

BOT*4380 - Metabolism in the Whole Life of Plants

Winter 2024 Course Outline

Section: 01

Credits: 0.50

Land Acknowledgement: Guelph

The University of Guelph resides on the ancestral lands of the Attawandaron people and the treaty lands and territory of the Mississaugas of the Credit. We recognize the significance of the Dish with One Spoon Covenant to this land and offer respect to our Anishinaabe, Haudenosaunee and Métis neighbours. Today, this gathering place is home to many First Nations, Inuit, and Métis peoples and acknowledging them reminds us of our important connection to this land where we work and learn.

Calendar 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.

Prerequisite(s): BIOL*1090, BIOC*2580

Department(s): Department of Molecular and Cellular Biology

Lecture Schedule

MonWedFri 10:30am-11:20am in MINS*106 (1/8 to 4/23)

Instructor Information

Barry Micallef

Email: bmicalle@uoguelph.ca

Office: CRSC 424

Winter 2024 Office Hours:

Office hours by appointment, Office Ext. 54384 (messages only). Students are free to set up Microsoft Teams meetings at a mutually agreed-upon time to consult with B. Micallef if preferred.

Office Phone: 54384

Tariq Akhtar

Email: takhtar@uoguelph.ca

Office: SCI 4461

Winter 2024 Office Hours:

Office hours by appointment.

Office Phone: 54794

Learning Resources

Required Resources

There is no required text or other material to purchase..

Course Resources

Course Materials

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

The following textbooks are available in the library, not on reserve.

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

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

Crozier, Clifford, & 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 (2015) *Plant Physiology*. Sinauer Associates. QK 711.2 T35 2014.

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. include many original scientific articles in plant biology and related studies.

There are 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.

Campus Resources

If you are concerned about any aspect of your academic program: Make an appointment with a Program Counsellor (<https://www.uoguelph.ca/uaic/programcounsellors/>) in your degree program. If you are struggling to succeed academically: There are numerous academic resources offered by the Learning Commons (<https://www.lib.uoguelph.ca/using-library/spaces/learning-commons/>) including, Supported Learning Groups for a variety of courses, workshops related to time management, taking multiple choice exams, and general study skills.

Course Learning Outcomes

Course Level 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 in particular;
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.

Teaching and Learning Activities

This course will consist of interactive lectures with opportunity for questions and discussion, including some discussion of scientific papers. In addition, Required and Supplemental Readings will be posted on Courselink throughout the course.

Comprehensive treatments are given for all topics listed below. The list below is a general outline divided between the two lecturers in the course, and it does not necessarily provide all specific topics covered or the exact sequence of topics.

Lectures

(A) Lectures by Micallef (1st half of the course)

Module 1-Introduction to Plant Metabolism & The Light Reactions in Photoautotrophic Organisms

Introduction to BOT*4380; Definition for autotrophy, & introduction to photoautotrophs & chemoautotrophs; photoautotrophy in terrestrial (land) plants at different levels of organization.

Prokaryotic autotroph biodiversity; definition for a plastid; eukaryotic photoautotroph biodiversity.

Properties of light and light-absorbing pigments: basic properties of the light reactions; four crucial characteristics of chlorophyll; absorption spectrometry; specific chromophores in photoautotrophic organisms; chlorophyll species and their structure-function relationships; a pigment = a chromophore-protein complex; phycobilin pigments and their significance.

Photosystems and fates of absorbed light energy: characteristics of the light-harvesting apparatus in different photoautotrophs; definition of a photosystem; X-ray crystallography of membrane-bound proteins; structure and function of light-harvesting complexes, including the phycobilisome antenna network in cyanobacteria; fates for excitation energy; funnelling of excitation energy to the reaction center; efficiency of a plant photosystem in utilising sunlight.

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

Regulation of the light reactions: cyclic & non-cyclic electron transport; phosphorylation of LHC's; functional significance of the spatial arrangement of thylakoid complexes; processes to dissipate excess light energy; coping with reactive oxygen species (ROS) and varying irradiance. Improvement of the light reactions, impact of stress.

