germany; and in 1974, Deborah Delmer (Assistant Professor of Biochemistry) and Ken Poff (Assistant Professor of Botany), both from the University of California at San Diego.

Turning now to the monitoring part of the Director's job, I tried, of course, as anyone in such a position would do, to keep closely informed of research progress in each of the Laboratory's tasks. However, for a broader basis and greater objectivity, two mechanisms were introduced early in the existence of the Laboratory. One of these was the institution of visiting committees, which consisted of a number of distinguished members of other universities and institutions with expertise in those disciplines currently represented in the PRL program. These committees came to East Lansing at more or less regular intervals—alternating with similar committees appointed by AEC, ERDA, or DOE—spent time with all tasks in the Laboratory and submitted a report evaluating their performance and offering advice and criticism as a form of peer review. The other mechanism were internal reviews to which all faculty members were subjected, junior ones annually, more senior ones at greater intervals, and at which the performance of the faculty member was evaluated on the basis of an oral presentation, publication record, and other criteria. The opinion of graduate assistants and research associates was also sought and considered. Parenthetically, it may be mentioned here that quite early in its history, the PRL included a representative each of graduate assistants and research associates in its faculty meetings (which were therefore called Academic Personnel Meetings) and on all standing and ad hoc committees. This was done before student representation was mandated by the University bylaws and has remained a very positive feature of the PRL "constitution."

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How has this “philosophy” of developing and guiding the PRL worked out? Obviously, this is not for me to judge, but a few comments may be permissible. First, if —perish the thought—I had to do it all over again, some details in the personnel and the mechanics of the Laboratory would be different, but the concepts would be the same. Furthermore, some faculty left while I was still Director, and others have done so since and have been replaced by new appointees. Of the “charter members” of the faculty—those who started their research still in the Biochemistry Building—only four are still on board. Even though we regretted to see our colleagues leave, a steady turnover of faculty is a healthy process, which helps to keep the research program lively and allows for the attraction of new talent. Because of the activities of the “new” faculty and of changes in the programs of the “old” tasks, the overall research program of the PRL is quite different from what it was when our first annual report was published. The most striking increase is in work at the molecular level. However, this molecular work is plant biology driven, and the PRL’s research program as a whole continues to represent a well-balanced and well-integrated cross section of modern plant biology. My impression is that the PRL has evolved but has also stayed the same; my wish is that it will succeed in maintaining this balancing act in the years to come.

At the end of this sketch, it is only appropriate to recognize those individuals to whom the PRL owes its existence at MSU. On the University’s side, the first major factor was the strong commitment by President John Hannah, Vice President Philip May, Agricultural Experiment Station Director Sylvan Wittwer, and the Deans of the Colleges of Natural Science and of Agriculture and Natural Resources, Richard Byerrum and Thomas Cowden, to strengthen plant biology on campus, including construction of the necessary new building. After the contract had been awarded and before a Director was in place, Dean Byerrum and Professors Robert Bandurski (Department of Botany and Plant Pathology) and Edward Tolbert (Department of Biochemistry) devoted a great amount of time and effort to getting the project off the ground. Both helped Lloyd Wilson tremendously, Bob Bandurski particularly in selecting and obtaining supplies and equipment, and Ed Tolbert in supervising the construction of the building. Lloyd Wilson, who continued as a devoted, hard-working Assistant to the Director throughout the developmental phase of the Laboratory, was also instrumental in establishing excellent relations with the various administrative and supportive units at MSU. Lloyd retired in September 1, 1985, but the PRL continues to benefit from his services to this day.

The administration of the contract was in the hands of Howard Grider (MSU’s Contracts Office) and Fred Mattmueller (AEC’s Chicago Operations Office). Their cooperative attitude and flexibility were a great help. On the AEC side, the Director of the Division of Biology and Medicine, the late Charles Dunham and his Deputy Director, James Liverman, conceived the project. Richard Caldecott was specially appointed to evaluate, with assistance of Robert Reitemeier, the various proposals. After the PRL was established, several members of the Division’s staff supervised its affairs: George Duda, Charles Edington, John Kirby Smith, John Totter, George Stapleton and, last but not least, Robert Rabson who, in his capacity as Director of the Department of Energy’s Division of Energy Biosciences, became the immediate “boss” of the PRL in Washington.

The AEC was replaced in 1975 by the broader-based Energy Research and Development Administration (ERDA), and this agency, in turn, by the Department of Energy in 1978. The name of the Laboratory

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changed each time, too, from MSU-AEC to MSU-ERDA to MSU-DOE Plant Research Laboratory. These changes broadened the Laboratory's mandate to look at basic plant processes, especially with regard to the growth of plants as a renewable resource.

