האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

The Hebrew University of Jerusalem

Syllabus

GENETICS OF FUNGAL PLANT PATHOGENS - 71141

Last update 27-09-2017

HU Credits: 2

Degree/Cycle: 2nd degree (Master)

Responsible Department: agroecology & plant health

Academic year: 0

Semester: 2nd Semester

Teaching Languages: Hebrew

Campus: Rehovot

Course/Module Coordinator: Shay Covo

Coordinator Email: shay.covo@mail.huji.ac.il

Coordinator Office Hours: by appointment

Teaching Staff:

Dr. Shay Covo

Course/Module description:

Fungal plant pathogens serve a significant threat to crop health and food security. Resistance to fungicides as well as increase in virulence are common and cause severe economic loss. In order to become fungicide resistant or extremely virulent fungi have to mutate or adopt anew allele that will confer resistance. In this course we will discuss how such changes occur to the genomes of fungal plant pathogens and how in turn they lead to drug resistance.

Course/Module aims:

1. To expose the students to the importance and complexity of genetic diversity in fungal plant pathogens.
2. To introduce mechanisms generating genetic diversity: Meiotic and mitotic recombination; Non homologus end joining; Translesion DNA synthesis and Horizontal gene transfer. How these mechanisms operate to shape the chromosomes of fungal plant pathogens?
3. To described the novel and traditional approaches in studying changes in chromosome structure and number, with emphasis on next generation sequencing and comparative genome hybridization.
4.To provoke critical and creative thinking regarding the open questions in mutagenesis and genetic diversity in fungal plant pathogens.

Learning outcomes - On successful completion of this module, students should be able to:

At the end of this course the student should be able to:
1.Understand how different mutations are generated
2.Understand how mutations are studied
3.Understand the concept of par asexual recombination and horizontal gene transfer
4.Establish the connection between genetic diversity drug resistance and virulence
5.Understand the open questions in genome diversity of fungal plant pathogens.

Attendance requirements(%):

85

Teaching arrangement and method of instruction: Frontal teaching, discussion and group work

Course/Module Content:

Topics covered:

1.What is the importance of genetic diversity? – examples from fungicide resistance and virulence

2.Sources of genetic diversity – the dynamics of allele Topics covered:

1. What is the importance of genetic diversity? – examples from fungicide resistance and virulence

2. Sources of genetic diversity – the dynamics of allele composition in the population and de novo mutations.

3. How de novo mutations are generated?

a. Point mutations

b. Structural variations

c. Aneuploidy

4. How the allele composition is changed in the population or within isolates

a. Meiotic recombination

b. Mitotic recombination

c. Vegetative complimentary groups – formation of heterokaryon

d. Horizontal gene/chromosome transfer

Course detailed schedule

Week 1: Introduction, course requirements, evaluation.

Discuss the following questions:

What is genetic diversity? How genetic diversity is achieved? Why genetic diversity is important – mutation and selection, QTL and allele compositions. Types of mutations?

Week 2 - 3: How the allele composition is changed in the population? Sexual reproduction. Refresher on meiosis, genetic recombination and crossing-over. Describe the life cycle of Ustilago maydis, pose the open questions of sexual reproduction in biotroph fungi. Describe the life cycle of Puccinia graminis. Virulence of Ug99

Week 4: An example from Zymoseptoria tritici of how sexual reproduction contributes to fungicide resistance. Discuss the benefits of sex. Can mitotic recombination contribute to virulence? Mitotic loss of heterozygosity in Phytophthora capsici.

Week 5: Sex without sex, Vegetative complementary group what is it good for?

Week 6: Sex without sex, horizontal gene transfer. Specific example - transfer of dispensable chromosomes between isolates in Fusarium oxysporum.

Week 7: Molecular view into population genetics of fungal plant pathogens – from the field to the bench and back.

Week 8: How point mutations are generated? Fidelity of DNA replication, can mismatch repair be modulated? Introduction to DNA damage-induced mutations.

Week 9: SOS and other mutagenesis events mediated by translesion DNA synthesis (TLS). Stressed Lifestyle Associated Mutagenesis. Does TLS contribute to drug resistance?

Week 10 : What is double strand break repair? Mechanisms of DSBR. Error prone double strand break repair: Non allelic homologous recombination; microhomology mediated non homologous end joining.

Week 11: An example of error prone DSBR - Structural variations in Verticillium dahliae. DNA template switching
Week 12: Aneuploidy – uneven number of chromosomes. Cellular response to aneuploidy? Can aneuploidy be a driving force in adaptation?
Week 13: Examples in human fungal plant pathogens for aneuploidy-derived drug resistance, are there examples in plants?
Explanations about the test and the home assignment.

Required Reading:
Some of these papers will be discussed:

de Jonge, R., M. D. Bolton, A. Kombrink, G. C. van den Berg, K. A. Yadeta et al., 2013 Extensive chromosomal reshuffling drives evolution of virulence in an asexual pathogen. Genome Res 23: 1271-1282.

Donaldson, M. E., and B. J. Saville, 2008 Bioinformatic identification of Ustilago maydis meiosis genes. Fungal Genet Biol 45 Suppl 1: S47-53.

Feretzaki, M., and J. Heitman, 2013 Unisexual Reproduction Drives Evolution of Eukaryotic Microbial Pathogens. PLoS Pathog 9: e1003674.

Goodwin, S. B., S. Ben M'Barek, B. Dhillon, A. H. J. Wittenberg, C. F. Crane et al., 2011 Finished Genome of the Fungal Wheat Pathogen Mycosphaerella graminicola Reveals Dispensome Structure, Chromosome Plasticity, and Stealth Pathogenesis. PLoS Genet 7: e1002070.

Holliday, R., 2011 The recombination, repair and modification of DNA. DNA Repair (Amst) 10: 993-999.

Kojic, M., J. H. Sutherland, J. Perez-Martin and W. K. Holloman, 2013 Initiation of meiotic recombination in Ustilago maydis. Genetics 195: 1231-1240.

Ma, L. J., H. C. van der Does, K. A. Borkovich, J. J. Coleman, M. J. Daboussi et al., 2010 Comparative genomics reveals mobile pathogenicity chromosomes in Fusarium. Nature 464: 367-373.

Ni, M., M. Feretzaki, W. Li, A. Floyd-Averette, P. Mieczkowski et al., 2013 Unisexual and Heterosexual Meiotic Reproduction Generate Aneuploidy and Phenotypic Diversity De Novo in the Yeast Cryptococcus neoformans. PLoS Biol 11: e1001653.

Selmecki, A., A. Forche and J. Berman, 2006 Aneuploidy and Isochromosome Formation in Drug-Resistant Candida albicans. Science 313: 367-370.
Selmecki, A. M., K. Dulmage, L. E. Cowen, J. B. Anderson and J. Berman, 2009

Acquisition of aneuploidy provides increased fitness during the evolution of antifungal drug resistance. PLoS Genet 5: e1000705.

Additional Reading Material:

Course/Module evaluation:
End of year written/oral examination 50 %
Presentation 0 %
Participation in Tutorials 0 %
Project work 50 %
Assignments 0 %
Reports 0 %
Research project 0 %
Quizzes 0 %
Other 0 %

Additional information:
1. 50% of the grade will be a very brief proposal to tackle one of the open question raised in the course
2.50% of the grade will be a test that will include an analysis of a figure from one of the papers discussed in class or given as reading assignment.