



# HK\*4460 Regulation of Human Metabolism

Winter 2019

Section(s): C01

Department of Human Health and Nutritional Sciences

Credit Weight: 0.50

Version 1.00 - December 20, 2018

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## 1 Course Details

### 1.1 Calendar Description

The course focuses on the underlying metabolic events that occur in association with exercise. Skeletal muscle metabolism and substrate delivery are discussed with respect to the intracellular biochemical events integrated with both the endocrine and the chemical aspects of neural mechanisms.

**Pre-Requisite(s):** (HK\*3810 or HK\*3940), NUTR\*4210

### 1.2 Course Description

The course focuses on skeletal muscle but also examines adipose tissue and liver and the involvement of the neural, pulmonary, cardiovascular and endocrine systems.

### 1.3 Timetable

Lectures: Tuesdays and Thursdays @ 11:30 am to 12:50 pm. Classes are held in ANNU (Animal Science Nutrition) 156.

### 1.4 Final Exam

Exam time and location is subject to change. Please see WebAdvisor for the latest information.

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## 2 Instructional Support

### 2.1 Instructional Support Team

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|----------------------|---|
| <b>Instructor:</b>   | David Dyck  |
| <b>Email:</b>        | ddyck@uoguelph.ca                                     |
| <b>Office:</b>       | ANNU 345  |
| <b>Office Hours:</b> | Appointments can set up by email. I make myself quite |

available! Drop in is OK, too, but I cannot guarantee I might not be busy. Please, just don't drop in the hour before lecture time - I'm usually prepping for the lecture!

## 2.2 Teaching Assistant

The teaching assistant is Dan Cervone (ANNU 203/205; [dervone@uoguelph.ca](mailto:dervone@uoguelph.ca)). Dan will assist in marking the exams and the seminar presentations.

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## 3 Learning Resources

No textbooks are required!! All lecture material, and any additional resources, will be posted ahead of time on the Courselink site.

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## 4 Learning Outcomes

### 4.1 Course Learning Outcomes

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

1. To examine how the intracellular energy provision pathways of the human body provide the required energy to fuel the cellular functions that demand energy. Skeletal muscle metabolism is emphasized due to the enormous requirements for energy during movement or exercise, but altered nutritional states are also considered.
  2. To examine the processes controlling the delivery of substrates to skeletal muscle, both at rest and during exercise. Hormonal and neural signals regulating substrate mobilization from adipose tissue and liver are emphasized.
  3. To provide a physiological approach towards understanding the integration of substrate supply to skeletal muscle and energy production by skeletal muscle cells during exercise.
  4. To provide an understanding of the plasticity of the various processes associated with substrate delivery to and energy production by skeletal muscle.
  5. To participate in an independent project and further develop oral presentation skills.
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## 5 Teaching and Learning Activities

### 5.1 Course Content

24, 80 min lectures (minus 1 for mid-term = 23 lectures)

1. Introduction to, or Review of Skeletal Muscle Metabolism (handles varied backgrounds)

1. Challenges for skeletal muscle – exercise, storage of food (post-exercise and post-prandial) and response to nutritional manipulations (fasting, high fat diet)?
2. Adenosine triphosphate (ATP) - immediate source of cellular energy. How much is stored in muscle? Consumers of cellular energy – ATPases. Fluctuation in cellular energy demand - varying tissues.
3. Replenishment of ATP in muscle – Pathways of ATP synthesis. Oxidative and substrate phosphorylation. Why are there two major systems?
4. Sources of metabolic fuels/substrates for ATP synthesis - dietary/atmospheric, dependence on other body systems. Overview of substrate supply network including hormonal and neural involvement.
5. Overview of energy providing pathways in skeletal muscle.

#### 1. Review of Skeletal Muscle Physiology - Emphasis on Metabolism

1. Structural organization
2. Electrical and chemical communication
3. Classification of fibres
4. Motor unit organization
5. Plasticity of skeletal muscle

#### 1. Review of Exercise Physiology

1. What is power? What is oxygen uptake – maximal oxygen uptake ( $VO_2$  max)?
2. Absolute and relative power outputs.
3. Power outputs above maximal oxygen uptake
4. Intensity of contraction/exercise - percent  $VO_2$  max (25, 65, 85 and >100%) as whole body context example vs. maximal voluntary contraction (MVC)
5. Potential for aerobic and anaerobic energy production – onset of exercise. When are the systems needed and advantages and disadvantages of each system.
6. Training and limiting factors for maximal oxygen uptake

- **Practical Issue: Does oral creatine loading increase muscle creatine content and enhance "sprint" exercise performance? Does it increase the rate of muscle accretion when weight lifting?"**

## 1. Enzyme Kinetics and a Metabolic Pathway

1. Near- and non-equilibrium reactions, flux-generating reactions
2. Regulation of enzymes
3. Metabolic pathways

## 1. Mitochondrial Metabolism

1. Respiratory chain & oxidative phosphorylation
2. Energy transduction between mitochondria and cytoplasm
3. Control of mitochondrial metabolism
4. Tricarboxylic acid (TCA) cycle control

- **Practical Issue: "Maximum response with minimum investment – Does high intensity interval training work?"**

## 1. Carbohydrate Metabolism

1. Introduction
2. Liver glycogen synthesis, glycogenolysis (glucose output) and gluconeogenesis
3. Glucose transport and regulation in blood
4. Muscle glucose uptake and phosphorylation
5. Muscle glycogenolysis and glycolysis
6. Cytoplasm to mitochondria shuttles for reducing equivalents
7. Pyruvate conversion to acetyl-CoA and acetylcarnitine formation
8. Pyruvate to lactate conversion and acid-base status

