Bio 4023 How plants work: physiology, growth and metabolism

TuTh 2:30-4:00; LS118; 3 credits

Instructors:
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Office Hours:
Drs. Pikaard, Neff and Kunkel: by appointment (e-mail contact suggested)
Julie's office hours: Tuesdays 1:15-2:15 P.M.; LS111

Course description
This is a new course designed to introduce students to the fundamentals of how plants grow, metabolize and respond to their environment. Topics to be covered will include the conversion of light energy into chemical energy through photosynthesis and carbon fixation; nitrogen assimilation; water and mineral uptake and transport; source-sink relationships and long-distance transport of carbon and nitrogen; cell growth and expansion; hormone physiology; and physiological responses to a changing environment. The latter include defined events of the life cycle, including seed germination/emergence from dormancy, cues for flowering, nutrient salvaging prior to leaf abscission in perennials, and dormancy. Responses to biotic and abiotic stresses will also be introduced.

Prerequisite: Principles of Biology III: Biochemistry and Physiology (Biol 3050), or permission of the instructors.

Grading and absence policies
There will be three exams, each worth 25% of the final grade. The remaining 25% of the grade will be based on three problem sets assigned as homework approximately midway through each of the three sections. There will not be a cumulative exam during finals week.

If you are ill and need to miss an exam you will need a note from the student health center stating that you were too ill to take the test. No make-up exams will be given; final grades will be based on your scores excluding the missed exam. Homework assignments turned in late (after 5 P.M. on the due date) will be penalized 20% per day (i.e. the maximum score for an assignment turned in late, but within the first 24 hours of the assigned time, will be 80%).

Reading
The textbook for this course is Plant Physiology, by Taiz and Zeiger. 3rd edition; Publisher: Sinauer Associates Inc. This book is also used by Bio 3041, which also meets during Fall semester. Two copies of the book are on reserve in the Biology library.

Course website: We will have a website for the course hosted by the Biology Department's Natural Sciences Learning Center. The URL for accessing the course website is: http://www.nslc.wustl.edu/courses/courses.html

Syllabus for Bio 4023 How plants work: physiology, growth and metabolism

Section I. (Pikaard) Plant metabolism, the basis for life on earth: Photosynthesis, oxygen evolution and the production of organic compounds from an inorganic environment.

1. Thurs. 9/1 Course overview; a (midsummer) day in the life of a plant.

   Stomate opening, carbon and nitrogen fixation, ion uptake, sugar and amino acid transport, water uptake and transpiration, dealing with stresses.

   Reading assignment for lectures 2 &3: Taiz and Zeiger, Chapter 7

2. Tues 9/6 Photosynthesis I: Chloroplasts, photosynthesis and pigments that harvest light.

   Overview of photosynthesis; chloroplast structure, chlorophyll and light harvesting complexes.

3. Thurs 9/8 Photosynthesis II: Running chemical pumps on stolen electrons.

   Photosystems I and II, stripping electrons from water, oxygen generation, pumping protons across membranes, the protonmotive force and ATP generating motor.

   Reading assignment for lectures 4 and 5: Taiz and Zeiger, Chapter 8

4. Tues 9/13 Photosynthesis and carbon fixation: Light energy becomes chemical energy.

   ATP and NADPH production; capturing $C0_2$ into organic molecules.

5. Thurs 9/15 Carbon fixation in C3, C4, CAM plants, and pathways of carbon storage and breakdown.

   Specialized anatomies; starch and/or oil accumulation and breakdown.

   Reading assignment for lecture 6: Taiz and Zeiger, Chapter 12

6. Tues 9/20 Nitrogen and mineral uptake.

   The nitrogen cycle; nitrogen assimilation; overview of carbon and nitrogen-based chemical backbone molecules.

   Reading assignment for lecture 7: Taiz and Zeiger, Chapter 10

7. Thurs 9/22 Long-distance transport of carbon and nitrogen.

   Source-sink relationships; Phloem loading and unloading.

