Botanical Society Of America

Plant Science Bulletin

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Applications in Plant Sciences

What can you contribute?

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FROM THE EDITOR

For the past few years I've been working on a project to interpret the history of botanical education in this country. One of the themes that becomes increasingly clear in the twentieth century is that individual botanists and small groups of botanists have consistently gone through phases of "reinventing the wheel." Virtually all of the pedagogical "innovations" that you could list today have been tried in the past—but they haven't "stuck"! I hope to address some of the reasons why in future issues of *PSB* and in a final presentation at the 2013 annual meeting in New Orleans. But let me jump ahead quickly to the present. There is one major difference between all of the previous cycles of attempting to improve science education and the one we are currently in. Today it's not just a few individuals, or a single organization, that is taking the lead. Instead, we have a confluence of efforts, both top down and bottom up, that are all reaching the same conclusions. The National Academy of Sciences Board on Science Education, The College Board's Advanced Placement Biology Curriculum, and the American Association for the Advancement of Science all have developed guidelines for revising the science curriculum – and they're all basically alike. Botanists, through BSA and ASPB, have had our input into the latter: AAAS's *Vision and Change*. Our final effort is included in these pages. We encourage you to reassess your own introductory courses with these guidelines in mind.

Finally, you may notice something missing in this issue. For the first time since I became editor, we are not publishing a single feature article. In fact, only a single article is currently in review, although I've been assured that several are in preparation. I want to take this opportunity to encourage you to consider sharing some of your work with the membership and other readers of these pages. Submit your articles at http://www.editorialmanager.com/psb.

-Marsh

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Alligator Bayou is easily accessible off I-12 at Prairieville, just south of Baton Rouge on the way to New Orleans. A short distance from the landing the bayou expands into Cypress flats where a few old-growth trees, and numerous stumps from logged trees emerge from a mat of water hyacinth. Scenes like this occur throughout South Louisiana - - be sure to sign up for one of the field trips associated with the annual meeting next summer. (photo by Marsh Sundberg)

Plant Science Research Summit Final Report

The final report of the Plant Science Research Summit, held in September 2011, is now available at http://www.botany.org/plantsciencebulletin/121011_final_PSummit_report.pdf. The summit was convened by the American Society of Plant Biologists, with the goal of defining a set of common priorities for plant science research. As described in the Plant Science Bulletin (2012, 58: 1), the summit was attended by three representatives of the BSA, then President-elect Elizabeth Kellogg, Past-president Judy Skog, and Treasurer Amy Litt. This summary document represents the input of a broad set of plant biologists, although as noted in my original report in PSB, ecology and evolutionary biology were somewhat under-represented. In fairness to the organizers, the people who they originally invited to represent those disciplines were unable to attend.

It is worth reading the document as a statement of broad goals shared by many plant biologists. The hope is to use this in efforts to generate funding for plant research in its broadest sense. The first paragraph of the Executive Summary reads: "Now, more than ever, it is vital to increase public and private support for plant science research and recognize the critical need to invest in its future and embrace its potential." The four grand challenges identified by the document are (1) Ensure nourishment for all, now and in the future; (2) Protect, enhance and illuminate the benefits of nature; (3) Fuel the future; and (4) Be sustainable.

Much of the sort of science described in this report fits into the concept of "use-inspired basic research," outlined by Donald Stokes in the book Pasteur's Quadrant (Brookings Institution Press, 1997). He observes that the linear view of a continuum between basic and applied research is too constraining. Instead he suggests that some scientific studies may search for fundamental understanding of nature, while working in areas that may ultimately benefit humans.

Like all policy documents, the summary report represents the views of a particular set of people at a particular time and is likely to lead to other similar documents in the future that highlight different aspects of the plant science agenda. It is perhaps worth recalling Ben Franklin's famous statement "We must all hang together, or assuredly we shall all hang separately." At a time when knowledge of plants is becoming ever more critical – whether we are discussing ecosystems, fields, or single cells – it is useful to begin discussion of points we can agree on and put forward to policy-makers.

-Elizabeth A. Kellogg, President, Botanical Society of America

ASPB – BSA Core Concepts and Learning Objectives in Plant Biology for Undergraduates

The American Association for the Advancement of Science, National Science Foundation (NSF), and other stakeholders recently published a call to transform undergraduate biology education, titled *Vision and Change* (http://visionandchange.org/finalreport). Major themes of *Vision and Change* include teaching core concepts and competencies, focusing on student-centered learning, promoting campus-wide commitments to change, and engaging the biology community in implementation of change. The American Society of Plant Biologists (ASPB) and Botanical Society of America (BSA) were among the first societies to become involved in *Vision and Change*. NSF awarded ASPB a grant to host a workshop in 2011 to gather feedback from plant biologists on how to put the *Vision and Change* recommendations into practice. One of the major concerns that emerged from this workshop was the lack of a defined set of core concepts in plant biology that undergraduates should learn. This lack results in underrepresentation or misrepresentation of plants in undergraduate curricula and misunderstanding about the importance and unique functions of plants and their broader contributions to understanding biology (e.g., plants "don't do much"; plants are "only important for photosynthesis"; plants are "not interesting" to study).

To address these concerns, a working group of ASPB and BSA members was assembled: Kathleen Archer (Trinity College), Erin Dolan (University of Georgia), Roger Hangarter (Indiana University), Ken Keegstra (Michigan State University), Judith Skog (George Mason University), Susan Singer (Carleton College), Neelima Sinha (UC Davis), Anne Sylvester (University of Wyoming), and Sue Wick (University of Minnesota). The working group was tasked with generating a set of core concepts that:

- outline what undergraduate biology majors should learn about plants;

- are consistent with themes from *Vision and Change* and the new K-12 science education framework;
- are the enduring, big ideas that explain what makes plants distinct from other lineages of organisms and describe the essential attributes and life strategies of plants; and
- are broad and foundational in nature, and can be divided further into multiple sub-concepts or units of knowledge (e.g., learning objectives) that are measurable.

For the purposes of this effort, plants were defined as: *eukaryotic photosynthetic organisms with multicellular haploid and diploid stages in their life cycle and protected diploid embryos*.

ASPB and BSA members were invited to comment on a draft of the core concepts, and their feedback was used to generate the final version that follows. The concepts are organized into the four life science domains of the new framework for K-12 science education developed by the National Academy of Sciences Board on Science Education (http://www.nap.edu/catalog.php?record_id=13165): (1) *From Molecules to Organisms: Structures and Processes*, (2) *Ecosystems: Interactions, Energy, and Dynamics*, (3) *Heredity: Inheritance and Variation of Traits*, and (4) *Biological Evolution: Unity and Diversity*. Each set of concepts begins with a description of the foundational knowledge in the domain. Individual concepts are followed by sample learning objectives: what students could do to demonstrate their understanding of the concept. ASPB and BSA leadership urge all who teach undergraduate biology students to use this document as a guide for curricular design and instruction.

1. From Molecules to Organisms: Structures and Processes. Plants are living organisms that grow, reproduce, and die. Plants and their parts are made up of cells, which contain DNA and other molecules that support plant functions. Plants are attached and do not move from place to place to acquire resources for survival. Plants grow toward resources and have specific structures, called chloroplasts, which carry out the reactions of photosynthesis. Using the energy captured from sunlight, plants produce molecules to support their own growth and development. Plants also take up water and inorganic nutrients from their terrestrial or aquatic environment. Plant cells are bounded by cell walls that are essential for growth and development of the plant body.

1A: Structure and Function. *How do structures of plants enable life functions?*

- Plants growing in various environments have a diversity of structures for acquiring and retaining water, exchanging gases, optimizing photosynthesis, and supporting growth and reproduction.
  - » *Learning objective (LO): Compare and contrast the structures by which vascular and non-vascular plants obtain and retain water, allow for gas exchange for photosynthesis, and allow for long-distance internal transport of water.*
  - » *LO: Map onto a phylogenetic tree of plants the locations where innovations for acquiring water, retaining water, exchanging gases, upright stature, and reproduction in the absence of swimming sperm arose.*
  - » *LO: Analyze structural and anatomical features that optimize photosynthesis under various environmental conditions such as shading, water deficit, or high temperature.*
- Plants have carbohydrate-based cell walls that serve diverse functions.
  - » *LO: Contrast the primary cell wall component of plants, fungi, and bacteria.*
  - » *LO: Analyze the roles of cellulose and cell wall matrix components in support, growth, and cell-cell recognition as well as protection against pathogens.*
- Plants have specialized structures and systems for defense against disease and predation.
  - » *LO: Categorize defense mechanisms into structural, constitutive biochemical, and induced biochemical responses, evaluating the cost and benefits of each.*
- Plants have conducting tissues that transport water, carbohydrates, and nutrients through both passive and active mechanisms.
  - » *LO: Compare and contrast the long-distance transport of carbohydrates with that of water and nutrients in a plant.*
  - » *LO: Diagram the pathway of carbohydrate transport from a source to a sink, indicating where active transport is required.*
- Some plants and plant parts are able to move.
  - » *LO: Categorize plant structures and their*

particular features that facilitate dispersal of the plant in the environment

» *LO: Select a plant structure that is capable of movement and analyze the features that enable it to move.*

1B: Growth and Development of Organisms. ***How do plants grow and develop?***

- Plants can reproduce sexually and asexually.

» *LO: Categorize examples of asexual reproduction based on the plant structures involved.*

» *LO: Select a plant and diagram the contributions of the gametophyte(s) to sexual reproduction.*

- Plants grow from single cells and retain groups of undifferentiated and dividing cells throughout their lives.

» *LO: Support the claim that plants continue to develop and differentiate new structures after formation of a multicellular structure by drawing and identifying regions of a plant with persistent meristem activity.*

» *LO: Using examples, explain how shoots and roots are repeatedly added to a plant through meristem activity.*

- Plant germ-line cells are established after vegetative growth has started.

» *LO: Explain when and where in the plant meiosis occurs.*

- The development of plant form is influenced by external and internal cues.

» *LO: Categorize internal and external cues based on their effects on plant form.*

» *LO: Draw a diagram that represents the effect of a specific wavelength of light on plant form; include photoreceptors, signal transduction, gene expression, and morphological change in the diagram.*

» *LO: Draw a diagram that illustrates the effect of gravity on plant form; include receptors, signal transduction, gene expression, and morphological change in the diagram.*

» *Plants produce and respond to hormones that regulate growth and development.*

» *LO: Identify the categories of plant hormones and provide examples of their effects on growth and development.*

» *LO: Compare and contrast the production of and response to a steroid hormone in a plant and an animal.*

- Cell expansion depends on biochemical and biophysical processes, including wall loosening and water pressure inside the cell.

» *LO: Diagram how internal and external cues integrate to contribute to mechanisms of cell expansion.*

1C: Organization of Matter and Energy Flow in Organisms. ***How do plants obtain and use matter and energy to live and grow?***

- Plants capture light energy to assimilate inorganic carbon dioxide into organic compounds.

» *LO: Create a diagram showing how inorganic carbon is assimilated into organic compounds in plants and overlay this with the flow of energy through the plant.*

- Plants take up and transport inorganic materials from their surroundings.

» *LO: Trace the path of movement of inorganic nutrients from soil into the aboveground part of the plant*

» *LO: Compare the roles of mycorrhizae and root nodules in the uptake of inorganic materials in plants.*

» *LO: Identify the two inorganic molecules that are used to produce the majority of a plant's mass, and indicate their sources.*

» *LO: Explain how the availability of soil microorganisms has supported or limited the growth of economically important plants.*

- Plants capture and use energy from sunlight. Almost all other organisms on the planet eat plants as a source of energy.

» *LO: For a terrestrial ecosystem, analyze the flow of energy among organisms.*

- Plants photosynthesize and respire.

