Environmental Microbiology – MI322
Module Information – Read this document!

Coordinator: Dr Gavin Collins (GC)

Welcome to your module on Environmental Microbiology. In this module, our objective is to bring microbiology alive for you in terms of the natural and built environment.

This module aims to provide an understanding of the phylogenetic, and metabolic diversity, as well as the energy conservation strategies and metabolic flexibility, of microorganisms in the Environment. Students will contextualise this in terms of the major biogeochemical cycles in Nature, as well as the industrial exploitation of element cycling for waste treatment and other aspects of environmental management. Students will consider how molecular microbial ecology is applied to understand metabolic interactions between microbes in the environment.

It will comprise approx. 14 h of lectures. It will also include 9 h of practicals (delivered in 3 sessions) focused on detecting microbes in environmental samples.

We'll consider how the hugely diverse (and, often, flexible) metabolism of the planet's smallest organisms:

- shapes entire ecosystems;
- underpins the nature, and pace, of cycling of Life's major essential elements and nutrients;
- affects, and protects our health and the quality of our environment;
- and is applied in the world's single biggest biotechnology – wastewater treatment.

To get there, we need to consider some demanding concepts around:

- how microbes make their 'living' (i.e. how they make, and conserve, their energy, which they use to 'grow' i.e. multiply)
- the tools used for modern (molecular) microbial ecology
- and the processes underpinning nutrient cycling in nature.

The module will be delivered by Gavin Collins (GC) and Alma Siggins (AS) (lectures), and Mike Coughlan, Ann Smyth (laboratory classes), with assistance from Simon Mills, Neyaz Khan, Victor Birlanga and Marco Prevedello. As far as possible, we will convey to you our passion for this area of science, which is the basis for much of the interests Dr Siggins and I pursue with our postgrads and postdocs in our research. We hope you'll be inspired by the material, and that you'll find it as interesting and engaging as we do.

Here, you'll find:

Section 1: MI322 Lecture Timetable

Here is an overview of the schedule. You are STRONGLY advised to attend ALL of the lectures: we will be discussing the topics – not just reading the slides! – so you must attend to understand the basis of the material and the nuances of the concepts and science involved. It is also not easy to pick-and-choose topics to study, as we'll most likely intertwine these topics in the exam questions (you have been warned!).

*Dates format: day/month. Lectures start on 4th March and finish on 30th March 2020.

Lecture	Date*	Focus	Lecturer
1	W, 4/3	Introduction to the module; learning objectives and outcomes. Important concepts	GC
2	Th, 5/3	Microbial Metabolism 1	GC
3	M, 9/3	Microbial Metabolism 2	GC
4	T, 10/3	Microbial Metabolism 3	GC
5	W, 11/3	Microbial Metabolism 4	GC
6	Th, 12/3	**Microbial Ecology 1**: plate count anomaly; gene fingerprinting	AS
7	M, 16/3	**Microbial Ecology 2**: high-throughput DNA sequencing; concept of 'systems biology'; the scope of the 'molecular toolbox'.	AS
8	W, 18/3	***Biogeochemistry 1***: Carbon cycling	AS
9	Th, 19/3	***Biogeochemistry 2***: Nitrogen cycling	AS
10	M, 23/3	**Water quality microbiology.** Introduction to the microbiology of the water infrastructure – where environmental protection, public health and water quality collide.	AS
11	T, 24/3	**ENVIRONMENTAL BIOTECHNOLOGY 1:** Introduction to biological wastewater treatment.	GC
12	W, 25/3	**ENVIRONMENTAL BIOTECHNOLOGY 2:** Biological nutrient recovery from waste	GC
13	Th, 26/3	**ENVIRONMENTAL BIOTECHNOLOGY 3:** Anaerobic digestion technology	GC
14	M, 30/3	Q & A, and Discussion session. *Come with questions: we'll discuss them in this forum.*	GC/AS

Lectures will start on-the-hour and finish 10 minutes to-the-hour. Please be on time.