   Reading assignment for lectures 8 & 9: Taiz and Zeiger, Chapter 11 (can skip pp.235-246)

8. Tues 9/27 Metabolic pathways unique to plants; amino acids, lipids etc; targets of herbicides.

9. Thurs 9/29 Integration of basic metabolic pathways

   How a relatively few precursor molecules are the basis for carbohydrate, amino acid, nucleic acid and lipid pathways; review of the metabolic events that occur during a midsummer day in the life of a plant.

10. Tues 10/4 **Exam I**

Section II. (Neff) Basic Plant Physiology and physiological changes during the life cycle

Reading assignment for lectures 11 & 12: Taiz and Zeiger, Chapters 3 ,4, 15

11. Thurs 10/6 Maintaining water homeostasis.
Xylem as the major water conduit; loss of water by transpiration. Cellular water retention; relationship between osmotic potential and turgor pressure. Dealing with water deficit: changes in leaf angle to the sun to decrease vapor pressure, changes in stomatal conductance, accumulation of ions, adaptations of desert plants etc. The circulatory system dominated by xylem, phloem, transpiration and loading/unloading of solutes.

12. Tues 10/11 Role of water in cell expansion and growth. Cell wall architecture, turgor pressure, cell wall loosening, role of expansins, directionality of expansion to alter cell shape. Role of auxin. Reversible cell expansion in physiological responses: stomata opening, mimosa (sensitive plant) or venus fly trap touch responses, flower opening and closing.

13. Thurs 10/13 Seed germination and seedling development: Environmental cues for germination (water, light, temperature); mobilization of stored C and N to the embryo and early seedling; roles of hormones; development of plastids into chloroplasts; transition from dependence on molecules stored in the seed to self-sufficiency.

14. Tues 10/18 Circadian rythms. Circadian control of leaf movements, nitrogen and carbon assimilation pathways etc. Explorations of the clock mechanism.

15. Thurs 10/20 Physiology of flowering. Plastochron counting in some species, responses to the environment in others. Short day, long day and day neutral plants; vernalization-requiring plants; hormonal controls of flowering; graft-transmissible signals and the search for the elusive florigen.

16. Tues 10/25 Physiology of fruit and seed development. Fertilization vs. parthenocarpy; mobilization of resources from vegetative tissues; Storage of C and N in monocot and dicot seeds for use during germination. Coupling of embryo and fruit development; role of hormones.

17. Thurs 10/27 Physiology of dormancy. Preparing for dormancy, salvaging N from leaves prior to abscission; Seed and bud dormancy; over-wintering or drought avoidance strategies; hormonal, metabolic and/or physical (e.g. seed coat) changes. Vegetative dormancy in response to water availability (e.g. mosses, turfgrass).

18. Tues 11/1 Breaking dormancy for germination or growth resumption to occur; A year in the life of a perennial plant: review of the physiological changes that accompany the major life cycle transitions.

19. Thurs 11/3 **Exam II**

Section III. (Kunkel) Responses to the environment, abiotic and biotic stress.

20. Tues 11/8 Tropisms: Directional responses to environmental stimuli
Sensing and responding to gravity (gravitropism), light (phototropism) or physical contact (thigmotropism); differential cell growth; role of auxin transport.

21. Thurs 11/10 Plasticity of plant form and metabolism in response to environmental conditions:
Changes in root architecture, leaf shape and root/shoot ratios in response to water stress; responses to nutrient availability.

22. Tues 11/15 Abiotic stress I: Responses to cold stress, heat stress, water stress and salt stress and adaptations of plants that tolerate these stresses.

23. Thurs 11/17 Abiotic stress II: Oxidative stress, response to ozone, etc.

24. Tues 11/22 Wounding and insect attack: jasmonate signaling, systemin & defense responses

25. Thurs 11/24 **Thanksgiving break**

26. Tues 11/29 Pathogen attack: Perception and defense; hormone-mediated signaling, hypersensitive response, systemic acquired resistance

27. Thurs 12/1 Symbiotic interactions to facilitate nutrient and water uptake: Rhizobia, endophytes and Myccorhizal interactions

28. Tues 12/6 Attracting helpful insects: Production of volatiles to attract pollinators, indirect defense strategies; floral mimicry.

29. Thurs 12/8 **Exam III**