

PLP 6245 Fastidious Bacteria and Plant Diseases

(Fall 2024)

COURSE INSTRUCTOR: Dr. Nabil Killiny

Office: Room 5 building 7103, Citrus Research and Education Center, Lake Alfred

Phone: 863-956-8833

Email: nabilkilliny@ufl.edu

Office Hours: Mondays and Tuesdays 10:00 am-12:00 am, or by appointment

COURSE: Fastidious Bacteria and Plant Diseases

PREREQUISITE: None

CREDITS: 3

CLASS TIME: Thursday @ 9:35-11:30 am and Friday @9:35-10:25 am

LOCATION: Ben Griffin Building, CREC, Lake Alfred, and via Zoom to Dept. Plant Pathology at Gainesville and other RECs

COURSE DESCRIPTION:

Provides in-depth explanations of the complicated and varied cycles of plant diseases caused by insect-transmitted, vascular-colonizing fastidious bacteria including mollicutes, *Candidatus Liberibacters*, and *Xylella fastidiosa*, including their classification, biology, symptomatology, epidemiology, transmission, plant responses, insect-vector interactions, and management strategies.

RECOMMENDED TEXTBOOKS:

- 1- Phytoplasmas. (2010) by Phyllis G. Weintraub and Phil Jones, CAB International Press, Preston, UK.
- 2- Phytoplasmas: Plant Pathogenic Bacteria – Books I-III (2019); Eds. Rao, Beraccini, Fiore, Weintraub & Liefting; Springer Nature, Singapore.

- 3- Mollicutes and Diseases. (2004) by Shubhrata R. Mishra, Discover Publishing House, Inc, New Delhi-110002.
- 4- Insect Vectors and Plant Pathogens. (2018) by N. S. Butter, CRC Press, Inc, Taylor & Francis Group, New York.

READING LIST:

Spiroplasmas

- Bendix C, Lewis JD. The enemy within: phloem-limited pathogens. *Mol Plant Pathol*. 2018 Jan;19(1):238-254.
- Bolaños LM, Servín-Garcidueñas LE, Martínez-Romero E. Arthropod-Spiroplasma relationship in the genomic era. *FEMS Microbiol Ecol*. 2015 Feb;91(2):1-8.
- Bové JM, Renaudin J, Saillard C, Foissac X, Garnier M. *Spiroplasma citri*, a plant pathogenic mollicute: relationships with its two hosts, the plant and the leafhopper vector. *Annu Rev Phytopathol*. 2003;41:483-500. doi: 10.1146/annurev.phyto.41.052102.104034.
- Takahashi D, Fujiwara I, Sasajima Y, Narita A, Imada K, Miyata M. ATP- dependent polymerization dynamics of bacterial actin proteins involved in *Spiroplasma* swimming. *Open Biol*. 2022 Oct;12(10):220083.
- Trachtenberg S. Shaping and moving a spiroplasma. *J Mol Microbiol Biotechnol*. 2004;7(1-2):78-87.

Phytoplasmas

- Bertaccini A, Arocha-Rosete Y, Contaldo N, Duduk B, Fiore N, Montano HG, Kube M, Kuo CH, Martini M, Oshima K, Quaglino F, Schneider B, Wei W, Zamorano A. Revision of the 'Candidatus Phytoplasma' species description guidelines. *Int J Syst Evol Microbiol*. 2022 Apr;72(4).
- Ermacora P, Osler R. Symptoms of phytoplasma diseases. *Methods Mol Biol*. 2019;1875:53-67.
- Ji X, Gai Y. Phytoplasma proteomic analysis. *Methods Mol Biol*. 2013;938:339-49.
- Kube M, Mitrovic J, Duduk B, Rabus R, Seemüller E. Current view on phytoplasma genomes and encoded metabolism. *Scientific World Journal*. 2012; 2012:185942.
- Nair S, Manimekalai R. Phytoplasma diseases of plants: molecular diagnostics and way forward. *World J Microbiol Biotechnol*. 2021 May 19;37(6):102.
- Pagliari L, Chucho J, Bosco D, Thiéry D. Phytoplasma transmission: Insect rearing and infection protocols. *Methods Mol Biol*. 2019;1875:21-36.
- Sugio A, Hogenhout SA. The genome biology of phytoplasma: modulators of plants and insects. *Curr Opin Microbiol*. 2012 Jun;15(3):247-54.
- Sugio A, MacLean AM, Kingdom HN, Grieve VM, Manimekalai R, Hogenhout SA. Diverse targets of phytoplasma effectors: from plant development to defense against insects. *Annu Rev Phytopathol*. 2011;49:175-95.
- Tomkins M, Kliot A, Marée AF, Hogenhout SA. A multi-layered mechanistic modelling approach to understand how effector genes extend beyond phytoplasma to modulate plant hosts, insect vectors and the environment. *Curr Opin Plant Biol*. 2018 Aug;44:39-48.

