

**PLP6262 Fungal Plant Pathogens/PLP4260 Introduction to Plant Pathogenic Fungi**  
**Fall 2022**

**Instructor:** Dr. Jeffrey Rollins

**Office:** 1419 Fifield Hall

**Phone:** 352-273-4620

**email:** rollinsj@ufl.edu

**Lab Coordinator:** Dr. Morgan Byron ([maconn00@ufl.edu](mailto:maconn00@ufl.edu))

**Class Location:** 2306 Fifield Hall and online via Zoom

<https://ufl.zoom.us/j/96265920723>

**Class Times:** 7 week module : February 28 to April 27, 2022

Lectures: MF period 5 (11:45-12:35 pm); W period 5-6 (11:45- 1:40 pm)

Labs: TR period 5-6 (11:45- 1:40 pm)

**Class Website:** <http://elearning.ufl.edu/> (e-Learning in Canvas)

**Office Hours:** By appointment

**Class Recordings:** Within the Canvas e-Learning site

**Course Description:** This course is an introduction to the biology and diversity of fungal plant pathogens. Fungi and their allies are a diverse group of organisms that comprise the majority of plant pathogens. Their members are found in every fungal order, as well as among numerous orders outside the Kingdom Fungi but traditionally studied as fungi, e.g., the Stramenopiles. This course will include a survey of taxonomic groups of fungal and fungal-like plant pathogens, an overview of common fungal pathogens in various types of plant culture systems, and discussion of general plant pathology principles as they relate to fungal pathogens. Lectures and labs are co-taught with PLP4260C: Introduction to Plant Pathogenic Fungi. Students enrolled in the graduate course will have a course project and more rigorous Exams and Quizzes relative to their undergraduate classmates.

**Course Objectives:** Students will learn to

- distinguish among taxonomic orders that contain fungal pathogens, and identify fungal pathogens to order and genus level;
- recognize several of the most common fungal plant pathogens and understand key aspects of their biology and lifecycles that distinguish them;
- differentiate patterns in disease development and control strategies as they pertain to specific growing systems;
- use knowledge of pathogen biology and epidemiology to develop reasonable hypotheses about effective long and short term control strategies for fungal pathogens.

**Course Texts:**

Recommended: **Plant Pathology 5th Edition** (2005) by G. N. Agrios, Elsevier Academic Press, Inc.;

**Mycology Guide: Key Terms and Concepts, 2<sup>nd</sup> Edition**, by N. Vargas et al., APS Press

Required: Journal articles will be assigned throughout the course. These will be made available through the class website. **A Reading List is attached.**

**Exams and Grading:** There will be three, non-cumulative lecture-lab exams. There will also be regular lab assignments, five short quizzes throughout the term, and a Fungal Biology Oral Presentation (PLP6262 only).

**Quizzes:** Quizzes will be unannounced, and will be given at the beginning of class or lab periods. They will be **open-book**, but students will have a limited time to complete the questions. If you arrive late, you will not be given additional time to complete the quiz, nor will make-up quizzes be given for unexcused absences. Quiz questions will come from recent lectures or assigned readings, and will be designed to reinforce key concepts and help prepare you for questions that will appear on the exams.

**Fungal Biology Presentation:** Each PLP6262 student will develop and present a PowerPoint talk on a topic of fungal biology. Additional information concerning project requirements and due dates can be found on page 5.

### Course Grade

Your course grade will be based on the following assessments:

Assessment	Points
Exam I	100
Exam II	100
Exam III	100
Quizzes	35
Lab Assignments	65
Oral Presentation	50
<b>Total Possible Points</b>	<b>450</b>

Your course grade will be assigned as follows.

