The Good, the Bad, and the Endophyte: The Continuum from Mutualism to Parasitism


Date
Thursday, November 6, 2007

Location
The symposium will be held at the Cargill Building — Microbial and Plant Genomics on the St. Paul campus. Directions to the Cargill Building can be found at this link. Room location and other details will be provided as the event approaches.

Topic
This year's symposium, "The Good, the Bad, and the Endophyte," will explore the continuum from mutualism to parasitism, with an emphasis on interactions between plants and microorganisms. It is known that similar or identical microorganisms can be both beneficial and harmful to their plant hosts under differing conditions. However, it is unclear what component of the interaction, the microbe, the host, or the environment, is responsible for this difference. Is a simple gene system involved or is it more complicated? Many mutualistic interactions have apparently developed and remained stable over long periods of time. How can mutualism persist when both parties are seeking their own self-interest? Five speakers from around the country will be on hand to discuss how their own research addresses these issues. Additionally, they will improve our understanding of pathogenic, mutualistic, and endophytic interactions in agricultural and forest production systems.

Agenda
9:00 Introduction and Welcome
9:15  Dr. Stanley Faeth, Arizona University  
Asexual endophytes and host grass interactions: the inside story

10:15 Dr. Betsy Arnold, University of Arizona  
Endophytic fungi from the tropics to the tundra: clues to the evolution of fungal symbioses with plants

11:15 Dr. Glen Stanosz, University of Wisconsin-Madison  
Latent or blatant: Contrasting phases in the lives of fungal pathogens of woody plants

12:20 Lunch

1:30 Dr. Rusty Rodriguez, Western Fisheries Research Center, U.S. Geological Survey  
It's a very thin line between love and hate: Symbiotic adaptation, modulation and lifestyle switching

2:30 Dr. Ford Denison, University of Minnesota  
Cooperation and conflict in legume-rhizobium symbiosis

3:30 Panel discussion

Abstracts

**Dr. Betsy Arnold**  
Endophytic fungi from the tropics to the tundra: clues to the evolution of fungal symbioses with plants

In the last five years, tremendous progress in inferring the fungal tree of life has provided new insight into broad patterns underlying the evolution of plant-fungal symbioses. A major missing piece, however, remains in the poorly known and cryptic microfungi, such as endophytes associated with healthy foliage, which are not yet routinely incorporated into multilocus phylogenies. I will highlight the tremendous diversity, variable host specificity, and diverse evolutionary history of endophytic fungi (1) associated with all major lineages of land plants and (2) at sites ranging from the tropics to the tundra. Using multi-gene phylogenies as a foundation, I will show that these often overlooked fungi are key to understanding the shape and content of the fungal tree of life, and that they provide a critical "missing piece" for understanding the evolution of major ecological modes -- from pathogenicity to mutualism -- in the Ascomycota, the most species-rich fungal phylum.

**Dr. Ford Denison**  
Cooperation and conflict in legume-rhizobium symbiosis

The legume-rhizobium symbiosis is a classic example of cooperation between species, but it also depends on cooperation among rhizobia. By supplying their host plants with nitrogen, rhizobia may increase photosynthesis, thereby increasing their own access to photosynthate. But what if this benefit is shared with other rhizobium strains infecting the same individual plant – strains which are likely competitors for future hosts? In that case, mathematical models predict that rhizobial "cheaters", which divert
resources from N2 fixation to their own reproduction, should displace more cooperative strains. Host sanctions, shown experimentally to reduce rhizobium reproduction inside nodules when they fix less nitrogen, may explain the evolutionary persistence of rhizobium cooperation. Many important questions remain, however. Given sanctions, why are less-beneficial rhizobia still common in some soils? Are they mostly cheaters that somehow avoid sanctions, strains adapted to different hosts, or simply defective mutants not yet eliminated by natural selection? Do rhizobia that lose the ability to reproduce (when they differentiate into the N2-fixing form) cheat less than those that retain the ability to reproduce? If so, are sanctions less strict in legume species that host nonreproductive rhizobia? Could selected legume genotypes enrich the soil with the best local rhizobium strains? Only preliminary answers are available for most of these questions.

Dr. Stanley Faeth

Asexual endophytes and host grass interactions: the inside story

Fungal endophytes are ubiquitous and abundant symbionts in all plants that have been examined to date. In cool season grasses, some endophytes are highly specialized, and some (e.g., Neotyphodium species) are strictly asexual and only transmitted vertically via seeds. Evolutionary theory predicts these asexual endophytes should be strong mutualists. Empirical tests show that these endophytes provide host benefits, including increasing herbivore resistance via fungal alkaloids and increasing host competitive abilities. However, the vast majority of tests of the effects of endophytes on herbivores, plant competition, trophic structure, community diversity and ecosystem functions have been conducted with two introduced agronomic grasses, tall fescue and perennial ryegrass. Concepts derived from these models systems may be erroneous because they fail to capture the wide variability in endophyte-host-natural enemy interactions in wild grasses. Our long term experiments with two native grasses produce very different results at the physiological, population and community levels. Interestingly, our recent experiments indicate that asexual endophytes, promote rather than decrease herbivory. This increase in herbivory, however, leads to greater seed output and therefore transmission of the endophyte. Systemic endophytes in these native grasses also increase tolerance to herbivory across plant genotypes and environmental conditions. Asexual endophytes, often considered evolutionary dead ends and under control of the host grass, may instead control host growth and reproduction and tolerance to herbivory to enhance their own transmission. In doing so, they also initiate trophic cascades that affect abundances diversity and trophic structure of the associated arthropod community.