Liberibacters

- Blaustein RA, Lorca GL, Teplitski M. Challenges for managing *Candidatus Liberibacter* spp. (Huanglongbing disease pathogen): current control measures and future directions. *Phytopathology*. 2018 Apr;108(4):424-435.
- Killiny N. Generous hosts: ' *Candidatus Liberibacter asiaticus*' growth in Madagascar periwinkle (*Catharanthus roseus*) highlights its nutritional needs. *Phytopathology*. 2022 Jan;112(1):89-100.
- Killiny N. Generous hosts: What makes Madagascar periwinkle (*Catharanthus roseus*) the perfect experimental host plant for fastidious bacteria? *Plant Physiol Biochem*. 2016 Dec;109:28-35.

- Killiny N. Made for each other: Vector–Pathogen Interfaces in the Huanglongbing pathosystem. *Phytopathology*. 2022 Jan;112(1):26-43.
- Mishra S, Ghanim M. Interactions of *Liberibacter* Species with their psyllid vectors: molecular, biological and behavioural mechanisms. *Int J Mol Sci*. 2022 Apr 5;23(7):4029.
- Pandey SS, Hendrich C, Andrade MO, Wang N. *Candidatus Liberibacter*: from movement, host responses, to symptom development of citrus huanglongbing. *Phytopathology*. 2022 Jan;112(1):55-68.
- Pierson EA, Cubero J, Roper C, Brown JK, Bock CH, Wang N. '*Candidatus Liberibacter*' pathosystems at the forefront of agricultural and biological research challenges. *Phytopathology*. 2022 Jan;112(1):7-10.
- Prager SM, Cohen A, Cooper WR, Novy R, Rashed A, Wenninger EJ, Wallis C. A comprehensive review of zebra chip disease in potato and its management through breeding for resistance/tolerance to '*Candidatus Liberibacter solanacearum*' and its insect vector. *Pest Manag Sci*. 2022 Sep;78(9):3731-3745.
- Tabachnick WJ. *Diaphorina citri* (Hemiptera: Liviidae) Vector competence for the citrus greening pathogen '*Candidatus Liberibacter asiaticus*'. *J Econ Entomol*. 2015 Jun;108(3):839-48.
- Wang N, Pierson EA, Setubal JC, Xu J, Levy JG, Zhang Y, Li J, Rangel LT, Martins J Jr. The *Candidatus Liberibacter*-host interface: insights into pathogenesis mechanisms and disease control. *Annu Rev Phytopathol*. 2017 Aug 4;55:451-482.
- Yang C, Ancona V. An overview of the mechanisms against "*Candidatus Liberibacter asiaticus*": virulence targets, citrus defenses, and microbiome. *Front Microbiol*. 2022 Mar 10;13:850588.
- Xylella fastidiosa***
- Almeida RPP, De La Fuente L, Koebnik R, Lopes JRS, Parnell S, Scherm H. Addressing the new global threat of *Xylella fastidiosa*. *Phytopathology*. 2019 Feb;109(2):172-174.
- Bucci EM. *Xylella fastidiosa*, a new plant pathogen that threatens global farming: ecology, molecular biology, search for remedies. *Biochem Biophys Res Commun*. 2018 Jul 12;502(2):173-182.
- Castro C, DiSalvo B, Roper MC. *Xylella fastidiosa*: A reemerging plant pathogen that threatens crops globally. *PLoS Pathog*. 2021 Sep 9;17(9):e1009813.
- Chatterjee S, Almeida RP, Lindow S. Living in two worlds: the plant and insect lifestyles of *Xylella fastidiosa*. *Annu Rev Phytopathol*. 2008;46:243-71.
- Farigoule P, Chartois M, Mesmin X, Lambert M, Rossi JP, Rasplus JY, Cruaud A. Vectors as sentinels: rising temperatures increase the risk of *Xylella fastidiosa* outbreaks. *Biology (Basel)*. 2022 Aug 31;11(9):1299.
- Landa BB, Saponari M, Feitosa-Junior OR, Giampetruzzi A, Vieira FJD, Mor E, Robatzek S. *Xylella fastidiosa*'s relationships: the bacterium, the host plants, and the plant microbiome. *New Phytol*. 2022 Jun;234(5):1598-1605.
- Pavlović TV, Đorđević D. "*Xylella* is the enemy that must be fought": representations of the *X. Fastidiosa* bacterium in the media discourse. *Corpus Pragmat*. 2022;6(4):291-306.
- Rapicavoli J, Ingel B, Blanco-Ulate B, Cantu D, Roper C. *Xylella fastidiosa*: an examination of a re-emerging plant pathogen. *Mol Plant Pathol*. 2018 Apr;19(4):786-800.
- Roper C, Castro C, Ingel B. *Xylella fastidiosa*: bacterial parasitism with hallmarks of commensalism. *Curr Opin Plant Biol*. 2019 Aug;50:140-147.
- Sicard A, Zeilinger AR, Vanhove M, Schartel TE, Beal DJ, Daugherty MP, Almeida RPP. *Xylella fastidiosa*: Insights into an Emerging Plant Pathogen. *Annu Rev Phytopathol*. 2018 Aug 25;56:181-202.