Letter Grade	Grade Points	Percentage	Assignment Points
A	4.0	90 or above	≥405
A-	3.67	87-89.9	392-404
B+	3.33	84-86.9	378-391
B	3.0	80-83.9	360-377
B-	2.67	77-79.9	347-359
C+	2.33	74-76.9	333-346
C	2.0	70-73.9	315-332
C-	1.67	67-69.9	302-314
D+	1.33	64-66.9	288-301
D	1.0	60-63.9	270-287
D-	0.67	57-59.9	257-269
E	0.0	56.9 or below	≤256

**Class Attendance & Participation:** Participation is a vital part of both the course experience and the course grade. Students will be expected to arrive at each class on time and prepared to fully participate in the lecture, lab, or other class activities. If you must miss a class due to illness or other extenuating circumstances, notify the instructor as soon as possible. Student athletes will be excused for official events through the University Athletic Association. Absences due to personal planning (leaving town, attending club functions, picking someone up at the airport, etc.) will not be excused, and missed points may not be made up.

**Make-up Work:** If you are ill on an exam day, notify the instructor as soon as you are able, and a make-up exam will be scheduled for you. If you must miss an exam for any other reason, please make arrangements ahead of time to reschedule. In most cases, **laboratory exercises may not be made up**. Laboratory cultures, demonstrations, and other materials are typically prepared in advance, often ephemeral or expendable by nature, and cannot be easily recreated. If you absolutely must miss a lab, it is particularly important to notify the instructor before the end of the missed lab period, so that at least some of the demonstration materials may be set aside for you to view and work on later.

**Grades and Grade Points:** More information on UF grading policy may be found at

[UF Graduate Catalog](#)

[Grades and Grading Policies](#)

# **UNIVERSITY POLICIES AND SERVICES**

## **Academic Honesty, Software Use, Campus Helping Resources, Services for Students with Disabilities**

### **Academic Honesty**

In 1995 the UF student body enacted an [honor code](#) and voluntarily committed itself to the highest standards of honesty and integrity. When students enroll at the university, they commit themselves to the standard drafted and enacted by students.

**The Honor Pledge: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.**

On all work submitted for credit by students at the university, the following pledge is either required or implied: **"On my honor, I have neither given nor received unauthorized aid in doing this assignment."**

Students should report any condition that facilitates dishonesty to the instructor, department chair, college dean, Student Honor Council, or Student Conduct and Conflict Resolution in the Dean of Students Office.

It is assumed all work will be completed independently unless the assignment is defined as a group project, in writing by the instructor.

This policy will be vigorously upheld at all times in this course.

### **Services for Students with Disabilities**

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the [Disability Resource Center](#). It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### **Campus Health and Wellness Resources**

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- **U Matter, We Care:** If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352 392-1575 so that a team member can reach out to the student.
- University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,  
[www.counseling.ufl.edu/cwc/](http://www.counseling.ufl.edu/cwc/)
  - Counseling Services
  - Groups and Workshops
  - Outreach and Consultation
  - Self-Help Library
  - Training Programs
  - Community Provider Database
- **Sexual Assault Recovery Services (SARS)**, Student Health Care Center, 392-1161.
- **University Police Department** at 392-1111 (or 9-1-1 for emergencies), or [police.ufl.edu](http://police.ufl.edu).

### **Academic Resources**

[E-learning technical support](#), 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).

[\*\*Career Resource Center\*\*](#), Reitz Union, 392-1601. Career assistance and counseling.

[\*\*Library Support\*\*](#), Various ways to receive assistance with respect to using the libraries or finding resources.

[\*\*Teaching Center\*\*](#), Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

[\*\*Writing Studio\*\*](#), 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

[\*\*Student Complaints Campus\*\*](#)

[\*\*On-Line Students Complaints\*\*](#)

**Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

**Student Privacy**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see the [Notification to Students of FERPA Rights](#).

THE INSTRUCTOR RESERVES THE RIGHT TO CHANGE OR MODIFY INFORMATION PROVIDED IN THE SYLLABUS. CLASS ANNOUNCEMENTS SUPERSEDE SYLLABUS STATEMENTS.

# Fungal Biology Oral Presentation Information

## **Topic Selection**

Each student will develop and present a **20 min oral presentation** on a fungal biology topic. Topics may be chosen from the spreadsheet list found on the class website or a topic of your own choosing with approval from the instructor. Topics will be claimed on a first-requested-first-assigned basis. You will sign up by e-mailing me directly with the topic that you have chosen. I will update and post the spreadsheet in the order that I receive the e-mail requests. I will send an e-mail confirmation when I have approved your choice. Once someone has signed up for a particular topic, no other student will be permitted to present on this topic. **A topic must be chosen by the end of lecture on April 1.** Sign up early if you have a topic you are particularly interested in! **Presentations will begin on April 12.** The order of presentations will be chosen at random.

