PSS6001 – Special Topic in Plant and Soil Science
Molecular Basis of Plant Responses to the Environment
(Spring 2017; Wednesdays, 10:00 AM to 12:45 PM, BPS118)

Instructor

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Consultation: By appointment

References

Buchanan BB, Gruissem W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd Edition, American Society of Plant Biologists, John Wiley and Sons Ltd., ISBN:9780470714218; ISBN: 978-0-47071-422-5. ***(Highly Recommended)***

Taiz L, Zeiger E (2010) Plant Physiology, 5th Edition, Sinauer Associates, Inc., ISBN: 978-0-87893-866-7.

All lecture materials will be provided in electronic form to the students.

Course description

Prerequisites: Consent of instructor; ***Credits:*** 3 credits including lectures, literature reading and class discussions

Plants adapt to changes in their environment through exquisitely coordinated and fine-tuned processes regulated at the cellular and molecular levels. Advances in genetics, genomics, biochemistry, and molecular biology during the last half century uncovered the molecular underpinnings of complex processes by which plants adjust their physiological status and biochemical attributes in order to cope with a plethora of biotic and abiotic insults. This course is a platform for integrating the advances in mechanistic and genome-enabled biology with the seminal science and classical paradigms of plant stress physiology towards appreciation of the '*cause-and-effect*' relationships between the processes occurring at the *cellular* and *genome* levels and the *phenotype* observed at the whole-plant level.

Stress is integral to almost all phases of plant growth and development. To address this dogma, the course will be presented in three modules. In the first module, students are led to the ***big picture*** of the molecular life of a plant, by dissecting the processes of growth and development, and the interaction between genetics and environmental factors in their regulation. Understanding the molecular basis by which plant growth and development are regulated by the environment sets the stage for dissecting the biochemical and molecular adaptive responses to abiotic and biotic stresses, and the genetic regulatory mechanisms that configure those processes. These aspects of plant stress physiology are covered in-depth in the second and third modules, respectively. Translation of molecular mechanisms to innovative genetic engineering strategies for enhancing the stress tolerance or disease resistance of crop plants sums up each module. Lessons on such topics provide students a basic

understanding of how the outcome of functional genomics is directly applied to stress physiology and breeding.

Purpose of the course

The grand challenge to sustainable agriculture is to continuously make incremental enhancements in crop productivity in order to meet the food demands of the projected world population of 10 billion people by the middle of the 21st century. This challenge is further complicated by the continuous marginalization of agricultural ecosystems, steady deterioration or depletion of natural resources, and rapidly changing dynamics of pest and pathogen populations, all of which are consequences of global climate change. Addressing such a challenge requires in-depth understanding of the fundamental mechanisms that are critical to plant resilience and productivity under sub-optimal environments, and the application of such knowledge to crop breeding and other innovative crop management approaches.

With the burgeoning impact of climate change to plant agriculture, this course is very timely as it serves as a platform for educating graduate students interested in either fundamental plant biology or applied crop science on the mechanisms by which plants respond and adapt to various forms of stresses at the cellular level, and how these processes are integrated to configure whole-plant level defenses. Every student specializing in any sub-discipline of fundamental plant biology, agronomy, or horticulture must have a decent understanding of the mechanisms of how plants adapt to stresses and their genetic regulation. Therefore, this course aims to complement other applied courses in crop physiology taught in agronomy, horticulture and other fields of applied plant science, by presenting the mechanistic aspects. ***The goal is to illuminate the physiological processes observed at the whole plant or population level with molecular genetic and biochemical mechanisms*** to assist students in gaining appreciation of the potential of genetic technologies in developing the next generation of climate-resilient and disease-resistant crops.

Grading criteria and scale

Research paper presentation (10%), Written critique of research papers (10%), Participation in class discussions (10%), Written research proposal (40%), Oral presentation of research proposal (15%), Written critique of research proposal (15%)

A = 85% to 100%; **B** = 75% to 84%; **C** = 65% to 74%; **D** = 50% to 64%; **F** = below 50%

Topic outline

Module-1: Environmental regulation of plant growth and development

1) Growth regulation by hormones
   a) Overview of signal transduction
   b) Auxin: Biosynthesis, degradation, signal transduction, gene expression
   c) Gibberellin: Biosynthesis, degradation, signal transduction, gene expression
   d) Cytokinin: Biosynthesis, degradation, signal transduction, gene expression
2) Phototropism and regulation of plant growth and development by light
   a) Phytochrome signaling
   b) Circadian rhythms
   c) Genetic control of light regulated responses
3) Environmental regulation of flowering
   a) Floral meristem, evocation, and floral organ development
   b) Photoperiodism and the circadian clock
   c) Florigen and long distance signaling
   d) Vernalization
   e) Regulation of gene expression during transition of the floral meristem
4) Maturation and senescence
   a) Programmed cell death during plant development
   b) Regulation of gene expression during senescence