BACKGROUND INFORMATION:

The fastidious plant bacteria cause various economically important diseases. These bacteria are phylogenetically diverse and are grouped together because of *i*- their association with similar plant diseases, *ii*- their endophytic habitat within plants (restricted to phloem or the xylem of the vascular system), *iii*- their transmission by insect vectors from the order Hemiptera and *iv*- their fastidious nature. These bacteria include the cell wall-less bacteria, mollicutes (phytoplasmas and spiroplasmas), the alpha-proteobacteria '*Candidatus Liberibacter spp.*', and the gamma-proteobacteria *Xylella fastidiosa*.

Plant responses to vascular-limited bacteria include phloem or xylem dysfunction. Mollicutes and '*Ca. Liberibacter spp.*' multiply within phloem sieve elements and utilize a high quantity of photosynthesis products. In addition, the mollicutes and '*Ca. Liberibacter spp.*' induce blockage of the phloem by callose deposits, which interrupts or inhibits nutrient transportation. *Xylella fastidiosa* causes xylem blockage by attachment and forms a biofilm in xylem vessels. The bacteria also alter the phytohormonal balance causing leaf, stem and flower deformities, phyllody, and virescence. In general, the common yellowing symptoms of these bacteria reflect physiological changes and effects on metabolic pathways.

The insect transmission of mollicutes and '*Ca. Liberibacter spp.*', involves propagation, circulation, and persistence within the vector body. The growth of plant-pathogenic bacteria in the vector's hemolymph indicates that the hemolymph contains all the necessary nutrients for bacterial growth. Thus, insect-transmitted plant-pathogenic bacteria may alter their vectors' fitness, survival, behavior, and metabolism. In addition to nutrients, bacteria can acquire energetic nucleotides, such as ATP, from their vectors. In contrast, *Xylella fastidiosa* is not circulative within the vector body but localizes only in the foregut where it multiplies and forms a biofilm.