Module 2-Primary Carbon Metabolism in Source and Sink Tissues in Plants

Introduction to photosynthetic C metabolism and the Calvin-Benson cycle: why organisms on earth are C-based; elucidating the 1st product of C fixation in C3 plants; elucidating the reactions of the Calvin-Benson cycle; phases and reactions of the Calvin-Benson cycle; interactions with respiratory metabolism; end products of photosynthesis.

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 transitory starch synthesis, including regulation; chloroplast phosphate translocator and phosphate cycling; chloroplastic starch degradation; phloem loading and unloading. Improving photosynthetic C metabolism, impact of stress.

Sucrose utilization in sink tissues: sucrose hydrolytic enzymes and relationship to respiratory metabolism. Synthesis of storage starch and cellulose & hemicelluloses.

Module 3-N & S Uptake, Assimilation and Utilization in Plants

Overview of N metabolism and N uptake: major inorganic forms of N & S; nitrogen cycle, including biochemical aspects of N₂ fixation; roles of N and S in the plant; phases and enzymes of N uptake and assimilation; N uptake and transport, including cellular transport processes.

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

S uptake and assimilation: sulfate uptake and transport; activation and reduction of sulfate; formation of cysteine and glutathione; functions for glutathione in the plant.

N & S utilization in plants; amino acid synthesis in plants; storage proteins; N-use efficiency in plants.

Module 4-Plant Germination & Early Seedling Establishment in Plants

The 'switch' from seed development to seed germination; the mobilization of seed reserves, including protein, starch, and fatty acid degradation.

Early seedling establishment, including photomorphogenesis mediated by photoreceptors; chlorophyll synthesis and degradation, including regulatory mechanisms.

(B) Lectures by Akhtar (2nd half of the course)

Module 5-Introduction to Secondary Metabolism

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 6-Isoprenoid Metabolism

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 7-Lipid Metabolism

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

Module 8-Phenolics

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

Module 9-Vitamins, Cofactors, and Polyketides

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

Assessment Breakdown

Description	Weighting (%)	Due Date
Midterm Exam	25%	
First 3-Page Essay	15%	
Second 3-Page Essay	15%	
Final Exams	35%	
Quiz	10%	

Assessment Details

Essay

3-page Page Essays (2 in total)

30%

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. Each essay is worth 15% of the final grade. The 1st Essay and 2nd Essay will be marked by B. Micallef and T. Akhtar, respectively.

The topic for the 1st 3-page essay is open, and it must be related to primary metabolic processes in plants. It must be selected and approved by B. Micallef by Mon., Jan. 15 at 11:59 pm. A list of potential general topics (for guidance only, other topics can be chosen if approved by the instructor) for the 1st 3-page essay are provided in the instructions posted on CourseLink, and approval will occur by the instructor through email.

To provide writing assistance for the 1st 3-page essay, a Pre-submission, including the complete introductory paragraph, the final introductory sentence for each remaining paragraph, and a minimum of 10 references (5 must be original scientific articles), will be submitted to B. Micallef for marking on Mon., Jan. 29 by 11:59 pm as electronic copies (Word & pdf versions) using Dropbox in CourseLink. 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%, which will not be remarked in the final submission); and (2) a portion of the total grade for Research worth 5% of the total essay value out of 100%. Thus, the Pre-submission is worth 2.25% of the final grade in the course.

The completed 1st 3-page essay is due by Monday, February 26 at 10:30 am as electronic copies (Word and pdf) using DropBox in CourseLink.

The Pre-submission for the 1st 3-page essay and the completed 1st 3-page essay cannot be handed in for marking past Feb. 5 and March 4, respectively, or a grade of 0 will be assigned (no exceptions).

The topic for the 2nd 3-page essay will be provided by T. Akhtar on Monday, February 26. It is due by .