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Hans Kende

Anton Lang retired from the directorship of the PRL on June 30, 1978, but remained a regular faculty member of the Laboratory and of the Department of Botany and Plant Pathology until his mandatory retirement five years later. Since no replacement was on board, Hans Kende became Acting Director of the PRL. The transfer of responsibilities was accomplished smoothly and unceremoniously. On July 1, Anton appeared in the office of Hans and handed him a pile of papers pertaining to ongoing business. From then on, he completely removed himself from the administration of the Laboratory. Anton generously offered advice when asked but he never tried to influence administrative decisions of his successors. The main activity during the first year of Anton's retirement from the directorship was the search for a permanent Director. Unfortunately, it was unsuccessful. Even though, we managed to add one more faculty member, Andrew Hanson, to the PRL. Originally, Andrew came from the University of Marseille as a research associate to the Kende lab; in 1979, he was appointed as Assistant Professor, with the Department of Crop and Soil Sciences as his academic home. Andrew chose to work on biochemical adaptations that increase drought resistance of plants. In July 1979, Hans Kende went on sabbatical leave and was replaced by Phil Filner as Acting Director. During Phil's tenure, our efforts to find a permanent Director finally succeeded. Charles Arntzen was recruited from the University of Illinois and assumed his duties on July 1, 1980.



Charles Arntzen

After two years during which the Laboratory was essentially in a holding pattern, Charlie's arrival set into motion a flurry of new activities. First, he brought along an active group of people and a new major field of research, photosynthesis. Second, his arrival coincided with the advent of modern plant molecular biology. Fittingly, the three faculty appointments during Charlie's tenure were all in that field: Barry Chelm (Assistant Professor of Microbiology) came in 1981 from the University of California at San Diego and established a research program in nitrogen fixation; Lee McIntosh (Assistant Professor of Biochemistry) joined us the same year from Harvard University to work on molecular biological aspects of photosynthesis; and Chris Somerville (Associate Professor of Botany) was recruited jointly with the Department of Botany and Plant Pathology from the University of

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Alberta in 1982 to continue his studies on the molecular biology of photorespiration using the new model plant for plant molecular genetics, *Arabidopsis*. Chris was one of the three pioneers who introduced the use of *Arabidopsis* into plant biology, the other two being Maarten Koornneef and Elliot Meyerowitz. To appreciate the PRL's foresight in recruiting Chris to the PRL, one only has to look at the number of scientific articles with "Arabidopsis" in their title. In 1982, there were 20, in 2004 there were 1472. Both Lee and Chris subsequently widened the scope of their programs, Lee starting one on the molecular regulation and function of the alternative oxidase, and Chris on lipid metabolism and the plant cell wall. In all three areas, molecular biological aspects were based on strong biochemical foundations. Unfortunately, Charlie's tenure at the PRL came to an abrupt end when he left in 1984 to take up a position with the DuPont Company. However, by moving the PRL into the new area of molecular biology and by adding three outstanding new faculty members to our group, he left a lasting mark on the Laboratory.

In the wake of Charlie's unexpected departure, Hans Kende was again asked to serve as Acting Director while a search for a permanent director was conducted. When this search proved unsuccessful, he assumed the directorship of the Laboratory. The challenges and opportunities (as administrators like to phrase it) were great at that time. A new wing was added to our building, and the PRL received four new laboratories, an enlarged library, a room full of new growth chambers, and a graphics and photography facility. Even better, we were given the go-ahead to hire four new faculty members in the tenure track. Together with the Department of Botany and Plant Pathology, we were able to offer, in 1986, an assistant professorship to Shauna Somerville. Shauna established our monoclonal antibody facility and started a new task on plant-pathogen interactions. In the first round of our external search, we selected Natasha Raikhel and Jonathan Walton from over 200 applicants. Natasha came in the fall of 1986 as Assistant Professor of Botany from the University of Georgia to build a program in cell biology. Jonathan joined us in the spring of 1987 as Assistant Professor of Botany and Plant Pathology. He came from the ARCO Plant Cell Research Center in Dublin, California, to establish a program on the synthesis and action of host-specific fungal toxins. Pamela Green and Thomas Newman moved from the Rockefeller University to the PRL in the fall of 1988, Pam as Assistant Professor of Biochemistry and Tom as Research Assistant Professor in the PRL. Pam's research program dealt with the molecular determinants of mRNA turnover, and Tom's main contribution became the establishment of our DNA sequencing facility and the production of the first *Arabidopsis* EST library.

