UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF BIOLOGICAL SCIENCES
COURSE OUTLINE

1. Course: PLBI 403, Plant Physiology – Fall 2019

Lecture 01: MWF 12:00-12:50 in ES 443

Instructor	Email	Phone	Office	Hours
Dr. Dae-Kyun Ro	**daekyun.ro@ucalgary.ca**	**220-7099**	**BI 393**	**TBA**
Dr. Peter Facchini	**pfacchin@ucalgary.ca**	**220-7651**	**BI 396**	**TBA**

Course Site: D2L: PLBI 403 L01 – (Fall 2019) – Plant Physiology

Note: Students must use their U of C account for all course correspondence.

Department of Biological Sciences BI 186 220-3140 biosci@ucalgary.ca

2. **Requisites:**

See section 3.5.c in the Faculty of Science section of the online Calendar.

Prerequisite(s): Biology 371

3. **Grading:**

The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Component(s)	Weighting %	Date
Lecture (60%)		
Mid-term exam	30%	October 18 (In-Class)
Final exam*	30%	Scheduled by the Registrar
Laboratory (40%)		
Assignment 1	5%	
Assignment 2	10%	
Assignment 3	5%	
Assignment 4	5%	
Assignment 5	10%	
Assignment 6	5%	

*This course has a Registrar scheduled final exam.

Each piece of work (assignments, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

Letter Grade	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Min. Percent Required	95%	85%	82%	79%	76%	72%	68%	64%	60%	55%	50%

Department Approval: ORIGINAL SIGNED Date: _____

4. **Missed Components Of Term Work:**

In the event that a student misses the midterm or any course work due to illness, supporting documentation, such as a medical note or a statutory declaration will be required (see Section M.1; for more information regarding the use of statuary declaration/medical notes, see FAQ). Absences must be reported within 48 hours.

The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in Section 3.6. It is the student's responsibility to familiarize themselves with these regulations. See also Section E.3 of the University Calendar.

5. **Scheduled Out-of-Class Activities:**

There are no scheduled out of class activities for this course.

6. **Course Materials:**

Taiz, L. and Ziegler, E., Plant Physiology and Development, Sixth Edition: Sinaur Associates Inc, Sunderland, MA.

7. **Examination Policy:**

No aids are allowed on tests or examinations.

Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory And Optional Course Supplemental Fees:**

There are no mandatory or optional course supplemental fees for this course.

9. **Writing Across the Curriculum Statement:**

For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

10. **Human & Living Organism Studies Statements:**

Students will not participate as subjects or researchers in human studies.

See also Section E.5 of the University Calendar.

STUDIES IN THE BIOLOGICAL SCIENCES INVOLVE THE USE OF LIVING AND DEAD ORGANISMS. Students taking laboratory and field based courses in these disciplines can expect involvement with the experimentation on such materials. Students perform dissections on dead or preserved organisms in some courses. In particular courses, students experiment on living organisms, their tissues, cells or molecules. Sometimes field work requires students to collect a variety of living materials by many methods, including humane trapping.

All work on humans and other animals conforms to the Helsinki Declaration and to the regulations of the Canadian Council on Animal Care. The Department strives for the highest ethical standards consistent with stewardship of the environment for organisms whose use is not governed by statutory authority. Individuals contemplating taking courses or majoring in one of the fields of study offered by the Department of Biological Sciences should ensure that they have fully considered these issues before enrolling. Students are advised to discuss any concerns they might have with the Undergraduate Program Director of the Department.

Students are expected to be familiar with Section SC.4.1 of the University Calendar.

