Course memo for BB2560: Advanced Microbiology and Metagenomics

VT24 – last updated 2024-01-16.

This advanced course provides training on the methods used for microbial community analysis including recent innovations in metagenomics, metatranscriptomics, metaproteomics, and functional metagenomics. Students will investigate a series of case studies of meta-omic analysis of environmental and human-associated microbial communities.

This year, we plan for the whole course to take place in person. Nonetheless, there are still several winter viruses circulating and we do not want illness to break out. If you feel unwell during the course you must stay home and inform the responsible teacher Lauren McKee (mckee@kth.se) immediately. The wet lab project is important, but if you have to miss lab days because of sickness, we will find an alternative assignment for you, so please stay home if you're ill! Get tested for Covid-19 if you have any relevant symptoms, and follow current guidelines to reduce your risk of infection. –Thank you.

Important course dates

2024-01-16 Course starts at 08:00-10:00 in room FB53, AlbaNova building. You will receive a general introduction into the course and the lab project. You will be asked to look for a lab partner and sign up for one of the scheduled lab sessions as soon as possible.

2024-01-19 We have a mandatory workshop on how to give and receive constructive feedback via peer review, at 13:00-15:00 in room FB53. This will teach important skills you will need for the rest of the course and beyond!

2024-01-26 Students present proposals for the wet lab project so we can plan the sample collection field trip! Room FB53, 13:00-15:00.

2024-01-22 Last day to pass the online **Quiz1** for the R programme. This is **mandatory** to pass the **LAB1** assignment.

2024-01-23; 2024-01-29; 2024-01-30 Computer exercises, Introduction to analysing metagenomic data in R. This is called "First R exercise (LAB1)" on Canvas. You will have to attend one of these sessions, depending on whether you join lab group A, B, or C. You will work in pairs for the exercise, and write a joint report for the **LAB1** assignment. The report will comprise written answers to 16 questions about the R computer exercise. The report is **mandatory**, and we strongly recommend you attend at least the start of the session, but you are welcome to work on your own to complete the exercise.

2024-02-02 Last day to pass online **Quiz2** that tests your pre-reading of the wet lab protocols. This is **mandatory** to complete the **TEN1** assignment.

2024-01-30; 2024-02-13; 2024-02-27 Student peer teaching and discussion sessions for the **mandatory ÖVN1** assessment. All sessions are compulsory for all students to attend.

2024-02-05 Sample collection field trip – details to be determined.

2024-02-06; 2024-02-07; 2024-02-08 Wet lab sessions for DNA extraction and PCR for the **TEN1** exam project. You must attend one of these sessions, depending on whether you join lab group A, B, or C. You will work in pairs for the lab work, but you will write individual reports for the **TEN1** assessment.

2024-02-12 Last day to pass the online **Quiz3** that tests your fundamental knowledge from Ander's module introducing key metagenome concepts.

2024-02-12 Submission deadline for the **LAB1** assignment (report on Introduction to R exercise). You will receive feedback from teaching assistants by 2024-02-15, and be able to submit a corrected version by 2024-02-18.

2024-02-16 Study visit to the NGI facility at SciLifeLab.

2024-02-21; 2024-02-22 (morning); 2024-02-22 (afternoon) Data analysis labs for the **TEN1** project. You will have to attend one of these sessions, depending on whether you join lab group A, B, or C. You should work alone for the computer lab work, because you will write individual reports for the **TEN1** assessment.

2024-02-28 Deadline for first submission of the **TEN1** lab reports. You will read each other's reports and offer peer review. These lab reports will be graded and represent your final exam.

2024-03-04 Deadline for submitting peer review comments on another person's lab report.

2024-03-06 Deadline for submitting response to peer review on your **TEN1** lab reports.

Course contents and goals

Course contents

Recent years have seen an explosion of large datasets generated on microbial communities in natural and industrial environments, thanks to advances in metagenomics and related technologies. These new data can give insight into human health and disease, or the fitness of a natural environment. In addition, these data can inform biotechnological interventions into the microbiota for improved digestion or food production, or can be a source of new industrially relevant enzymes.

The course will cover five key themes:

T1. Introduction to advanced microbiology, and metagenomic methodology.

T2. Metagenomics for enzyme discovery in biotechnology.

T3. The human microbiome – roles in health and disease.

T4. Current and emerging methods for microbial diagnostics in the clinical setting.

T5. The environmental microbiome – function and metagenomic monitoring approaches.

Intended learning outcomes

After completion of the course, the student shall have:

Knowledge and understanding to:

- Describe how metagenomics can be used to diagnose environmental and human health, (TEN1)
- Explain and investigate the roles of microbes in natural ecosystems, (TEN1)
- Explain the roles of the human microbiota in health and disease, (TEN1)
- Understand and use the R programming language to analyse a metagenomic dataset (LAB1)

Skills and abilities to:

- Plan and conduct a microbial community analysis, including a full work-flow from sampling to DNA extraction and *in silico* data analysis, with discussion of safe sample handling, (LAB1)
- Explain how metagenomics can be used for enzyme discovery, (TEN1)

Values and approaches to:

- Evaluate and discuss the ethical challenges related to metagenomic analysis of the human microbiome (LAB1, ÖVN1)

After passing the course, the student shall demonstrate profound understanding of selected microbial ecosystems, and be able to design experiments and use meta-analysis in different microbiology applications. For higher grade (A-D) the student must demonstrate deeper understanding of the subject and the highest ability to apply knowledge of experimental techniques within a complex context.

Format of the course

Each theme in the course will present 2-3 class sessions of lectures and exercises. The exercises will involve mandatory student-led discussions and short presentations on current research topics. In addition, a lab project will be undertaken throughout the course. At the end of the course, students will submit a lab report on their work, which will serve as their final examination. This course presents a reasonable workload for a master's level programme, and students will take part in a varied range of activities.