Module-2: Plant responses to abiotic stresses

1) Cellular dehydration are induced by water deficit/drought, salinity, and cold
   a) Common denominator: Reactive oxygen species and cellular toxicity
   b) Physical and biochemical injuries to the cell
2) Hormonal regulation of plant responses to abiotic stresses
   a) Signal transduction: Ca^{2+} and oxidative signaling
   b) Abscisic acid: Biosynthesis, degradation, and signal transduction
   c) Ethylene: Biosynthesis, degradation, and signal transduction
   d) Brassinosteroid: Biosynthesis, degradation, signal transduction
   e) Coordination of transcription by stress hormones
3) Mechanisms of osmotic adjustment
   a) Osmotin and compatible osmolytes
   b) Late Embryogenesis Abundant (LEA) proteins
4) Mechanisms of salinity tolerance and subcellular sequestration
   a) Ionic toxicity and osmotic stress
   b) SOS signaling
   c) Vacuolar transport and efflux mechanisms
   d) Carriers, pumps, and membrane channels
5) Cold acclimation and thermotolerance
   a) Cell membrane stabilization
   b) Antifreeze proteins

c) DREB/CBF gene regulon and its role in cold acclimation and drought tolerance

6) Responses to flooding stress
   a) Anoxia and hypoxia
   b) Role of ethylene
   c) *Sub1* genetic network and tolerance to anaerobic stress

7) Genetic engineering for stress tolerant crops
   a) Stress physiological genomics and quantitative trait loci
   b) Agrobacterium-mediated transformation and regulon engineering
   c) Post-transcriptional gene silencing and genome editing

Module-3: Plant responses to biotic stresses

1) Pathogen virulence mechanisms
   a) Bacteria
   b) Fungi and oomycetes
   c) Virus
   d) Virulence molecules and effectors

2) Host plant responses and defense systems
   a) Baseline defenses
   b) Oxidative burst and defense-associated programmed cell death
   c) Secondary metabolites: Phenolics, alkaloids, terpenoids
   d) Hypersensitive response (HR)
   e) Systemic acquired resistance (SAR)
   f) Hormones and elicitors: Ethylene, salicylic acid, jasmonic acid

3) Genetic basis of plant-pathogen interaction
   a) Gene-for-gene mechanisms, R-genes, and R-gene-mediated disease resistance
   b) Signal transduction mechanisms: NBS-LRR family of receptor kinases
   c) Quantitative resistance mechanisms
   d) Cross-talks, synergism, and antagonism of defense signaling pathways
   e) Cross-talks of defense signaling against pathogens and abiotic stresses

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Class Schedule, Spring 2017

Date	***Topic***	***Activity***
Module-1. Environmental regulation of plant growth and development		
Week-1	*Organizational meeting*	*Orientation*
Week-2	Signal transduction; Hormonal signaling: Auxin, gibberellin, cytokinin	Lecture
Week-3	Hormonal signaling: Auxin, gibberellin, cytokinin	Lecture
	Phototrophism and growth regulation by light	Lecture
Week-4	Environmental regulation of flowering	Lecture
	Maturation and senescence	Lecture
Week-5	*Research papers for module-1 (Assigned readings)*	*Student presentation* *Class discussion*
Module-2. Plant responses to abiotic stresses		
Week-6	Cellular dehydration and stress common denominators	Lecture
	Hormonal regulation of stress response mechanisms	Lecture
	Topic and tentative title of research proposal	***Due date***
Week-7	Hormonal regulation of stress response mechanisms	Lecture
Week-8	Osmotic adjustment and detoxification	Lecture
	Cold acclimation and thermotolerance	Lecture
Week-9	Anoxia and hypoxia	Lecture
	Gene regulons and genetic engineering	Lecture
Week-10	*Research papers for module-2 (Assigned readings)*	*Student presentation* *Class discussion*
	Outline of research proposal	***Due date***
Module-3. Plant responses to biotic factors		
Week-11	Pathogen virulence mechanisms	Lecture
Week-12	Host plant defense systems	Lecture
Week-13	Genetics of plant-pathogen interaction	Lecture
Week-14	***Final research proposal***	***Due date***
Culminating activity – Research proposal		
Week-15	Oral presentation of research proposal	*Presentation/defense*
	Proposal review panel	*Review/critique*

