

University of Guelph
College of Biological Sciences
Department of Molecular and Cellular Biology
Metabolism in the Whole Life of Plants-BOT 4380
Winter 2018

Course Description

This course follows the developmental changes that take place in plants, and explores the molecular, biochemical, and physiological mechanisms that are responsible for development. Emphasis will be placed on the importance of modern experimental methods and critical evaluation of data. 0.5 U. Prerequisites: BIOL*1090 & BIOC*2580.

Course Schedule

Lectures are in MCKN (MacKinnon) 121, 10:30-11:20 am, Mon/Wed/Fri, starting Monday, January 8th, 2018 and ending Friday, April 6th, 2018 (36 lectures total).

Instructor Information

Dr. Tariq Akhtar, Science Complex, Room 4461, Ext. 54794, takhtar@uoguelph.ca &
Dr. Barry Micallef, CRSC Rm 424, Ext. 54384, bmicalle@uoguelph.ca.

B. Micallef will have office hours from 11:30-12:15 on MWF. We will also be available by appointment. Feel free to contact us by email; we will do our best to respond quickly. There are no GTAs in BOT 4380.

Course Content

Specific Learning Outcomes

By the end of this course, students should be able to:

1. grasp both the historical development and the current state of knowledge in plant biology, and particularly in plant metabolism, including an appreciation of emerging technologies and experimental methods;
2. integrate the physiological, biochemical, and molecular mechanisms whereby autotrophic organisms, and particularly seed plants, sustain themselves in the context of the whole life cycle of the plant;
3. interpret the scientific literature and data relevant to plant biology and to plant metabolism;
4. communicate effectively using scientific writing;

5. apply forms of inquiry including hypothesis development through critical analysis of relevant scientific literature and essay writing;

6. apply knowledge of plant metabolism to specific questions associated with relevant biological processes, agriculture, forestry, energy production, and medicine.

Lecture Content and Topics

Interactive lectures with opportunity for questions and discussion, including some discussion of scientific papers. In addition, required and supplementary readings will be posted on Courselink throughout the course. The topic for each 3-page essay will be provided in class and on Courselink. Supplementary readings from the textbook, required and supplementary readings, and scientific paper citations directed to each topic below will be indicated in the Powerpoint lectures posted on Courselink.

Comprehensive treatments are given for of all the topics listed below; the list below is a general outline divided between the two lecturers in the course. It does not necessarily provide all specific topics covered.

(A) Lectures by Micallef (Lectures 1-18) (Jan 8th to Feb 16th)

Module 1-Significance, Structure and Function of Autotrophic Organisms

Introduction to autotrophy: definition of autotrophy; characteristics shared by all autotrophic organisms; chemoautotrophy; anoxygenic photoautotrophy and oxygenic photoautotrophy, including origin in eukaryotes; photoautotrophy and symbiosis.

Characteristics of photoautotrophic organism: cyanobacterium; the Kingdoms Chromista and Plantae; photoautotrophy in angiosperms at the whole plant to organ levels, cellular to organellar levels (including plastids), and suborganellar to biochemical levels; ecological significance of photoautotrophy in marine and terrestrial ecosystems.

Module 2-The Light Reactions in the Chloroplast

Properties of light and light-absorbing pigments: methods used to study the light reactions of photosynthesis; basic properties of the light reactions; four crucial characteristics of chlorophyll; specific chromophores in photoautotrophic organisms; chlorophyll species and their structure-function relationships; a pigment = a chromophore-protein complex; phycobillin pigments and their significance.

Photosystems and fates of absorbed light energy: characteristics of the light-harvesting apparatus; definition of a photosystem; structure and function of light-harvesting complexes, including the phycobilisome antenna network; fates for excitation energy; funnelling of excitation energy to the reaction center.

Electron transport and ATP synthesis: photochemistry and quantum yield; reaction center complex in purple-sulfur bacteria; function of mobile electron carriers; structure-function relationships of the major thylakoid complexes; electron transport and generation of a proton gradient; coupling of the proton gradient to ATP synthesis.

Module 3-Primary Carbon Metabolism in Source and Sink Tissues

Introduction to photosynthetic C metabolism: why organisms on earth are C-based; elemental composition of terrestrial plants; methods used to study biochemical pathways; elucidating the 1st product of C fixation in C3 plants; elucidating the reactions of the Calvin-Benson-Bassham cycle; phases and reactions of the Calvin-Benson cycle

Regulation of the Calvin-Benson cycle: modulation of enzyme activity by the ionic & solute environment in the stroma; thioredoxin-ferredoxin system; properties of ribulose biphosphate carboxylase/oxygenase (Rubisco); Rubisco activase.

