

Twelve Activities to Accompany the Twelve Principles of Plant Biology

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Project Description

We propose to identify, trouble-shoot, assess, and disseminate hands-on, inquiry-based activities that exemplify each of the 12 Principles of Plant Biology that have been developed and widely distributed by the ASPB with support from the ASPB Education Foundation. This project would enhance ASPB outreach activities at our educational booth exhibits, which reach thousands of people each year both nationally and internationally. It would also provide outreach materials for the entire ASPB membership and a ready-made set of inquiry-based plant activities for teachers, students and the community.

Background and justification

The Principles in Plant Biology were developed by the ASPB “to provide basic plant biology concepts for science education at the K-12 levels.” ASPB member Carol Reiss illustrated the 12 Principles in a set of bookmarks, which have become one of our most appealing and popular outreach instruments. The Principles have also been linked with the National Science Education Standards published by the National Research Council (NRC) (see ASPB website). Through the PIs’ years of involvement with ASPB and plant biology education, we have collectively disseminated thousands of 12 Principles bookmarks to K-12 teachers, students and others. At the same time, we have realized that these bookmarks don’t fully support our visions for plant biology education; they’re colorful and appealing, but inherently a passive form of teaching and learning. The constant refrain we hear from teachers is that they have a pressing need for well-constructed (“foolproof”) hands-on inquiry-based *activities* involving plants. We propose to build upon the previous efforts of ASPB members who developed the 12 Principles

and the bookmarks (and upon examples of superb outreach efforts by Paul Williams and others), by identifying, trouble-shooting, assessing, and disseminating a set of 12 activities that allow students to become engaged in the Principles. Initially we will target these activities toward middle school and early high school students, but ultimately modify them for both older and younger students. The PIs have extensive experience interacting with teachers, and developing hands-on and inquiry-based activities for students of all ages.

Proposed work

There are five phases to the proposed work:

1. *Identify* suitable activities illustrating each of the 12 Principles.
2. *Adapt* each activity for the target age group, as needed.
3. *Create* a teacher-guide and student-guide for each activity.
4. *Optimize*, assess, and improve each activity.
5. *Disseminate* the resulting materials.

1. Identify suitable activities illustrating each of the 12 Principles.

Each of us is an experienced teacher dedicated to teaching through hands-on, inquiry-based materials. Materials we have developed on our own, plus the abundant resources available to us through our professional community and the internet, have provided us with a large number of previously developed activities from which to draw our set of twelve. From these pre-established activities, we have begun to identify those that illustrate each principle, are adaptable for use in classrooms (inexpensive, relatively simple and safe), and provide opportunities for student inquiry. Some of these activities are commonly available from multiple sources, while a few unique ones are protected by

limited copyrights but available for educational purposes. Each activity will properly cite significant sources for the ideas.

2. Adapt each activity for the target age group.

Middle school students are familiar enough with plants that they can ask questions and engage in inquiries related to the 12 Principles. At the same time, most middle schools have little access to sophisticated equipment. Therefore, each activity must provide opportunity for experimentation (i.e. be flexible in implementation) within a simple, inexpensive framework. This project is feasible because such frameworks already exist for many suitable activities. We will therefore focus on synthesizing and modifying them as needed to emphasize sound scientific practices of observation, inquiry, and experimentation rather than “demonstration.”

3. Create a teacher-guide and student-guide for each activity.

We will develop teacher and student guides for each activity. Each PI will be the lead developer for four activities (one activity for each principle) during each of the first two years of this proposal. The guides will be revised as needed based on our field trials with teachers and students (below). ASPB member Nathley Ceaser, a middle-school teacher at St. Mark’s school in Brooklyn, ad hoc member of the ASPB Minority Affairs Committee and specialist in inquiry-based learning has also agreed to review our materials.