» *LO: Explain why plants can grow in a closed terrarium.*

- Plants synthesize a wide variety of organic compounds through diverse biochemical pathways.

» *LO: Choose a class of organic compounds other than sugars and, in general terms, explain the carbon and energy sources for synthesis of these materials.*

1D: Information Processing. ***How do plants detect, process, and interpret information from the environment?***

- Plants detect and respond to physical and biological cues in their environment, including light, water, gravity, biochemical, and mechanical stimuli.

  » *LO: Construct a representation of a molecular receptor for a physical or biological signal that clearly shows how the signal is detected and how information is conveyed from the receptor to the plant cell.*

- Signals transmitted through a plant can induce changes in gene expression, protein activity, and protein turnover.

  » *LO: Compare and contrast a signaling pathway that leads to the activation of a cytosolic enzyme and a pathway leading to changes in gene expression.*

- Plants can respond to stimuli over a broad range of time scales.

  » *LO: Choose a stimulus that has an immediate response in a plant and a stimulus that results in a response days or weeks later; compare and contrast the information processing in the two examples.*

- Plants perceive and respond to each other and to other organisms in their environment.

  » *LO: Diagram how a signal from a plant is perceived and acted upon by another plant.*

  » *LO: Compare and contrast how a plant detects, processes, and interprets information from an herbivore and a pathogen.*

  » *LO: Provide examples of how herbivory alters plant growth.*

2. Ecosystems: Interactions, Energy, and Dynamics. Ecosystems are communities of organisms and their nonliving physical environment. Ecosystems are defined by complex hierarchical networks of interactions among individuals and populations, as well as interactions between organisms and their environment. All organisms in an ecosystem are linked through energy flow and cycles of water, carbon, nitrogen, and soil minerals. Energy enters the ecosystem mostly through photosynthesis and biomass production by plants. Other organisms obtain matter and energy from the plants. Decomposers act on dead organic matter, releasing carbon back to the atmosphere and facilitating nutrient cycling by converting nutrients stored in dead biomass back to forms that can be reused. Ecosystems are dynamic and changes in biotic and abiotic factors affect their stability and resilience. Humans are part of the biotic community and are having rapid effects on the biotic and abiotic aspects of ecosystems. In many cases, humans are placing profound stresses on the Earth's overall ecosystem to a point that ecosystem resilience, sustainability, and services are a major focus of concern.

2A: Interdependent Relationships in Ecosystems. ***How do plants interact with the living and non-living environment?***

- Plants are the primary food and oxygen producers on Earth.

  » *LO: Compare the relative contributions of plants and another photosynthetic organisms like lichens or terrestrial algae to production of food and oxygen on land.*

- Plants are foundational to large ecosystems.

  » *LO: Evaluate the statement that plants are the foundation of terrestrial ecosystems.*

- Plants live in close association and interact with other organisms, including other plants, animals, fungi, and microorganisms.

  » *LO: Chose an example of an interaction between a plant and another organism and elaborate on the ways in which they interact to the benefit of one or both organisms.*

- Plants produce metabolites that affect other organisms in ecosystems.

  » *LO: Choose a plant metabolite that affects other organisms in the ecosystem and explain the mechanism of the effect.*

- Plants have changed and continue to change Earth systems.

  » *LO: Evaluate the geological evidence that plants contributed to glaciation (i.e., ice ages).*

  » *LO: Contrast the general properties of plants, soil, and fauna on Earth at the time that plants first colonized dry land with the general properties of those organisms today.*

  » *LO: Analyze the progression of changes in plants and other organisms that occur after a volcanic eruption or a major wildfire.*

2B: Cycles of Matter and Energy Transfer in Ecosystems. ***How do matter and energy move through an ecosystem?***

- Energy first enters ecosystems through photosynthesis.
  - » *LO: Evaluate the claim that energy first enters the ecosystem through photosynthesis; consider relative to chemosynthesis.*
- Plants cycle oxygen and carbon dioxide through photosynthesis and respiration.
  - » **LO:** *Create a diagram that illustrates the flow of oxygen and carbon dioxide through photosynthesis and respiration in an ecosystem.*
- Plants cycle water in ecosystems through photosynthesis, respiration, and transpiration.
  - » *LO: Diagram the flow of water through an ecosystem, incorporating photosynthesis, respiration, and transpiration.*
- Plants are central to the global carbon cycle through photosynthesis.
  - » *LO: Estimate the impact of a reforestation and/or deforestation project of 1 million hectares on the global carbon cycle.*
- Plants participate in cycling nitrogen and other nutrients.
  - » *LO: Evaluate the nitrogen runoff into watersheds from fields of nitrogen-fixing crops versus fields of crops fertilized with inorganic nitrogen.*

2C: Ecosystem Dynamics, Functioning, and Resilience. ***What happens to ecosystems when the environment changes?***

- Resilience of ecosystems depends on the diversity of plant species.
  - » *LO: Evaluate a current research paper on how plant diversity affects ecosystem resiliency after a disturbance.*
- Plant populations are affected by environmental changes, which alter ecosystems.
  - » *LO: Consider a situation in which population size or distribution of plants is altered due to changes in climate, herbivore populations, or invasive species, and predict how this might affect other aspects of the ecosystem.*

3. Heredity: Inheritance and Variation of Traits. Like other organisms, plants use DNA to store genetic information and encode proteins, which underlie the plant's traits. Genes containing DNA are organized into chromosomes and variants of a given gene are called alleles. Each cell of a plant contains a complete set of chromosomes, and the same genetic information. As in other organisms, plants transmit their genetic information from parent to offspring, and from parent cell to daughter cell. Inheritance of chromosomes from parent to offspring explains why offspring have traits that resemble the traits of their parents. Mutations also cause variation in traits, which may be harmful, neutral, or occasionally advantageous for an individual.

3A: Variation of Traits. ***Why do individuals of the same species vary in how they look and behave?***

- Some natural populations of plants vary widely in their phenotypes.
  - » *LO: Identify a trait in a natural population of plants, then collect and analyze phenotypic data to determine how much the trait varies.*
- Gene expression in plants is controlled by genetic and environmental cues.
  - » *LO: Analyze data from an online repository of gene expression data to determine how genetic differences or environmental cues affect patterns of gene expression.*
  - » *LO: Design and conduct an experiment to compare the expression of a gene of interest under different environmental conditions.*
  - » *LO: Predict differences in gene expression in mutant versus wild-type plants based on the function of the gene.*

3B: Inheritance of Traits. ***How are characteristics of one generation related to the previous generation?***

- Plants can exist in haploid, diploid, and polyploid states.
  - » *LO: Design an experiment to determine the ploidy of a plant tissue.*
- Plants vary in their reproductive strategies. Some self-fertilize, which can lead to offspring that are genetically similar. Others have mechanisms to ensure transfer of gametes between different plants, which results in novel genetic combinations.

» *LO: Compare the genetic diversity of the offspring of a plant that is reproducing sexually versus asexually.*

- Some plants can reproduce asexually, producing offspring that are genetically identical to each other and to the parent.

» *LO: Compare the amount of genetic variation in the offspring of a plant that self-fertilizes and a plant that reproduces asexually.*

- Some plants can hybridize within and between species, which can result in novel traits in the offspring.

» *LO: Select an example of within species hybridization (e.g., hybrid corn) and explain why this can result in desirable agricultural traits.*

» *LO: Diagram the flow of chromosomes from plants of two different species that hybridize to their offspring; construct an argument for whether the offspring will reproduce.*

» *LO: Select a crop plant that is the result of hybridization and subsequent polyploidy (e.g., wheat or banana) and discuss how polyploidy corresponds with important agricultural traits.*

4. Biological Evolution: Unity and Diversity. Like all organisms, plants evolved from a single celled organism and continue to evolve. The fossil record of plants and many characteristics of living plants provide strong evidence for evolution. For example, plants use the same genetic code as other organisms, providing evidence for a single origin of life. Like other eukaryotic organisms, plants have mitochondria and a nuclear envelope. Plants also have chloroplasts, which resulted from the endosymbiosis between a eukaryotic cell and a photosynthetic bacterium. Diversity of plants is especially critical in the face of global climate change; plants and other photosynthetic organisms have the capacity to reverse increases in atmospheric carbon dioxide levels. The important roles that plants play in human life as food, feed, fuel, fiber, shelter, and pharmaceuticals have shaped human civilization. The evolution of plants is affected by humans, and affects humans.

4A: Evidence of Common Ancestry and Diversity. ***What evidence shows that different species are related?***

- Plants have many genes and gene families in common with all other organisms.

» *LO: Using gene trees, support the argument that plants have many genes and gene families in common with all other organisms.*

- All plants have chloroplasts with similar structure and pigment composition; this is the result of a single endosymbiotic event between a eukaryotic cell and an ancestral cyanobacterium.

» *LO: Analyze the structural and biochemical evidence for the claim that a single endosymbiotic event between a eukaryotic cell and a cyanobacterium was ancestral to all chloroplasts, including chloroplasts in algal groups.*

» *LO: Formulate an evolutionary hypothesis that accounts for the both the similarities and differences among the chloroplasts of red algae, brown algae, green algae, and land plants, including differences in the number of membranes.*

- Plants have multicellular haploid and multicellular diploid stages in their life cycles.

» *LO: Draw a generic plant life cycle indicating the role of meiosis and mitosis in establishing multicellular haploid and multicellular diploid stages.*

» *LO: Contrast the relative size of the multicellular haploid stage in mosses, ferns, and angiosperms.*

- DNA sequences have helped establish the relationships among major plant clades and between plants and other organisms.

» *LO: Use a computational phylogenetic tool and DNA sequences of one or more genes to predict the evolutionary relationships among major plant clades or between plants and other organisms.*

4B: Natural Selection. ***How does variation among plants affect survival and reproduction?***

- Diversity of organisms at the chromosome and gene level can be generated in several ways, including recombination, mutation, hybridization, and polyploidy, resulting in the variation underlying evolution by natural selection.

» *LO: Compare the relative contributions of recombination, mutation, hybridization, and polyploidy to plant diversity.*

» *LO: Explain the biological constraints for hybridization and polyploidy to successfully increase plant diversity.*

- Diversity among plants may be influenced by factors such as epigenetics (i.e., structural rather than sequence level changes in DNA) that affect the way genes are expressed.

» *LO: Explain how epigenetic phenomena such as DNA methylation and histone modification lead to phenotypic variation among plants that are otherwise genetically identical.*

- Some plant species can survive a diverse and changing environment. Others cannot, which results in their extinction.

» *LO: For various species that exhibit a range of diversity, predict some possible outcomes of expansion of their distribution due to climate change.*

» *LO: If a new pathogen or herbivore is introduced, predict possible outcomes for a plant species, relative to its diversity.*

4C: Adaptation. ***How does the environment influence populations of plants over multiple generations?***

- Adaptation of plants to a variety of environments on Earth has resulted in a great diversity of structures and physiological processes.

» *LO: Categorize symbiotic relationships that have adapted plants to life in a terrestrial environment.*

» *LO: Compare strategies that have evolved for population migration and dispersal in mosses, ferns, gymnosperms, and angiosperms.*

» *LO: Select and evaluate an adaptation in plants for retaining water while facilitating gas exchange.*

» *LO: For an aquatic plant, select, and evaluate an adaptation for retaining gases needed for photosynthesis.*

» *LO: Compare structures and their modifications in desert plants from the southwestern U.S. and South Africa.*

4D: Biodiversity and Humans. ***What is biodiversity, how do humans affect it, and how does it affect humans?***

- Diversity of plant species is important for the long-term health of an ecosystem.

» *LO: Analyze data from a recent paper on ecosystem biodiversity and evaluate the authors' conclusions.*

- Human activity has affected global plant diversity, especially through the alteration of habitats.