The interactions between the pathogenic bacteria and their host plant are limiting factors for insect vector transmission. Vector-plant interactions including attraction, preference, host specificity, and feeding sites are also key factors relevant to transmission. The availability of bacterial cells to the vector in the host tissues is essential for the acquisition step. In addition, in certain cases, the bacteria possess different transcriptomic phase in plants and only one phase is transmissible. In brief, the interactions should be well studied to achieve successful transmission.

The course will discuss all aspects of diseases caused by vascular-colonizing fastidious bacteria and will include several study cases. Students will actively participate in lectures by reading and evaluating publications prior to the lectures. There will be two lectures per week, a two-hour lecture about a main topic and a one-hour lecture for discussion or guest lecture. Guest lectures will be given by renowned professors and researchers. Some guest lectures will be in pre-recorded video format. One research paper on a vector-borne bacterial disease (of the student's choice) is required for course completion.

LEARNING OBJECTIVES: The economic importance of vector-borne fastidious bacterial diseases has increased dramatically in the last few decades due to the fast spread and challenge of eradicating them. Having a third party (the vector) in the pathosystem increases the difficulty of disease control, but also provides opportunities. Understanding the mechanisms underpinning plant host colonization and insect transmission will certainly help in designing reliable control strategies.

The overall goal of this course is for students to learn about both endemic and exotic vector-borne diseases caused by fastidious bacteria and the biochemical and molecular interactions among the bacteria, the host plant, and the insect vector. By the end of this course, the student should be able to:

- Define and recognize plant diseases caused by vascular-colonizing fastidious bacteria.
- Categorize and characterize the classification of vascular-colonizing fastidious bacteria.
- Recall and explain the plant responses to vascular-colonizing fastidious bacteria.
- Differentiate and illustrate the disease components associated with insect transmission modes of plant bacterial pathogens.
- Discuss the role of insect vector biology and behavioral ecology in the spread of vector-borne diseases.
- Evaluate and propose potential control strategies to disrupt insect transmission and/or plant colonization.

LEARNING MODULES: The course content for this class is divided into five learning modules including i. Characterization of fastidious vascular-colonizing plant pathogenic bacteria, ii- Diseases caused by spiroplasmas, iii-Diseases caused by phytoplasmas, iv-Diseases caused by '*Ca. Liberibacter spp*', v-Diseases caused by *Xylella fastidiosa*, vi- Questions for open discussion.

Every module has a graded quiz after the completion of the module.

DISCUSSIONS: Students will participate in article discussions, occasionally. Briefs and discussion participation will be graded through a combination of peer review and instructor review.

GRADE: Grading is based on five quizzes, a term paper, participation in discussion sessions, a midterm exam, and a cumulative final exam. Grades will be based on the following assessments:

Component	Points
Quiz 1	20
Quiz 2	20
Quiz 3	20

Quiz 4	20
Quiz 5	20
Mid-term Exam	200
Discussion Sessions	100
Term paper	100
Final Exam (Comprehensive)	300
TOTAL	800

Exams and quizzes: There will be two exams (a mid-term [200 points] and final [300 points]). The exams will be proctored live in Fifield building and libraries of RECs in Gainesville and the Centers' teaching rooms. Additionally, there will be five quizzes (20 points each) covering the five modules. Quizzes would be given online in class and cameras would need to be turned on and the midterm and final exams would be given in person in the classroom in Gainesville and at the RECs with an appropriate proctor.

Term paper: Every student will need to write a term paper about a vector-borne disease of his/her choice. The term-paper should discuss the disease description, pathogen life cycle, vector life cycle, transmission mode, and pathogen-vector interactions. 100 points are assigned for the term-paper.

Discussion Sessions: Discussion sessions are scheduled during several lectures. 100 points will be assigned to the discussion activity. 50 points for peer review and presenting a research paper and 50 points for participation in discussions.

Grading Scale: Final grades will be determined according to the following grading scale. This course uses the grade book function in Canvas for record-keeping and grade calculation; grades will be calculated on a percentage basis, but total course points associated with each percentage are given here for your convenience.