4. Optimize, assess, and improve each activity.

During the summer of 2008, PI Jeffrey Coker will teach plant biology in a one-month course to middle school and/or early high school students through the Elon Academy at Elon University (NC). Elon Academy is a new program for talented students from under-privileged backgrounds. During the spring of 2008, Jeffrey will work with two pre-

science-teachers (undergraduates majoring in biology and education) to optimize and learn to teach six of the activities. These students will serve as teachers and TAs for this summer course, and will provide ongoing feedback to the PIs. Observing these new teachers as they try to implement the activities is crucial for this project because it will allow us to foresee problems that teachers and students will have and assess effectiveness in a realistic situation. The remaining 6 activities will be optimized, assessed, and improved in Elon Academy during 2009. Jane Ellis will follow the same procedure as Jeff Coker but adapt it to the CHAMPS summer program at Presbyterian College. CHAMPS (Communities Helping, Assisting, Motivating, Promising Students), started in 1995, involves over 150 sixth through tenth graders and represents a partnership between Presbyterian College and the community. Over 80% of the students are on free/reduced lunch programs and come from both rural and urban environments. One component of CHAMPS is an on-campus, residential summer program at PC beginning with the sixth grade students. During the summer of 2008 the middle school students in the CHAMPS program will work with six activities developed the first year. During the summer of 2009 they will work with six developed the second year. PC hires full time science teachers for the CHAMPS program; therefore, the only money needed for this purpose will support a part-time TA to assist with preparation of the materials. These teachers can provide us with important feedback in assessing and optimizing the activities. The PIs have extensive experience developing rubrics and assessment materials for inquiry-based learning.

During the Fall of 2008, we will present two workshops for teachers at the NABT (National Association of Biology Teachers) to introduce this project and the first six

activities to teachers. We will demonstrate the advantages of using plants in the classroom, solicit feedback from the teachers about the materials we have developed, and recruit a subset to continue to give us feedback on the materials after they have used them in their own classrooms. Similarly, the remaining six will be introduced through two NABT workshops in 2009. Participating teachers will receive a small stipend after turning in assessment data (\$100 per teacher; 10 teachers each year). This will plant 20 “seeds” in school systems around the country that can spread to other teachers.

5. Dissemination

This project will reach several thousand new people around the country each year. We will disseminate these activities as PDF files through the ASPB website as companions to the 12 Principles and the 12 bookmarks. We will also develop a set of “traveling booth activities” for teachers to conduct at the ASPB booth at conferences including NABT and NSTA (National Science Teachers Association), as well as public science events including AAAS’s Family Science Days. Engaging teachers at the ASPB booth in a hands-on activity will introduce them to our 12 activities and direct them to the ASPB website where they can find the complete set of materials. Periodically we will offer workshops at NABT and NSTA conferences to introduce, educate and empower teachers to teach the 12 Principles of Plant Biology. Finally, when our set of 12 activities is complete, we will make a presentation to the Council of State Science Supervisors at their annual meeting during the NSTA conference. The State Science Supervisors can alert their teachers and science coordinators statewide about our materials, and have been effective allies for ASPB in disseminating information about the 12 Principles when they were first developed.

Budget and Budget Justification

	2008 Year 1	2009 Year 2	2010 Year 3
TAs	7000	7000	0
PI stipend	2000	2000	2000
Teacher stipend	0	1000	1000
Supplies	1500	1500	0
Travel	1000	1000	1000
Annual totals	11500	12500	4000
		TOTAL	28000

Budget Justification

Funds are requested to support TAs assisting in the development and teaching of the summer programs at Elon University and Presbyterian College during the summers of 2008 and 2009. Supply monies are also requested for these summer programs as well as the preliminary testing of the modules by the PIs. PIs Coker and Ellis will receive a stipend for their work with the summer students and the teacher workshops. Funds are requested to support the PIs travel to conferences to offer teacher workshops. Participating teachers will be awarded small stipends (10 x \$100) after turning in assessment data.

JEFFREY SCOTT COKER

Position

Assistant Prof. Elon University Department of Biology

Education

Ph.D. N.C. State University Botany (Biotechnology minor)
M.Ed. N.C. State University Science Education (Botany minor)
B.S. Davidson College Biology

Recent Educational Leadership

Education Committee Member for the American Society of Plant Biologists. 2005-2009. Help plan education and outreach activities for the ASPB. Coordinate the Education Booth at annual meetings.

