

COURSE SYLLABUS

CSES 5124 CROP MOLECULAR AND PHYSIOLOGICAL GENETICS

Offered: Spring Semester, Even years

Instructor: James McD. Stewart

Presentation and Instructional Material:

The course consists of two 80-minute lecture periods and one 50-minute discussion period. Questions and discussions are encouraged and input solicited from the students during the lecture periods, and the discussion period is devoted to questions and clarifications of the subject matter covered in the two previous lecture periods. Much of the course material is covered in Genes V, VI or VII by Benjamin Lewin (Oxford Press,) and Biochemistry & Molecular Biology of Plants by Buchanan, Gruissem and Jones. Chapters from these and other books and annual reviews of the subjects to be covered are made available to the students. Reading materials are updated each biennium.

Course Overview:

The course provides a broad coverage of the knowledge, techniques and application of molecular and physiological genetics and how these relate to crop productivity and improvement in its environment. Successful completion of this course material will enable the students to understand the basic principles of the discipline, to have a broad over-view of molecular gene expression, and to undertake advanced study in any of the various sub-disciplines.

The course is primarily plant oriented but includes microbial genetics to the extent they are important to plant molecular techniques, host-microbe interactions, and genetic engineering. A diversity of subjects are covered dealing with molecular structure and development and environmental modulation of genetic expression. The course sequence begins with a basic treatment of molecular methodology followed by a discussion on genetic organization from DNA sequence to chromosomes. Subsequent material includes the various levels of control of genetic expression during development, and in response to abiotic and biotic parameters in the environment; molecular biology of mitochondria and chloroplast; transposable elements and retrotransposons; host symbiotic and pathogenic relationships; genetic engineering of plants; and molecular markers and genome mapping.

Grade Contract: A = 540-600
 B = 480-539
 C = 420-479
 D = 360-419
 F = < 360

Quizzes and weekly assignments: (100 points) There are a series of 10 min. quizzes or special take-home assignments totaling 110 points. These are 10 points each and the lowest grade is dropped. (Everybody has a bad day now and then).

Examinations: There are three examinations of 80 minutes each (if closed book) cumulative of material covered but with emphasis on the subject matter covered since the preceding examination. Each exam has 100 points. At the instructor's option one or two of the examinations may be take-home.

Final Exam: Comprehensive with 200 points.

Adverse Weather Policy: The policy established by the University of Arkansas Board of Trustees will be followed.

Subject Modules:

I. Introduction, genetic over-view, macromolecules.

Content: Over-view of the course content; review of mitosis and meiosis and the basis of inheritance; structure of nucleic acids and proteins.

Objective: Assure that the students are familiar with the proposed content of the course, and provide a refresher in chromosome segregation, and macromolecular structure.

II. Techniques in molecular genetics

Content: Familiarity with the basic techniques used in molecular biology is essential to understanding much of the course content. A general coverage of techniques and principles behind them are presented, including (but not limited to) useful enzymes; DNA restriction; gel electrophoresis; southern, northern and western blotting; nucleic acid hybridization; cDNA synthesis; cloning; polymerase chain reaction; etc.

III. Nuclear structure, organization, and function

Content: Strong correlation is drawn between structure and function of nuclear material during the cell cycle, including chromosome structure. Genome organization and the various classes of DNA is described. Emphasis is placed on the packaging of DNA into the nucleus and ultimately into chromosomes. A general treatment of the biochemistry and resolution of spacial DNA replication and segregation at the molecular level is presented.

Objective: Provide an understanding of the complexity of genetic management and continuity.

IV. Gene structure, transcription, translation and regulation of gene expression

Content: This is a large unit that covers the basic sequences of DNA that define genes transcribed by the three RNA polymerases. The structural distinctions and roles of the

different classes of RNA are explained. Molecular mechanisms of transcription and translation are presented with emphasis on levels of regulation of each process. Major emphasis is placed on genes coding for proteins and the various response elements controlling transcription. Inducing phenomena are discussed including sequential development, tissue specific, phytohormone, light, heat, heavy metal, anoxia, drought, salinity, wounding and herbivory, microbial invasion, etc.

Objective: Assure that gene structure, mechanisms of expression, and regulation of expression are understood.

V. Cytoplasmic genomes

Content: The structure and organization of the genomes in chloroplasts and mitochondria are described with speculation on their origin. Significance of genes retained in the organelle genomes versus nucleus is considered in terms of the functional roles of the organelles. Nuclear-cytoplasmic interactions are discussed with special attention given to the relation of mitochondrial genomes to cytoplasmic male sterility.

Objective: Provide an awareness of cytoplasmic inheritance and characteristics of organelle gene expression.

VI. Transposons, retrotransposons, and retroviruses

Content: Non-mendelian genetics encompassed in somatically mobile DNA is discussed. Transposons, retrotransposons, and retroviruses are defined in terms of their molecular structures and mechanisms by which they function, and the genetic consequences of their activity.

Objective: Assure that students are aware of non-mendelian inheritance and the molecular mechanisms by which they function.

VII. Plant-biote interactions

Content: This unit deals with plant-biote interactions including associative, symbiotic, parasitic, and predatory. The assumptive approach is that all interactions involve a basic finite set of responses at the biochemical and molecular level. Included in the discussion are general plant defensive responses to herbivores and microbes, basic compatibility, basic incompatibility, specific incompatibility, and gene-for-gene interaction. The molecular genetics of symbiotic nitrogen fixation is included in this unit.

Objective: Provide knowledge and appreciation of the mechanics by which plants deal with their biotic environment.

VIII. *Agrobacterium* biology and genetic engineering

Content: *Agrobacterium* is considered as a unit separate from plant-microbe interaction because of its importance to genetic engineering in plants. The etiology of the crown gall disease is described, followed by discussions of the regulation, products and activities of genes involved in the virulent response, which is to say, transfer of DNA from the bacterium to a plant cell genome. Once an understanding of *Agrobacterium* biology is established, various modifications and manipulations to the system for incorporation and transfer of foreign genes to plants is discussed. The requirements for effective gene expression as they apply to chimeric genes used in genetic engineering are reviewed. Other methods of genetic engineering are briefly discussed. The unit concludes with consideration of specific genes that have been genetically engineered into crop plants.

Objective: Provide knowledge of *Agrobacterium* biology that allows manipulation for genetic engineering. Assure that the basic requirements for expression of transgenes are understood.

IX. Molecular markers and genome mapping

Content: This unit describes the types and origins of molecular polymorphisms and enumerates the various ways they are detected. Included are isozymes, RFLPs, RAPDs, AFLPs, microsatellites, etc. The requirements for developing a molecular map of a plant genome are discussed. A model data set is provided in which the students utilize the computer program MapMaker to predict linkages and arrangements among molecular markers.

Objective: Provide an introduction to molecular markers and their use in genome mapping.

X. Social issues in molecular genetics

Content: This unit briefly covers current regulatory and legal requirements associated with molecular genetics. Subsequently environmental, ethical and moral questions concerning molecular genetics are raised for class discussion.

Objective: Instill an awareness of the legal requirements and social concerns associated with molecular genetics.