» *LO: Using Long Term Ecological Research (LTER) data sets, examine historical and current biodiversity data for a particular region and illustrate how the physical environment and biodiversity have changed as a result of human activity.*

- Human selection has affected almost every aspect of crop plants, including their structure, reproduction, genetics, and adaptation.

» *LO: For a given crop plant (corn, Brassica, wheat, soy, potato, tomato, bean, banana, etc.), compare its structure, reproduction, genetics, and adaptation relative to its wild ancestors.*

» *LO: Select a crop plant (e.g., corn, rice, potato) and trace the evolutionary changes that occurred through human domestication of the wild relative.*

» *Agriculture shapes human populations, including their size, distribution, and cultures.*

» *LO: Compare the size, distribution, and culture of a human population before and during the introduction of agriculture.*

» *LO: Compare the size, distribution, and culture of a human population as agriculture became more sophisticated after 1900.*

BSA Science Education News and Notes

BSA Science Education News and Notes is a quarterly update about the BSA's education efforts and the broader education scene. We invite you to submit news items or ideas for future features. Contact: Claire Hemingway, BSA Education Director, at chemingway@botany.org or Marshall Sundberg, PSB Editor, at psb@botany.org.

Cross-Organization Connections and Education Opportunities

In this issue, we highlight a variety of efforts and opportunities to advance education reform on the national level. **It is exciting to see involvement of BSA members integral to many of these current collaborations — thank you for your important contributions.** A number of the national initiatives address the Vision and Change call to action to transform undergraduate biology education (http://visionandchange.org). Other efforts aim to provide teaching and learning resources or to tackle issues that have come to the attention of the biology education community.

These education efforts will continue to be all the richer with BSA members adding their botanical education expertise! If you would like more information about these, get in touch. Please also let us know about the initiatives you are involved in so we can share this information with the broader community.

Digital Resource Discovery and Life Discovery Conference Collaboration

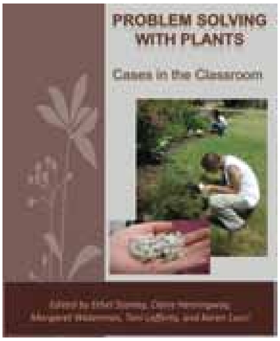
The Digital Resource Discovery Grant is a collaboration among the Ecological Society of America, Botanical Society of America, Society for the Study of Evolution, Society for Economic Botany, and other professional societies to support high-quality resources in ecology, evolution, and plant sciences. The inaugural conference Life Discovery – Doing Science Education Conference will be held March 15-16, 2013 in St. Paul, Minneapolis (http://www.esa.org/ldc/). **Beverly Brown** served on the planning committee for the 2013 conference and advisory panel for the collaborative grant. **Phil Gibson** has been nominated to serve on the 2014 Life Discovery Conference planning committee.

Understanding Evolution Invitation to Partner

An invitation to partner with Understanding Evolution (UE) (www.evolution.berkeley.edu) was positively received by the BSA Education Committee in June. Through this partnership, BSA members' expertise on plant evolution can expand and enhance the resources that target undergraduate Introductory Biology. New resources include an interactive syllabus connecting an evolutionary perspective to each topic, a journal club toolkit for accessing the literature, an evolution misconception diagnostic, an Evo Gallery for student projects, etc. BSA members can actively contribute to UE by serving as an External Advisor responsible for reviewing resources for both science and pedagogy, evaluating resources, or submitting teaching resources for possible inclusion in the UE database.

New Free Resource for Case-Based Learning

Are you looking for real-world contexts for your students to explore plant biology and its interdisciplinary connections? An outcome of the PlantIT Careers, Cases and Collaborations project (DRL 0737669) is the e-book *Problem Solving with Plants: Cases for the Classroom.* Download your free e-book at: http://www.myplantit.org.



Problem Solving with Plants: Cases for the Classroom *contains 14 cases adaptable from middle school to college classes and helps for teaching with investigative cases.*

Core Concepts in Undergraduate Plant Biology

BSA members **Judy Skog** and **Susan Singer** joined with education leaders in the American Society of Plant Biologists to draft core concepts in undergraduate plant biology and circulated these for community feedback. These core concepts will be used to guide learning objectives for 200-level plant biology units within the HHMI-funded CourseSource initiative, which will be created by partnerships with the National Academies Summer Institutes and professional societies and made available through a digital repository.

American Institute for Biological Sciences (AIBS) and Partner Activities

The American Institute of Biological Sciences (AIBS), including board member **Judy Skog** and AIBS education committee chair **Muriel Poston,** is tackling the issue of credentialing faculty that was raised this summer (e.g., someone with a PhD in botany is not considered qualified to teach introductory biology). AIBS will be developing a position statement, and president of HAPS Dee Silverthorn is also working with other societies to develop guidelines for accrediting organizations. We'll continue to keep you informed of developments on this important issue.

The AIBS Education Committee is exploring the feasibility of developing an initiative that would support biology/life sciences department leaders.

Presentations and posters from the Introductory Biology Project Summer Conference, led by **Gordon Uno**, are now online at http://ibp.ou.edu. **Beth Schussler, Marsh Sundberg,** and **Susan Singer** were among the presenters. Several action items emerged from the sessions on the role of professional societies and introductory biology. A group will be getting together to write an article that features the many different successful models to promote education within specific scientific societies and ways that education organizations can work with scientific societies. Two-year faculty would like to be able to more easily become involved in professional societies, and encouraged societies to consider new ways of welcoming them into their communities. There was a call for the development of a common statement on the importance of introductory biology.

The PULSE Vision and Change Fellows were announced in early September. **Susan Singer** is a PULSE mentor in this joint effort by NSF, HHMI, and NIH to support Leadership Fellows. PULSE welcomes community involvement to help develop and implement systemic change in undergraduate life science education (http://pulsecommunity.org).

The AIBS is participating in an initiative funded by the U.S. Department of Education to address the big sustainability questions in our classrooms (understanding and engaging in problem solving around societal issues such as access to food and water, poverty reduction, and cleaner energy supplies). More information about this "Sustainability Improves Student Learning in STEM" initiative is online: http://www.aacu.org/pkal/disciplinarysocietypartnerships/sisl/index.cfm.

Are you helping to educate for a more sustainable future? Help impact hundreds of thousands of students by infusing sustainability into textbooks from major publishers and get paid for your efforts. Textbook publishers have seen the demand from educators and students for sustainability-related materials in our discipline. We have been asked by major textbook publishers (e.g., Cengage and McGraw-Hill) to gather names of potential reviewers who can receive remuneration for suggesting ideas about how to educate for a sustainable future. These ideas will be used as examples and themes in their textbook revisions. If you are interested in educating for a sustainable future by serving as a reviewer or subject matter expert, please fill out a survey at https://www.surveymonkey.com/s/JGN89ZD.

For more information contact Susan Musante at smusante@aibs.org.

BSA at National Association of Biology Teachers

A number of BSA members presented at the recent NABT Professional Development Conference in Dallas, TX. **Gordon Uno** led sessions in an AP Biology Symposium. **Stephen Saupe** presented a poster on using leaf morphology to measure mean annual temperature in the 4-year college poster session. **Susan Singer** and **Gordon Uno** will present in the 2012 NABT Faculty Professional Development Summit. **Stanley Rice** presented on root foraging investigations for classrooms. **Gordon Uno** and **Marsh Sundberg** led a special Saturday workshop on Planting Inquiry in Science Classrooms. In association with the NABT meeting, a PlantingScience Focus Group meeting of teachers and mentors was held to gain stakeholder input.

The new student roadmap through a science project planned for the revised PlantingScience website will have helps for science practices doing science, recording ideas in notebooks and sketches, presenting science, and talking science. A graphic will be associated with each main support, such as this one for Arguing the Evidence.

PlantingScience Successes and Next Steps

PlantingScience is in high gear reviewing lessons learned from the DRK12 grant (DRL 0733280) to build on successes and plan next steps. The online platform is currently undergoing a complete overhaul. Some of the new resources include a student roadmap through a project and supports for science practices in keeping with the Next Generation Science Standards. An Inquiry Task Force, including representatives from the American Society of Plant Biologists, Ecological Society of America, American Phytopathological Society, was established in the spring as a mechanism for partner societies to participate in new inquiry development. For highlights of some successes and collaborative efforts, see the American Society for Plant Biologists' September/October 2012 newsletter: http://newsletter.aspb.org/2012/septoct12.pdf

Plant Blog on Huffington Post

Chris Martine has taken his "Plants Are Cool, Too!" efforts to the popular media site Huffington Post. Don't miss his blog:
http://www.huffingtonpost.com/dr-chris-martine/leaf-fossils-preserved-leaves_b_1967427.html

Plant Reproduction & the Pollen Tube Journey – How the Females Lure the Males

Lorbiecke, René. 2012. *The American Biology Teacher* 74(8): 575-580.

Many of us have had students germinate pollen to observe pollen tube growth on a slide, but Lorbiecke has taken this one step further to demonstrate chemotaxis as the pollen tube approaches an ovule in this semi-in vivo assay. Rapid cycling Brassica (Fast Plants) flowers are the research material and the author provides detailed instructions, including a diagrammatic flow-chart of the procedure, for students to follow. Excellent macrophotographs illustrate the results.

Do College Introductory Biology Courses Increase Student Ecological Literacy?

Cheruvelil, Kendra Spence and Xuemel Ye. 2012. *Journal of College Science Teaching* 42(2): 50-56.

Do prospective biology majors have greater motivation for study and more positive perception of environmental issues than non-majors? Yes. Do they have better conceptual understanding? Not so much. Are they more ecologically literate at the end of the course? Not significantly. I'm sure these results would be different in any of the courses we teach. Or would they be? Actually, for most of us, the results would probably be quite similar. Read this article and set yourself a challenge.

Ethics CORE - Can You Help?

Together with the National Science Foundation, Ethics CORE is working to give researchers and professionals easier access to ethics information through a new online portal. Ethics CORE (http://nationalethicscenter.org) leverages its digital platform to bring together a novel collection of traditional library resources (e.g., encyclopedia, research articles, etc.) with new media (e.g., blogs, online communities and multimedia tools). The goal is to create a virtual space where students, faculty, researchers and practicing professionals can seamlessly receive and share information on everything from Authorship to Whistle-blowing.

As we seek to create a virtual hub for ethics information, we would very much like to solicit your input on the following questions:

1) What ethics resources (articles, documents, books, websites, etc.) have been particularly useful or relevant to researchers or practitioners in your field?

2) Are there any case studies, particularly case studies with positive outcomes, involving ethical issues that might be interesting or useful to other members of your discipline?

The Ethics CORE team can help you connect with ethics resources useful to you. If you are aware of any gaps in the ethics resources available to members of your discipline, or if you need a digital environment to serve a need particular to your group, we would like to collaborate with you. We also hope you consider Ethics CORE as a mechanism for distributing your own related work.

-Megan Hayes Mahoney Visiting Digital Library Research Librarian, Grainger Engineering Library, University of Illinois at Urbana-Champaign Email: mohayes2@illinois.edu

-Gene Amberg, Ph.D Collaborations Director, National Center for Professional & Research Ethics, University of Illinois at Urbana-Champaign Email: gamberg@illinois.edu

BULLARD FELLOWSHIPS IN FOREST RESEARCH

Each year Harvard University awards a limited number of Bullard Fellowships to individuals in biological, social, physical and political sciences to promote advanced study, research or integration of subjects pertaining to forested ecosystems. The fellowships, which include stipends up to $40,000, are intended to provide individuals in mid-career with an opportunity to utilize the resources and to interact with personnel in any department within Harvard University in order to develop their own scientific and professional growth. In recent years Bullard Fellows have been associated with the Harvard Forest, Department of Organismic and Evolutionary Biology and the J. F. Kennedy School of Government and have worked in areas of ecology, forest management, policy and conservation. Fellowships are available for periods ranging from six months to one year after September 1. Applications from international scientists, women and minorities are encouraged. Fellowships are not intended for graduate students or recent post-doctoral candidates. Information and application instructions are available on the Harvard Forest web site (http://harvardforest.fas.harvard.edu). Annual deadline for applications is February 1.