Chair of the Science Education Committee of the N.C. Academy of Science. 2004-present.

Elon University General Studies Assessment Task Force. 2006-present. Work with an interdisciplinary team to design and implement a long-term General Studies assessment plan for Elon University.

Chair of the Elon University General Studies Council. 2006-present. Oversee Elon's GST Program.

Elon Academy Curriculum Committee. 2006. Developed a summer curriculum for talented high school students from underprivileged backgrounds.

CASTL Institutional Leadership Program. 2006-2008. Part of a team selected by the Carnegie Foundation to advance "Student Participation in the Scholarship of Teaching and Learning."

Associate Editor for the Journal of Natural Resources and Life Sciences Education (JNRLSE). 2003-2006. Served as the official representative to the JNRLSE from the American Society of Plant Biologists.

Project Director of Terra Nova Community. 2005-2006. Led an interdisciplinary team to promote a science-spirituality dialogue in the context of environmental issues. Managed \$30,000 budget.

NACTA Journal Awards Committee. 2004-2005. Selected the top articles published each year in the educational journal of the North American Colleges and Teachers of Agriculture.

Textbook Chapter Reviewer. 2005. Reviewed Presson and Jenner's *Introduction to Biology* for McGraw-Hill.

Educational Video Content Reviewer. 2005. Reviewed Introductory Biology video clips for McGraw-Hill.

Coordinator of 2005 CANCAS Undergraduate Research Workshop at Elon University. Nov. 5, 2005. Arranged workshops for 100 undergraduates from 14 different institutions on how to perform scientific research.

Textbook Chapter Reviewer. 2004. Reviewed Johnson's *The Living World*, for McGraw-Hill.

Scientific Reviewer for the N.C. Department of Public Instruction. 2004. Content reviewer of North Carolina's new 7th grade science textbook as a part of the N.C. textbook adoption process.

Awards and Honors

Elon University CATL Scholar. 2006-2008. Recognized as a University Teaching Scholar by Elon's Center for the Advancement of Teaching and Learning.

N.C. State University Dissertation Award (Pollock Award). Selected as the university's only recipient of the award for "positive impact of graduate-level research on both the North Carolina economy and the quality of life for all its citizens."

Alcoa Teaching Fellowship. For cultivating classroom environments conducive to diverse students.

University Outstanding Teaching Assistant Award. N.C. State University.

Martha Sue Sebastian Memorial Award for Excellence in Teaching. N.C. State University.

NACTA Graduate Student Teaching Award. North American Colleges and Teachers of Agriculture.

CALS Outstanding Teaching Assistant Award. College of Ag. and Life Sciences at N.C. State University.

GSA Outstanding Teaching Award. Graduate Student Association at N.C. State University.

