

University of Guelph
College of Biological Science
Department of Molecular and Cellular Biology (MCB)
COURSE OUTLINE

MBG*3080 Bacterial Genetics
Fall Semester, 2015

Course description

This course focuses on the genetics of prokaryotic microorganisms and their viruses. Some major topics covered are: regulation of gene expression, analysis of bacterial and phage genomes, plasmids, transposable elements, and mutation studies.

Prerequisite(s): (MBG*2020 or MBG*2040), (1 of MICR*2020, MICR*2030, MICR*2420)

Teaching team

1. Dr. Wendy J. Keenleyside, Course Instructor
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2. Ashley Brott, Graduate Teaching Assistant
Dept. of Molecular and Cellular Biology

Course schedule

Lectures: RICH2520

Mondays, Wednesdays and Fridays, 9:30 - 10:20 am

Course goals

The learning outcomes (A-H) and their associated concepts (a→) are listed below; these will be assessed through the various graded components of the course. They may be updated periodically, through deletion or addition, depending upon the pace and depth of coverage of a given topic. The material in this course will also further develop the broader MCB Program Learning Outcomes ([MCB Learning Outcomes](#)) and the University of Guelph learning outcomes ([UofG Learning Outcomes](#)).

A. NUCLEIC ACID STRUCTURE

By the end of the semester, the student will be able to:

- a. Describe the molecular structure of DNA, including base pairing, 5' → 3' orientation, major/minor grooves
- b. Describe the roles of plasmids in bacterial cells and the various genetic elements in a natural and synthetic plasmid.
- c. Describe the structures of different types of RNA, how they are synthesized/processed and their functions in the bacterial cell.
- d. Understand the types of molecular interactions between proteins and nucleic acids and how specific interactions can be achieved.
- e. Describe template and coding strands and relate how genes are organized on both DNA strands of a chromosome

B. DNA REPLICATION

By the end of the semester, the student will be able to:

- a. Describe the process of DNA replication (plasmids and chromosome) in a bacterial cell.
- b. Understand how initiation of chromosome replication is accomplished, and how this is coordinated with cell division
- c. Understand the molecular basis of plasmid incompatibility and how plasmid copy number is regulated in a bacterial cell.
- d. Identify the major DNA polymerases in *E. coli* and their molecular properties/functions
- e. Explain how proofreading and repair occurs during DNA synthesis.
- f. Understand the principle behind the polymerase chain reaction and how this differs from DNA synthesis in a cell.
- g. Explain techniques of DNA sequencing using specific types of DNA polymerases and modified nucleotides.

C. EVOLUTION AND THE FLOW OF GENETIC INFORMATION

By the end of the semester, the student will be able to:

- a. Understand the relationship between genotype and phenotype
- b. Describe the molecular mechanisms of gene transfer by conjugation (including Hfr strains), transformation and transduction
- c. Understand the concept of lysogenic conversion of bacterial pathogens
- d. Describe pathogenicity islands and their evolution
- e. Understand the concept of a minimal genome and how this can be tested experimentally
- f. Understand the fluidity and evolution of bacterial genomes
- g. Understand the concept and rationale behind comparative genomics
- h. Recognize the convention and symbols used to describe bacterial genotype and phenotype

D. GENE EXPRESSION

By the end of the semester, the student will be able to:

- a. Describe at the biochemical level the events that occur from genes to phenotype
- b. Identify different types of promoter sequences and the different sigma factors that recognize each type of promoter.
- c. Understand the concept of promoter "strength"
- d. Understand the concept of *cis*- and *trans*-acting factors in gene expression
- e. Describe the process of transcription at the molecular level including transcription termination
- f. Describe the process of translation at the molecular level in monocistronic and polycistronic mRNAs.
- g. Explain the various molecular mechanisms of transcription regulation in bacteria.
- h. Explain how the *lac*, *trp* and *ara* operons are regulated.
- i. Understand the difference between negative and positive transcriptional regulation and induction vs derepression
- j. Understand how transcription and translation are coupled in bacteria
- k. Understand and describe some examples of gene regulation by attenuation
- l. Understand the difference between specific gene regulation and global gene regulation
- m. Understand how the phenotype of specific mutants can be used to determine the mechanism of gene expression and regulation in bacteria.