Mondays	12-1pm	MRA201 –Ryan Institute Lecture Theatre (MRI Annex)
Tuesdays	2-3pm	AM250 – Colm Ó hEocha Theatre
Wednesdays	12-1pm	AM200 – Fottrell Theatre
Thursdays	9-10am	AM200 – Fottrell Theatre

Section 2: Summaries of each of the MI322 lectures

Lecture 1 *4th March 2020*
Introduction to the module; learning objectives and outcomes.
The first life and cells on Earth. Overview of microbial morphology (cell anatomy), metabolic diversity and phylogenetic diversity.
Overview of important concepts in Environmental Microbiology:

- modes of living;
- energy conservation;
- the Great Plate Count Anomaly;
- and the Central Dogma of Biology.

Preview of themes we'll cover and how we want you to try to weave them together.

Lecture 2 MICROBIAL METABOLISM 1 *5th March, 2020*
Detail on metabolic diversity. An introduction to the Winogradsky column and the early biogeochemists. An introduction to biogeochemistry.
Autotrophy, phototrophy and primary production.
An introduction to:

- energetics;
- microbial eclectrochemistry;
- and electron transfer in electron transport chains.

Lecture 3 MICROBIAL METABOLISM 2 *9th March, 2020*

- Photosynthesis by microbes: photoheterotrophy oxygenic photoautotrophy.
- Anoxygenic photosynthesis. What does this mean for nature?
- The relationship between production and consumption.

Lecture 4 MICROBIAL METABOLISM 3 *10th March, 2020*

- Microbial aerobic respiration. Alternative electron acceptors; the anaerobic world. Fermentation; anaerobic respiration. Chemolithotrophy, CO2 fixation
- Examples of chemolithotrophic groups
- Importance of chemolithotrophs in nature; Energetics strategies – how, and why, are 'fit' microbes fit?

Lecture 5 MICROBIAL METABOLISM 4 *11th March, 2020*

- The Winogradsky column and the influence of metabolism on ecology.
- Strategies for energetics – how, and why, are 'fit' microbes fit?
- The link between metabolisms and genes – why are they important?
- A brief preview of Dr Abram's lectures on microbial ecology.
- And, a question: *what if there were no microbes?* (we'll examine a recent paper that asks just that).

Lecture 6 Microbial Ecology 1 *12th March, 2020*
An introduction to microbial ecology. DNA fingerprinting: who is there?

Lecture 7 Microbial Ecology 2 *16th March, 2020*
DNA fingerprinting and introduction to systems biology. DNA: who is there?; microbial diversity; RNA and proteins: who is doing what?; metabolites: who is doing what with whom? The rest of the molecular toolbox: a tool for every question….but you must know what the question is!

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17th March is a Public Holiday and there won't be a lecture

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Lecture 8 THE CARBON CYCLE *18th March, 2020*
How carbon is recycled through geological and biological systems and the role of microorganisms in carbon cycling.

Lecture 9 THE NITROGEN CYCLE *19th March, 2020*
How nitrogen is recycled through geological and biological systems and the role of microorganisms in nitrogen cycling.

Lecture 10 WATER QUALITY MICROBIOLOGY *23rd March, 2020*
Introduction to the microbiology of the water infrastructure – where environmental protection, public health and water quality collide.

- The 'faeco-oral route of infection' and an overview of 'water-associated' diseases, with a focus on 'water-borne' diseases.
- Concepts: biochemical oxygen demand and eutrophication: why discharging untreated wastes and wastewaters comes at a cost to the environment.

Lecture 11 *24th March, 2020*
ENVIRONMENTAL BIOTECHNOLOGY 1:
Introduction to biological wastewater treatment.
Why should we 'treat' wastes and wastewaters? What is sewage? The microbiology of conventional biological treatment treatment of municipal wastewaters:

- collection;
- primary sedimentation and the generation of primary sewage sludge;
- secondary treatment by aerobic respiration and activated sludge digestion, with BOD removal and nitrification;
- the need for tertiary treatment and nutrient recovery;
- the incorporation of anaerobic digestion technologies;
- an overview of the complexity of sewage treatment

Lecture 12 *25th March, 2020*
ENVIRONMENTAL BIOTECHNOLOGY 2:
Biological nutrient recovery from waste.
A focus on nutrient recovery from wastewaters.