## **Presentation Style and Length**

Length: 20 min; an extra five minutes will be available for questions.

Format: PowerPoint

Organization: A title slide including the topic and your name is required. Background/introductory information is expected. A clear and concise explanation of the topic is expected. Examples of how the topic advances understanding of biology (fungal or otherwise) or is applied to managing disease, improving ecosystems, producing useful products, etc is expected. Presentation of information from a recently published paper concerning the topic may be helpful. A summary of key take away points should be obvious and emphasized.

Style: These presentations are intended to be mini topical lectures. Your audience is graduate and Doctor of Plant Medicine students.

Exam question: Each presenter will create one multiple-choice question pertaining to his/her presentation topic. You should e-mail this question to me ([rollinsj@ufl.edu](mailto:rollinsj@ufl.edu)) after your presentation is given.

## **Resources and References**

Every source of data, pictures, text, information, etc. used in your presentation should be cited on the slide. If too many for each slide, include a reference list at the end.

## **Due Dates**

A pdf copy of your presentation is due by the end of the class period on the day of your presentation. A submission portal will be created on the class website for you to upload a pdf copy of your presentation.

## **Grading**

Your presentation is worth 50 points assigned by the instructor: 20 points for structure (organization of slides and presentation, turned in on time, etc.), 5 points for presentation style, and 25 points for accuracy of information.

**PLP6262 Fungal Plant Pathogens**

Spring 2022

Course Schedule (Tentative)

Date	Day	#	Topic
Feb 28	M	Lecture 1	<p>Ways of Being: Plant-Fungal Interactions</p> <ul style="list-style-type: none"> <li>• Mutualism-parasitism continuum</li> <li>• Mycorrhizae</li> <li>• Epiphytes &amp; Endophytes</li> <li>• Biotrophs, hemibiotrophs, and necrotrophs</li> </ul>
Mar 1	T	Discussion 01	<p>Course Overview</p> <ul style="list-style-type: none"> <li>• Syllabus, Schedule, Objectives, Assessments</li> </ul>
Mar 2	W	Lecture 2	<p>Adaptations for Pathogenicity</p> <ul style="list-style-type: none"> <li>• Obligate vs. opportunistic pathogens</li> <li>• Pathogenicity factors</li> </ul>
Mar 2	W	Syllabus	Syllabus Review and Discussion
Mar 3	Th	Discussion 02	<p>Plant-Fungal Interactions</p> <ul style="list-style-type: none"> <li>• Endophytes</li> </ul> <p>Working with Fungal Pathogens</p> <ul style="list-style-type: none"> <li>• Storage methods</li> </ul>
Mar 4	F	Lecture 3	<p>Groups of Fungal Pathogens</p> <ul style="list-style-type: none"> <li>• Review of fungal orders &amp; Stramenopiles</li> <li>• Taxonomic vs. functional groups</li> </ul>
Mar 5-13		Spring Break	NO CLASS
Mar 14	M	Lecture 4	Stramenopiles: Taxonomy, Biology, and Ecology
Mar 15	T	Lab 01	<p>Microscopy Basics, Isolation and maintenance of fungal cultures</p> <ul style="list-style-type: none"> <li>• Selective Media</li> <li>• Types and purposes of various fungal storage methods</li> </ul>
Mar 16	W	Lecture 5	<p>Chytrids: Taxonomy, Biology, and Ecology</p> <ul style="list-style-type: none"> <li>• Chytrid pathogens &amp; pathogen vectors</li> <li>• Chytrid mycoparasites</li> </ul>
Mar 16	W	Discussion 03	<ul style="list-style-type: none"> <li>• Readings and Lecture Discussion</li> </ul>
Mar 17	Th	Lab 02	<p>Stramenopile pathogens: the Oomycetes</p> <ul style="list-style-type: none"> <li>• <i>Pythium</i> vs. <i>Phytophthora</i></li> <li>• Downy mildews</li> </ul>
Mar 18	F	Lecture 6	Mucromycota: Taxonomy, Biology, and Ecology
Mar 21	M	Lecture 7	Ascomycota: Taxonomy, Biology, and Ecology
Mar 22	T	Lab 03	<p>Chytrid &amp; Mucormycota pathogens</p> <ul style="list-style-type: none"> <li>• Chytrids in natural, agricultural, and landscape settings</li> <li>• Mucormycetes: field and postharvest rotters</li> </ul>
Mar 23	W	Lecture 7 cont.	Ascomycota: Taxonomy, Biology, and Ecology continued
Mar 23	W	Review	Exam Review