Exam

Midterm Exam

25%

There will be an in-person Midterm Exam scheduled outside of class the evening of Tuesday, Feb. 6 from 7:00-8:30 pm (Room TBA). Micallef will have a review session for ~1 hour through Microsoft Teams starting at 7:30 pm on Monday, Feb. 5 for the Midterm Exam. The Midterm Exam will cover all class material to the February 2 lecture, inclusive.

The Midterm Exam will be open book (hard copies only, no computer or other electronic aids) consisting primarily of short-answer questions, but some multiple-choice & true-or-false questions will be included. The Midterm Exam will test: (1) all information provided in the Powerpoint presentations posted on CourseLink; (2) additional information discussed in lecture; and (3) any Required Readings posted on CourseLink.

Final Exam

35%

Includes material from T. Akhtar's lectures starting on Monday, Feb. 26, 2024.

B. Micallef's lecture material will not be directly tested on the Final Exam.

Quizzes

Quiz

10%

There will be one in-class Quiz directed to Micallef's material starting at 10:30 am for 50 min on Friday, Feb. 16. It will cover all class material not tested on the Midterm Exam. The Quiz will consist of multiple-choice, true-or-false, fill-in-the-blank, and short-answer questions. Important: The Quiz will test: (1) all information provided in the Powerpoint presentations posted on CourseLink; (2) additional information discussed in lecture; and (3) any Required Readings posted on CourseLink.

Last Day to Drop Course

The final day to drop Winter 2024 courses without academic penalty is the last day of classes: April 08

After this date, a mark will be recorded, whether course work is completed or not (a zero is assigned for missed tests/assignments). This mark will show on the student's transcript and will be calculated into their average.

Course Standard Statements

Copies of Out-of-Class Assignments, Lecture Notes

Keep paper and/or other reliable back-up copies of all out-of-class assignments: a student may be asked to resubmit work at any time. It is advisable to 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 first half of the course will be removed from CourseLink at 11:59 pm on Monday, February 26, so it is essential to download ALL materials posted on CourseLink prior to this time. This is done for the following reasons: (1) to encourage students to download & read the lecture presentations in a timely manner; (2) to encourage students to keep the information for future activities; (3) lecture notes are the property of the instructor (automatically copyrighted) and not the University; and (4) as observed in Fall 2022, the U of G website is not necessarily secure. Copies of course materials will not be provided separately to students using email or other means under any circumstances.

Grading and Submitting Assignments

For the essays, a deduction will be assessed worth 10% of the 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 unless an accommodation has been approved by the instructor. Students must ask for an accommodation prior to the Midterm Exam, Quiz, and due date for the essays or marks may be deducted for not conforming to instructions.

For the Midterm Exam, Quiz, and essays, if a reconsideration of grade is requested the entire marked test or essay will be provided to the instructor, and the entire essay or assignment will be re-marked.

Also ensure that any files submitted for marking are working properly (i.e., they open properly and can be read properly) prior to submitting them or marks may be deducted for not conforming to instructions.

Accessing Course Materials on CourseLink

All materials for Micallef's portion of the course are provided in a course webpage embedded in CourseLink that contains the lecture schedule and course materials. The link for this embedded webpage is provided in the News item section of CourseLink under the Announcement 'Welcome to BOT*4380 Winter 2024'. Students must download each file in this embedded webpage individually and not as a zip file. This approach is being used to encourage students to download all course materials gradually and not just prior to the quizzes. It is recommended to download and read over each Powerpoint presentation prior to lecture. Lectures presented by Micallef will be posted on CourseLink prior to the lecture.