Recent Publications

- Coker, J.S. and Johnson, A. 2007. Using presidential elections to engage students in science issues. *American Biology Teacher*. In press.
- Coker, J.S. and Davies, E. 2006. Ten time-saving tips for undergraduate research mentors. *Journal of Natural Resources and Life Sciences Education* 35:110-112.
- Coker, J.S. 2006. Citing by example: Responsible science teaching in the information age. *Journal of College Science Teaching* 35: 6.
- Coker, J.S. and Agnew, J.D. 2005. The story of dinosaur evolution. National Center for Case Study Teaching in Science Case Collection. http://www.sciencecases.org/dinosaur_evolution/dinosaur_evolution_notes.pdf.
- Coker, J.S., Vian A., and Davies, E. 2005. Identification, accumulation, and functional prediction of novel tomato transcripts systemically up-regulated after fire damage. *Physiologia Plantarum* 124: 311-322.
- Coker, J.S. 2005. Anatomy of woody stems. *Journal of Natural Resources and Life Sciences Education* 34: 3
- Coker, J.S. and Van Dyke, C.G. 2005. Evaluation of teaching and research experiences undertaken by botany majors at N.C. State University. *NACTA Journal* 49: 14-19.
- Coker, J.S. and Scott, L.D. 2005. Rev. of *Successful Scientific Writing*, by J.R. Matthews, J.M. Bowen, and R.W. Matthews (Cambridge University Press, 2000). *American Biology Teacher* 67: 571-572.
- Coker, J.S. and Davies, E. 2004. Identifying adaptor contamination when mining DNA sequence data. *Biotechniques* 37: 194-198.
- Coker, J.S. 2004. Rev. of *Writing and Presenting Scientific Papers, 2nd Edition*, by B. Malmfors, P. Garnsworthy, and M. Grossman (Nottingham University Press, Nottingham, 2004). *Journal of Natural Resources and Life Science Education* 33: 183.
- Coker, J.S. and Davies, E. 2003. Selection of candidate housekeeping controls in tomato plants using EST data. *Biotechniques* 35: 740-748.
- Coker, J.S., Jones, D., and Davies, E. 2003. Identification, conservation, and relative expression of V-ATPase cDNAs in tomato plants. *Plant Molecular Biology Reporter* 21: 145-158.
- Coker, J.S. 2003. Growing students. *NACTA Journal* 47: 60-61.
- Coker, J.S. and Davies, E. 2002. Involvement of plant biologists in undergraduate and high school student research. *Journal of Natural Resources and Life Science Education* 31: 44-47.
- Coker, J.S. and Davies, E. 2002. Correspondence re: A.H. Ree et al., Expression of a Novel Factor in Human Breast Cancer Cells with Metastatic Potential (*Cancer Res.*, 59: 4675-4680, 1999). *Cancer Research* 62: 4164-4165.

Jane Price Ellis

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Education

- Ph.D. Plant Physiology, Clemson University (1994) Dissertation Title: Characterization of In Vitro Cultured Cocklebur: Biotypes Resistant and Susceptible to the Organic Arsenical Herbicides
- MA Biology, Appalachian State University (1972)
- BA Biology, Erskine College (1969)

Professional Experience

- 1995-Present: Presbyterian College, Associate Professor of Biology. Courses Taught: Taxonomy of Native and Economic Plants (Biology 206), Plant Physiology (Biology 312), General Biology (Biology 101 and 102), The Biology of Medicinal Plants (Biology 458), Introduction to Tropical Biology and Natural History of Costa Rica (Biology 458), Earth Science (Physics 211). Past Teaching Assignments: Introduction into Bioinformatics (Biology 458), Senior Seminar (Biology 401), Co-Teaching Methods and Materials of High School Teaching: Biology (Education 302A)
- 2006-Present: Clemson University, Adjunct Associate Professor in the Department of Entomology, Soils, and Plant Sciences
- 1994: Lander University, Adjunct Professor in Education. Course Taught: Science Methods (K-12) (Education 321)
- 1989-1994: Graduate Research Assistant, Department of Plant Pathology and Physiology. Clemson University, Clemson, South Carolina
- 1990-1994: Coordinator Monsanto Biotechnology Grant. Clemson University, Clemson, South Carolina
- 1977-1991: Science Department Chair. Dixie High School, Due West, South Carolina. Teacher of Advanced Biology, Biology I (College Prep), Chemistry (Other responsibilities included sponsor of Beta Club and Science Club, chairman of the school and science academic competition teams, and chairman of school academic banquet.)

Honors

- 2004: Selected to participate in National Science Foundation's "Plant Molecular Genomic Workshop" presented by Cold Springs Harbor and held at Clemson University in August, 2004
- 1996. Frances Livingston Cardwell Distinguished Lecturer, Erskine College
- 1991-1994. Recipient of Philip Morris Fellowship for graduate work
- 1987. South Carolina Science Teacher of the Year awarded by the South Carolina Academy of Science