Position Available

Assistant/Associate/Full Professor Bioeducation Position # F99418

Job Summary:

The position is for an Assistant Professor (tenure track), Associate Professor (tenure track or tenure eligible), or Full Professor (tenure eligible) nine-month appointment with a possible three months of summer support for first three years. We are seeking a colleague to contribute to our unique PhD program in Biological Education. Preference will not be given to a particular rank; all applicants will be judged in accordance with their years of experience. We seek a candidate with a Doctorate, with research experience in teaching and learning at the postsecondary level, and expertise in at least one biology content area sufficient to add to and collaborate with current expertise in the school.

The job duties include: teaching undergraduate lectures and laboratories in biology content area and graduate courses in Bioeducation and Biology; training graduate students emphasizing biological education research topics at the postsecondary level of teaching and learning; providing service for the school, college, university, and community; conducting research in biological education; applying for grants; and publishing original research results.

UNIVERSITY of NORTHERN COLORADO

Bringing education to life.

Minimum Qualifications:

Doctorate (Ph.D. or Ed.D.) in Biology or Science Education (or closely related field) with demonstrated experience in Biological Education Research:

- Evidence or potential for excellence in teaching
- Demonstrated research and publication record in the area of teaching and learning
- Potential or past success securing external funding
- Ability to teach graduate courses in bioeducation topics and educational research techniques
- Ability to teach undergraduate courses in some biology topic(s) that complements current expertise in the school
- Potential or past experience in supervising research students

Preferred Qualifications:

- Demonstrated pedagogical research at the collegiate level of teaching and learning
- Ability to provide leadership with the pedagogical aspect of our Ph.D. program in Biological Education
- Teaching experience at the university level
- Ability to teach other courses in areas of need (e.g., molecular biology, general biology, etc.)

Salary and Benefits:

Salary and rank is commensurate with qualifications and experience. Benefits available include health, life, and dental insurance, as well as a selection of several defined contribution retirement programs. Dependents and spouses of UNC employees who are employed as 0.5 FTE or above are entitled to and eligible for Dependent Tuition Grants. These tuition grants will cover in-state tuition charges. Further requirements may exist. Other benefits may be available based on position. The position is a nine-month appointment with a possible additional three months of summer support provided by the Winchester Distinguished Professorship Endowment for the first three years to help the faculty member establish a productive research agenda.

Requested Start Date: August 19, 2013

Application Materials, Contact, and Application Deadline:

Screening of applications will begin on December 3, 2012 and will continue until the position is filled. Interested persons should apply online at https://careers.unco.edu and select "View/Apply for Faculty Positions" then choose "Assistant/Associate/Full Professor – BioEducation." Application documents to be submitted online are a letter of application/cover letter, a *curriculum vitae*, and the names and contact information of at least three references. In addition to the material provided online, please send unofficial or official copies of all undergraduate and graduate school transcripts, a statement of research interests, a statement of teaching philosophy, a list of courses you would like to teach, and copies of published original research articles to: Cynthia Budde, School of Biological Sciences, Ross Hall, Box 92, University of Northern Colorado, Greeley, CO 80639. Tel: 970-351-2921. email: cynthia.budde@unco.edu. For questions, contact Rob Reinsvold, Chair of the search committee, at robert.reinsvold@unco.edu.

Additional Requirements:

Satisfactory completion of a background check, educational check, and authorization to work in the United States is required after a conditional offer of employment has been made. Original transcripts must be submitted at least one (1) month before the start date.

Location and Environment:

The University of Northern Colorado is a Doctoral/Research University enrolling 12,000+ graduate and undergraduate students. The university, founded in 1889, is located in Greeley, Colorado, which has a growing population of 90,000 and is situated an hour north of Denver and 30 miles east of the Rocky Mountains. The School of Biological Sciences currently has 18 full time faculty members, 40 graduate students (MS, MBS, and PhD), and 450 undergraduate majors. The unique Ph.D. program in Biological Education specializes in training biologists to be experts in their disciplines and outstanding college biology teachers. This degree program allows the student to choose between an emphasis on the biology content or an emphasis on biology pedagogy. Another strength is our long tradition of cooperative interactions between faculty of the Sciences and Education. Further information about UNC and the City of Greeley is available at http://www.unco.edu.

Additional Information:

This position is contingent on funding from the Colorado State Legislature, approval by the Board of Trustees, and subject to the policies and regulations of the University of Northern Colorado. Federal regulations require that the University retain all documents submitted by applicants. Materials will not be returned or copied for applicants.

The University of Northern Colorado is an equal opportunity/affirmative action institution that does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation or veteran status. For more information or issues of equity or fairness or claims of discrimination contact the UNC AA/EEO/Title IX Officer at UNC Human Resource Services, Campus Box 54, Carter Hall 2002, Greeley, CO 80639, or call 970-351-2718.

UNC

Angiosperm Origins—Monocots First?

The origin of angiosperms continues to be an unresolved issue, but has always been framed within the paradigm of seed plant monophyly. This is a parsimonious view, based on the improbability that both seed-and-pollination and cambium-and-woody growth are likely to have evolved more than once. A Monocots-First scenario denies both assumptions and claims that angiosperms arose directly from a pteridophytic base and built their seeds independently of all other living seed plants. The cambium and woody growth developed later, during the diversification of early dicots.

A Monocots-First scenario is both falsifiable and has considerable explanatory power. The similarity of early embryology in monocots and pteridophytes is either a recent "reversion" or a deep symplesiomorphy. Genomics of early development should be able to verify which is correct. Because a tubular cambium and woody growth came later—in the diversification of early dicots—it can explain "Darwin's abominable mystery." Woody growth allowed more complex branching—a platform for the evolution of smaller leaves that became both petiolate and deciduous. These, in turn, fossilize much more readily than herbaceous growth and produced the "sudden appearance" that troubled Darwin. Please take a look at this very different Perspective: http://fieldmuseum.org/explore/angiosperm-origins-monocots-first-scenario.

–William Burger, Department of Botany, Field Museum (e-mail: wburger@fieldmuseum.org)

Funding for Plant Conservation and Native Plant Materials Programs

Dear Plant Conservation Alliance Colleagues,

I am writing with some tentatively good news as well as with a request.

As you know, the Bureau of Land Management (BLM) has supported a modest native plant materials program for a number of years. This program, like many federal activities, has been in jeopardy of reduced funding in the current budgetary climate.

In 2011 we were successful in obtaining language as part of the appropriations bill for the

Department of the Interior that instructed the BLM to maintain a robust native plant program. This language was secured, in part, through the efforts of the Plant Conservation Alliance NGO members who communicated its importance to their elected officials.

Earlier this year, we had some additional success when the report that accompanied the House Interior, Environment, and Related Agencies Appropriation Bill for FY 2013, included the following language:

"Native Plant Program. The Committee is supportive of the Bureau of Land Management's existing plant conservation and native plant materials program and expects the Bureau to continue the program through resources provided under various accounts. The Committee directs the threatened and endangered species account to contribute to this program."

These two sentences express the support of the Committee for native plant programs and instruct the Bureau of Land Management to maintain the contribution to the program that comes through the funding line item for the Threatened and Endangered Species account. It is imperative that elected officials, committee staff members and agency personnel are repeatedly reminded of the importance of funding for endangered and native plant materials. If we don't speak up for plants, no one else will.

This brings me to my request: Please take a minute to send a message to your elected officials regarding the importance of protecting funding for plant materials and native plant programs. Following is some suggested text:

Dear _________:

On behalf of (organization), I am contacting you to ask for your help in supporting funding for plant conservation and native plant materials programs through the Bureau of Land Management.

The United States has inherited a rich legacy of biodiversity, with native plants delivering essential ecosystem services such as waste purification, climate modulation and habitat for myriad wildlife and fish services across the United States. Native plant communities are threatened by unsustainable urban and rural development, expanding energy production, the spread of invasive species, and pollution. The United States needs to ensure that native plant communities are protected and that future generations benefit from the same legacy that we have inherited.

The work of the Bureau of Land Management (BLM) is critical to these efforts. Funding provided through BLM is critical to these efforts. Funding provided through BLM accounts for Land Resources, Wildlife & Fisheries Management and Threatened and Endangered Species supports work on native plants, rare plants and addresses problems posed by invasive plant species. These funds not only protect biodiversity, but also contribute to generating more science competency and green jobs—new scientists, ecologists and land managers.

As Congress works to finalize the Department of Interior's 2013 funding, please ensure that resources provided for plant activities is included at no less that the FY12 level. We suggest including the following language with the Bureau of Land Management Appropriation:

"Native Plant Program. The Committee is supportive of the Bureau of Land Management's existing plant conservation and native plant materials program and expects the Bureau to continue the program through resources provided under various accounts. The Committee directs the threatened and endangered species account to contribute to this program."

Contacting Congress:

You can find your Senators by visiting www.senate.gov and following the "Find your Senators" dropdown in the upper right corner. Or, if you want to call and know the name of your Senator, you can call the Capitol switchboard at 202-224-3121 and ask to be connected to their office.

You can find your Representatives by visiting www.house.gov and entering your service area zip code(s) in the upper left corner. Or if you know the name of your Representative, you can call the Capitol switchboard at 202-224-3121 and ask to be connected to his or her office. Once connected to the Congressional office, please ask for the staff handling appropriations for the Department of Interior.

Sophia Siskel, President & CEO, Chicago Botanic Garden, www.chicagobotanic.org. ssiskel@chicagobotanic.org, 847-835-8351

Hunt Institute Receives National Film Preservation Foundation Grant

(PITTSBURGH, PA)—Hunt Institute for Botanical Documentation has been awarded preservation project funding from the National Film Preservation Foundation (NFPF) to preserve Walter Hodge's film of Peru in the 1940s. The award will be used to clean, conserve and make both a film copy for preservation and a digital copy for access.

Walter Henricks Hodge began his botanical career in 1934 as a graduate teaching assistant at Massachusetts State College. Eventually his resume included time on the faculties of the University of Massachusetts, the Universidad Nacional de Colombia and Harvard University and service in governmental and scientific organizations, including the United States Department of Agriculture and the National Science Foundation. Hodge traveled extensively, including periods in the West Indies, Peru, Colombia and Japan, which provided him with ample opportunities to indulge his interest in photography. His photographic work illustrates practical and economic uses of plants throughout the world and records not only a large variety of plant species, but also informal portraits of botanists he encountered in his travels. Hodge's still photographs have been published in various United States Department of Agriculture bulletins, *National Geographic* and the *Christian Science Monitor*. From 1943 to 1945 he was a botanist for the United States Office of Economic Warfare's Cinchona Mission in Lima, Peru, and the film we will preserve is a result of this assignment.