Mar 24	Th	Exam	Exam I
Mar 25	F	Lecture 8	Basidiomycota: Taxonomy, Biology, and Ecology
Mar 28	M	Lecture 7-8	Ascomycota - Basidiomycota cleanup •
Mar 29	T	Lab 04	Ascomycota pathogens • Structures & Functions • Recognizing an Ascomycete
Mar 30	W	Lecture 09	Fungal Disease Cycles and Epidemiology • Disease progress curves • Polycyclic vs. Monocyclic diseases Inoculum density and inoculum potential
Mar 30	W	Discussion 04	Readings and Lecture Discussion
Mar 31	Th	Lab 05	Ascomycota pathogens, cont. • Sexual and asexual ascomycetes • Conidial structures and identification
April 1	F	Lecture 10	Fungi in the Air: Airborne pathogens and Foliar diseases
April 4	M	Lecture 11	Soilborne Fungal Pathogens
April 5	T	Lab 06	Basidiomycota pathogens • Structures & functions • Recognizing a Basidiomycete
April 6	W	Lecture 12	Fungal Pathogens in Row Crops vs. Perennial Crops
April 6	W	Discussion 05	Readings and Lecture Discussion
April 7	Th	Review	Exam Review
April 8	F	Exam	Exam II
April 11	M	Lecture 13	Diseases in Perennial Crops
April 12	T	Presentations	Presentations 1-4
April 13	W	Lecture 14	Forest Pathology & Pathogen Ecology
April 14	Th	Presentations	Presentations 5-8
April 15	F	Lecture 15	Diseases in Ornamental Plants
April 18	M	Lecture 16	Management of Fungal Diseases • Whetzel's principles of plant disease control • Cultural controls
April 19	T	Presentations	Presentations 8-11
April 20	W	Lecture 17	Chemical Control of Fungal Diseases • Classes of chemicals and their modes of action • Chemical Resistance
April 20	W	Discussion 06	Review of Lecture and Lab materials
April 27	M	Exam	Exam III