For information on current UF policies for assigning grade points, see:
<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Letter Grade	Percentage	Points
A	92.00 – 100	736 – 800
A-	90.00 – 91.99	720 – 735
B+	88.00 – 89.99	704 – 719
B	82.00 – 87.99	656 – 703

B-	80.00 – 81.99	640 – 655
C+	78.00 – 79.99	624 – 639
C	72.00 – 77.99	576 – 623
C-	70.00 – 71.99	560 – 575
D+	68.00 – 69.99	544 – 559
D	62.00 – 67.99	496 – 543
D-	60.00 – 61.99	480 – 495
E	00.00 – 59.99	000 – 479

ATTENDANCE AND MAKE-UP WORK:

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at:

<https://gradcatalog.ufl.edu/graduate/regulations/>.

For online course with recorded materials a statement informing students of privacy related issues such as:

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Online Course Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals.

Guidance on how to give feedback in a professional and respectful manner is available at: <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens and can complete evaluations through the email they receive from GatorEvals, in their

Canvas course menu under GatorEvals, or via <https://ufl.bluer.com/ufl/>. Summaries of course evaluation results are available to students at: <https://gatorevals.aa.ufl.edu/public-results/>.

ACADEMIC HONESTY

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following 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." You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment."

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: <http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>.

Use of generative Artificial Intelligence tools such as ChatGPT is discouraged. However, when used as a tool for learning or studying, such as for improving English, providing clarity, generating ideas, or gathering general information on a topic, it is permitted. Written passages, mathematical models, or answers synthesized based on AI results should be attributed as such: "The author generated this text/model in part with GPT-3, GPT3.5 or GPT4 through ChatGPT or Bing, OpenAI's large-scale language generation model. Upon generating draft language, the author reviewed, edited, and revised the language to their own liking and takes ultimate responsibility for the content created."

Software Use and Copyright: 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.

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 requesting classroom

accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation 0001 Reid Hall, 352-392-8565, <https://disability.ufl.edu/>

Campus Helping 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.

Health and Wellness

- *U Matter, We Care*: If you or someone you know is in distress, please contact umatter@ufl.edu, 352-392-1575, or visit [U Matter, We Care website](#) to refer or report a concern and a team member will reach out to the student in distress.
- *Counseling and Wellness Center*: [Visit the Counseling and Wellness Center website](#) or call 352-392-1575 for information on crisis services as well as non-crisis services.
- *Student Health Care Center*: Call 352-392-1161 for 24/7 information to help you find the care you need, or [visit the Student Health Care Center website](#).
- *University Police Department*: [Visit UF Police Department website](#) or call 352-392-1111 (or 9-1-1 for emergencies).
- *UF Health Shands Emergency Room / Trauma Center*: For immediate medical care call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608; [Visit the UF Health Emergency Room and Trauma Center website](#).
- *GatorWell Health Promotion Services*: For prevention services focused on optimal wellbeing, including Wellness Coaching for Academic Success, visit the [GatorWell website](#) or call 352-273-4450.

Academic Resources

- *E-learning technical support*: Contact the [UF Computing Help Desk](#) at 352-392-4357 or via e-mail at helpdesk@ufl.edu.

- [Career Connections Center](#): Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services.
- [Library Support](#): Various ways to receive assistance with respect to using the libraries or finding resources.
- [Teaching Center](#): Broward Hall, 352-392-2010 or to make an appointment 352- 392-6420. General study skills and tutoring.
- [Writing Studio](#): 2215 Turlington Hall, 352-846-1138. Help brainstorming, formatting, and writing papers.
- *Student Complaints On-Campus*: [Visit the Student Honor Code and Student Conduct Code webpage for more information](#).
- *On-Line Students Complaints*: [View the Distance Learning Student Complaint Process](#).