Photorespiration and altered photosynthetic types: definition of photorespiration; Rubisco oxygenase reaction; evolutionary kinetics of Rubisco; C2 oxidative photosynthetic cycle and photorespiratory N cycle; elucidation of the photorespiratory cycle; effects of photorespiration on net C assimilation and the quantum requirement for C fixation; atmospheric CO₂, temperature and photorespiration; C4 photosynthesis; chloroplast ultrastructure in C4 plants; CAM metabolism; carboxysomes in bacteria.

End product synthesis and transport: properties of sucrose and starch; pathways of sucrose and starch synthesis, including regulation; chloroplast phosphate translocator and phosphate cycling; chloroplastic starch degradation; phloem loading & transport; phloem unloading.

Sucrose utilization in sink tissues: sucrose hydrolytic enzymes; respiratory metabolism; structure, synthesis and assembly of the primary cell wall, including cellulose, hemicellulose and pectin.

Module 4-N & S Uptake, Assimilation and Utilization

Major inorganic forms of N & S; roles of N and S in the plant; cellular transport processes, including N & S uptake.

Assimilation of nitrate and ammonium to organic N: nitrate and nitrite reductase, including regulation; assimilation of ammonium by GS-GOGAT; sources of ammonium in plant cells; nitrate assimilation in roots and shoots; organic N transport compounds; interactions between C and N metabolism; N-use efficiency in plants.

S uptake and assimilation: activation and reduction of sulfate; formation of cysteine.

N & S utilization in plants: metabolites derived from 5-aminolevulinic acid, including chlorophyll synthesis and degradation; glutathione and its functions in plants; plant hormones derived from N and S compounds; storage proteins in plants.

Module 5-Germination

Germination in plants: the 'switch' from seed development to seed germination; the mobilization of seed reserves, including protein, carbohydrates and fatty acids.

(B) Lectures by Akhtar (Feb 26th to April 6th)**Module 6-Introduction to Secondary Metabolism (Lectures 19-22, February 26th-March 5th)**

Understanding the interface between primary and secondary metabolism: Classification of the three main clades of 'specialized metabolites'; focus will be on alkaloid, glucosinolate, and polyamine biosynthesis and their physiological importance. Medicinal plants will be discussed.

Module 7-Isoprenoid Metabolism (Lectures 23-27, March 7th-March 16th)

Isoprenoids: the largest class of secondary metabolites. Focus will be on isoprenoid synthesis from primary precursors to the physiological and ecological roles that these compounds serve. Focus will be on terpenes, sterols, carotenoids, polyprenols and isoprenoid-derived vitamins and plant hormones. Industrial applications of isoprenoids will be discussed.

Module 8-Lipid Metabolism (Lectures 28-30, March 19th-March 23rd)

Fatty acid biosynthesis and nomenclature: Assembly of phospholipids, galactolipids, triacylglycerols, and cutin/epicuticular waxes. Biophysical properties of plant lipids and the regulation their synthesis will be explored.

Module 9-Phenolics (Lectures 31-33, March 26th-March 28th)

Biosynthesis and function of plant phenolics: Flavonoids, aromatic amino acid metabolism, plant volatiles, and cell wall assembly.

Module 10-Vitamins, Cofactors, and Polyketides (Lectures 34-36, April 2nd-April 6th)

Co-factor biosynthesis: Emphasis will be on B-vitamins and their functional roles. Branched chain amino acid metabolism, prenylated polyketides and their industrial significance.

Course Assessment

Form of Assessment	Weight of Assessment	Date of Exams/Due Dates for Essays	Additional Comments	Learning Outcomes Addressed
Mid-term examination	25% of final grade	Wed., Feb. 7 th , 7:00-8:30 pm (outside of	Includes lecture material up to and	1-3, 5-6

Form of Assessment	Weight of Assessment	Date of Exams/Due Dates for Essays	Additional Comments	Learning Outcomes Addressed
		class), Location TBA	including the Feb. 5 th lecture (13 lectures total).	
Final examination	45% of final grade	Time & Location TBA	Includes lecture material directed to the Feb. 7 th to April 6 th lectures (23 lectures in total).	1-3, 5-6
Complete Intro paragraph, Intro sentence for all remaining paragraphs & a min of 4 references for the 1 st 3-page essay	2.25% of final grade	On Fri., Jan. 26 th by 4 pm as an electronic & hard copy to B. Micallef.	Topic for the 1 st 3-page essay will be provided in the 1 st lecture on Mon., Jan. 8 th .	1-6
Completed 1 st 3-page essay	12.75% of final grade	By Fri., Feb. 16 th at 4 pm as an electronic & hard copy to B. Micallef.	Topic for the 2 nd 3-page essay will be provided on Fri., Feb. 16 th .	1-6
Completed 2 nd 3-page essay	15% of final grade	By Mon., Apr. 2 nd at 4 pm as an electronic & hard copy to T. Akhtar.	Marked essays will be returned during the final exam period.	1-6