Unfortunately, the happy events surrounding the enlargement and rejuvenation of our faculty were seriously clouded by the tragic death of Barry Chelm in September 1987. Barry died of respiratory failure on a camping trip in Wisconsin. In the six years that he was at the PRL, he had built an internationally recognized program on the molecular biology of nitrogen fixation by *Bradyrhizobium japonicum*. At the time of his death, he had a large group of graduate students and postdoctoral research associates, all of whom were able to finish their projects or to move to other laboratories.

After four years of service, Hans Kende stepped down from the directorship of the PRL in the summer of 1988 to devote himself again fully to his research program. He was replaced as Director by Peter Wolk, another "charter member" of the PRL. Very soon, Peter had to face a situation of financial retrenchments, both within the University and at DOE. However, he managed to steer our research programs clear of major financial reductions. In spite of the financial problems, he was successful in filling, jointly with the Depart-

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Peter Wolk

ment of Microbiology and Public Health, Barry Chelm's former position. In the summer of 1990, Frans de Bruijn arrived from the Max-Planck-Institute of Breeding Research in Cologne, Germany, to continue his work on nitrogen fixation and microbial ecology.

Peter Wolk announced his plans to retire from the directorship of the PRL in 1992 and to return to full-time faculty duties at the end of that year. A search was initiated for his successor, and Ken Keegstra, Chair of the Department of Botany at the University of Wisconsin-Madison, was successfully recruited. He assumed his position on January 1, 1993, bringing with him John Froehlich who, in 2003, was appointed research assistant professor. Ken rebuilt his group at the PRL, focusing on two research topics. He continued his work from Wisconsin on the transport of proteins from the cytoplasm into the chloroplast with the aim of identifying the components of the transport apparatus and determining their individual function. His second project reached far back into his career, namely to his dissertation work on the plant cell wall in Peter Albersheim's laboratory at the University of Colorado. The initial experiments resulted in the isolation of a fucosyl transferase that is involved in xyloglucan biosynthesis. This work grew into one of the first group projects of the PRL, and its success led to the award of an NSF genome grant shared with Jonathan Walton and Natasha Raikhel after she had moved to the University of California at Riverside. John Froehlich assumed Co-Principal Investigator status for the chloroplast import project.



Ken Keegstra

Under Ken Keegstra's leadership, the PRL initiated several group projects, which combined the talents and interests of faculty members from the PRL and other departments to tackle difficult and risky research projects. As mentioned above, one of these projects concerned the biosynthesis of cell wall components. Another project, with Frans de Bruijn and Peter Wolk as lead investigators, was devoted to establishing a genetic system for the nitrogen-fixing actinomyces *Frankia*; and Jan Zeevaart, Lee McIntosh, Doug Gage (Department of Biochemistry and Molecular Biology), and Hans Kende established a project on the molecular basis of flower induction. There was a three-year sunset on these projects. Research on the synthesis of the cell wall was continued with funding from the National Science Foundation.

During Ken's tenure as director, the PRL experienced major turnover in its faculty. Chris and Shauna Somerville left in December 1993. Chris assumed the directorship of the Plant Biology Department of the Carnegie Institution of Washington at Stanford, and Shauna became a staff member of the Department. Natasha Raikhel and Frans de Bruijn left in December 2000. Natasha became Director of the Center for Plant Cell Biology and Ernst and Helen Leibacher Chair of Plant Cell Biology at the University of California in Riverside, and Frans assumed the directorship of the INRA-CNRS Laboratory for the Molecular Biology of Plant-Microbe Interactions in Toulouse, France. Pam Green left in December 2001 to become Crawford

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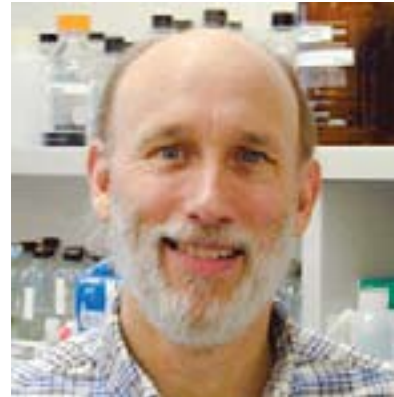
H. Greenewalt Chair and Professor of Plant and Soil Sciences and of Marine Studies at the University of Delaware Biotechnology Institute.