- Why, and how, it's done;
- Nitrification; denitrification; luxury phosphorus uptake;
- Integrating nutrient recovery into sewage treatment and BOD removal;
- New frontiers: anammox (anaerobic ammonium oxidation); comammox; aerobic granules; gas treatment (oxidation) systems.

Lecture 13 *26th March, 2020*
ENVIRONMENTAL BIOTECHNOLOGY 3:
Anaerobic digestion technology:

- Microbial trophic groups involved
- Sustainable technology
- Applications

Lecture 14 *30th March, 2020*
Q & A, and Discussion.
A joint session with GC & AS. Discussion on weaving together the major themes of this module, and what this means for how you should study the material and prepare for your assessment. Questions and discussion from you will be welcomed at this session!

Lecture content and slides
All lecture slides, links and additional/suggested reading information will be posted on Blackboard. Keep an eye out for alerts/announcements on Blackboard and please check your NUI Galway email at least once a day.

Recommended textbooks for MI322
In addition to understanding the lecture slides content, and the notes you'll take during lectures and practicals, you should also consult one/both of the following books:

- **Brock Biology of Microorganisms** by Michael T. Madigan *et al.* (latest edition)

and/or

- **Microbiology: an evolving science** by Slonczewski & Foster. Published by Norton.

Some copies are available in the library.

Section 3: Information, and timetable, for MI322 practical sessions

You will have **nine** hours of practical work as part of the MI322 module. The topic will be molecular microbiology and genetic engineering for environmental microbiologists.

After this set of practicals, you'll understand how to perform a variety of mainstay techniques in molecular biology, including: preparing and running agarose gel electrophoresis; transformation of bacteria with ligated plasmid DNA; determination of cloning efficiencies; and polymerase chain reaction (PCR).

Here's how it works:

- The 3rd year Microbiology class has been divided into three groups: A, B & C.
- Check your assigned group (A, B or C) on the notice board in Microbiology.
- All MI322 practicals: 3rd yr lab (Room 222, Corrib Wing, Biochemistry
- *Times are:* Tuesdays 3–6pm and Thursdays 10am–1pm

The timetable for each group is:

GROUP A	GROUP B	GROUP C
10am, Thurs, 13th Feb	3pm, Tues, 25th Feb	10am, Thurs, 5th March
3pm, Tues, 18th Feb	10am, Thurs, 27th Feb	3pm, Tues, 10th March
10am, Thurs, 20th Feb	3pm, Tues, 3rd March	10am, Thurs, 12th March

Other important dates:

- Teaching term ends: 4th April, 2020
- Study week: 14th – 20th April, 2020
- Exams: 21st April – 8th May, 2020

Section 4: MI322 Attendance – marks and penalties

You should attend:

- all scheduled lectures
  AND
- all practical classes scheduled for your group (A, B or C)

Attendance will be recorded:

- …using Blackboard's *Qwickly* for lectures
- …using a roll call for practical sessions (you must attend the correct session)

Marks for attendance (and penalties for absences):

- You will receive marks for attendance (and full participation in, and contribution to) the practical sessions
- There will not be any marks awarded for attendance at lectures
    - **However,** marks awarded for attendance at the MI322 practicals will be penalised for any 'uncertified' absences from MI322 lectures (i.e. you will lose a percentage of your MI322 practical class attendance marks based on the number of such uncertified absences from MI322 lectures)
    - (For example, and for your information, it is our view that it would be unreasonable, and considered unacceptable, for you to attend an MI322 practical so as to get attendance marks but miss the MI322 lecture immediately previously on the same day!)

Certified absences

- Students taking any of the 3rd year Microbiology modules are requested to inform the Microbiology Administrator, Ms Caroline O'Connell (Room 202, upstairs in Microbiology), if they encounter any problems or ill-health resulting in non-attendance during the course of the academic year.
- Students are requested to provide a **copy** of relevant medical (doctor's/hospital/clinic) certificates/notes so as to certify absences.
- **FOR MI322 absences:**
    - You will receive an email after any absence recorded by *Qwickly*
    - If you have a certified absence, and you'd like me to 'excuse' you on *Qwickly* (i.e. reverse your absence), then please inform me (gavin.collins@nuigalway.ie) of your certified absence and send me a copy of your med cert, etc.
        - Equally, if you would like to discuss any related issue with me, please schedule a meeting by e-mailing me.
- **All student matters of this nature will be treated in the strictest of confidence**.