Professional Activities in the Last Ten Years

- 2006-2010. American Society of Plant Biologists, Education Committee
- 2005-2008. Secretary, South Carolina Academy of Science
- 2004-Present. Judge for Siemens Westinghouse Competition in Math, Science, and Technology. Judging takes places at Educational Testing Service, Princeton, NJ
- 2006-Present. Bylaws and Constitution Committee, National Association of Biology Teachers (NABT)
- 2006-Present. Membership Committee, National Association of Biology Teachers (NABT)
- 2007-Present. South Carolina State Director, National Association of Biology Teachers (NABT)
- 2004-Present. Committee member to select the South Carolina Science/Math Teacher of the Year.
- 2005. Consultant: Southeastern Community College, Whiteville, NC in the development of a Two-Year Program in Plant Biotechnology
- 2005. Invited Participant: "Global Literacy in Science-Think Tank" in Costa Rica (May 21-26)
- 2001-2003. Board of Directors, National Association of Biology Teachers (NABT)
- 2003. Chair of the Four-Year College/University Section of NABT
- 2002. Vice-Chair of the Four-Year College/University Section of the NABT

- 2001. Secretary of the Four-Year College/University Section of the NABT
- 2000-Present. Executive Committee, Four Year College University Section, NABT
- 2000. President, South Carolina Academy of Science
- 1999. President Elect and Program Chair of Annual Meeting, South Carolina Academy of Science
- 1998. Vice-President, South Carolina Academy of Science
- 1996-Present. Board of Councilors, South Carolina Academy of Science
- 1995-Present. Judge for Sigma Xi-South Carolina Academy of Science Undergraduate Competitions
- 1994-Present. Advanced Placement Biology Reader and Table Leader: AP Biology Exam

Other Recent Responsibilities

- 2005. Prepared Presbyterian College's NCATE Biology Spa Report
- 2003. One of the three members of the "Working Committee" to produce the National Biology Standards prepared for NABT, the National Science Teachers Association (NSTA), & NCATE
- 2003. Prepared the "Outreach Section" of Presbyterian College's Howard Hughes Medical Institute (HHMI) Grant Proposal

Sabbatical and Recent Research.

- 2006. Submission of grant to American Orchid Society to study medicinal properties and volatile oil composition of several native and cultivated orchid species.
- 2003-Present. Medicinal plant bioassays and volatile oil composition of various plants including orchid species.

Recent Workshops/Presentations/Published Poster Abstracts

- 2006. Oxford International Conference on the Science of Botanicals. Poster: Composition of the Essential Oil of *Cupressus arizonica var glabra* ('Carolina Sapphire'). Authors: D. Wedge, N. Tabanca, B. Demirci, K. Basar, J. Ellis, S. Gray, C. Murphy, D. Camper
- 2006. Presented Workshop "Testing Nature's Pharmacy: Assaying Properties of Herbal and Medicinal Plants" at the October 2006 National Association of Biology Teachers' Convention in Albuquerque, New Mexico.
- 2005. Presented Demonstration "Testing Nature's Pharmacy: Assaying Properties of Herbal and Medicinal Plants" at the October 2005 National Association of Biology Teachers' Convention in Milwaukee, Wisconsin.
- 2003. American Society of Plant Biologists Meeting. Poster: Antitumorigenic and Medicinal Properties of *Chimaphila maculata*. Honolulu, Hawaii. Authors: Jane Ellis, L. Terry, N. D. Camper
- 2003. American Society of Plant Biologists Meeting. Poster: Assaying properties of medicinal plants as long term projects in plant physiology laboratory using antitumor, antibacterial, and toxicity protocols. Honolulu, Hawaii. Authors: Jane Ellis, P. Coker, N. D. Camper
- 2002. Presentation and Proposal: "How Much Do Middle School Students and Teacher Candidates Know about Weather and the Environment as Prescribed by the National Science Education Standards? Meeting the Challenge!" at the Annual Meeting of JUSTEC (Japan-United States Teacher Education Consortium) in Naruto, Japan. (Authors: Jane Ellis and Anita Dutrow)
- 1999, 2000, 2001. Invited to participate in and present at 3 conferences "Forging A Link I, II, III: Developing High School and College Partnerships in Biology" at Hope College, Holland, Michigan.