Sheng Yang He



Gregg Howe



Michael Thomashow

In place of the colleagues who had left, a new group of faculty members joined the PRL. Sheng Yang He (appointed with the Department of Botany and Plant Pathology) arrived in September 1995 from the University of Kentucky to start a program on the molecular biology of plant-pathogen interactions, with main emphasis on the type-III protein secretion system in the susceptible interaction between *Arabidopsis* and *Pseudomonas syringae* pv. tomato. In August 1997, Gregg Howe (appointed with the Department of Biochemistry) joined us from Washington State University to continue his work on wound-induced signaling and its function in defense responses against herbivorous insects. In particular, Gregg is interested in the roles of systemin and jasmonic acid in the elicitation of systemic resistance. Michael Thomashow, from the Departments of Crop and Soil Sciences and Microbiology and Molecular Genetics, became a member of the PRL in January 2001. Mike's research program on the molecular basis of cold acclimation had already brought him national and international recognition, and his move to the PRL was a great boost to the overall scientific program of the Laboratory.



Jianping Hu

The search for successors of Natasha Rai-khel and Pam Green resulted in the recruitment of Jianping Hu (appointed with the new Department of Plant Biology) and Robert Larkin (appointed with the re-named Department of Biochemistry and Molecular Biology), both of whom joined us in the spring of 2003 from the Salk Institute in La Jolla. Jianping's research deals with the molecular mechanisms controlling peroxisome biogenesis and communication between peroxisomes and other organelles.



Robert Larkin

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Rob Larkin's research involved plastid-to-nucleus interactions via the control of nuclear gene expression by plastid signals.



Federica Brandizzi

Three faculty vacancies became available in 2004/2005. Two of the founding members of the PRL retired from formal University duties, Jan Zeevaart in the summer of 2004 and Hans Kende at the end of 2005. However, both Jan and Hans continue to be active in the PRL. In June 2004, we mourned the passing of Lee McIntosh, who died one day short of his 55th birthday after a five-year valiant fight against leukemia. During this period, three new faculty members were recruited to the PRL. Beronda Montgomery (appointed with the Department of



Beronda Montgomery

Biochemistry and Molecular Biology) joined us from Indiana University in 2004 and established a research program on the synthesis and role of biliprotein-type photo-receptors in higher plants and cyanobacteria. In *Arabidopsis*, Beronda studies the function of cell- and tissue-specific phytochromes in photomorphogenesis. In cyanobacteria, she investigates the role of biliproteins, which show significant similarity to phytochrome, in chromatic adaptation. Two other new colleagues joined the PRL in the spring of 2006, Federica Brandizzi (appointed with the Department of Plant Biology), a cell biologist from the University of Saskatchewan, and Markus Pauly (appointed with the Department of Biochemistry and Molecular Biology) from the Max-Planck-Institute for Molecular Plant Physiology in Golm, Germany. Federica is a plant cell biologist who works on the endomembrane system using cutting-edge imaging techniques. Marcus investigates the role of non-cellulosic cell wall polymers in the diverse of functions of the cell wall, using molecular-genetic and structural methods.

In 2005, two new group projects were initiated. The first focused on membrane-tethered transcription factors, with Rob Larkin, Christoph Benning, Lee Kroos (both from the Department of Biochemistry and Molecular Biology), Sheng Yang He, Jianping Hu, and Beronda Montgomery as collaborators. The second group project aims at elucidating the proteome in response to biotic and abiotic stress, with Sheng Yang He, Gregg Howe, Mike Thomashow, and Curtis Wilkerson (Proteomics Facility) as collaborators.

Near the end of 2005, Ken Keegstra announced his intention to step down as Director in order to return full time to research and teaching. A discussion of whether to perform an external search for a new director or to seek an internal candidate was decided in favor of the latter path. On November 1, 2006 Mike Thomashow began his appointment as the sixth PRL Director.

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Upon assuming the Director position, Thomashow engaged in discussions with program officers at DOE-



Michael Thomashow

Basic Energy Sciences (BES) regarding the future of the program. He was informed that the Energy Biosciences program, which had funded the PRL, was undergoing reorganization and that the goals of the program would change to focus on fundamental aspects of energy and carbon capture, conversion, and deposition in energy-rich molecules. This new emphasis posed a challenge to the PRL as the research programs of a number of PRL faculty did not directly address this new programmatic theme. Upon extensive discussion within the PRL, and conversations with DOE-BES officers about program policy, a way forward to “evolve” the PRL was formulated: new faculty who worked on various aspects of

energy and carbon capture, conversion, and deposition would be hired and group projects would be developed that address this research theme.