11. **Reappraisal Of Grades:**

A student wishing a reappraisal, should first attempt to review the graded work with the Course Coordinator/ Instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the Grade being reappraised may be raised, lowered or remain the same. See Section 1.3 of the University Calendar.

a. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within 15 days of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall immediately submit the Reappraisal of Graded Term work form to the department in which the course is offered. The department will arrange for a re-assessment of the work if, and only if, the student has sufficient academic grounds. See sections I.1 and I.2 of the University Calendar.

b. **Final Exams:** The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **Other Important Information For Students:**

a. **Mental Health:** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 30, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

b. **SU Wellness Center:** The Students Union Wellness Centre provides health and wellness support for students including information and counselling on physical health, mental health and nutrition. For more information, see www.ucalgary.ca/wellnesscentre or call 403-210-9355.

c. Sexual Violence: The University of Calgary is committed to fostering a safe, productive learning environment. The Sexual Violence Policy ttps://www.ucalgary.ca/policies/files/policies/sexual-violence-policy.pdf) is a fundamental element in creating and sustaining a safer campus environment for all community members. We understand that sexual violence can undermine students' academic success and we encourage students who have experienced some form of sexual misconduct to talk to someone about their experience, so they can get the support they need. The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208 .

d. Misconduct: Academic misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under Section K. Student Misconduct to inform yourself of definitions, processes and penalties. Examples of academic misconduct may include: submitting or presenting work as if it were the student's own work when it is not; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; collaborating in whole or in part without prior agreement of the instructor; borrowing experimental values from others without the instructor's approval; falsification/ fabrication of experimental values in a report. These are only examples.

e. Assembly Points: In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on assembly points.

f. Academic Accommodation Policy: Students needing an accommodation because of a disability or medical condition should contact Student Accessibility Services in accordance with the procedure for accommodations for students with disabilities available at procedure-for-accommodations-for-students-with- disabilities.pdf.

Students needing an accommodation in relation to their coursework or to fulfill requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Associate Head, Undergraduate of the Department of Biological Sciences, Heather Addy by email addy@ucalgary.ca or phone 403 220-6979. Religious accommodation requests relating to class, test or exam scheduling or absences must be submitted no later than 14 days prior to the date in question. See Section E.4 of the University Calendar.

g. Safewalk: Campus Security will escort individuals day or night (See the Campus Safewalk website). Call 403-220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.

h. Freedom of Information and Privacy: This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

i. Student Union Information: VP Academic, Phone: 403-220-3911 Email: suvpaca@ucalgary.ca. SU Faculty Rep., Phone: 403-220-3913 Email: sciencerep@su.ucalgary.ca. Student Ombudsman, Email: ombuds@ucalgary.ca.

j. Internet and Electronic Device Information: Unless instructed otherwise, cell phones should be turned off during class. All communication with other individuals via laptop, tablet, smart phone or other device is prohibited during class unless specifically permitted by the instructor. Students that violate this policy may be asked to leave the classroom. Repeated violations may result in a charge of misconduct.

k. Surveys: At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

l. Copyright of Course Materials: All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or non-academic misconduct, in addition to any other remedies available at law.

TENTATIVE LECTURE SCHEDULE

Date	Topic	Instructor
September 6	Introduction to plant physiology	PJF
September 9	Xylem transport I	PJF
September 11	Xylem transport II	PJF
September 13	Xylem transport III	PJF
September 16	Phloem transport I	PJF
September 18	Phloem transport II	PJF
September 20	Phloem transport III	PJF
September 23	Photosynthesis I	PJF
September 25	Photosynthesis II	PJF
September 27	Photosynthesis III	PJF
September 30	Photosynthesis IV	PJF
October 2	Respiration and lipid metabolism I	PJF
October 4	Respiration and lipid metabolism II	PJF
October 7	Respiration and lipid metabolism III	PJF
October 9	Nutrient assimilation I	PJF
October 11	Nutrient assimilation II	PJF
October 14	Holiday - Thanksgiving	No lecture
October 16	Nutrient assimilation III	PJF
October 18	**Mid-term Exam (In-class)**	PJF
October 21	Introduction to growth and development	DKR
October 23	Cell walls	DKR
October 25	Signal transduction I	DKR
October 28	Signal transduction II	DKR
October 30	Light and plant development I	DKR
November 1	Light and plant development II	DKR
November 4	Seed physiology I	DKR
November 6	Seed physiology II	DKR
November 8	Seed physiology III	DKR
November 10 – November 16	Reading Break	
November 18	Gametophytes	DKR
November 20	Fruit development	DKR
November 22	Senescence and cell death I	DKR
November 25	Senescence and cell death II	DKR
November 27	Biotic interactions I	DKR
November 29	Biotic interactions II	DKR
December 2	Abiotic stress I	DKR
December 4	Abiotic stress II	DKR
December 6	Review	DKR