The purpose of the Cinchona Mission was to find reliable alternate sources of cinchona bark for the wartime production of quinine. The footage is a unique collection of material relating not only to Hodge's botanical mission, but also to his interests in the local culture and customs of Peru. Sequences include shots of local scenery (including Macchu Picchu) and anthropologically interesting material relating to native lives and customs (including sequences in local street markets and at a bullfight). Hodge's wife Barbara (1913–2009) traveled with him and can frequently be seen in the footage, occasionally acting as a model for close studies of textiles and jewelry. Finally, Hodge did not neglect his central work assignment; he included a sequence covering the entire process of the harvesting and preparation of cinchona bark. The film quality and color are

Walter Hendricks Hodge with his personal Cine-Kodak Special 16mm camera, which was used to create his film of Peru that will be preserved with the grant funds, 1944, Miraflores, Lima Peru, HI Archives portrait no. 94. Photo by Barbara Taylor Hodge. (c 2012 Hunt Institute for Botanical Documentation. All rights reserved)

excellent, and it is our feeling that this material will interest botanists, anthropologists and historians. Hunt Institute has had a long relationship with Hodge, which began when Founding Director George H. M. Lawrence (1910–1978) proposed that Hodge take informal portraits of botanists. Over the years Hodge has sold or donated thousands of photographs to the Hunt Institute Archives. We also hold 27 linear feet of Hodge's professional and personal correspondence and research.

The NFPF grant application process was undertaken by Hunt Institute Archivist Angela L. Todd with the assistance of Jeffrey A. Hinkelman, video collection manager and course instructor at Carnegie Mellon's University Libraries, and Hannah Rosen, preservation programs specialist at Preservation Technologies in Cranberry Township, Pennsylvania.

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library. The current collections include approximately 30,150 book and serial titles; 29,000+ portraits; 29,270 watercolors, drawings and prints; 243,000+ data files; and 2,000 autograph letters and manuscripts. The Archives specializes in biographical information about, portraits of and handwriting samples from scientists, illustrators and all others in the plant sciences. The Archives is a repository of alternate resort and as such has collected over 300 institutional and individual archival collections that may not have otherwise found an easy fit at another institution. Including artworks dating from the Renaissance, the Art Department's collection now focuses on contemporary botanical art and illustration, where the coverage is unmatched. The Art Department organizes and stages exhibitions, including the triennial *International Exhibition of Botanical Art & Illustration*. The Bibliography Department maintains comprehensive data files on the history and bibliography of botanical literature. Known for its collection of historical works on botany dating from the late 1400s to the present, the Library's collection focuses on the development of botany as a science and also includes herbals (eight are incunabula), gardening manuals and florilegia, many of them pre-Linnaean. Modern taxonomic monographs, floristic works and serials as well as selected works in medical botany, economic botany, landscape architecture and a number of other plant-related topics are also represented.

Impulsive micromanagers help plants to adapt, survive

EAST LANSING, Mich. — Soil microbes are impulsive. So much so that they help plants face the challenges of a rapidly changing climate.

Jen Lau and Jay Lennon, Michigan State University biologists, studied how plants and microbes work together to help plants survive the effects of global changes, such as increased atmospheric CO_2 concentrations, warmer temperatures and altered precipitation patterns. The results, appearing in the current issue of the Proceedings of the National Academy of Sciences, showed that microbes in the ground not only interact with plants, but they also prompt them to respond to environmental changes.

"We found that these changes in the plants happen primarily because of what global changes do to the below ground microbes rather than the plant itself," said Lau, who works at MSU's Kellogg Biological Station. "Drought stress affects microbes, and they, in turn, drive plants to flower earlier and help plants grow and reproduce when faced with drought."

The team conducted a multi-generational experiment that manipulated environmental factors above and below ground while paying close attention to the interaction between the plants and microbes in the soil. Close examination of this particle partnership revealed some interesting results.

Researchers already knew that drought stress reduced plant growth and altered their life cycle. The team was surprised, though, to observe that the plants were slow to evolve and, instead, microbes did most of the work of helping plants survive in new, drier environments. This happened because the microbes were quick to adapt to the changing environment.

This newfound aspect of their relationship gives plants an additional strategy for survival, Lau said. "When faced with environmental change plants may not be limited to traditional 'adapt or migrate' strategies," she said. "Instead, they may also benefit from a third approach—interacting with complementary species such as the diverse microbes found in the soil."

Jen Lau, MSU biologist studied how plants and microbes work together to help plants survive the effects of global changes. Photo courtesy of MSU.

Lau and Lennon's research is funded in part by MSU AgBioResearch.

Contact: Layne Cameron, Media Communications, Office: (517) 353-8819, Layne.Cameron@cabs.msu.edu; Jen Lau, Kellogg Biological Station, Office: (269) 671-5117, jenlau@msu.edu

Plants exhibit a wide range of mechanical properties, engineers find

Biological structures may help engineers design new materials.

CAMBRIDGE, Mass. — From an engineer's perspective, plants such as palm trees, bamboo, maples and even potatoes are examples of precise engineering on a microscopic scale. Like wooden beams reinforcing a house, cell walls make up the structural supports of all plants. Depending on how the cell walls are arranged, and what they are made of, a plant can be as flimsy as a reed, or as sturdy as an oak.

An MIT researcher has compiled data on the microstructures of a number of different plants, from apples and potatoes to willow and spruce trees, and has found that plants exhibit an enormous range of mechanical properties, depending on the arrangement of a cell wall's four main building blocks: cellulose, hemicellulose, lignin and pectin.

Lorna Gibson, the Matoula S. Salapatas Professor of Materials Science and Engineering at MIT, says understanding plants' microscopic organization may help engineers design new, bio-inspired materials.

"If you look at engineering materials, we have lots of different types, thousands of materials that have more or less the same range of properties as plants," Gibson says. "But here the plants are, doing it by arranging just four basic constituents. So maybe there's something you can learn about the design of engineered materials."

A paper detailing Gibson's findings has been published this month in the *Journal of the Royal Society Interface.*

To Gibson, a cell wall's components bear a close resemblance to certain manmade materials. For example, cellulose, hemicellulose and lignin can be as stiff and strong as manufactured polymers. A plant's cellular arrangement can also have engineering parallels: cells in woods, for instance, are aligned, similar to engineering honeycombs, while polyhedral cell configurations, such as those found in apples, resemble some industrial foams.

To explore plants' natural mechanics, Gibson focused on three main plant materials: woods, such as cedar and oak; parenchyma cells, which are found in fruits and root vegetables; and arborescent palm stems, such as coconut trees. She compiled data from her own and other groups' experiments and analyzed two main mechanical properties in each plant: stiffness and strength.

Among all plants, Gibson observed wide variety in both properties. Fruits and vegetables such as apples and potatoes were the least stiff, while the densest palms were 100,000 times stiffer. Likewise, apples and potatoes fell on the lower end of the strength scale, while palms were 1,000 times stronger

"There are plants with properties over that whole range," Gibson says. "So it's not like potatoes are down here, and wood is over there, and there's nothing in between. There are plants with properties spanning that whole huge range. And it's interesting how the plants do that." It turns out the large range in stiffness and strength stems from an intricate combination of plant microstructures: the composition of the cell wall, the number of layers in the cell wall, the arrangement of cellulose fibers in those layers, and how much space the cell wall takes up

In trees such as maples and oaks, cells grow and multiply in the cambium layer, just below the bark, increasing the diameter of the trees. The cell walls in wood are composed of a primary layer with cellulose fibers randomly spread throughout it. Three secondary layers lie underneath, each with varying compositions of lignin and cellulose that wind helically through each layer.

Taken together, the cell walls occupy a large portion of a cell, providing structural support. The cells in woods are organized in a honeycomb pattern — a geometric arrangement that gives wood its stiffness and strength.

Parenchyma cells, found in fruits and root vegetables, are much less stiff and strong than wood. The cell walls of apples, potatoes and carrots are much thinner than in wood cells, and made up of only one layer. Cellulose fibers run randomly throughout this layer, reinforcing a matrix of hemicellulose and pectin. Parenchyma cells have no lignin; combined with their thin walls and the random arrangement of their cellulose fibers, Gibson says, this may explain their cell walls' low stiffness. The cells in each plant are densely packed together, similar to industrial foams used in mattresses and packaging.

Unlike woody trees that grow in diameter over time, the stems of arborescent palms such as coconut trees maintain similar diameters throughout their lifetimes. Instead, as the stem grows taller, palms support this extra weight by increasing the thickness of their cell walls. A cell wall's thickness depends on where it is along a given palm stem: Cell walls are thicker at the base and periphery of stems, where bending stresses are greatest.

Gibson sees plant mechanics as a valuable resource for engineers designing new materials. For instance, she says, researchers have developed a wide array of materials, from soft elastomers to stiff, strong alloys. Carbon nanotubes have been used to reinforce composite materials, and engineers have made honeycomb-patterned materials with cells as small as a few millimeters wide. But researchers have been unable to fabricate cellular composite materials with the level of control that plants have perfected.

"Plants are multifunctional," Gibson says. "They have to satisfy a number of requirements: mechanical ones, but also growth, surface area for sunlight and transport of fluids. The microstructures plants have developed satisfy all these requirements. With the development of nanotechnology, I think there is potential to develop multifunctional engineering materials inspired by plant microstructures.."

Karl Niklas, a professor of plant biology at Cornell University, says Gibson's engineering parallels are fitting. Plants, in a way, he says, are "largely structural things … chemical factories that are architecturally arranged."

"Plants on Earth have evolved over three-and-a-half billion years, and that is a giant evolutionary experiment of trial and error, because the things that don't work are extinct, and the things that do work are more abundant," Niklas says. "We can learn things from nature and apply it to construct better panel boards, styrofoams and photovoltaics that will help society."

Triage for plants: NYBG scientists develop and test rapid species conservation assessment technique

To speed up the process of identifying threatened and endangered plant species, a team of New York Botanical Garden scientists has developed a streamlined method for evaluating the conservation status of large numbers of plant species, using information from plant research collections and Geographic Information Systems technology.

Faced with such threats as deforestation, climate change, and invasive species, a significant proportion of the world's plant species are commonly believed to be in serious decline and possibly headed toward extinction. For government officials, non-governmental organizations, and anyone working to preserve biodiversity, knowing which species are most at risk is a critical piece of information, but the conservation status of only a fraction of the world's plant species has been determined.

The rapid assessment method developed by Botanical Garden scientists uses the geographic range of a species as an indicator of its vulnerability. Sorting through thousands of species, the process identifies which ones are widespread in a region—and thus not in any immediate risk—and which have restricted ranges, making them more susceptible to extinction when faced with environmental problems.

"The lack of a comprehensive list of threatened and endangered species is one of the greatest impediments to the effort to preserve plant biodiversity," said James S. Miller, Ph.D., the Garden's Dean and Vice President for Science and the lead author of the paper that outlines the method and the results when it was tested on Puerto Rico's native plant species. "Having a more efficient system for assessing threats means that we can quickly focus conservation efforts on priority areas and species that need the most attention."

Using the Garden's streamlined assessment process could make it possible for the conservation community to meet a key target of the Global Strategy for Plant Conservation (GSPC), which calls for an assessment of the conservation status of all known plant species by 2020. (The GSPC is a product of the 1992 Convention on Biological Diversity, an international treaty that calls for the conservation and sustainable use of Earth's biodiversity.)

Currently, the standard conservation assessment method is the one created by the International Union for the Conservation of Nature (IUCN) for its Red List, which since 1994 has used a scientifically rigorous, multicriteria process that assigns a species to such categories as "extinct," "least concern," "endangered," and "critically endangered."

Red List assessments have been completed for large groups of animal species—birds, mammals, and amphibians—but so far, fewer than 15,000 plant species have been evaluated under the Red List process, in part because the procedure requires more data than is readily available for many species. According to Dr. Miller, there are approximately 300,000 known plant species, but many more remain to be discovered.

In designing a simpler process for evaluating plant species, Dr. Miller and his colleagues decided to assign species to only two categories: "At Risk" or "Not at Risk." The key criterion for determining a species' status was the size of its geographical range, or extent of occurrence (EOO). Under one of IUCN's criteria, a species with an EOO of more than 20,000 square kilometers (about 7,700 square miles, slightly smaller than the state of New Jersey) is considered not threatened, so that became the cutoff for determining whether a species would be categorized as At Risk or Not At Risk.