Refereed Publications

- Ellis, J. and N. D. Camper. 1995. *In Vitro* Cultured Cocklebur (*Xanthium strumarium* L.) Responses to Dimercaptopropanesulfonic Acid and Monosodium Methanearsonate. *Journal of Plant Growth Regulation* 14:9-13.
- Ellis, J. and N. D. Camper. 1994. *In Vitro* Culture of *Xanthium strumarium* L. (Cocklebur). *Plant Cell, Tissue and Organ Culture* 36:369-372.
- Haldeman, J. and J. Ellis. 1988. Using Cauliflower to Demonstrate Plant Tissue Culture. *The American Biology Teacher* 50:154-159.

Other

Ellis, J. 2007. ASPB's Presence at the NABT Convention in Albuquerque. ASPB Education Forum.

ASPB News: The Newsletter of the American Society of Plant Biologists. 34 (1):26.

Ellis, J. 2006. The Russell Program for Media, Technology, and Society Annual Report.

Coker, S., J. Ellis, E. Fairey, A Brown, S. Gray, N. D. Camper, C.Murphy. 2004. Laboratory Manual for Bioassays.

Sanders, R. L. and J. Ellis. 2007. Assessing the Biological Activity of Downy Rattlesnake Plantain (*Goodyera pubescens*). Bulletin of the South Carolina Academy of Science (Abstract). Vol.69.

Serdah, A. M., J. Ellis, A. Dutrow. 2007. Images of Female Professional Scientists. Bulletin of the South Carolina Academy of Science (Abstract). Vol.69.

Corpening, J. C. and J. Ellis. 2004. Antitumorigenic and Antibacterial Capabilities of *Chimaphila umbellata*. Bulletin of the South Carolina of Science. Vol. 66 Abstract of Poster

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EDUCATION

University of California at Berkeley	Biochemistry / Jesse Rabinowitz	B.A. 1985
The Rockefeller University	Plant Molecular Biology / Nam-Hai Chua	Ph.D. 1991
University of California at Berkeley	Plant Development / Ian Sussex	1991-1995

APPOINTMENTS

Assistant Professor of Biology, Harvey Mudd College (1995 – 2001)
Associate Professor of Biology, Harvey Mudd College (2001 to present)

EDUCATIONAL ACTIVITIES

- 1. Development and dissemination of novel, inquiry-based laboratory exercises and courses for undergraduates** I was awarded an NSF-CCLI award to develop an integrated plant and animal physiology lab, which is currently one of the core lab classes at HMC. Posters describing this course were presented at the Experimental Biology and the ASPB meetings in 2003. I developed an Arabidopsis genomics module for Molecular Biology Lab and an Arabidopsis genetics lab for Introductory Biology Lab, which I freely share with others (www.biology.hmc.edu). I described the genomics module in an invited lecture and poster at the ASPB meeting in 2005.
- 2. Member (2002-2007) and Chair (2005-2007) ASPB Education Committee** My involvement on this committee has included selection and coordination of outreach activities at ASPB annual meetings and outreach to teachers at NSTA and NABT conferences, and increasing the visibility and representation of Educational and Outreach efforts by scientists at ASPB annual meetings. Other current efforts are directed towards facilitating coordination and cooperation in outreach efforts between the ASPB and other plant professional societies including the Botanical Society of America (BSA) and the Society of Experimental Biology (SEB).
- 3. Outreach to K-12 Teachers and Students** Since I began my faculty appointment at HMC in 1995 I have been increasingly engaged in efforts to foster interactions with K-12 students and teachers. I have served as a judge at the California State Science Fair for the past 10 years. I am a scientific contributor, mentor and member of the Steering Committee of the web-based mentoring program “Planting Science” supported by the BSA and ASPB. I believe that professional societies can serve critical roles as conduits between scientists and teachers. While disseminating ASPB educational materials in April 2006 at the NSTA convention in Anaheim, CA, I interacted with hundreds of teachers learned what kinds of information and materials they would like us to provide them with. With the goal of addressing the teachers’ needs, I am co-organizing with Claire Hemingway, Education Director of BSA, a workshop called “Idea to Impact, Designing and Disseminating Effective Educational Materials” for the July 2007 ASPB/BSA joint annual meeting.
- 4. Undergraduate research advisor** During my 12 years at Harvey Mudd College I have supervised 28 summer research students and 20 senior thesis students. Many have served as co-authors on peer-reviewed publications and/ or presented their research at local and national conferences including the ASPB.