Lab schedule

Week of	Lab	Topic
September 9	1	Plant water status
September 16	2	Photosynthesis I
September 23	3	Photosynthesis II
September 30	4	Nitrate reductase
October 7	5	Rhizobium set-up
October 14	No lab - Thanksgiving	
October 21	6	Brassinolide set-up
October 28	7	Brassinolide data collection / Germination assay set-up
November 4	8	Germination assay data collection
November 11	Reading break	
November 18	9	Rhizobium data collection

Course Outcomes:

Dr. Peter Facchini

1. Transport of Water in the Xylem
   - Know the meaning of diffusion and osmosis
   - Understand the meaning of free energy, chemical potential and water potential in a plant physiological context
   - Understand the components and applications of the water potential equation
   - Understand the effect of solutes, positive and negative pressure, and gravity on water potential in a plant
   - Know the meaning of the apoplast and symplast
   - Understand the location and role of the Casparian strip
   - Understand the cause and effects of root pressure
   - Know the major cell types involved in xylem transport and be able to define their anatomy
   - Understand the concept of the surface tension of water and the effect of curved water surfaces on water potential and its components in soil and leaves
   - Be able to explain the cohesion tension theory
   - Understand the role of transpiration in the movement of water in the xylem
   - Know the meaning of cavitation in the movement of water in the xylem
   - Know the basic anatomy of leaves as it pertains to the movement of water in a plant
   - Understand the role of guard cells in controlled the opening and closing of stomata
   - Know what elements are macronutrients and micronutrients in plants

2. Transport of Solutes in the Phloem
   - Understand the difference between active and passive transport
   - Understand the meaning of a chemical potential gradient
   - Understand how proton gradients are coupled to the formation of ATP
   - Know the difference between channels, carriers and pumps
   - Know the difference between a symport and an antiport
   - Know the general location of phloem and xylem in a plant
   - Know the major cell types in the phloem and be able to define their anatomy
   - Know what I meant by plasmodesmata
   - Understand the basic differences between companion cells, intermediary cells and transfer cells
   - Understand the relationships and transitions between sources and sinks in phloem transport
   - Be able to explain the pressure-flow model using the water potential equation
   - Understand the basic processes involve in phloem loading and unloading
   - Know the role of the sucrose symporter in phloem transport
   - Understand the concept of the polymer-trapping model in symplastic phloem loading
   - Understand the meaning of allocation and partitioning in phloem transport

3. Photosynthesis
   - Know the overall chemical equation describing the process of photosynthesis
   - Understand basic physical concepts of light as they pertain to photosynthesis
   - Know the general composition of chlorophyll and understand how these pigments can trap light energy
   - Know the identity and function of accessory pigments
   - Know the difference between and absorption spectrum and an action spectrum
   - Know the general absorption spectra of chlorophyll and carotenoids
   - Understand the meaning of reaction center
   - Understand the concept of quantum yield as it pertains to photosynthesis
   - Understand the general concept of a redox reaction
   - Know the difference between the Hill (or light) reactions and the Calvin-Benson cycle (or dark reactions)
   - Be able to draw the components of, and describe, the Z Scheme (or Hill reactions)
   - Understand the anatomy of chloroplasts and it pertains to photosynthesis
   - Know the differences between, and the roles of, Photosystem I and Photosystem II
   - Understand the importance and role of electron transport in the Hill reactions
   - Know the roles of carboxylation, reduction and regeneration in the Calvin-Benson cycle
   - Understand the key roles of RuBP and rubisco in the Calvin-Benson cycle
   - Know the role of the triose phosphate G3P in the Calvin-Benson cycle