The Garden's scientists tested their approach by evaluating the 2,025 species of seed plants native to Puerto Rico, which was chosen because its plants are well documented in research collections. Data for the study came from the Global Biodiversity Information Facility, an international, open-access resource, and from the Garden's C.V. Starr Virtual Herbarium, a repository of digitized information about more than 1.6 million plant specimens.

As described in the team's paper in a recent issue of the scientific journal *Biodiversity and Conservation*, the assessment consisted of two stages. An initial evaluation of the plant data determined that 1,476 species had ranges of more than 20,000 square kilometers and were classified as Not at Risk. Focusing on the remaining 549 species, the Garden scientists added more precise latitude and longitude references for the locations where many of the species samples had been collected. After recalculating their ranges, the team was able to determine that 90 additional species could be categorized as Not at Risk.

That means, however, that 459 species, or 23 percent of Puerto Rico's flora, should be considered At Risk. The analysis of more than 2,000 species took less than four months.

To test the method's reliability, the Garden scientists compared their results with the Red List, which has assessed only 77 species of Puerto Rican seed plants, assigning 53 to threatened categories. The Garden's rapid assessment process categorized 47 of the 53 species on the Red List as At Risk.

In addition to Dr. Miller, the Garden team consisted of Brian Boom, Ph.D., Director of the Garden's Caribbean Biodiversity Program; Holly A. Porter-Morgan, Ph.D.; Hannah Stevens; James Fleming; and Micah Gensler.

The *Biodiversity and Conservation* paper also describes a second rapid assessment method developed by the Smithsonian Institution, which categorized 367 species as At Risk. It overlapped with the Red List for 42 out of 53 species.

Beyond identifying a broad range of threatened species, the two methods could serve as valuable planning aids, the authors conclude. "The tools used to conduct these analyses can also map distributions of 'At Risk' species and identify specific geographic places where threatened plants are concentrated," they write. "The places thus identified may be considered priority areas for conservation and possible candidate areas for protected status."

Developmental and Structural

Floral Diagrams. An Aid to Understanding Flower Morphology and Evolution

Louis P. Ronse de Craene.
2010. ISBN 978-0-521-72945-1
Paperback, $63.00 (£37.00); 441 pp.
Cambridge University Press, Cambridge, England

Making floral diagrams—diagrams that show the spatial relationship of the various parts of the flower—is an excellent way for student, teacher, and researcher alike to understand how a flower is put together. However, it is somewhat of a lost skill, and Ronse de Craene rectifies this in this profusely illustrated book. The various parts of a flower are discussed in an introductory chapter, and then we turn to a justification for making floral diagrams; a brief introduction to the floral diagrams follows. (Keep a bookmark in p. 52, where the symbols used in the diagrams are explained.) A brief statement of the systematic significance of floral diagrams follows, which he returns to in the conclusion, and a glossary and two indices are also included. The bulk of the book consists of floral diagrams of over 150 families. There is sometimes more than one example per family, and always discussion explaining the diagrams to put them in the general context of the floral variation in the family to which they belong. Floral formulae are given for each species illustrated, as well as a general floral formula for the family as a whole.

The classic study that uses floral diagrams is A. W. Eichler's *Blütendiagramme Konstruiert und Erläutert* of 1875-78, which has been digitized. Ronse de Craene's diagrams are much more elaborate that those of Eichler, sometimes showing relationships between parts at different levels in the flower, or at different times during development. Indeed, as he claims in the introduction, "the information contained in floral diagrams is potentially immense and replaces complex descriptions." Although a vast amount of information is summarized in individual diagrams, the typographic result can be like a Rorschach inkblot. However, if floral diagrams cannot replace text, they are still an invaluable aid in understanding the relationships between parts.

The book is generally clearly written, although some terms are confusing. Members of the important positional term pairs *ventral/dorsal, adaxial/abaxial,* and *posterior/anterior* seem to be used randomly and are not even all in the glossary (but see p. 53); the term *pherophyll* is sometimes mentioned, but does no "work" at all. On the other hand, Ronse de Craene reasonably opts to use the term *disc* for some nectaries; if its use were precluded because it referred to non-homologous structures (whatever that might mean), the botanical lexicon would have to be expanded drastically to cope.

A few points I noted as I read through the book: Perianth members are distinguished in the diagrams by their appearance; even if the perianth is biseriate, no convention is used to distinguish between the two whorls. Rather surprisingly, all the perianth members of *Symphonia* and of *Calycanthus* are shown as being sepaloid. The flowers of families like Taccaceae, Hydrocharitaceae, and Araceae are drawn with the odd member of outer whorl in the adaxial position, the unusual position for monocots, but this is not discussed in the text. *Galphimia* is drawn with the only nectary glands of the flower being adaxial in position and on the bracteoles/prophylls, although in *G. brasiliensis,* there may be sepal glands as well, and both secrete oils (Castro et al., 2001, not cited).

Explicating inflorescence morphology is not a major goal of this book. However, in families such as Smilacaceae, Myrtaceae, Myristicaceae, Amborellaceae, Ranunculaceae, and Calycanthaceae, "bract" structures appear in odd places in the diagrams, or different flowers in the one inflorescence are shown with different orientations. Ronse de Craene refers to, but does not explain, European and American traditions in the use of floral formulae. As with the floral diagrams, the general floral formulae for families can be complex and difficult to understand readily. Recent efforts to make such formulae more widely used (Prenner et al., 2010) have tended toward the same result; less can be better. And, although this was probably an editorial decision, may I protest about the use of "et al." references when the bibliography is arranged alphabetically by the name of the second author? This is now quite a common practice, but when somebody has been as prolific as Ronse de Craene himself, life becomes quite difficult!

Problems like these are minor and can be fixed in the next edition. Like the author, I think floral morphology has much to offer systematists today. A better understanding of floral morphology would surely enliven that all-too-large subset of papers on phylogeny that seem to have sworn off looking closely at flowers, or at any other aspects of the morphology or anatomy of the plant, for that matter. Floral diagrams and formulae are great teaching tools in any plant diversity class. I still remember with pleasure the Diploma in Taxonomy I took at Edinburgh. I went out into the gardens and greenhouses at lunch to get flowers of different families; for each, I drew a longitudinal section, and made a floral diagram and floral formula. It was a great way to learn.

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Physiological

Plant Metabolomics. Methods and Protocols.

Hardy, Nigel W. and Hall, Robert D. (Editors) 2012. ISBN 978-1-61779-593-0, (Cloth US$139.00) 340 pp. Humana Press, 333 Meadowlands Parkway, Secaucus, NJ 07094.

Recent developments in technology, research and computing machinery along with the new horizons in the sciences also presents challenges for the plant sciences. An area witnessing rapid growth in research interest is the field of plant molecular biology, which integrates both general and applied science, focusing on monitoring, screening and profiling molecular behavior in plant cells and cellular systems. One branch of plant molecular biology is metabolomics, which utilizes technology aimed at obtaining a qualitative and quantitative overview of plant metabolites. This research domain is highly innovative and complex, and the empirical results have many potential applications in applied botany, crop science, horticulture, food technology, nutrition and the pharmaceutical industry. Research on metabolomics is very active. According to the Science Citation Index (SCI), the keywords "plant metabolomics" yielded a total of 850 papers published up to August 2012 in high-ranking scientific journals worldwide. During July-August 2012 alone, more than 15 new papers were published. This means that the research potential in the field is strong, with new results continually coming up for scientific debate. Important current topics include the research methods and protocols used and problems relating to their future development.

The book "*Plant Metabolomics. Methods and Protocols*" is fresh in ideas and a useful manual for scientists, researchers, scholars, students and the wider readership interested in plant metabolism and metabolite molecules. The authors represented in the book are scientists active in the EU project META-PHOR and the book´s editors are N. W. Hardy and R. D. Hall. The purpose of this volume is to provide information on basic practical questions concerning experimental work with metabolomics. The book is divided into three parts (Material preparation, Chemical analysis approaches, Data analysis) comprising 18 chapters and explains the terms and concepts used in the field. Chapter 1 describes the practical setting up of a metabolomics experiment, with information on data pre-processing, metabolite identification, data analysis and data reporting. Chapter 2 focuses on questions of experimental design in plant metabolomics experiments and gives guidelines on the growth of plant material. This chapter also describes various philosophical and historical aspects of plant empirical experimentation from Ptolemy, trough Copernicus, and Bacon to Fisher. Observations are also made and on omics experiments and provides a detailed checklist of factors on starting a plant metabolomic experiment. Chapter 3 describes an approach to the co-cultivation of *Arabidopsis* cell cultures and bacterial plant pathogens to assess dual metabolomics. The *Arabidopsis* cell cultures, bacterial strains, nutrients, chemicals, antibiotics and the equipment needed are presented in detail. The methods appropriate for such an experiment are also described along with practical recommendations touching research of this kind. The dual metabolomic approach could be adapted to investigate fungal-plant interactions. In chapter 4, the authors recommend various precautions in the preparation and handling of samples from crop plants, and in chapter 5 the methods and material for tissue preparation using *Arabidopsis* are presented. This chapter ends the Part I (chapters 2-5), which mainly focuses on the preparation of material in metabolomics research, mostly with *Arabidopsis* as a model plant, and on pathogens. Research experience, methodology and the appropriate laboratory routines are presented. However, a critical reader of the book may be surprised at the absence of any consideration of metabolomics in the context of plant-herbivore interactions or of ecological aspects of symbiotic and antagonistic interactions, or plant signaling. Moreover, no empirical indication of the scientific reliability of the methods described in this part of the book is given, while the sources reveal a certain degree of bias.

Part II presents chemical analytical approaches used in metabolomic research. Chapter 6 is illuminating on solid phase micro-extraction in natural volatile components in melon and rice using gas chromatography-mass spectrometry (GC-MS), and chapter 7 on GC-MS materials and methods for profiling primary metabolites of tomato fruit. Materials and methods for the use of high-perfomance liquid chromatography coupled to mass spectrometry (HPLC-MS) in metabolomics of the plant family Brassicaceae are described in detail in the following chapter. This description is followed by typical chromatographs and their interpretation, and by the practical recommendations for conducting research of this kind. Chapter 9 contains a detailed presentation of tomato metabolite analysis by ultraperfomance liquid chromatography (UPLC), and chapter 10 describes high precision measurement and fragmentation analysis for metabolite identification. All the materials, methods, equipment and standards used in such investigations are presented in depth. Similarly, the succeeding chapters describe Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR) for plant metabolite profiling and identification (chapter 11), the use of nuclear magnetic resonance (NMR) and flow injection electrospray mass spectrometry (FI-ESI-MS) for metabolomics research in Brassicaceae (chapter 12), and the spectroscopy research protocols of trace element content and speciation in cereal grains (chapter 14). The Part II ends with chapter 14, describing the use of genomics and metabolomics methods to quantify fungal endosymbiots and alkaloids in grasses. A very detailed presentation of the methods and the interpretations of chromatograms greatly help the reader to understand the procedures. Part II (chapters 6-14) of the book is chemical in character and shows the practices and challenges of research in metabolomes. As metabolomes constitute an extremely large field with very diverse groups of molecules, the chemical methods used must be considered case by case. The examples presented in part II are very useful for this purpose. Moreover, readers of the book will benefit from the fact that the methods with many physical and technical parameters and terms of high technology are presented simply and intelligibly.