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

Course lecture schedule – Fall 2024

Module	Date	Topic	Items
Module I: Characterization of fastidious vascular-colonizing plant pathogenic bacteria	August 22	Introduction to plant vascular-colonizing bacteria (genetic variation but having similar lifestyles)	Cause similar plant diseases Restricted to the vascular system Transmitted by hemipteran vectors Fastidious growth in artificial media
	August 23	Pathogenesis and plant responses	Responses to phloem-colonizing bacteria
	August 29	Pathogenesis and plant responses	Responses to xylem-colonizing bacteria
	August 30	Mechanism of insect vector transmission	Modes of transmission: Circulation, Multiplication, and Persistence
	September 5	Mechanism of insect vector transmission	Molecular and biochemical bases of transmission process: Bacterial membrane proteins, Insect receptors in gut and salivary glands
	September 6	Factors affecting the transmission efficiency	
	September 12	Role of exopolysaccharides/lipopolysaccharides/ extracellular polymeric substances in plant pathogenicity and insect transmission	Case study i - <i>Xylella fastidiosa</i>
	September 13	Role of exopolysaccharides/lipopolysaccharides/ extracellular polymeric substances in plant pathogenicity and insect transmission	Case study ii - ' <i>Ca. L. asiaticus</i> '
	September 19	Role of quorum sensing in plant pathogenicity and insect transmission	Case study i - <i>Xylella fastidiosa</i> (diffusible signaling factor, DSF)
	September 20	Role of quorum sensing in plant pathogenicity and insect transmission	Case study ii - ' <i>Ca. L. asiaticus</i> ' (the two components quorum sensing, LuxR-AHSL)
	September 26	Mid-term exam	
Module II: Diseases caused by Spiroplasmas	September 27	Evolution, phylogeny, taxonomy, and morphological properties of Spiroplasmas	
	October 3	Case studies ; epidemiology, symptoms, host range, insect transmission, and control strategies	i- Citrus stubborn (<i>S. citri</i>) ii- Corn stunt (<i>S. kunkellii</i>) iii- Periwinkle dwarfing (<i>S. phoeniceum</i>)
	October 4	Quiz 1 and Paper discussion	
Module III: Diseases caused by Phytoplasmas	October 10	Evolution, phylogeny, taxonomy, and morphological properties of phytoplasmas	
	October 11	Case studies ; epidemiology, symptoms, host range, insect transmission, and control strategies	i- Phytoplasma diseases of fruit crops: Ex. Flavescence drée and Stolbur in grape, Western X in cherries ii- Phytoplasma diseases of vegetable crops: Ex. Witches broom, little leaf, flat stem iii- Phytoplasma diseases of ornamental and medical plants: Ex.

			Aster yellow, virescence and phyllody
	October 17	Quiz 2 and Paper Discussion	
Module IV: Diseases caused by Liberibacters	October 18	Evolution, phylogeny, taxonomy, and morphological properties of ' <i>Ca. Liberibacter spp</i> '	
	October 24	Case studies ; epidemiology, symptoms, host range, control strategies	i- Citrus Greening (' <i>Ca. L. asiaticus</i> ') ii- Potato zebra chip (' <i>Ca. L. solanacearum</i> ')
	October 25	Quiz 3 and Paper discussion	
Module V: Diseases caused by <i>Xylella fastidiosa</i>	October 31	Evolution, phylogeny, taxonomy, and morphological properties of <i>Xylella fastidiosa</i>	
	November 1	Case studies ; epidemiology, symptoms, host range, insect transmission, and control strategies	i- Pierce's disease of grapes ii- Olive quick decline syndrome iii- Citrus variegated chlorosis iv- Leaf scorch/Golden Death of Almond
	November 7	Quiz 4 and Paper discussion	
Module VI: Questions for open discussion, students should prepare in advance. <i>Students need to prepare in advance</i>	November 8	What makes periwinkle an excellent experimental host for fastidious bacteria? Why can fastidious bacteria be easily transmitted by dodder and grafting?	
	November 14	Why are all fastidious bacteria insect-transmitted? Can we block the insect transmission of fastidious bacteria? If so, would the strategies be different between phloem-restricted and xylem-restricted bacteria?	
	November 15	Quiz 5 and Paper discussion	
	November 21	Does natural competence play a role in the evolution and diversity of mollicutes, ' <i>Ca. Liberibacter spp</i> ', and <i>Xylella fastidiosa</i> ?	
	November 22	General Discussion	
	November 28	Holiday	
	November 29	Holiday	
	December 5	Reading day	
	December 6	Reading day	
	December 12	Final exam	