- Recognize the components of the regeneration of RuBP from G3P in the Calvin-Benson cycle
- Know the products and understand the consequences of the dual carboxylation and oxygenation functions of rubisco
- Understand the general components and associated locations of the photorespiration pathway and describe its consequences in plants
- Understand the major components and function of C4 metabolism
- Understand what is meant by Krantz anatomy
- Understand the major components and function of crassulacean acid metabolism
- (CAM) metabolism
- Know why cacti can grow in deserts
- Be able to describe why the addition of C4 metabolism is beneficial to a plant only under stress conditions, such as high temperature or drought
- Know generally how sucrose and starch or formed from the products of the Calvin-Benson cycle

4. Respiration and Lipid Metabolism
- Know the overall chemical equation describing the process of respiration
- Understand the general processes and roles of, and interconnections between, glycolysis, oxidative pentose phosphate pathway, citric acid cycle and oxidative phosphorylation in the utilization of sucrose to generate ATP
- Know the compartmentalization of respiratory pathways in a plant cell
- Understand the relationships between, and roles of, NAD+ and NADH, and
- NADP+ and NADPH
- Know the major steps in, and outcomes of, the conversion of sucrose to pyruvate in glycolysis
- Know the major steps in, and outcomes of, the conversion of glucose 6-phosphate
- to G3P in the oxidative pentose phosphate pathway
- Know the major steps in, and outcomes of, the breakdown of pyruvate yielding
- NADH and FADH2 in the citric acid cycle
- Know the major steps in, and outcomes of, the utilization of NADH (and FADH2) yielding ATP in oxidative phosphorylation
- Know the basic anatomy of mitochondria as it pertains to respiration
- Know why carbon monoxide, cyanide and nitric oxide are toxic, and why plants have some degree of tolerance to these compounds
- Know the basic structure of, and differences between, triacylglycerols and polar glycolipids
- Understand the superiority of fat over starch as an energy storage material
- Understand why unsaturated fatty acids melt at a low temperature than saturated fatty acids
- Know the composition and function of oil bodies in plant cells
- Understand the basic differences between glycerolipids and glycerophospholipids, and what plant cellular membranes are made of these components
- Know the basic processes of fatty acid and lipid metabolism, and in which cellular compartments they occur in plants

5. Nitrogen Metabolism
- Understand the basis for the discrepancy between the occurrence of nitrogen in the environment and the availability of nitrogen to plants
- Know the major components of the nitrogen cycle
- Understand the chemical relationships between molecular nitrogen, ammonium, nitrate and nitrite
- Understand the structure and function of nitrate reductase
- Understand the function of nitrate reductase
- Understand the major biochemical processes for the assimilation of ammonium in plants, especially the GS/GOGAT pathway
- Understand the roles of glutamate dehydrogenase, aspartate aminotransferase and asparagine synthase in the assimilation of ammonium in plants
- Understand the general role of aminotransferases in amino acid metabolism
- Understand what is meant by biological nitrogen fixation
- Know the structure and role of root nodules in the process of biological nitrogen fixation
- Understand the formation of root nodules in nitrogen-fixing plants, and the relationship between root nodules and nitrogen-fixing bacteria
- Know what is meant by rhizobia and bacteriods

- Know the structure and function of nitrogenase
- Understand the role of leghemoglobin in regulating O2 levels in root nodules
- Know what is meant by amides and ureides