## Reading List for PLP6905 (6262) (tentative, subject to change)

Lab #	Reading
01	Bidartondo, Dawn of symbiosis between plants and fungi.pdf
01	Johnson, Functioning of mycorrhizal associations along the mutualism-parasitism continuum.pdf
01	Redman, Fungal Symbiosis from mutualism to parasitism.pdf
01*	Elliot_Longterm_Storage.pdf
01*	Woodward_Symbiogenics.pdf
01	Xia_Culturable_Endophytes.pdf
01	Kuo, Secret lifestyles of <i>Neurospora crassa</i> .
02	DeZwaan, <i>Magnaporthe grisea</i> pth11p.pdf
02	Jaroszuk-Scisel, Activities of CWDE.pdf
02	Thomma, <i>Alternaria</i> saprophyte to parasite.pdf
02	Schafer, One enzyme makes a fungal pathogen.pdf
03	Rossmann, Systematics of Plant Pathogenic Fungi.pdf
03	Taylor, One Fungus = One Name
03	Hawksworth, The Amsterdam Declaration on Fungal Nomenclature
03	Crous, Identifying and Naming Plant-Pathogenic Fungi_Past, Present, and Future
04	Beakes, Evolutionary phylogeny of oomycetes.pdf
04	Ivors, Microsatellite markers identify lineages of <i>P. ramorum</i> .pdf
04	Kroon, Genus <i>Phytophthora</i> Anno 2012.pdf
04	Nelson, Rhizosphere regulation of oomycete pathogens.pdf
04	vanWest, Oomycete Plant Pathogens use Electric Fields.pdf
05	Hwang, <i>Plasmodiophora brassicae</i> review.pdf
05	Kanyuka, <i>Polymyxa graminis</i> .pdf
05	Fry, Transmission of TNV by <i>Olpodium</i> .pdf
06	Hanson, Interaction of <i>Rhizoctonia</i> & <i>Rhizopus</i> .pdf
06	Holmes, Influence of wound type on <i>Rhizopus</i> soft rot.pdf
06	Partida-Martinez, Pathogenic fungus harbours endosymbiotic bacteria.pdf
06	Spatafora, Phylogenetic classification of zygomycete.pdf
07	Schoch, Ascomycota tree of life.pdf
08	Binder and Hibbett, Boletales.pdf
08	Lutz&Baur, Double Life of a Fungus.pdf
09	Scott, Spatiotemporal analysis of epiphytotes of downy mildew.pdf
09*	Beltran, Epidemiology of <i>Monosporascus</i> root rot.pdf
09*	Montes-Borrego, Role of oospores as primary inoculum.pdf
10	Noblin, Surface tension propulsion of fungal spores.pdf
10	Paul, Rain splash dispersal of <i>Gibberella</i> .pdf
10	Stolze-Rybczynski, Adaptation of spore discharge in basidiomycota.pdf
10	Trail, Fungal cannons- explosive spore discharge in ascomycota.pdf
11	Allen&Newhook, Chemotaxis of zoospores to ethanol in capillaries.pdf
11	Dobbs&Gash, Microbial and Residual Mycostasis.pdf
11	Duniway, Movement of Zoospores of <i>Phytophthora</i> in soils.pdf
11	Garcia-Garza, Fusox spore movement through soil.pdf
11	MacDonald&Duniway, Influence of soil texture and temp on motility of <i>Phytophthora</i> .pdf
11*	Subbarao, Effects of Deep Plowing on <i>Sclerotinia minor</i> .pdf
14	Newhouse et al. - 2014 - Transgenic American chestnuts show enhanced blight.pdf
14	Multigene phylogeny of filamentous ambrosia fungi associated with ambrosia and bark beetles.pdf

## Full bibliography of Reading List articles

Alamouti, S.M., Tsui, C. K. M., and Breuil, C. 2009. Multigene phylogeny of filamentous ambrosia fungi associated with ambrosia and bark beetles. *Mycol. Res.* 113:822–835.

Allen, R.N., and F.J. Newhook. 1973. Chemotaxis of zoospores of *Phytophthora cinnamomi* to ethanol in capillaries of soil pore dimensions. *Transactions of the British Mycological Society*. 61:287–IN12.

Beakes, G.W., and S. Sekimoto. 2008. The Evolutionary Phylogeny of Oomycetes—Insights Gained from Studies of Holocarpic Parasites of Algae and Invertebrates. In *Oomycete Genetics and Genomics: Diversity, Interactions, and Research Tools*. K. Lamour and S. Kamoun, editors. John Wiley & Sons, Inc. 1–24.

Beltrán, R., A. Vicent, J. García-Jiménez, and J. Armengol. 2008. Comparative Epidemiology of *Monosporascus* Root Rot and Vine Decline in Muskmelon, Watermelon, and Grafted Watermelon Crops. *Plant Disease*. 92:158–163.

Bidartondo, M.I., D.J. Read, J.M. Trappe, V. Merckx, R. Ligrone, and J.G. Duckett. 2011. The Dawn of Symbiosis Between Plants and Fungi. *Biol. Lett.* 7:574–577.

Crous, P.W., D.L. Hawksworth, and M.J. Wingfield. 2015. Identifying and Naming Plant-Pathogenic Fungi: Past, Present, and Future. *Annual Review of Phytopathology*. 53:247–267.