Department of Molecular and Cellular Biology Statements

Academic Advisors

If you are concerned about any aspect of your academic program. Please make an appointment with a program counsellor in your degree program. B.Sc. Academic Advising (<https://bsc.uoguelph.ca/>) or Program Counsellor (<https://www.uoguelph.ca/uaic/programcounsellors/>)

Academic Support

Science Commons: Located in the library, the Science Commons provides support for physics, mathematic/statistics, and chemistry. Details on their hours of operations can be found at: Chemistry / Physics Help (<http://www.lib.uoguelph.ca/getassistance/studying/chemistry-physics-help/>) and Math / Statistics Help (<http://www.lib.uoguelph.ca/getassistance/studying/math-stats-help/>)

Course Offering Information Disclaimer

Please note that course delivery format (face-to-face vs online) is subject to change up to the first-class day depending on requirements placed on the University and its employees by public health bodies, and local, provincial and federal governments. Any changes to course format prior to the first class will be posted on WebAdvisor/Student Planning (<https://www.uoguelph.ca/webadvisor/>) as they become available.

Online Behaviour

Inappropriate online behaviour will not be tolerated. Examples of inappropriate online behaviour include:

- Posting inflammatory messages about your instructor or fellow students
- Using obscene or offensive language online
- Copying or presenting someone else's work as your own
- Adapting information from the Internet without using proper citations or references
- Buying or selling term papers or assignments
- Posting or selling course materials to course notes websites
- Having someone else complete your quiz or completing a quiz for/with another student
- Stating false claims about lost quiz answers or other assignment submissions
- Threatening or harassing a student or instructor online
- Discriminating against fellow students, instructors and/or Tas
- Using the course website to promote profit-driven products or services
- Attempting to compromise the security or functionality of the learning management system
- Sharing your username and password
- Recording lectures without the permission of the instructor

Personal Information

Personal information is collected under the authority of the University of Guelph Act (1964), and in accordance with Ontario's Freedom of Information and Protection of Privacy Act (<http://www.e-laws.gov.on.ca/index.html.html>) (FIPPA). This information is used by University officials in order to carry out their authorized academic and administrative responsibilities and also to establish a relationship for alumni and development purposes.

For more information regarding the Collection, Use and Disclosure of Personal Information policies (<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/intro/index.shtml/>) please see the Undergraduate Calendar.

Wellness

If you are struggling with personal or health issues:

- Counselling services (<https://www.uoguelph.ca/counselling/>) offers individualized appointments to help students work through personal struggles that may be impacting their academic performance.
- Student Health Services (<https://www.uoguelph.ca/studenthealthservices/clinic/>) is located on campus and is available to provide medical attention.
- For support related to stress and anxiety, besides Health Services and Counselling Services, Kathy Somers runs training workshops (<http://www.selfregulationskills.ca/>) and one-on-one sessions related to stress management and high performance situations.

Standard Statements for Undergraduate Courses

Academic Integrity

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.

The Academic Misconduct Policy (<https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-misconduct/>) is outlined in the Undergraduate Calendar.

Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability. Use of the SAS Exam Centre requires students to make a booking at least 10 days in advance, and no later than the first business day in November, March or July as appropriate for the semester. Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time. For students at the Guelph campus, information can be found on the SAS website. (<https://www.uoguelph.ca/sas/>)

Accommodation of Religious Obligations

If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements.

See the Academic calendar for information on regulations and procedures for Academic Accommodations of Religious Obligations (<https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-accommodation-religious-obligations/>).

Copies of Out-of-class Assignments

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.

Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all undergraduate students except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in the Undergraduate Calendar - Dropping Courses (<https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/dropping-courses/>).

Email 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.

Health and Wellbeing

The University of Guelph provides a wide range of health and wellbeing services at the Vaccarino Centre for Student Wellness (<https://wellness.uoguelph.ca/>). If you are concerned about your mental health and not sure where to start, connect with a Student Wellness Navigator (<https://wellness.uoguelph.ca/navigators/>) who can help develop a plan to manage and support your mental health or check out our mental wellbeing resources (<https://wellness.uoguelph.ca/shine-this-year/>). The Student Wellness team are here to help and welcome the opportunity to connect with you.

Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g., final exam or major assignment).

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 student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Resources

The Academic Calendars (<http://www.uoguelph.ca/registrar/calendars/?index>) are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. See the Undergraduate Calendar for information on regulations and procedures for Academic Consideration. (<https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-consideration-appeals-petitions/>)