General information

Texas Tech University Statement of Academic Integrity

Academic integrity is taking responsibility for one's own work, being individually accountable, and demonstrating intellectual honesty and ethical behavior. Academic integrity is a personal choice to abide by the standards of intellectual honesty and responsibility. Because education is a shared effort to achieve learning through the exchange of ideas, students, faculty, and staff have the collective responsibility to build mutual trust and respect. Ethical behavior and independent thought are essential for the highest level of academic achievement, which then must be measured. Academic achievement includes scholarship, teaching and learning, all of which are shared endeavors. Grades are a device used to quantify the successful accumulation of knowledge through learning. Adhering to the standards of academic integrity ensures that grades are earned honestly and gives added value to the entire educational process. Academic integrity is the foundation upon which students, faculty, and staff build their educational and professional careers. [Texas Tech University ("University") Quality Enhancement Plan, Academic Integrity Task Force, 2010].

Texas Tech University Code of Conduct – Academic integrity

"Academic dishonesty" includes, but is not limited to, cheating, plagiarism, collusion, falsifying academic records, misrepresenting facts and any act designed to give unfair academic advantage to the student. Students must understand the principles of academic integrity, and abide by them in all class and/or course work at the University. Academic integrity violations are outlined in the Code of Student Conduct, Part II, Section B1 and can be found here: **www.ttu.edu/studenthandbook**.

If there are questions of interpretation of academic integrity policies or about what might constitute an academic integrity violation, students are responsible for seeking guidance from the faculty member teaching the course in question.

University-wide policies on addressing Incidents of Academic Integrity

Texas Tech University policies and procedures regarding academic integrity can be found in the Student Handbook in Part II, section B and online here: **www.ttu.edu/studenthandbook**.

Any person becoming aware of alleged violations of academic integrity should report the allegation to the instructor of record in the course. The instructor in a course is responsible for initiating action in each case of dishonesty or plagiarism that occurs in that class. The instructor may contact the Office of Student Conduct to discuss the nature of the violation and the student's record of academic integrity violations. The instructor should attempt to discuss the matter with the student and receive a response from the student about the allegations. Then, the instructor may assign academic sanctions including, but not limited to a assigning a paper or research project related to academic integrity, make-up assignment that is different than the original assignment, issue no credit for the original assignment, reduce the grade for the assignment and/or course, issue a failing grade on the assignment, and/or issue a failing grade for the course. All academic integrity violations will be referred to the Office of Student Conduct as a central clearinghouse of violations and for adjudication as a Code of Student

Conduct violation where disciplinary sanctions, conditions, and/or restrictions will be assigned. These disciplinary sanctions could include suspension or expulsion from Texas Tech University.

Students with disabilities

Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructor's office hours. Please note that instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, you may contact the *Student Disability Services Office* at *335 West Hall* or *806-742-2405*.

TTU resources for discrimination, harassment, and sexual violence

Texas Tech University is committed to providing and strengthening an educational, working, and living environment where students, faculty, staff, and visitors are free from gender and/or sex discrimination of any kind. Sexual assault, discrimination, harassment, and other Title IX violations are not tolerated by the University. Report any incidents to the Office for Student Rights & Resolution, (806)-742-SAFE (7233) or file a report online at titleix.ttu.edu/students. Faculty and staff members at TTU are committed to connecting you to resources on campus. Some of these available resources are: TTU Student Counseling Center, 806-742-3674, https://www.depts.ttu.edu/scc/(Provides confidential support on campus.) TTU 24-hour Crisis Helpline, 806-742-5555, (Assists students who are experiencing a mental health or interpersonal violence crisis. If you call the helpline, you will speak with a mental health counselor.) Voice of Hope Lubbock Rape Crisis Center, 806-763-7273, voiceofhopelubbock.org (24-hour hotline that provides support for survivors of sexual violence.) The Risk, Intervention, Safety and Education (RISE) Office, 806-742-2110, https://www.depts.ttu.edu/rise/ (Provides a range of resources and support options focused on prevention education and student wellness.) Texas Tech Police Department, 806-742-3931,http://www.depts.ttu.edu/ttpd/ (To report criminal activity that occurs on or near Texas Tech campus.)