Fostering Broader Impacts at Harvey Mudd College Harvey Mudd College is a prestigious college of science and engineering situated adjacent to an educationally underserved school

1. district. As a Co-Chair of the Broader Impacts Committee at Harvey Mudd College, I am working towards increasing our faculty, staff and student participation in outreach activities in our local community.

SELECTED PUBLICATIONS (* indicates undergraduate co-author)

- Williams ME, Torabinejad J, Parker K*, Cohick E*, Drake EJ, Thompson JE, Hortter M*, DeWald DB (2005) Mutations in the Arabidopsis phosphoinositide phosphatase gene *SAC9* lead to overaccumulation of PtdIns(4,5)P₂ and constitutive expression of the stress-response pathway. *Plant Physiology* **138**: 686-700
- Haskell RC, Williams ME, Petersen DC, Hoeling BM, Schile AJ*, Pennington JD*, Seetin MG*, Castelaz JM*, Fraser SE, Papan C, Ren HI, de Boer JF, Chen Z (2004) Visualizing early frog development with motion-sensitive 3-D optical coherence microscopy. *Proceedings, 26th International Conference IEEE Engineering in Medicine and Biology Society*.
- Hettlinger JW, Mattozzi M*, Myers WR*, Williams ME, Reeves A, Parsons RL, Haskell RC, Petersen DC, Wang R, Medford JI (2000). Optical Coherence Microscopy: a technology for rapid, *in vivo*, non-destructive visualization of plants and plant cells. *Plant Physiology* **123**, 3 - 15.
- Hoeling BM, Fernandez AD*, Haskell RC, Huang E*, Myers WR*, Petersen DC, Ungersma SE*, Wang R, Williams ME, Fraser SE (2000) An optical coherence microscope for 3-dimensional imaging in developmental biology. *Optics Express* **6**, 136 - 146.
- Williams ME, Sussex IM (1995) Developmental regulation of ribosomal protein L16 genes in *Arabidopsis thaliana*. *Plant Journal* **8**, 65 - 76.
- Sussex IM, Godoy JA, Kerk NM, Laskowski MJ, Nusbaum HC, Welsch JA, Williams ME (1995) Cellular and molecular events in a newly organizing lateral root meristem. *Phil. Trans. R. Soc. Lond. B* **350**, 39 - 42.
- Laskowski MJ, Williams ME, Nusbaum, HC, Sussex IM (1995) Formation of lateral root meristems is a two-stage process. *Development* **121**, 3303 - 3310.
- Williams ME, Foster R, Chua N-H (1992) Sequences flanking the hexameric G-box CACGTG affect the specificity of protein binding. *Plant Cell* **4**, 485 - 496.
- Williams ME, Mundy J, Kay SA, Chua, N-H (1990) Differential expression of two related organ-specific genes in pea. *Plant Mol. Biol.* **14**, 756 - 774.
- Barlowe CK, Williams ME, Rabinowitz JC, Appling DR (1989) Site-directed mutagenesis of yeast C₁-tetrahydrofolate synthase: analysis of an overlapping active site in a multifunctional enzyme. *Biochemistry* **28**, 2099 - 2106.

GRANTS RECEIVED

- Co-PI NSF Optical Science and Engineering Award 1996 - 2000 \$628,850
“Optical Coherence Microscopy in Developmental Biology”
- NSF CAREER Award, Integrative Plant Biology 1997 - 2004 \$395,349
“Molecular, genetic and physiological studies of lateral root development in *Arabidopsis thaliana*”
- Co-PI NSF CCLI DUE-0088138 2000 – 2004 \$49,655
“A novel integrated laboratory for plant and animal physiology”
- Co-PI NSF Development of Biological Infrastructure
DBI-0137973 2002 - 2004 \$247,828
"An Enhanced Optical Coherence Microscope for the Study of Dynamic Processes in the Early Development of Plants and Animals."
- Co-PI NSF DBI-0420538 2004 – 2007 \$355-583
“Acquisition of a Confocal Microscope”