BIOC*4520 Metabolic Processes

Fall 2021
Section(s): C01

Department of Molecular and Cellular Biology
Credit Weight: 0.50
Version 1.00 - September 04, 2021

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1 Course Details

1.1 Calendar Description

This course is an in-depth study of the role of bioenergetics, regulation, and chemical mechanisms in carbohydrate, lipid, and nitrogen metabolism.

Pre-Requisites: BIOC*3560 or BIOC*3570

1.2 Course Description

Objectives:

This course will provide a detailed study of the key autotrophic and heterotrophic metabolic pathways which provide the essential foundations for life, and consider the biochemical, molecular and cellular mechanisms which contribute to their regulation. Examples will be taken from mammals, micro-organisms and plants to demonstrate the underlying principles on which carbon, nitrogen, hydrogen and oxygen are acquired and utilised. The synthesis and turnover of carbohydrates, amino acids and lipids as the organic building blocks for energy storage, transfer and homeostasis will be discussed. Effects of stress and aberrant metabolism will be considered in relation to health and disease. An integrated approach will be adopted, linking metabolism at the cellular level to processes within the whole organism.

1.3 Timetable

Lectures: Monday, Wednesday, Friday 12:30 - 1:20, in-person. This course is currently scheduled to take place in MACS 209 but please check Webadvisor regularly, as this may change. Midterms will also be face-to-face and mandatory during scheduled class time.

Following each lecture, subject to available technology, a recording will be posted on

CourseLink for asynchronous viewing by students.

Please note the proposed course format, schedule or location for the Fall 2021 semester may change up to the first day of classes due to personnel, resource, and public health circumstances and if conditions cannot be met to ensure the safety of our students and instructors. Continue to watch the Student Planning website as format information could be updated until the first day of classes.

1.4 Final Exam

In person Dec 16th, 11.30 am - 1.30 pm, location TBD

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Michael Emes BSc, PhD
Email:	bioc4520@uoguelph.ca
Office:	SSC 4448
Office Hours:	Generally available 1.30 - 2.30 following each lecture or by arrangement.

2.2 Teaching Assistants

Teaching Assistant (GTA):	Caitlin Sande
Email:	csande@uoguelph.ca

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3 Learning Resources

Very Highly Recommended Texts (not required).

Detailed and comprehensive texts, esp. for metabolism, regulation and mechanisms.

You need not buy a new book, if you already have any of these (including earlier editions).

3.1 Recommended Resources

Biochemistry (Textbook)

Very Highly Recommended:

Nelson and Cox, *Lehninger's Biochemistry* - 6th Edition, 2013 or 7th Edition, 2017

Publisher: W H Freeman. ISBN 978-1-4641-2611-6

Biochemistry (Textbook)
Very Highly Recommended:

Voet and Voet, *Biochemistry* - 4th Edition, 2011 or 5th Edition, 2016

Publishers: Wiley. ISBN 978-1-118-91840-1

3.2 Additional Resources

Biochemistry (Textbook)
Jeremy M.Berg, John L. Tymoczko and Lubert Stryer. *Biochemistry* 8th Edition

Publisher: Freeman Macmillan. ISBN 978-1-4641-2610-9

Biochemistry (Textbook)
Alison M. Smith et al,(7 other authors). *Plant Biology*.

Publisher: Garland Science, Taylor and Francis Group

ISBN 978-0-8153-4025-6

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Explain the role of entropy and enthalpy, Gibbs free energy change, equilibrium constants, coupled reactions and redox reactions in biochemical processes.
2. Comprehend the complex nature of metabolic networks and how flux through pathways is regulated, including by application of Metabolic Control Analysis, as well as through understanding the properties of individual enzymes.
3. Understand the detailed mechanisms by which ATP is produced through primary photochemistry, oxidative phosphorylation and substrate level phosphorylation.
4. Describe the principle pathways and regulation of carbohydrate metabolism including: glycogen metabolism in humans; glycolysis; the TCA cycle; the Calvin cycle in plants; the oxidative pentose phosphate pathway; alternative pathways of respiration.
5. Understand the process of primary nitrogen fixation, nitrate assimilation and amino acid

biosynthesis and turnover in microorganisms, plants and animals in the context of the global nitrogen cycle.

6. Describe the mechanism of fatty acid synthesis and degradation, triglycerides, cholesterol and the effects of diet on metabolism.
7. Explain how disorder of metabolic regulation results in important medical consequences, such as increased glycolysis in tumours, insulin resistance and diabetes in obesity, reactive oxygen species and free radical damage in electron transport, and high cholesterol states.

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5 Teaching and Learning Activities

5.1 Lecture

Topics:

There will be three lectures a week, in-person, Monday, Wednesday and Friday, 12.30 - 1.30. There are no labs or assigned readings, but you are expected to maintain a sufficient record of the material presented in lectures to be able to handle questions on mid-terms and final examinations. Suggested readings will be provided in lectures when appropriate.