Additional Information on the Midterm and Final Exam

The Midterm will consist of definitions, short answer questions, and data interpretation. The Final Exam only covers material presented after the Midterm (see **Course Assessment** above for details). The Final Exam will consist of short to medium answer questions, and data interpretation.

Additional Information on the 3-Page Essays

Complete instructions on writing the 3-page essays, including the evaluation scheme, are provided in a separate document posted in the News Item section of Courselink. The 1st Essay and 2nd Essay will be marked by B. Micallef and T. Akhtar, respectively. To provide writing assistance for the 1st 3-page essay, a Pre-submission, including the complete introductory paragraph, the introductory sentence for each remaining paragraph, and a minimum of 4 references, will be handed into B. Micallef for marking on Friday, January 26th. The grade provided for this Pre-submission will include: (1) the entire grade for the Introductory paragraph (i.e. 10% of the total essay value out of 100%); (2) a portion of the total grade for

Research worth 5% of the total essay value out of 100%. The Pre-submission ends up being worth 2.25% of the final grade in the course. The completed version of the 1st 3-page essay can include a revised Introduction and revised Introductory sentences based on comments from B. Micallef, although these portions of the essay will not be remarked. Do consider the comments and revisions provided by B. Micallef. When handing in each essay, both a hard copy and an electronic copy must be submitted to the appropriate instructor by the deadline.

Course Resources

Lecture Material and Supplemental Reading (there is no text to purchase)

There will be Lecture Presentations and other Required Reading posted on Courselink, and Supplemental Readings including references from the scientific literature will be also be posted on Courselink.

Sources of Information (On Library Shelves)

Bowsher, Steer & Tobin (2008) *Plant Biochemistry*. Garland Science, Taylor & Francis Group, LLC, New York, New York. QK 861.B69 2008.

Bassham & Calvin (1957) *Path of Carbon in Plants*. Prentice-Hall Publishing. QK 882.B3.

Buchanan, Gruissem & Jones (2000) *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists. QK 861.B45.

Calvin (1962) The path of carbon in photosynthesis. *Science* 135: 879-889. QH 9 B6.B29.

Crozier, Clifford, and Ashihara (2006) *Plant Secondary Metabolites: Occurrence, Structure, and Role in the Human Diet*. Blackwell Publishing. QK 881.P55 2006.

Dennis (1997) *Plant Physiology, Biochemistry, and Molecular Biology*. Longman Publishing. QK 881.P54 1997.

Heldt (1997) *Plant Biochemistry and Molecular Biology*. Oxford University Press. QK 861 H4513 1997.

Taiz & Zeiger (2006) *Plant Physiology*. Sinauer Associates. QK 711.2 T35 2006.

Additional Useful Sources

There are several journals that provide original scientific articles dedicated to plant biology such as *Plant Physiology*, *The Plant Cell*, *The Plant Journal*, *Plant Molecular Biology*, *Plant and Cell Physiology*, *Journal of Experimental Botany*, *Plant, Cell and Environment*, etc.

Wider-audience journals such as *Science*, *Nature*, *Proceedings of the National Academy of Sciences*, *Cell*, etc. also include many original scientific articles in plant biology and related studies.

There are also several journals that publish review articles such as *Annual Reviews of Plant Physiology and Plant Molecular Biology*, *Annual Plant Reviews*, *Trends in Plant Science*, *Current Opinion in Plant Science*, *Annual Reviews of Biochemistry*, etc.

University Policies

Academic Consideration:

The University of Guelph is committed to supporting students in their learning experiences and responding to their individual needs and is aware that a variety of situations or events beyond the student's control may affect academic performance. Support is provided to accommodate academic needs in the face of personal difficulties or unforeseen events in the form of Academic Consideration.

Information on regulations and procedures for Academic Consideration, Appeals and Petitions, including categories, grounds, timelines and appeals can be found in [Section VIII \(Undergraduate Degree Regulations and Procedures\) of the Undergraduate Calendar](#).

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing, with your name, id#, and e-mail contact, and be prepared to provide supporting documentation.