- **Practical Issue: "Glycogen supercompensation and oral rehydration-carbohydrate drinks for exercise"**

## 1. Fat Metabolism

1. Introduction
2. Synthesis and storage of triacylglycerol (TG) in adipose tissue
3. Adipose tissue lipolysis and release of free fatty acids (FFA)
4. FFA transport in blood, across muscle membrane and in cytoplasm
5. Beta-oxidation

- **Practical Issue: "Is IMTG used during exercise, and if so, when?"**

## 1. Interaction of Fat and Carbohydrate Metabolism

1. Classic theory and contemporary view
2. Recent malonyl-CoA and CPT I findings
3. Advantages of fat and carbohydrate metabolism
4. Overview of major signal systems controlling ATP synthesis from fat and carbohydrate in skeletal muscle.

## 1. Protein and Amino Acid Metabolism

1. Introduction and general information
2. Regulation of protein synthesis in response to exercise

- **Practical Issue: "Dietary protein requirements in athletes and the effect of diet on protein synthesis and breakdown during resistance training"**

## 5.2 Important Dates

- First class: Tuesday, January 8, 2019
- Seminar Presentations: ongoing from 4th to last week of seminar (Mon and Weds afternoons each week)
- Midterm Exam: Thurs Feb 14, 2019 in class
- Deadline for dropping courses without penalty (40<sup>th</sup> class day): Fri Mar 8, 2019
- Last scheduled class for this course: Thurs Apr 4, 2019
- Final Exam: TBA.

## 6 Assessments

### 6.1 Marking Schemes & Distributions

The weighting of the midterm and final exams depends on which you do better on. If you do better on the midterm, the weighting will be 35% midterm and 35% final. If you do better on the final, the weighting will be 20% midterm and 50% final.

| Name                | Scheme A (%) | Scheme B (%) |
|---------------------|--------------|--------------|
| Midterm Examination | 20           | 35           |
| Seminar             | 30           | 30           |
| Final Examination   | 50           | 35           |

| Name  | Scheme A (%) | Scheme B (%) |
|-------|--------------|--------------|
| Total | 100          | 100          |

## 6.2 Assessment Details

### Midterm Examination (20%)

**Date:** Thu, Feb 14, In class

**Learning Outcome(s):** 1,2,3,4

Course Content: 1st half of lecture material

### Seminar (30%)

**Due:** Between weeks 4 & 12

**Learning Outcome(s):** 1,2,3,4

- Course Content: Individual choice
- Schedules will be set throughout the semester beginning approximately the 4th week. Room 355 in ANNU (Canary Room) has been booked from noon to 4:00 pm, Mondays and Weds, starting February 1st running to the end of the semester. The seminar may be done individually or in pairs, although I encourage individual presentations. Please note that you and your partner will share the same grade if you do it as a pair. Try to do it early! Seminars will be booked in small groups, so that you will be presenting in front of about 4-6 people, including myself and the TA. Please note that the seminar room is not large, so friends and guests outside of those scheduled to present are not permitted.

### Final Examination (50%)

**Date:** , TBA

**Learning Outcome(s):** 1,2,3,4

Course Content: 2nd half of lecture material

## 7 Course Statements

### 7.1 Grading

- Exams: Note that the midterm and final exams have a flexible weighting. If the midterm has the better performance, it will count for 35% and the final for 35% of the final grade. If the performance on the final is better, then it will be weighed at 50% and the midterm at 20%.
- The midterm and final are typically a combination of shorter and longer form questions - no multiple choice or one/two word answers! I mark most of the

longer questions myself. A marking scheme will be provided when the midterm is returned. If you feel that marks were missed, you may return the exam to me within 2 weeks of the midterm being handed back, with a separate page indicating where/why you think you deserved more marks. Please note that I reserve the right to look at the entire exam. Sometimes, where one question may have been marked a bit stringently, another was marked somewhat "generously". Marking also takes into account the context in which facts are provided, and not merely by "bean counting" using a rigorous rubric.

- Missing the midterm. If you miss the midterm, you must provide documentation, or a grade of zero will be assigned. The deferred midterm must be written within one week of the originally scheduled midterm. If this cannot be achieved, then there will be no penalty, but the grade will be transferred to the final exam (now worth 70%).
- Seminars: Seminars count for 30% of the final grade. These will be evaluated by myself and/or the TA; as much as possible, we will both be there. I will do my best to provide your grade along with brief written feedback indicating strengths and weaknesses of the presentation, in a timely fashion. My intention is to get you the grade and feedback within several days, usually at the end of one of the next lectures. Please note that if you do the seminar as a pair, then the feedback and grade will be shared by both of you.

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## 8 Department of Human Health and Nutritional Sciences Statements

### 8.1 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](#)

### 8.2 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>

## 8.3 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.uoguelph.ca/~ksomers/>

## 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 regulations and procedures for [Academic Consideration](#) are detailed in the Undergraduate Calendar.

### 9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for [Dropping Courses](#) are available in the Undergraduate Calendar.



## 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.

More information: [www.uoguelph.ca/sas](http://www.uoguelph.ca/sas)

## 9.6 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.

The [Academic Misconduct Policy](#) is detailed in the Undergraduate Calendar.

## 9.7 Recording of Materials

Presentations which 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.

## 9.8 Resources

The [Academic Calendars](#) are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

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