Topics:

Detailed course outline:

1. Introduction, orientation to course, principles
2. Thermodynamics, forms of energy, life and the second law of thermodynamics
3. Free energy of hydrolysis, bioenergetics, coupled reactions
4. Redox reactions and free energy – the Nernst equation and its application.
5. Photochemistry and the absorption of light by pigments.
6. Autotrophy – electron transport and photophosphorylation
7. Autotrophy – CO_2 fixation, the Calvin Cycle
8. The problem of oxygen – photorespiration and

free radicals.

9. RUBISCO – the most abundant enzyme on the planet
10. Variations on autotrophic carbon metabolism
11. Nitrogen cycle, nitrogen fixation and the role of microorganisms
12. Metabolism of oxidised forms of nitrogen
13. Nitrate and ammonia assimilation,amino acid synthesis
14. Glycogen synthesis, regulation, post- translational modification.
15. Glycogen breakdown, regulation, control of blood glucose levels.
16. Glycogen storage diseases.
17. Glycolysis, pathway and key reactions
18. Glycolysis –regulation in different organs, role of fructose 2,6-bisphosphate. Anaerobic metabolism - the Pasteur effect and the Warburg effect, diseased states.
19. TCA cycle – historical perspective, reactions.
20. Entering the mitochondrion - pyruvate dehydrogenase complex, structure, mechanism and regulation
21. TCA cycle – bioenergetics, control.
22. Mitochondrial metabolism and biogenesis.
23. Mitochondrial electron transport, complexes and bottlenecks. State 3/state 4 metabolism.
24. Oxidative phosphorylation, proton-motive force, energy coupling.
25. Oxidative phosphorylation, structure and mechanism of ATP synthase complex
26. Oxidative phosphorylation vs Photophosphorylation. The oxidative pentose phosphate pathway, role and regulation in different tissues.
27. Lipid degradation, ketone body formation.

28. Fatty acid biosynthesis, triglycerides, cellular compartmentation.
29. Cholesterol biosynthesis, metabolism and regulation.
30. Principles of metabolic regulation, flux control analysis.
31. Hormonal integration of metabolism.
32. Course review

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6 Assessments

6.1 Course Evaluation

The course grade will be based on performance on two midterms (in person, in class, 25% each), and a cumulative final examination (50%).

6.2 Midterm Examinations

There will be 2 in-class midterm exams, in person, during scheduled class times, using a combination of multiple choice and short-answer questions. Each midterm will be based on discrete sections of the course and a subsequent scheduled class period will be used to review questions and answers. Persons with a scheduled academic conflict should inform the instructor immediately via the course e-mail.

6.3 Final Examination

The final examination will consist of two sections. The first section will be a combination of multiple choice and short answer questions, equivalent to the previous midterms and focussed on the final part of the course (contributing 25% of overall course mark). The second section will be cumulative. It will involve writing **essays** on **two topics** from a choice of **six titles** which will be integrative in nature, and will draw on material covered in the entire course (25% of course mark).

Exams will be in-person and scheduled by the Registrar's office.

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7 Course Statements

7.1 Policy on Missed Examinations

If you miss an exam, please let the instructor know as soon as possible at <bioc4520@uoguelph.ca>

Requests for Academic Consideration may require medical documentation as appropriate.

7.2 Exam Aids

To be determined

8 Department of Molecular and Cellular Biology Statements

8.1 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 as they become available.

8.2 Academic Advisors

If you are concerned about any aspect of your academic program:

- Make an appointment with a program counsellor in your degree program. B.Sc. Academic Advising or Program Counsellors

8.3 Academic Support

If you are struggling to succeed academically:

- Learning Commons: There are numerous academic resources offered by the Learning Commons including, Supported Learning Groups for a variety of courses, workshops related to time management, taking multiple choice exams, and general study skills. You can also set up individualized appointments with a learning specialist. http://www.learningcommons.uoguelph.ca/
- 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: http://www.lib.uoguelph.ca/get-assistance/studying/chemistry-physics-help and http://www.lib.uoguelph.ca/get-assistance/studying/math-stats-help

8.4 Wellness

If you are struggling with personal or health issues:

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

8.5 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 (FIPPA) http://www.e-laws.gov.on.ca/index.html. 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 please see the Undergraduate Calendar. (https://www.uoguelph.ca/registrar/calendars/undergraduate/current/intro/index.shtml)

9 University Statements

9.1 Email Communication

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

9.2 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. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 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 students (undergraduate, graduate and diploma) 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 their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 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.

9.5 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 book their exams at least 7 days in advance and not later than the 40th Class Day.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 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 encourages academic integrity. 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.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 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.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

9.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

9.10 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).

9.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.