- n. Describe some examples of how bacteria sense environmental conditions and respond by controlling gene expression.
- o. Identify the characteristics of a gene from a DNA sequence

E. GENE MUTATIONS

By the end of the semester, the student will be able to:

- a. Understand the difference between DNA lesions and mutation
- b. Describe the various mechanisms of how mutations can arise spontaneously within a cell or can be induced.
- c. Identify the various kinds of DNA mutations (point mutation, insertion, deletion, nonsense, nonsense suppressor, frameshift and reversion) and how these might affect the resultant mRNA transcript or protein product as well as the phenotype.
- d. Understand the relationship between nonsense and frameshift mutations and polarity
- e. Understand how gene complementation can be used to identify if a specific gene mutation is dominant or recessive
- f. Explain how creating mutants and merodiploids in genetic model systems can help us infer the function of genes
- g. Be able to predict the effects of mutations in specific genes of systems covered in the course and identify, based on mutant phenotype, the affected gene(s)
- h. Describe the various mechanisms of DNA repair and the hierarchy of induction of systems of the SOS regulon

F. TRANSPOSONS

By the end of the semester, the student will be able to:

- a. Identify the key characteristics of various types of transposons
- b. Describe how transposition occurs at the molecular level
- c. Understand transposon mutagenesis *in vivo* as an evolutionary force and *in vitro*, as a tool in bacterial genetics
- d. Understand how transposon activity is assayed in the lab and how to identify the site of transposon integration from a DNA sequence
- e. Understand the underlying molecular events and roles of site-specific recombination in bacteria and bacteriophages

G. PHAGE GENETICS

By the end of the semester, the student will be able to:

- a. Understand, through comparing and contrasting, the temporal regulation of gene expression in phage T4 and lambda.
- b. Understand the molecular basis for transcriptional antitermination (λ)
- c. Describe the molecular events that occur in the lysogenic and lytic phases of lambda
- d. Describe the process of induction of a phage lysogen and its relationship with the SOS response
- e. Understand the differences between generalized and specialized transduction and the applications of each in bacterial genetics
- f. Understand the role of lysogenic conversion in bacterial pathogenesis

H. SELF-REGULATED LEARNING

Over the course of the semester, successful students will:

- H1. Develop an understanding of what is required to learn, and the relationship between understanding and remembering
- H2. Identify and plan the behaviours necessary for deep learning
- H3. Set learning goals and periodically assess progress towards attaining those goals
- H4. Critically assess performance on course assessments, and draw connections between performance, learning strategies and effort
- H5. Describe the learning skills that were acquired, or further developed, and explain their application to future endeavors

Course content

- a. Lectures - The following is a list of lecture topics: the relative amount of time spent on a given topic and the order of topics may be subject to minor modifications.

Lecture # ^a	Topic	Textbook chapter or other reading ^b
1	Introduction to bacterial genetics, Bloom's taxonomy (http://www.celt.iastate.edu/teaching-resources/effective-practice/revised-blooms-taxonomy/) & PeerWise (https://peerwise.cs.auckland.ac.nz/docs/)	Course outline, Leamson (2002), Dewancker <i>et al.</i> , 2015
2, 3, 4	Chromosome structure and organization. DNA replication	1
5	Plasmids. Replication and copy number control	4
6,7	Transcription	2
8,9	Translation, and Protein Folding	2
10	Genome sequences and gene sequence analysis in-class exercise	
11, 12,13	DNA Repair and Mutagenesis	11
14, 15	Regulation of gene expression I – the <i>lac</i> operon	12
16,17	Regulation of gene expression II – the <i>trp</i> and <i>ara</i> operons	12
18	Mid-term exam	
19, 20	Global regulatory mechanisms and signal transduction I	13
21, 22, 23	The bacterial gene pool and evolution of bacterial genetic diversity Minimal genome and synthetic life	Articles in D2L
24	Conjugation and gene mapping	5
25	Transformation	6
26, 27, 28	Transposition and Site-Specific Recombination	9
29	Transposon mutagenesis	Articles in D2L
30, 31, 32	Bacteriophages: Lytic Development, Genetics, and Transduction	7
33-34	Lysogeny: the λ Paradigm and the Role of Lysogenic Conversion in Bacterial Pathogenesis	8

^a these are approximate dates and are subject to minor alteration.

^b not all topics within the indicated textbook chapter will necessarily be covered. Students are responsible for the specific levels of detail given in lectures. Readings that are not from the textbook are provided via link or pdf, on Counselink.

- b. Method of presentation – Students will learn the course material through lectures, which will include active learning components including clicker questions and problem solving in *ad hoc* groups, independent reading, online quizzes and 2-stage (independent + collaborative) midterm & final exam. Lectures will be recorded and made available after the lecture.

Course resources

Textbook: the primary textbook for the course is Molecular Genetics of Bacteria, 4th Edition 2012. Authors: Larry Snyder; Joseph E. Peters; Tina M. Henkin; Wendy Champness. This is available for purchase in the bookstore and there is one copy in the Library's reserve desk.

