PlantingScience Mentor Tip Sheet: C-Fern® Curricular Module

The **purpose of this tip sheet** is to help you as a scientist mentor **anticipate and respond** to students as they post online about their C-Fern® investigations.

Expect teachers to adapt the module for their students:

Students learn **laboratory techniques and microscopy skills** as they investigate life cycle and reproduction. Activities target **high school**, but can be adapted for middle school and college. Basic **equipment** includes spores, sterile media, petri dishes, ethanol, pipettes, hot plate, gloves, microscopes, and growing system. Students may have access to cameras or drawing materials.

- Connect with your teams' teacher via the **Class Discussion Forum** for details on modifications for the class.
- See the **C-Fern Module Guide** for all suggested learning goals and activities.
- General hints for talking with students are in the **Mentor Guide**.

Ceratopteris richardii (C-Fern®) has a relatively rapid life cycle. Students can sow spores, observe gametophyte development, swimming sperm, fertilization, and sporophyte development in approximately 90 days under optimal growing conditions.

The opportunity for students to see first-hand alternation of generations makes C-Fern a powerful learning tool for plant life cycle and reproduction, which are typically abstract and difficult for students to understand. Students take on the role of laboratory researchers. They learn how to maintain sterile conditions, monitor growing systems, make a wet mount slides, and use compound and dissecting microscopes.

An **observational study** serves as a backbone to the module guide so that students gain foundational understanding of the life cycle stages. At each stage of the life cycle, students are guided to make sketches and record qualitative descriptions based on observations made under dissecting and compound microscopes. Ideally, students would build on the foundation of an observational study and subsequently conduct an **open inquiry** chosen by teams. Most classrooms do not have that time luxury. Possibilities for open inquiry exist throughout the life cycle sequence, and teachers may focus student team investigations at particular stages (such as spore germination or gametophyte development) or on reproductive features (such as sexual differentiation, sperm motility). The module timeline is based on the wild type strain (RNWT1); additional strains are also available from biological supply companies.

Juicy questions for student investigations.

- What happens to spores in germination?
- What is the relationship of the gametophyte and sporophyte?
- How do different wavelengths of light impact gametophyte growth?
- What conditions are necessary for fertilization?
- Can the proportion of male gametophytes in a population be altered?
- How do sperm find the eggs? How fast can they swim?
- What happens to gametophytes after fertilization?

What are students thinking when it comes to plant life cycles and reproduction?

As students blog about their investigations, they reveal their ideas. It is common for students to think….

- Young students sometimes fail to consider death as part of a life cycle.

- Students may not recognize that the gametophyte and the sporophyte are life cycle stages of all plants.
- Students may think plant sporophytes grow from haploid spores.
- Students may think meiosis in plant life cycles results in the production of egg and sperm.

Attending to students' ideas and thinking

While students might memorize life cycle terms, their qualitative descriptions of forms and processes at various stages reveal much about their understanding of alternation of generations. By attending to students' thinking, attention shifts from a right-answer orientation to uncovering reasoning. As experts, we often make assumptions about students' ideas and connect concepts in ways novice learners cannot. Also, responding as a naïve mind opens up discussion possibilities.

Anticipating technical problems and conversation threads

In high school settings, students will likely play a more active role in lab set ups than in middle school. Contamination of petri dishes and fluctuations in growth chambers may occur. If students encounter procedural troubles, don't let them get overly bogged down in technical debugging at the expense of **thinking about the big ideas**.

- **Student background and experience.**
  Many middle school students will have broadly compared animal and generalized plant life cycles. Detailed comparisons of life cycles across mosses, ferns, conifers and flowering plants typically occur in high school textbooks. High school students will be more experienced using lab equipment and microscopes than middle school students, but making wet mount slides will likely be new.
- **Making sense of life cycles.**
  Antheridia, archegonia, gametophyte, sporophyte—an initial focus on complex terminology can impede the ability of students at all levels to grasp the big idea that plant generations alternate between diploid and haploid forms. When students can visualize a gametophyte or sporophyte, they have a mental hook on which to hang the terms.
- **What's cool to kids?**
  Middle school students will find the sterile techniques and laboratory equipment very exciting: it can make them feel "scientific" and be their first chance to see themselves in the role of a scientist. Seeing swimming sperm and talking about plant sex is also a big hit for secondary school students. In student-directed inquiries, expect students to be drawn to manipulating the environment, such as temperature, media contents, pH and help them seek biologically meaningful conditions.

Resources and References

Perhaps useful to you as a mentor

•C-Fern official website
http://c-fern.org

Hickok, L. G., T. R. Warne, and M. K. Slocum. 1987. *Ceratopteris richardii:* Applications for Experimental Plant Biology. *American Journal of Botany* 74: 1304-1316.

Renzaglia, K. S., T. R. Warne, and L. G. Hickok. 1995. Plant development and the fern life cycle using *Ceratopteris richardii. American Biology Teacher* 57: 438-442.

Kiss, H. G., and J. Z. Kiss. 2005. Sensing Red, White, and Blue: Using Spores of the Sensitive Fern to Introduce Important Concepts in Biology. *American Biology Teacher* 67: 550-555.

Spiro, M. D., and K. I. Knisely. 2008. Alternation of Generations and Experimental Design: A Guided-Inquiry Lab Exploring the Nature of the *her1* Developmental Mutant of Ceratopteris *richardii (*C-Fern). *CBE-Life Sciences Education* 7: 82-88.

Perhaps useful to student teams

•C-Fern official site
http://c-fern.org

•Alternation of Generations: Brad and Paris Analogy
http://www.bio.miami.edu/dana/dox/altgen_new.html

•Alternation of Generations: Life Cycle Stages
http://www.bio.miami.edu/dana/dox/altgen.html

•Encyclopedia of Life: *Ceratopteris richardii*
http://www.bio.miami.edu/dana/dox/altgen.html

•Bioimages: *Ceratopteris richardii*
http://www.cas.vanderbilt.edu/bioimages/species/ceri2.htm

•RPI Bio: C-Fern Life Cycle and Sperm Release
http://www.youtube.com/watch?v=IyWoo_U-uQo

Accessible, accurate information for students can be hard to find. Are there resources you recommend?