Dr. Dae-Kyun Ro

Chapter 15
- Understand the key experimental tools used in studying signaling pathway.
- Understand the two major types of signaling mutants.
- Know the six major plant hormones and identify the hormones by their structures
- Know the biosynthetic origins of the six hormones
- Know the major functions of the six hormones in plant development and physiology and possible agricultural or biotechnological applications.
- Understand the history of the hormone discoveries.
- Understand how auxin and cytokinin are used to generate whole plants from tissue cultures.
- Understand the roles of *Agrobacterium tumefaciens* in advancing our knowledge in hormone and in biotechnology.
- Understand how genetically modified organism is generated.
- Understand how seedless fruit is generated.
- Understand the contribution of terpenoid (isoprenoid) metabolism in hormone biosynthesis.
- Know the similarity and differences between animal and plant signaling cascades.
- Understand three general mechanisms of hormone perceptions by hormone receptors.
- Understand the mechanism of ubiquitination and its role in hormone signaling pathways.
- Understand the concept of molecular glue in Auxin and GA hormone perceptions.
- Understand the concept of de-repression in plant hormone signaling.
- Know the mechanisms and influences of DELLA repressor in increasing food production.

Chapter 14
- Know three major polysaccharide components in the cell wall and understand their chemical characteristics.
- Understand the definition and differences of primary and secondary cell walls
- Know the subcellular sites for the synthesis of major cell wall components.
- Understand the biochemical mechanism of cellulose synthesis.
- Understand the function, chemical properties, and deposition (Casparian strip model) of lignin.
- Understand acid growth model.
- Know the evidence to support that protein is required for cell wall expansion.

Chapter 16
- Know the red-light receptor and photo-reversible response.
- Understand the photo-stationary phase.
- Know the general structure of phytochrome and its signal perception and relay mechanism.
- Know the definition of lag time and escape from photoreversibility
- Know the definition of fluence and irradiance (or fluence rate)
- Understand the three different types of red-light responses and their characteristics.
- Understand the major blue-light responses, which are not controlled by red-light.
- Know the three blue-light receptors and the physiological responses mediated by these receptors.
- Know the general features of three blue-light receptors.
- Know how the proton-ATPase is regulated in stomata upon blue-light perception.
- Understand some key experiments which help us understand red- and blue-light perceptions and signaling.

Chapter 10
- Understand some key observations and experiments which allowed us to elucidate the regulation of stomata opening.
- Know the role of proton-ATPase in initiating stomata opening.
- Understand the three key physiological phases mediating stomata opening and closure.

Chapter 17

- Understand the double-fertilization and subsequent embryo pattern formation.
- Understand the directional movement of auxin in embryo and seedling.
- Know how the influx and efflux of auxin are controlled in cells to achieve polarity of auxin.
- Understand the AUX anion efflux carrier (PIN) and ABC transporter.
- Understand the key experiments to prove the roles of PIN in auxin polarity.
- Understand the definitions of RAM, SAM, columella, quiescent center, and initial.

Chapter 18

- Know the structures of two major types of seeds.
- Know the definition, roles, and types of seed dormancy.
- Understand the hormonal regulations determining seed dormancy.
- Understand the various factors influencing the dormancy breaks.
- Understand the three distinct phases during seed germination.
- Understand the mechanism of phototropism.
- Understand the mechanism of gravitropism.

Chapter 23

- Know the roles of mechanical barriers and secondary metabolites in constitutive defense.
- Understand how toxicities of glucosinolate and cyanogenic glycosides are generated in plants.
- Know the characteristics of two insect elicitors.
- Understand the role of jasmonic acid in plant's defense against insects.
- Know the biosynthetic precursor of jasmonic acid.
- Understand the gene-for-gene hypothesis.
- Know the fungal structures used in their infections on plants.
- Know the definition and types of effectors.
- Understand MAMP- and effector-triggered immunity in plant.
- Understand the guard hypothesis.
- Understand the hypersensitive response in plant defense.