"Microbiology an evolving Science 3rd edition, by Slonczewski and Foster" Chps 7, 8, 9, 10, 11 and 12 can be used as a reference if you need a basic understanding of the topic before reading the primary textbook.

Courselink: the course website will be used extensively and will include all relevant course materials, including lecture slides, lecture videos, discussion boards, online quizzes, links for additional readings, a course calendar and study aids. Note that the slides are lecture aids NOT comprehensive course notes. You are expected to read the textbook and other readings supplied through D2L and attend lectures to supplement the material presented in the slides.

Instructor's office hours - times tba or by appointment

Clickers – You will be required to purchase a 1-semester subscription to REEF Polling 2.0 (by iclicker), to allow participation in class polling (participation marks are attached). This is a cloud-based platform that allows you to use your laptop or digital device to respond to MCQs or short/long answer questions. The cost is \$9.99 USD. Register at <http://support.reef-education.com>. The first 14 days are a free trial, then you will be prompted to buy the subscription.

PeerWise – this is a free online tool for authoring, answering, commenting on and rating student-authored multiple-choice questions. A site for MBG*3080 F15 has been set up and the class list imported. You will need to create an account (assuming you have not used the tool before) and then select the course. Student activity is anonymous to other students, but not to the instructor, who will be grading student participation. The tool is simple to use but instructions for creating, and for answering, questions, are provided in text as well as video and screencasts. There are a few introductory/review questions already in the MBG*3080 repository, to help you get started.

<https://peerwise.cs.auckland.ac.nz/docs/>

Methods of assessment

Form of Assessment	Weight of assessment = highest of A or B		Due date of assessment	Course content/ activity	Learning outcomes addressed ^b
	A	B ^a			
Lecture quizzes ^c	10%	10%	1 Sept 23 (L1-6) 2 Oct 7 (L7-12) 3 Nov.4 (L19-23) 4 Nov. 25 (L24-32)	Non-cumulative on preceding lecture material	Those ID'd in class for the relevant lectures
Participation	a. 5% b. 5% TOTAL: 10%	a. 5% b. 5% TOTAL: 10%	a. Seminars 1-12 b. Oct. 21/23, Dec. 2/4	a. Clicker use ^d b. PeerWise use ^e	a. A-H b. (1) A-B, D-E(2) C, F-H
Midterm exam ^{f, e} (in class)	35% (28% individual + 7% group)	0%	Oct 23 – during lecture time	Lectures 1-17	A-B, D-E, H
Final exam ^{g, e} (location tba)	45% (38% individual + 7% group)	80% (68% individual + 12% group)	Sat. Dec 12 th 2:30-4:30	Cumulative on all course material	A-H

^a Students who miss the midterm write an 80% (cumulative) final exam. For students who **DO** write the midterm, but perform better on the final, the midterm grade will be dropped and the grade weight transferred to the final exam. You are strongly encouraged to write the midterm rather than gamble on performing well on the final exam. **The midterm will not be handed back** however there will be opportunities to view and discuss midterms.

^b These may be subject to minor change, depending upon the pace of lectures.

^c Lecture quizzes are best 3 of 4. They are done online - you will have a 24h window (4:30 pm to 4:30 pm) to sign on. Once begun, every student will have 45 min to complete the quiz; this is at least 3x longer than the time deemed necessary for successful completion (assuming you have done the readings and attended class) – no extra time will be provided. Specific lectures covered are indicated in brackets.

^d Clickers: each lecture will include 1 or more clicker questions which, depending upon the difficulty level, may be polled, discussed, then re-polled, prior to revealing answers. Students will be graded on participating, not accuracy, as follows:

90-100% participation 5/5

80-89% participation 4/5

70-79% participation 3/5

60-69% participation 2/5

50-59% participation 1/5

^e PeerWise: each student is required to contribute 2 questions by Oct. 21 and another 2 by Dec. 4. Each student is also required to have answered at least 10 questions by Oct. 23/the midterm and another 10 by Dec. 4/the last day of classes. Meeting the required contributions is worth 2.5

participation marks and answering the required number of questions is also worth 2.5 participation marks. **Answering the review questions contributed by Dr. Keenleyside may be counted towards the pre-midterm 10-question requirement.** In addition, any good quality, higher Bloom's level questions, will be considered for inclusion in the midterm and final exams, and prizes will be awarded on Dec. 4 for the top 3 students appearing on the PeerWise leaderboards or with high PeerWise reputations. Grading for PeerWise activities is further broken down below:

4 contributions (2.5%) + 20 questions answered (2.5%) = full marks (5%)

2-3 contributions (1%) + 20 questions answered (2.5%) = 3.5%

4 contributions (2.5%) + 10-19 questions answered (1%) = 3.5%

Anything less than the above: 0%

Failure to participate by the midterm: 0%

^f 2-stage midterm: consists of individual, followed by group using IF-AT cards (<http://www.epsteineducation.com/home/>). Group grade will only be used if it is no lower than the individual grade. **Students writing in SAS need to talk to Dr. Keenleyside ASAP.** Any high quality questions from PeerWise repository will considered for inclusion.