Part III of the book (chapters 15-18) describes data analysis, data interpretation and accuracy estimation. Chapter 15 describes the processing of nominal and accurate mass LC-MS or GC-MS data using the MetAlign software package, and chapter 16 focuses on the methods for the fingerprinting and profiling of metabolome chromatography data. TagFinder software is presented. The chemical identification strategies using liquid chromatography-photodiode array-solid-phase extraction-nuclear magnetic resonance-mass spectrometry (LC-PA-SPE-NMR) are discussed in chapter 17. Part III concludes with chapter 18, which details a strategy for selecting data mining techniques in metabolomics. It is stated that the development of metabolomics depends not only on advances in techniques of chemical analysis but also on advances in computing and data analysis methods.

Overall, the book presents methods and protocols relating to all the stages of accurate plant metabolomics workflow, which is the foundation for innovative and prospective research worldwide. The book is a mix between a scientific treatise and a laboratory manual. As such it is an excellent one. It is also a good example of how a difficult and multi-complex matter can be presented simply. On the other hand, the book does not give answers to all the questions connected with plant metabolomics research and its quality. A more critical approach to the methods and protocols described and recommended could serve as fruitful basis for discussion, leading to more rapid analytical progress in the field. In its present form, the book hints at this opportunity, but clearly transfers this responsibility to the reader. Moreover, the use of different referencing styles in different chapters, and a rather routine style in the presentation of the data, and other small defects which, while they do not interfere with the reading of this book, can, from the formal point of view, be considered as minor blemishes. In sum, this is a most useful volume, which helps in separating the inseparable and measuring the un-measurable.

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Systematics

Flora of Tropical East Africa: Solanaceae

Edmonds, Jennifer M., with contributions by Maria S. Vorontsova and Sandra Knapp.
2012. ISBN 978-1-84246-395-6
Paper, US$51.85; 240 pp. + 4 unnumbered pages of back matter
Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, UK; www.kew.org

The publication history of this series dates from 1952. The final part appeared in early 2012, and whether this treatment of Solanaceae is in fact the final part is not explicitly stated, but one suspects it is. (There are no "Forthcoming Titles in Production" listed in the back matter.) Tropical East Africa is here defined as the modern states of Kenya, Uganda, and Tanzania, excluding Rwanda and Burundi on the west.

Commendably, the authors present an artificial key to all genera represented in the flora area, even those only represented by cultivated plants. The taxonomic treatments are enriched by remarks on folk uses of some species, including folk medicine. Nearly every genus is accompanied by one or more full-page drawings, all of which are original to this work.

There are extensive discussions of generic limits, where necessary. In the treatments of the individual species, the authors cite a very full synonymy and often digress into extended discussions of typification, encompassing even some species that are not native to Africa. The work is therefore important far beyond its stated coverage.

There is what might be called a "companion piece" to this volume: Edmonds, J. M. 2005. The Solanaceae in the Flora of Tropical East Africa, pp. 157-196 in A Festschrift for William G. D'Arcy. Monographs in Systematic Botany No. 104. In this contribution, which includes a goodly array of full-page illustrations, the stated intention was that the formal treatment of the Solanaceae would appear in 2005. A delay of seven years may well be due to unanticipated difficulties in finishing the work, especially the knotty problems presented by often-weedy species of Solanum, where all manner of trivial variants have been named in the literature, many of them without preserved types. I counted

23 species-level synonyms just for Solanum aethiopicum L., a widely cultivated food plant, and these are only the binomials in common use or based on African types; the reader is referred to a Solanaceae Source website for even more details.

The sometimes-cryptic abbreviations for literature citations throughout the work are explained on an unnumbered page just after p. 240.

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Flora Zambesiaca, 12(1) Araceae (including Lemnaceae).

Haigh, Anna and Peter C. Boyce, with contributions from Josef Bogner. 2012. ISBN 978-1-84246-374-1, paperback; 54 pp. + 3 unnumbered pages of back matter. US$55.00. Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, UK; www.kew.org; published by University of Chicago Press and available at their website, uchicago.edu.

It may be mentioned first that the contents of this part of the flora are given neither on the cover nor on the title page, as is also true for all the preceding parts of this series, which was begun in 1960. The area covered by Flora Zambesiaca is the modern nations of Botswana, Malawi, Mozambique, Zambia, and Zimbabwe, and also the Caprivi Strip, which falls between Zambia and Botswana. The inclusion of the Lemnaceae follows the recommendation of the Angiosperm Phylogeny Group, although the overall arrangement of the flora follows Bentham & Hooker of the nineteenth century. It is estimated that, when completed, the flora will account for some 10,000 species. As hinted at by the numbers in the title proper, the entire flora is to be treated in a series of volumes, 14 in all, with these volumes divided into 50 parts. Of these 50 parts, 38 have appeared thus far.

The Araceae, in the traditional sense, include a great many cultivated species. The authors elected to treat these as a separate group, just after the family description, and they are not included in the keys. All the genera in the keys have at least one species illustrated.

The species treatments mention no common names, nor is there any discussion of local uses of any of the species, so far as I could detect. This is a general pattern throughout the series, not peculiar to just this treatment.

The genera and species are all accompanied by complete citations of protologs and typification. The literature citations are conventionally abbreviated. Chromosome numbers are nowhere mentioned, probably because the authors and editors recognize that chromosome numbers have no place in a regional flora.

As best one can tell, from the listing given in the back matter just after p. 54, the Cyperaceae, Asclepiadaceae, and Commelinaceae are the major elements yet to appear in this monumental effort.

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Sarraceniaceae of the Americas.

Sarraceniaceae of South America.

McPherson, Stewart, Andreas Wistuba, Andreas Fleischmann, and Joachim Nerz. 2011. ISBN 978-0-9558918-7-8 (cloth, $89.99). 566 pp. Redfern Natural History Productions, Dorset, England. www.redfernnaturalhistory.com.

Sarraceniaceae of North America.

McPherson, Stewart and Donald Schnell 2011. ISBN 978-0-9558918-6-1 (cloth, $89.99). 810 pp. Redfern Natural History Productions, Dorset, England. www.redfernnaturalhistory.com.

These two volumes are a much expanded volume of Stewart McPherson's 2007 book, *Pitcher Plants of the Americas* (reviewed in PSB 53: 176-177). Combined, the two new volumes are more than 1000 pages longer than *Pitcher Plants of the Americas* and they present many more gorgeous photographs of pitcher plants and their habitats. Unfortunately they add little new scientific value, and most critically, they neglect much recent literature and add much confusion to the taxonomy of Sarraceniaceae.

The two new Sarraceniaceae volumes are intended as a set. *Sarraceniaceae of South America* has chapters introducing both carnivorous plants and the family, and provides an overall broader context for looking at pitcher plants of the Western

Hemisphere. This introductory material, especially on the history of the discovery of these plants, is very interesting to read, but it will be frustrating to future scholars because most of the references cited in text are not listed in the Bibilography. *Sarraceniaceae of North America* dives right into the two North American genera and all their extreme morphological variation; like its counterpart, much of the literature cited in text is unfortunately missing from the Bibliography. The two volumes also can be read independently – each focuses on particular genera (*Heliamphora* in the first, *Darlingtonia* and *Sarracenia* in the second), each has its own index, and because each has its own cadre of co-authors, each has a very different take on taxonomy of the three genera. Nevertheless, new species and infraspecific taxa, complete with Latin descriptions and assignments of type specimens, are formally described in each volume. Although it is not unheard of to erect new taxa in peer-reviewed floras, it is very rare to do it in non-peer-reviewed coffee-table books. McPherson et al. (2009a, 2009b) did the same in this two-volume treatment of *Nepenthes* (reviewed in PSB 56: 45-46). In all of these cases, it would have been better to subject these systematic hypotheses to peer review.

Although there are many more species of *Heliamphora* than of *Darlingtonia* and *Sarracenia* combined, *Sarraceniaceae of South America* is the smaller of the two, and the more taxonomically conservative. In part, the smaller size of South America reflects the lack of overall information on *Heliamphora*, which grows primarily on the sandstone massifs (tepuis) of the Guyana Shield of Venezuela, Guyana, and Brazil. Tepuis are hard to access, difficult places to work once there, and consequently *Heliamphora* has received much less scientific attention. Co-author Andreas Fleischmann is working on the systematics of the group for his dissertation project, and because that is not yet complete, the authors are rightly conservative in identifying species in the field and not identifying innumerable ecotypes, subspecies, varieties, or forms.

The same cannot be said for *Sarraceniaceae of North America*. Here, contemporary systematic approaches to the North American pitcher-plant genera, such as those in Flora of North America (Mellichamp, 2009) derived from a careful consideration of both morphological and molecular data, and literally centuries of botanical research, are completely swept aside in favor of Schnell's (2002) nomenclatural approach that formally names nearly every color morph, every isolated population, and every cultivated "sport" as a new variety or form. Although not prohibited by the International Code of Nomenclature for Algae, Fungi, and Plants, this system is neither rationally consistent (if it's appropriate for Sarracenia, why not for *Heliamphora*?) nor can it be supported by morphological, molecular, or field data (summarized in Mellichamp, 2009). Rather, it can be seen most charitably as a philosophical view of species (and infraspecific taxa) as Platonic entities, a view roundly rejected by modern systematists who treat systematic taxonomy as a series of hypothesis to be tested, not as revealed truth. Alternatively, the seemingly infinite identification of infraspecific taxa could be seen as a way to bolster the market for unique (cultivated) varieties of pitcher plants among hobbyists and collectors. Given the extensive space in each volume dedicated to discussion of carnivorous plant "Societies and Recommended Suppliers" in both volumes, and that *Sarraceniaceae of South America* is co-authored by the owner of *Wistuba – Exotic Plants in Germany,* the latter explanation cannot be discounted.

Like other titles in McPherson's burgeoning list of volumes on carnivorous plants, the two volumes on *Sarraceniaceae in the Americas* introduce carnivorous plants to a wide audience, and the exquisite photographs and lavish production makes them a joy to leaf through. But as a resource for botanists, systematists, and evolutionary ecologists doing serious research on carnivorous plants, these volumes are disappointing.

–Aaron M. Ellison, Harvard Forest, Harvard University, 324 North Main Street, Petersham, MA 01366.

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Tropical Plant Collecting: From the Field to the Internet.

Mori, Scott A., Amy Berkov, Carol A. Gracie & Edmund F. Hecklau.

ISBN 978-85-65005-00-5
(Paper US$34.95) 332pp.
TECC Editora LTDA, Rua João Pio Duarte Silva, 602, Apto.eos, Bloco A, CEP: 88037-000, Florianópolis, Santa Catarina, Brasil.

Scott Mori, the senior editor, with nearly half a century of experience in tropical botany as a collector and specialist of neotropical plants, is a dedicated and well-published scientist and a curator of various herbaria. He and the three co-authors manage to condense this lifetime worth of experience into 600 pages of well-written, easy-to-read tips, suggestions, and recommended protocols for tropical plant collection and curation. When I first heard about Mori's *Tropical Plant Collecting: From the Field to the Internet,* I assumed it was a technically written textbook. I was pleasantly surprised that it was not. Instead, this book is a narrative of the editors' experiences and lessons learned while collecting plants in the tropics. The first portion of the book is comprised of a series of colloquial anecdotes that describe living in the tropics and the many issues that arise. The book then systematically provides the reader suggestions and detailed protocols on how to collect and preserve plants and then submit the specimens to herbaria. It also describes herbarium curation and suggestions for utilizing herbarium records for online databases.

The first two chapters are autobiographical. Chapter one covers Mori's 47-year career as a tropical botanist, and in chapter two, one of Mori's past students, Amy Berkov, describes how a year in the tropics transitioned her from a 36-year-old artist to what she is now—a PhD-trained tropical entomologist. Though the first two chapters establish the credibility of the editors and describe some trials and tribulations of tropical work, there is little tangible information in them for aspiring tropical biologists. They did, however, discuss the feelings of loneliness and depression that come along with the excitement the tropics bring.