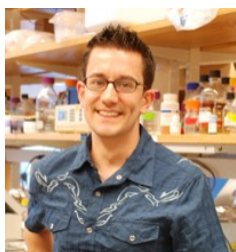
Following the departure of Markus Pauly to the University of California at Berkeley in 2009, David Kramer



David Kramer

joined the PRL faculty as a Hannah Distinguished Professor in Photosynthesis and Bioenergetics (appointed with the Department of Biochemistry and Molecular Biology) in 2010. Dave came from Washington State University, bringing with him a vibrant research group working on gaining a molecular level understanding of how plants and photosynthetic microbes convert light energy into chemical energy and how these events are regulated in response to environmental inputs. Additionally, he brought a vision of establishing a facility that would use novel spectrophotometric instrumentation—developed by David and his colleagues—to monitor an array of photosynthetic phenotypes, such as photosynthetic efficiency and non-photochemical quenching, in a non-invasive, high-throughput manner. This vision became a reality in 2012 with the founding of the Center for Advanced Algal and Plant Phenotyping

(CAAPP), an enterprise largely made possible through a \$5M investment in instrumentation and other infrastructure support by MSU.



Danny Ducat

In 2013, two additional faculty members joined the PRL. Early in the year, Danny Ducat came from Harvard Medical School to establish a research program using biotechnology and synthetic biology to produce novel energy-related and high value products in cyanobacteria and to better understand how photosynthesis is regulated in this microorganism (appointed with the Department of Biochemistry and Molecular Biology). And later in the year, we successfully recruited Cheryl Kerfeld



Cheryl Kerfeld

from the Joint Genome Institute and the Lawrence Berkeley National Laboratory to become a Hannah Distinguished Professor of Structural Bioengineering (appointed with the Department of Biochemistry and Molecular Biology).

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Cheryl's research program incorporates structural and synthetic biology approaches to study the assembly of bacterial microcompartments, carbon fixation, and photoprotection mechanisms in cyanobacteria.

In regard to group projects, the PlaNet (“Plant Bioenergy Network”) project was initiated in 2009. The goal was to “map” the transcriptional regulatory networks that control and optimized energy and carbon capture, flow, and conversion in plants. It involved Sheng Yang He, Gregg Howe, Mike Thomashow, Tom Sharkey and Jin Chen, a computational biologist hired into the PRL in 2009 as a research assistant professor. Then, in 2013, the group project model became the fundamental research model—research teams addressing research themes—for all DOE-BES funded PRL research.

One project entitled “Robust Photosynthesis in Dynamic Environments”, aims to examine the functions of genes and pathways involved in enhancing photosynthetic robustness in an ever-changing environment. Dave Kramer is the Project Lead and the participating faculty include Federica Brandizzi, Jianping Hu, Beronda Montgomery, Tom Sharkey, Mike Thomashow, Jin Chen, and John Froehlich. A second project entitled “Integrating Energy Status, Growth, and Deposition” involves the research groups of Danny Ducat, Sheng Yang He, Tom Sharkey, Mike Thomashow and Jin Chen with Gregg Howe serving as the Project Lead. This research is aimed at understanding how plants and microalgae sense and regulate the proportioning of energy and carbon between growth and other processes such protection against abiotic and biotic stresses. And a third project, entitled “Engineering Subcellular Modules for Photosynthetic Productivity”, centers on structure-function studies of proteins that comprise subcellular the micro-compartments of cyanobacteria. The long-term goal of this research is to allow repurposing of these natural compartments to improve photosynthetic productivity in cyanobacteria and plants. The Project Lead is Cheryl Kerfeld with participating faculty including Danny Ducat, David Kramer, Beronda Montgomery, and Peter Wolk.



Christoph Benning

In the middle of 2014, Mike Thomashow announced his intention to step down as Director and return to full time research and teaching. Another discussion of whether to perform an external search for a new director or to seek an internal candidate resulted in an external search. Following an international search with many outstanding candidates, the next Director was found on the MSU campus. On August 15, almost exactly 50 years after Anton Lang became the founding Director, Christoph Benning became the seventh PRL Director.

Since its inception, the PRL has been an important institution for the training of plant biologists at the graduate student and postdoctoral levels. It has also served as a stimulating place for senior scientists who came to spend sabbatical leaves during which they learned new technologies and approaches, such as Arabidopsis molecular genetics. As of 2015, the PRL had over 900 alumni worldwide, many of whom have assumed important academic, industrial, and governmental positions.