^g cumulative 2-stage final exam (with IF-AT cards). Group grade will only be used if it is no lower than the individual grade. **Students writing in SAS need to talk to Dr. Keenleyside ASAP.** Any high quality questions from PeerWise repository will considered for inclusion.

Important Dates

➤ these are also identified in the Courselink calendar

	DATE	DESCRIPTION
1	Wed. Sept. 23	Lecture quiz 1
2	Wed. Oct. 7	Lecture quiz 2
3	Mon. Oct. 12	Thanksgiving – no classes
4	Tues. Oct. 13	Fall Study Break day
5	Wed. Oct. 21	PeerWise contribution deadline 1
6	Fri. Oct. 23	2-stage midterm PeerWise answers deadline 1
7	Wed. Nov. 4	Lecture quiz 3
8	Fri. Nov. 6	40 th class day – drop deadline
9	Wed. Nov. 25	Lecture quiz 4
10	Wed. Dec. 2	PeerWise contribution deadline 2
11	Fri. Dec. 4	Last lecture (rescheduled from Oct. 12) PeerWise answers deadline 2
12	Sat. Dec. 12 (2:30-4:30)	2-stage final exam

Course and University Policies

a. UNIVERSITY POLICIES

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, and be prepared to provide supporting documentation. See the undergraduate calendar for information on regulations and procedures for

Academic

Consideration: <http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

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 Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: <http://www.csd.uoguelph.ca/csd/>

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:

<http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

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.

Drop Date

The last date to drop one-semester courses, without academic penalty, is the 40th class day. To confirm the actual date please see the schedule of dates in the Undergraduate Calendar. For regulations and procedures for Dropping Courses, see the Undergraduate Calendar:

<http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

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.

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.

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 Centre for Students with Disabilities (soon to be re-named Student Accessibility Services) as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or refer to the [CSD website](#). The standard statements are available on the [AVPA website](#) (undergraduate courses) or from the Office of Graduate Studies (Graduate Courses).

B. INSTRUCTOR POLICIES

Grading

1. *Midterm* - students who miss the *midterm* write an 80% (cumulative) final exam. For students who **DO** write the midterm, but perform better on the final, the midterm grade will be dropped and the grade weight transferred to the final exam.
2. *Lecture quizzes* - online, available for 24h, best 3 of 4. Students who fail to write 1 quiz will have their quiz grade calculated from the 3 remaining quizzes. Students who fail to write more than 1 quiz and wish an adjustment to their distribution of marks are required to provide documentation in support of academic consideration.
3. *Collaborative tests* (midterm & final exams) - the individual grade will contribute 100% of that grade item if higher than the collaborative component. Students who choose to write the individual component only will similarly have that count as 100% of that grade item. *Students registered with SAS* may a) write early so that they can join the class for the collaborative portion, or b) write a 100% individual test or c) get the class average of the group test as their group component.

Student responsibilities

1. Student conduct:
 - a. Students will work collaboratively on clicker questions and for the group components of the midterm and final exams. They are expected to contribute to all group discussions and to be respectful of their group members and their ideas.
 - b. Technology in the classroom: you are welcome to bring your laptop to lectures, but only use it for activities related to this course and in a manner that will not disturb those around you. Turn your cell phone on silent, and do not text-message during class.

C. CAMPUS RESOURCES

The Academic Calendar is the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs:

<http://www.uoguelph.ca/registrar/calendars/index.cfm?index>

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

- make an appointment with a program counsellor in your degree program.

<http://www.bsc.uoguelph.ca/index.shtml> or

<https://www.uoguelph.ca/uaic/programcounsellors>

If you are struggling to succeed academically:

- 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/>

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/>

If you have a documented disability or think you may have a disability:

- The Centre for Students with Disabilities (CSD) can provide services and support for students with a documented learning or physical disability. They can also provide information about how to be tested for a learning disability. For more information, including how to register with the centre please see: <https://www.uoguelph.ca/csd/>