For the Midterm, an alternative time will be determined by B. Micallef if warranted in consultation with the student. The time selected must be prior to Friday, February 16th, 2018, which is when the Midterm will be returned. B. Micallef will attempt to include all students that require a deferred Midterm in the same time period, and thus a deferred date may not be finalized immediately. Arrangements for a deferred Final Exam can potentially be made through either a course instructor or the Registrar's Office. For the Essay Assignments, any alternative submission dates for compassionate reasons must be established by the instructor marking the Essay (B. Micallef for the 1st Essay and T. Akhtar for the 2nd Essay).

Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community, faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring.

University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Detailed information regarding the Academic Misconduct policy is available in [Section VIII \(Undergraduate Degree Regulations and Procedures\) of the Undergraduate Calendar](#).

Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Student Accessibility Services (SAS), formerly Centre for Students with Disabilities (CSD), as soon as possible.

For more information, contact SAS at 519-824-4120 ext. 56208 or email sas@uoguelph.ca or visit the [Student Accessibility Services website \(http://www.uoguelph.ca/csd/\)](http://www.uoguelph.ca/csd/).

Course Evaluation Information

End of semester course and instructor evaluations provide students the opportunity to have their comments and opinions used as an important component in the Faculty Tenure and Promotion process, and as valuable feedback to help instructors enhance the quality of their teaching effectiveness and course delivery.

While many course evaluations are conducted in class others are now conducted online. Please refer to the [Course and Instructor Evaluation Website](#) for more information.

Your responses will not affect your grade. Course evaluation data are distributed to individual instructors after final grades have been submitted to the Registrar, following the completion of each academic semester.

Please be honest, respectful, constructive and thorough. Instructors and review committees place great value on student course ratings and read all comments provided in course evaluations. It is helpful to provide comments on the strengths of the course, in addition to the areas for improvement. Please refrain from personal comments unless they relate to teaching and learning.

The timing and type of course evaluation for each instructor will be indicated in lecture. Since T. Akhtar and B. Micallef are in different Colleges, their course evaluations will be conducted separately.

Drop Period

The drop period for single semester courses starts at the beginning of the add period and extends to the Fortieth (40th) class day of the current semester (the last date to drop single

semester courses without academic penalty) which is listed in [Section III \(Schedule of Dates\) of the Undergraduate Calendar](#). In the Winter 2018 semester, the 40th class day is March 9th, 2018.

The drop period for two semester courses starts at the beginning of the add period in the first semester and extends to the last day of the add period in the second semester.

Information about Dropping Courses can be found in [Section VIII \(Undergraduate Degree Regulations and Procedures\) of the Undergraduate Calendar](#).

E-mail Communication

As per university regulations, all students are required to check their <uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

Additional Course Information

Copies of Out-of-Class Assignments and Lecture Notes

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time. It is also advised that you keep a hard copy of all lecture notes; electronic copies of the lecture notes will not be provided to students apart from Courselink. Thus, files cannot be obtained once access to the Courselink site has expired. Materials applicable to the Midterm will be removed from Courselink right after the Midterm is written, so it is essential to download ALL materials posted on Courselink.

Recording of Materials

Presentations that are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Grading

Information on dates for exams and due dates for essays are provided in **Methods of Assessment** above. For the essay assignments, a deduction will be assessed worth 10% of the essay assignment value per working day late = a deduction of 1.5% of your final grade per working day late, where a working day does not include Saturday and Sunday for both students and the instructors. For the Essays or Midterm, if a reconsideration of grade is requested the entire marked Essay or Midterm will be provided to the instructor, and the ENTIRE essay or ALL Midterm answers will be re-marked by the instructor.

Important Dates

The Midterm is on Wednesday, February 7th outside of class from 19:00-20:30 (location TBA); time conflicts should be reported immediately to B. Micallef once the conflict is identified.

The Pre-submission for the 1st 3-page essay, including the Introductory paragraph, Introductory sentences, and a minimum of 4 references, are due on Friday, January 26th by 4 pm to B. Micallef both as an electronic copy emailed to B. Micallef and a hard copy.

The completed 1st 3-page essay is due by Friday, February 16th at 4 pm to B. Micallef both as an electronic copy emailed to B. Micallef and a hard copy.

The 2nd 3-page essay is due by Monday, April 2nd at 4 pm to T. Akhtar both as an electronic copy emailed to T. Akhtar and a hard copy.

The Final Exam is (time and location TBA).

The Winter Break is February 19th-23rd, and the 40th day of classes is March 9th.