Dr. Rusty Rodriguez

It's a very thin line between love and hate: Symbiotic adaptation, modulation and lifestyle switching
Throughout evolutionary time plants have been confronted with changing environmental conditions, forcing them to adapt or succumb to selective pressures such as extreme temperatures, insufficient water, salinity and disease. Since plants lack any form of locomotion, they have evolved mechanisms to mitigate the detrimental effects of abiotic and biotic stresses. Plant responses to abiotic stresses such as salinity, heat and drought are genetically complex and it is thought that all plants have the capability to perceive stress, transmit signals and respond to stress (Bartels & Sunkar, 2005; Bohnert et al., 1995). Plant responses common to these stresses include osmolyte production, altering water transport and scavenging reactive oxygen species (Leone et al., 2003; Maggio et al., 2003, Tuberosa et al., 2000). Regardless, relatively few species are able to thrive in habitats that impose high levels of abiotic stress (Alpert, 2000). Although there has been extensive research in plant stress responses (Smallwood et al., 1999), two questions remain unanswered: What are the mechanisms by which plants adapt to abiotic stress? and Why is there not a greater diversity and ecological distribution of stress tolerant plants? One of the least studied aspects of plant biology is symbiosis with endophytic fungi. Fossil records indicate that fungi have been associated with plants since at least 400 MYA (Redecker et al., 2000) and it has been proposed that fungal symbiosis was responsible for the movement of plants onto land (Pirozynski & Malloch, 1975). There are at least three classes of fungal symbionts: mycorrhizae, class 1 endophytes, and class 2 endophytes (Rodriguez et al., 2005). A great deal is known about mycorrhizal fungi that are found associated with plant roots and share nutrients with their plant hosts, and about the clavicipitaceous fastidious endophytes (class 1) that infect cool season grasses (Read, 1999; Schardl et al., 2004). However, comparatively little is known about the ecological significance of class 2 endophytes, which represent the largest group of fungal symbionts and are thought to colonize all plants in natural ecosystems (Petrini, 1986). This is partially because the symbiotic functionality of class 2 endophytes have only recently been elucidated. In my presentation I will discuss three aspects of Class 2 endophyte biology that we have elucidated:

Habitat-Adapted Symbiosis - Native grass species from coastal and geothermal habitats require symbiotic fungal endophytes for salt and heat tolerance, respectively. Symbiotically conferred stress tolerance is a habitat-specific phenomenon with geothermal endophytes conferring heat but not salt tolerance, and coastal endophytes conferring salt but not heat tolerance. The same fungal species isolated from plants in habitats devoid of salt or heat stress did not confer these stress tolerances. Moreover, fungal endophytes from agricultural crops conferred disease resistance and not salt or heat tolerance. We define habitat-specific, symbiotically-conferred stress tolerance as Habitat-Adapted Symbiosis and hypothesize that it is responsible for the establishment of plants in high stress habitats.
Symbiotic Modulation - Individual plant species optimize fitness by changing fungal symbionts as they grow across environmental gradients. These findings indicate that plants change class 2 endophytes, and class 2 endophytes change plant hosts, in adjacent microhabitats that impose different selective pressures, a phenomenon we describe as Symbiotic Modulation. We hypothesize that Symbiotic Modulation is a novel mechanism that allows plants and fungi to make quantum evolutionary jumps resulting in rapid adaptation to environmental stresses and habitat expansion that occurs in natural habitats.

Symbiotic Lifestyle Switching - Several pathogenic Colletotrichum species have both disease and non-disease hosts. These "pathogens" asymptptomatically colonize non-disease hosts and confer fitness benefits including disease resistance, drought tolerance and growth enhancement. We have isolated a region of genomic DNA that is responsible for lifestyle switching and have used it to construct gene disruption vectors for site directed mutagenesis. Gene disruption mutants are no longer pathogenic and express mutualistic lifestyles.

Currently, we are using endophyte technology to develop novel strategies for mitigating the impacts of global climate change on agricultural and native plant communities, and aquatic ecosystems around the world.

Dr. Glen Stanosz
Department of Plant Pathology. University of Wisconsin - Madison

Latent or blatant: Contrasting phases in the lives of fungal pathogens of woody plants

A dictionary indicates that “latent refers to a power or quality that has not yet come forth but may emerge and develop.” A plant pathologist might refer to a “latent pathogen” as an organism that: is virulent; can persist with its susceptible host plant for long periods in the absence of gross symptoms due to host-imposed quiescence; and, upon alteration in host condition, may be released from inactivity to result in rapid disease development. If thus considered, latent fungal pathogens of trees and shrubs are a distinct and unique subset of the vast array of microorganisms accumulated on or in the annual and perennial organs of woody plants. Studies of potential fungal latent pathogen-woody plant host interactions may offer insights into diverse strategies of pathogens and hosts during interactions that belie classical etiological and epidemiological descriptions of plant disease development.

Sponsors

- Department of Plant Pathology, University of Minnesota
- College of Agricultural, Food, and Environmental Sciences, University of Minnesota
- Graduate and Professional Student Assembly, University of Minnesota (GAPSA)
- Student Unions & Activities, University of Minnesota
- University of Minnesota Academic Initiative in partnership with Coca-Cola
Committee Members

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- James Jacobs
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