The remainder of the book is packed with practical information for not only those who plan to collect plants in tropical locations but those who are interested in herbarium curation and maintenance. I could not pin-point a single most important section because each chapter has information tailored for individuals who fall into specific niches and responsibilities within the field of botany.

For those preparing to travel to the tropics, the gem of the book is chapter three, 'Tips for Tropical Biologists.' This chapter provides suggestions for setting up camp and navigating the forest. Though admittedly not all-inclusive, it does provide a laundry list of many dangers, which include not only parasites and animals but common accidents tropical biologists should know.

Chapter four is the most useful chapter for those who do not know the proper etiquette and protocol to follow when collecting and preparing plants for distribution to herbaria. This chapter discusses what samples to collect, how and when to collect the samples, and how to preserve and maintain the samples prior to submission into an herbarium. Mori stresses often the importance of collecting underrepresented plants and making high-quality specimens. This chapter also presents protocols and general rules for collecting vouchers for ecological studies, which answered many questions I had for my own research. This chapter provides information that will maintain continuity and keep information parsimonious if ecologists follow the protocols established by Mori.

Chapters five and six focus on herbaria operation and use. In chapter five, Mori describes procedures for submitting specimens to herbaria and how a well organized, up-kept herbarium is maintained with proper labeling systems, modern databases, and how hard copy records can be supplemented with digital information and images. This will provide continuity of record keeping within and between herbaria. He also provides an example of a mission statement that could be used as a template for those who plan to establish an herbarium. Chapter six illustrates how herbarium records can be used and presented to a large audience via the internet as e-floras, e-monographs, and descriptions of individual species.

Mori finishes with a chapter on rainforest conservation, in which he describes rainforest ecology and the consequences of land use conversion and fragmentation. In this chapter, Mori makes an exceptionally strong economic case for tropical rainforest protection by focusing on ecosystem services and the value of harvested foods or other commodities provided by the forests.

The book includes appendices that provide information on potential funding sources, and also includes useful checklists of essential equipment. An index is also included to help the reader find important topics.

Throughout this book, the reader senses Mori's enthusiasm and concern for uninformed, naive, or poorly trained tropical botanists. Anecdotes in this book illustrate why it's important to be prepared and not delve into the tropics lightly. The rewards are huge for science and scientists, but the costs can be large and may result in death. Readers will also get a sense of the time and effort required for studies in tropical biology, where five years of collection is the suggested minimum time, though it typically takes a lifetime.

I have few complaints regarding this book, and those I do have are superficial and do not detract from the quality of the information presented. My primary complaint is that many of the photos provided are not clear, especially those showing pathogen infections and insect vectors. Mori discusses the importance of high quality, high resolution photos of plant characteristics, but the examples provided in this book are poor quality, black-and-white dot matrix images. Color plates of high-resolution photographs would have been ideal.

Mori provides addresses, phone numbers, and e-mails of companies that sell the equipment he uses in the field. He also references Google often and specific software packages used for database creation. Obviously these references are fine for the present, but this information will become outdated rather quickly and will certainly not be useful in the future.

This book is not a pocket guide or one I would travel with if space was limited and weight was a factor. Most of the tips and suggestions are hidden in blocks of text, so they may be inaccessible when needed. I would recommend that readers transcribe the information gleaned from this book into their field notebook for quick reference.

In conclusion, the style of Mori's writing makes the book approachable for scientist and laypersons alike who wish to spend time in the tropics collecting plants. This book is also a great resource for people who are establishing an herbarium or aspire to write floras or monographs. Mori and his colleagues aim to "make the work of tropical biologists safer, easier, and more comfortable." This aim will certainly be achieved if tropical botanists read this book.

-Kevyn J. Juneau, The School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI 49931.

Aldrovanda: The Waterwheel Plant.

Adam Cross.

2012. ISBN-13: 978-1-908787-04-0
Hardcover, UK£17.99 (approx. US$ 34.99).
xiii+248 pp.
Redfern Natural History Productions, Poole, Dorset, England. http://www.redfernnaturalhistory.com/

The waterwheel plant, *Aldrovanda vesiculosa*, is one of the most curious of all botanical curiosities. This perennial, rootless, aquatic carnivorous plant is essentially an aquatic Venus' flytrap (*Dionaea muscipula*)–its leaves have been modified into snap-traps–but with growth habits and physiological characteristics much more like the completely unrelated bladderworts (*Utricularia* spp.). *Aldrovanda vesiculosa* is the only species in the genus, and represents one of only three genera in the sundew family (Droseraceae); the other two are the monotypic and aforementioned *Dionaea* and the quite diverse *Drosera*. In spite of the many unique aspects of *Aldrovanda* and well over 150 years of research into all aspects of its biology, there has not until now been a book-length monograph devoted to it. As such, Cross' *Aldrovanda* is a most welcome compendium of information on this plant.

In a relatively short and lavishly illustrated book, Cross summarizes what is known about the taxonomic history; paleobotany and evolution; ecophysiology and morphology; habitat and distribution; population genetics; conservation issues; and methods for cultivation of *Aldrovanda*. Nearly 200 years of literature on the plant–from peer-reviewed through grey to popular–is thoroughly reviewed (the Bibliography itself is 30 pages long), and Cross not only summarizes this literature but also reflects on studies needed to fill in the gaps in our knowledge on all of these topics. Not bad for a young doctoral student from Western Australia!

Although the summaries of the basic scientific literature are most welcome, probably the most valuable aspect of the book is its discussion and highlighting of the pressing need to protect and conserve *Aldrovanda*. In spite of its geographically widespread distribution–*Aldrovanda* grows in Europe, Asia, Africa, and Australia–and relatively broad tolerance of water chemical characteristics and pH, it is very intolerant of habitat conversion, nutrient loading, or pollution, and so is locally extinct or on the brink thereof throughout its entire range. Some populations are protected and growing, but of 379 natural and restored populations known from historical records, herbarium data, or new observations, only 50 are extant. Similarly, of 69 introduced populations, only 28 are extant, including 10 in the United States, well outside of its natural range. The lengthy tabulation of the status of natural and introduced populations makes depressing reading indeed, but clearly illustrates the conservation challenges faced by many aquatic plants, including *Aldrovanda*.

As with all of the books on carnivorous plants published by Redfern Natural History Productions, the photography is exceptional. The majority of the photographs are by the author, but many others, including well-known experts on *Aldrovanda* biology, including Lubomír Adamec, Kamil Pasek, and Ryszard Kaminski grace the pages as well. Cross has clearly benefited from his interactions with these individuals, and many others, who not only provided him with great photographs but also fact-checked the manuscript. At the same time, Cross continues in the tradition of other Redfern publications in using the opportunity of a book-length publication to erect new taxa. Herein, only one new variety is formally named: *Aldrovanda vesiculosa* L. var. *rubsecens* A. T. Cross & L. Adamec. This variety is distinguished by its expression of anthocyanins in bright habitats and by its geographic restriction to all of Australia, Botswana, and Lake Balata-to in Hungary. It would really have been better to publish a new taxon in a peer-reviewed journal.

Aldrovanda: The Waterwheel Plant sets a series of benchmark for future studies of this species. It is not only a book every carnivorous plant aficionado will want on his or her shelf, but it also should be near at hand for botanists focused on the Caryophyllales and for those studying physiology of aquatic plants and how plants move. And it will look pretty on the coffee table, too.

– Aaron M. Ellison, Harvard Forest, Harvard University, Petersham, Massachusetts, USA

Books Received

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Diversity and Ecology of Lichens in Polar and Mountain Ecosystems. Hafellner, Josef, Ingvar Kärnefelt and Volkmar Wirth (eds). 2010. ISBN 978-3-443-58083-4 (Paper €104.00) 389 pp. J. Cramer in Borntraeger Science Publishers, Johannesstrasse 3 A, 70176 Stuttgart, Germany.

BOTANY 2013

July 27-31 New Orleans Celebrating Diversity!

Botany 2013 will be held in New Orleans Louisiana, at the Riverside Hilton, July 27 - 31, 2013. The theme of this year's meeting, "Celebrating Diversity," is well suited to the diverse flora of southern Louisiana and the wide array of talks provided by the five scientific societies participating in Botany 2013. These include are the American Bryological and Lichenological Society, American Society of Plant Taxonomists, American Fern Society, Botanical Society of America, and International Association for Plant Taxonomy.

We met in New Orleans recently to inspect our meeting facilities, meet the on-site staff, coordinate programs, and to plan events for our upcoming meeting. Downtown New Orleans and the surrounding natural areas in southern Louisiana offer tremendous opportunities for a memorable meeting this year. Our meeting facilities at the Riverside Hilton offer beautiful and state of the art facilities for our meeting. The rooms are spacious and are serviced by professional staff who will quickly attend to any needs that may arise to insure a seamless set of events. We are situated within easy walking distance to downtown New Orleans and the historic French Quarter, offering many places to socialize with our colleagues during evening get togethers with many restaurants, bars with outdoor seating, and entertainment venues.

Field trips are always popular, and Louisiana has noted natural areas. Our field trip schedule is taking shape with trips suiting attendees in all of our diverse disciplines. We are making every effort to have wonderful field trips led by professionals fully knowledgeable in the plants and sites under their direction. And how cool it will be to take some tours offering views of native carnivorous plants and maybe alligators!

Botany 2013 offers 12 symposia and nine colloquia (http://www.2013.botanyconference.org/info/symposia.php) in a wide range of botanical disciplines that is emblematic of our annual meetings. These range genomics, public policy, digitizing herbaria, taxonomy, evolution, ecology, conservation, biodiversity, and evolutionary topics from bryophytes and ferns to fossils to angiosperms.

This year's Sunday evening plenary speaker is Dr. Nalini Nadkarni, who will speak on "Celebrating diversity in the understanding of science: Botanists as ambassadors to a spectrum of humans." Please see a video of her work recently released on CNN: http://www.cnn.com/video/standard.html?hpt=hp_c2#/video/living/2012/11/16/the-next-list-nalini-nadkarni-weekend-pkg.cnn David White will be our Regional Botany speaker.

Botany 2012 experienced record levels of student involvement, and we are making every effort to continue this in Botany 2013: A generous grant from Monsanto Corporation is providing opportunities for students to network and socialize.

Abstract submission will begin on February 2 and close April 1, and we will keep you posted of this date and other activities and speakers as the meeting planning progress. We look forward to seeing you in New Orleans this summer!

Any questions - please feel free to contact Johanne Stogran (johanne@botany.org) or David Spooner (david.spooner@ars.usda.gov) for details, or refer to conference updates posted on our meeting website: http://www.2013.botanyconference.org/

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The Botanical Society of America is a membership society whose mission is to: promote botany, the field of basic science dealing with the study & inquiry into the form, function, development, diversity, reproduction, evolution, & uses of plants & their interactions within the biosphere.

Plant Science Bulletin Featured Image

The BSA's new journal, Applications in Plant Sciences (APPS), launches in January as part of BioOne's Open Access collection. APPS originated as the American Journal of Botany's online-only section, AJB Primer Notes & Protocols in the Plant Sciences, which was begun in 2009 to serve as a publication outlet for researchers in genetic and molecular areas. APPS is a monthly, online-only, open access, peer-reviewed journal that promotes the rapid dissemination of newly developed, innovative tools and protocols in all areas of the plant sciences, including genetics, structure, function, development, evolution, systematics, and ecology.

The Editorial Board welcomes submissions, particularly of protocols that improve investigations in any area of plant biology, including methods on genetic markers, and morphological, physiological, biochemical, anatomical, and ecological data collection. Authors wishing to contribute papers to APPS should submit their manuscripts online at http://www.editorialmanager.com/apps/ after consulting the newly expanded Instructions for Authors (http://www.botany.org/apps/APPS_Author_Instructions.html) for article types, editorial policies, and submission guidelines.