SPORE* SERIES WINNER

Building Botanical Literacy

Online mentors inspire interest in science while engaging students in thinking about plant biology.

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Betsy Justus, a doctoral student at Ohio University, has a fan club. It is a team of students from Cheyenne Central High School investigating spore germination in their classroom and posting research information to their team Web page. Betsy has been mentoring her team through online guidance and encouragement, posing questions throughout the inquiry process, and providing insights on what scientists know and how they think. Similarly, Eric Jones, a Florida State University doctoral candidate, hooked his St. Sebastian middle school team into an intriguing conversation about their investigations on pollinator visits to flowers. His reward was in experiencing his students' motivation to learn, expressed in statements such as, 'We are sad that our experiments are over," and 'We have developed a whole new interest in flowers!"

Multimedia sharing among students, scientists, and teachers. A student-generated photomicrograph of a C-Fern gametophyte documents the team findings.

Betsy and Eric are among the more than 500 scientists from 14 professional plant-related organizations volunteering as online mentors and personalizing an inquiry experience for student teams. Plant biology research projects and student dialogue with online mentors about the student-generated research are part of the PlantingScience (www.plantingscience.org) online learning community (see the first figure).

PlantingScience makes science experts accessible to secondary school classrooms with the goal of improving understanding of science while fostering an awareness of plants. Plants are essential to our everyday lives, and society faces major food, fuel, and environmental challenges, some of whose solutions will emerge from breakthroughs in plant biology (*1*). Meeting these challenges requires preparing future scientists and science-literate citizens. To rebuild botanical knowledge that has been declining across academic, private, and government sectors, strengthening education about plants across grade levels is recommended (*2*). This decline is part of the continuing U.S. crisis in science literacy, although some underlying causes, such as little exposure to plants in school and preferences for animals, are unique to botany (*3*). Textbook coverage is biased toward animals, and teachers use animal examples with which they are more familiar. There is also a general human tendency toward "plant blindness"—overlooking their presence in the environment (*4*). Plants, in their favor, have distinct advantages for generating excitement about science discovery. Inexpensive, easy to keep, and noncontroversial subjects for experimentation, plants are adaptable classroom organisms.

At the 2003 Botany Education Forum, Bruce Alberts, then president of the National Academy of Sciences, challenged the Botanical Society of America (BSA) to enhance science classroom experiences. Stakeholder meetings of plant scientists, middle school and high school teachers, and teacher leaders with the National Research Council identified curriculum standards teachers could introduce with plant investigations. Scientific Inquiry through Plants, a pilot program enabling teachers to extend inquiry learning beyond the classroom through interactive and integrated technology tools, was launched in 2005 (*5*).

Workshops for teachers. Teachers in the 2010 Summer Institute discuss celery morphology before beginning team investigations.

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The American Society of Plant Biologists signed on in 2006. Today, a big part of what makes PlantingScience special is our many partners (*6*). Over recent years, 108 Master Plant Science Team mentors, primarily graduate students, have made year-long mentoring commitments. Online mentoring allows scientists, from graduate students to professor emeriti, to contribute to school science without leaving their offices and to remain in constant contact with their teams.

Partnerships permeate PlantingScience. Societies unite volunteer efforts in a national network to address education needs: Online mentors and classroom teachers collaboratively support student teams; these teams develop curricula and Web site materials and provide professional development, and the Texas A&M University and Biological Sciences Curriculum Study colleagues investigate how online mentorship affects learning. Over 9000 students, 2500 research teams, and teachers in 34 states have thus far experienced inquiry science as a community endeavor with plant biologists. About 60% of the classes are in high schools, and 38% are in middle schools. College classes and 4-H clubs also participate. Educators seek to engage their students in collaboration, communication, and innovation—21st-century skills for success—and inquiry experiences that mirror the practices of scientists.

Participating in the science enterprise and communication are vital to science learning proficiency (*7*). Resources for reflection and argumentation are critical for students to construct their understanding. Teacher materials include guiding questions and options for profitable lines of investigation. Mentor materials—for example, the Power of Sunlight tip sheet—include common misconceptions about photosynthesis, and suggestions for helping students tweak experimental set-ups and make sense of their data. The key tool for reflection and discourse is the student team Web page where students and mentors post messages asynchronously.

Talking online with a scientist is exciting and motivating to students. Teachers commonly relate that their students develop a new level of confidence and responsibility toward their experiments. Preliminary results of before and after tests showed significant improvement in student attitudes toward enjoying studying plants and plant biology. Many students report that tending to and observing their plants is exciting and rewarding.

Teachers often encourage students to use the searchable research gallery to evaluate questions investigated by other teams; they report that seeing other students tackle similar topics opens them to the scientists' world of peer scrutiny. A search of Wonder of Seeds projects in the archive reveals that students from middle school through college have asked a wide range of questions about germination and growth—such as what is the effect of pH of soil, does the presence of earthworms influence growth, and how do seeds respond to gravity while germinating.

Flexibility within a framework allows teachers to tailor investigations for their students. We aim to shift curricula from repetitive lab exercises with predicable outcomes into the real world of science where ambiguity, messy data, and creativity reside (*8*). Modules range from widely accessible, open inquiries to more structured inquiries. Some incorporate the established classroom models of Wisconsin Fast Plants, C-Fern, and *Arabidopsis*. In drafting modules, scientist-teacher teams work with the curriculum coordinator. Classroom field-testing follows, with some mentors also assessing protocols.

Scientists from the module development teams then lead a 5-day inquiry immersion that opens the 9-day institute for teachers who wish to deepen their understanding of plant biology, inquiry learning, and online community platform use (see the second figure). Sixteen teachers are selected to experience the plant inquiries as learners. Plant scientists provide content background and teachers can become familiar with the interactive tools. The second week provides focused time for teachers to share strategies for using online and classroom discourse and science notebooks as they design an implementation plan for their own students.

The "digital generation" is often connected 24 hours, 7 days a week, and digital learning is now on the national education agenda (*9*). PlantingScience students voluntarily post findings and communicate with mentors on weekends and evenings. The Web site received 1,628,164 visitors between August 2005 and November 2010. Interest in the model has spread internationally, with a Dutch translation of the Web site managed independently, and Dutch–U.S. collaboration under way.

Science and society will benefit from piquing children's interest in plants at an early age and nurturing their thinking about how science works. The personal connection with an online mentor also holds promise for inspiring individual students. There is power in the collective commitment and expertise of scientist-school partnerships to efficiently raise engaging collaborative science learning to a national scale.

About the authors

From left to right: Rob Brandt, Claire Hemingway, and William Dahl. Not pictured are Chris Haufler and Carol Stuessy. C. Hemingway, W. Dahl, and C. Stuessy are co-principal investigators on the project. C. Haufler is BSA at-large director for education. R. Brandt is BSA and project information technology manager.

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