DeZwaan, T.M., A.M. Carroll, B. Valent, and J.A. Sweigard. 1999. *Magnaporthe grisea* pth11p is a novel plasma membrane protein that mediates appressorium differentiation in response to inductive substrate cues. *Plant Cell*. 11:2013–2030.

Dobbs, C.G., and M.J. Gash. 1965. Microbial and Residual Mycostasis in Soils. , *Published online: 25 September 1965; / doi:10.1038/2071354a0*. 207:1354–1356.

Duniway, J.M. 1976. Movement of Zoospores of *Phytophthora cryptogea* in Soils of Various Textures and Matric Potentials. *Phytopathology*. 66:877.

Elliott, M.L., 2005. Survival, growth and pathogenicity of *Gaeumannomyces graminis* var. *graminis* with different methods of long-term storage. *Mycologia* 97, 901–907. <https://doi.org/10.3852/mycologia.97.4.901>

Fry, P.R., and R.N. Campbell. 1966. Transmission of a tobacco necrosis virus by *Olpidium brassicae*. *Virology*. 30:517–527.

Gracia-Garza, J.A., and D.R. Fravel. 1998. Effect of Relative Humidity on Sporulation of *Fusarium oxysporum* in Various Formulations and Effect of Water on Spore Movement Through Soil. *Phytopathology*. 88:544–549.

Hanson, L.E. 2010. Interaction of *Rhizoctonia solani* and *Rhizopus stolonifer* Causing Root Rot of Sugar Beet. *Plant Disease*. 94:504–509.

Hawksworth, D.L., P.W. Crous, S.A. Redhead, et al. 2011. The Amsterdam Declaration on Fungal Nomenclature. *IMA Fungus*. 2:105–112.

Holmes, G.J., and R.R. Stange. 2002. Influence of Wound Type and Storage Duration on Susceptibility of Sweetpotatoes to *Rhizopus* Soft Rot. *Plant Disease*. 86:345–348.

Hwang, S.-F., S.E. Strelkov, J. Feng, B.D. Gossen, and R.J. Howard. 2011. *Plasmoidiophora brassicae*: a review of an emerging pathogen of the Canadian canola (*Brassica napus*) crop. *Molecular Plant Pathology*. 13:105–113.

Ivors, K., M. Garbelotto, I.D.E. Vries, C. Ruyter-Spira, B. Te Hekkert, N. Rosenzweig, and P. Bonants. 2006. Microsatellite markers identify three lineages of *Phytophthora ramorum* in US nurseries, yet single lineages in US forest and European nursery populations. *Mol. Ecol.* 15:1493–1505.

Jaroszuk-Scisel, J., E. Kurek, A. Slomka, M. Janczarek, and B. Rodzik. 2011. Activities of cell wall degrading enzymes in autolyzing cultures of three *Fusarium culmorum* isolates: growth-promoting, deleterious and pathogenic to rye (*Secale cereale*). *Mycologia*. 103:929–945.

Johnson, N.C., J.-H. Graham, and F.A. Smith. 2008. Functioning of mycorrhizal associations along the mutualism–parasitism continuum. *New Phytologist*. 135:575–585.

Kanyuka, K., E. Ward, and M.J. Adams. 2003. *Polymyxa graminis* and the cereal viruses it transmits: a research challenge. *Molecular Plant Pathology*. 4:393–406.

Kroon, L.P.N.M., H. Brouwer, A.W.A.M. de Cock, and F. Govers. 2012. The genus *Phytophthora* anno 2012. *Phytopathology*. 102:348–364.

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Montes-Borrego, M., B.B. Landa, J.A. Navas-Cortés, F.J. Muñoz-Ledesma, and R.M. Jiménez-Díaz. 2009. Role of oospores as primary inoculum for epidemics of downy mildew caused by *Peronospora arborescens* in opium poppy crops in Spain. *Plant Pathology*. 58:1092–1103.

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Redman, R.S., D.D. Dunigan, and R.J. Rodriguez. 2001. Fungal symbiosis from mutualism to parasitism: who controls the outcome, host or invader? *New Phytologist*. 151:705–716.

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