Section 5: MI322 Learning outcomes: what you're expected to be able to do

On completion of the module, students should be able to:

1. Explain the basis for microbial energy conservation and metabolic diversity
2. Identify microbial roles in productivity and degradation;
3. Explain the roles microbes play in carbon and nitrogen cycling;
4. Describe the harnessing of microbial metabolisms for environmental biotechnologies,
5. Discuss tools used for microbial ecology;
6. Critically discuss '[eco]systems [micro]biology' based on combining 'omics

Section 6: Exam: details; continuous assessment; advice/tips

1. Our top tip – pay attention during lectures, as we plan to – where possible – critically discuss the topics. You will be asked to **demonstrate** your understanding; **explain** concepts; and **discuss** topics, so it's important that you can take our lead

on doing this. At this stage in your degree, we are looking for some maturity of thought, so the standard is higher than for your modules in second year.

2. The marks available for your lab sessions (attendance; daybooks; presentations; formal reports) amount to 30% of the marks for this module (That's your continuous assessment component). Thus, 70% of the marks for MI322 are available you're your exam – therefore, it really is all to play for with these lectures.

3. There will be two sections (**A** and **B**) on your end-of semester exam paper. There will be two questions in each section. You are required to attempt **one** question from **section A** and **one** question from **section B**.

Tips:

- Do not attempt more than one question from either section: you will waste time and will **only gets marks for one (your better) question** from any section! Even if we wanted to, we **cannot** and **will not** award marks for two answers from the same section!
- Therefore, think carefully at the outset about which questions you'll attempt; make a decision and stick with it
- If you're unsure about which questions to attempt, quickly map out what you would include for each answer – write a quick list. Don't spend too long on this, but it may help you make the right decision.
- When you have decided on your questions, then my advice is to list out the points you're going to cover, so that you don't forget about any important information.
- Read the question CAREFULLY! (Then read it several more times!) As you read it, identify exactly what is being asked! Make sure that you consider all of the parts of the question!
- Questions may be multi-part questions (e.g. answer parts (i) and (ii), or they may be presented as a 'statement', which you're asked to discuss.
- Pay attention to the verb(s) used in the question – are you being asked to **explain; discuss; compare;** etc?

Examination grades

A	= 70 - 100%	1ST CLASS HONOUR
B	= 60 - 69%	2ND CLASS GRADE 1 HONOUR
C	= 50 - 59%	PASS
D	= 40 - 49%	PASS
E+	= 35 - 39%	FAIL
E-	= 30 - 34%	FAIL
F	= 0 - 29%	FAIL

Section 7: Information about progressing to 4th year Microbiology

Progression to the final-year (Honours) B.Sc. degree in Microbiology is on the basis of performance in the Third University Examinations in Science. Students on our main BSc degree (GY301 or "undenominated") will be asked in March of Year 3 to indicate their preferred subject for Year 4. Students will be offered a place in a Year-4 programme based on the following:

- Students are **not necessarily guaranteed their first choice of subject.**
    - If a student achieves **45% overall in the first sitting** of his/her [overall] third-year examinations, **he/she will be guaranteed** his/her first choice of subject.
    - If a student achieves **less than 45% overall** in his/her third-year

examinations or **achieves 45% (or greater) only after a second [or subsequent] sitting,** he/she will be allocated a subject from one of the major subjects taken in third year. **This may not be their preferred subject.**

**Note there are no quotas imposed by the Discipline regarding the number of students gaining entry into 4th year Microbiology. However, owing to the high demand for 4th year Microbiology the 45% rule – described above – will be strictly implemented.*

Section 8: Contribution of your overall 3rd yr marks to your final degree

Your overall degree result will be based on:

- 70% of your 4th year results

AND

- 30 % of overall results from the 3rd Science examinations

Section 9: Your feedback – to help us with quality control

We will ask you to complete a very **short survey about MI322** toward the end of the semester. I'd really appreciate your help in getting a high response rate to the survey – your answers will be completely anonymous and it won't be possible to trace them back to you.