Connection to degree programme goals

This course provides a range of analytical skills that are essential to modern biotechnology, and is of direct relevance to the topics studied in both the Medical Biotechnology programme and the Industrial & Environmental Biotechnology programme.

Language of instruction

English

Detailed schedule

In VT-2024 we intend to pursue in-person education for all course moments. **If you feel unwell during the course you must stay home and inform the responsible teacher Lauren McKee (**mckee@kth.se**) immediately.**

The lab project for this course will require use of the statistical programme R. We will provide an online quiz to test your knowledge of this programme before you start work on your lab project. The quiz can be taken on Canvas.

For T2, T3, and T5 of this course, we will hold student-led peer teaching exercises. Students will work in small groups to read a scientific paper in detail, then present that paper to the whole class in sufficient detail, so that everyone feels they have read the paper. Each group will present just once during the course. The presentations for T2 will be held on January 30th. The presentations for T3 will be held on February 13th. And the presentations for T5 will be held on February 27th. Full details for these exercises will be provided on Canvas. Students who are unable to attend these compulsory presentation sessions will be required to submit alternative written assignments.

For T4 of this course, there will be a mandatory discussion session that all students must take part in, reading a provided article in advance to prepare for the session.

The final examination for the course will be the **TEN1** lab report. Students will work in pairs for the lab exercises, but **must submit individual lab reports**. These will be graded, and you will have only one chance to submit. If you fail, there will be a chance to take a timed written exam in the summer, which will cover the content of the course lectures.

Key concepts

Metagenomic sequencing. Microbial communities. Microbiome. Microbiota. Enzyme discovery from sequencing data. Enzyme application in industry. Community sequencing for clinical diagnostics. Community sequencing for environmental monitoring.

Course literature and preparation

Recommended prerequisites

You should have completed basic courses in Microbiology. The course is currently only open to KTH students.

Equipment needed

For the data analysis part of the lab report, you will be allowed to work from home and use your own computer with the R programme. Computers on campus will be provided during the scheduled data analysis labs for those students who cannot install R on their own computers. We are providing information on Canvas to help you install the necessary software on your own computers.

Required reading

Scientific articles, web resources, and lecture handouts will be provided during the course. Review articles that provide background information on the different themes will be provided at least one week prior to the first class on that theme. There is no textbook for this course.

Disability and accessibility

If you have accessibility or disability issues, please inform the course leader so we can know how best to help you learn. You should contact Funka to make sure you have the support you need:

https://www.kth.se/student/studentliv/funktionsnedsattning

Examination and completion of the course

Grading scale

LAB1 - Laborationskurs (**R programme skills and data lab report**), 2.5, grading scale: P, F

TEN1 – Tentamen (**wet lab project report**), 4.0, grading scale: A, B, C, D, E, FX, F

ÖVN1 – Övning (**in-class exercises**), 1.0, grading scale: P, F

Other requirements for final grades

Students are required to PASS the LAB1 assignment and to PASS the in-class exercises (ÖVN1) in order to pass the course. Students are also required to PASS the final exam (TEN1) to pass the course. The final grade a student achieves is determined by their result on **TEN1**.

Examiner

Anders Andersson

Ethical approach

In group work, everyone in the group is responsible for all tasks performed. On examination (e.g. in written reports), each student must honestly report help received and sources used. The final **TEN1** lab report is an individual assignment, and students MUST work alone to do the writing, even though wet lab tasks and some data analysis tasks in the computer labs may be performed in pairs. "Writing" includes preparing data for visualisation, finding publications to cite, planning the content of the report, and all actual writing work. Reports that are too similar will raise suspicions over collaboration and/or cheating, and you will be dropped down a grade or fail the assignment.

Goal-related grading criteria

As students are required to attain a 'pass' for LAB1 and ÖVN1, final grades for the course are determined by the grade achieved on TEN1: E – basic fulfilment of every objective; A – excellent fulfilment of every objective. There are four assessment criteria for TEN1, as shown in this table. Your final grade will be determined as an average of the grade you achieve for each criterion.

TEN1 assessment criteria	Fx	F	E	C	A
Introduction to report ILO: Plan and conduct a microbial community analysis, with discussion of safe handling and ethical concerns.	Student participates in the lab but is unable to complete a lab report due to unavoidable circumstances e.g. illness supported by a doctor's note. A make-up report can be submitted and graded later.	Student does not participate in the lab, and/or does not submit a report, without any justification.	The aims of the project are stated but poorly explained.	The aims of the project are described in some detail but with little or no reference to literature.	The aims of the lab project are clearly explained with reference and comparison to existing literature that the student has found independently.

| Description of methods

ILO: Plan and conduct a microbial community analysis, with discussion of safe handling and ethical concerns.	Student participates in the lab but is unable to complete a lab report due to unavoidable circumstances e.g. illness supported by a doctor's note. A make-up report can be submitted and graded later.	Student does not participate in the lab, and/or does not submit a report, without any justification.	The methodology is presented as more or less a copy of the lab protocol, without additional detail or discussion.	The methodology is written in the student's own words with some additional detail compared to the lab protocol, but there is no connection to literature. There is no or insufficient mention of sample collection and storage.	The choice of methodology is supported by reference to literature the student has found independently. The report includes a discussion of how samples were collected and stored safely and in an ethical way.
Presentation of results

ILO: Explain and investigate the roles of microbes in natural ecosystems such as soils | Student participates in the lab but is unable to complete a lab report due to unavoidable circumstances e.g. illness supported by a doctor's note. A make-up report can be submitted and graded later. | Student does not participate in the lab, and/or does not submit a report, without any justification. | The data generated are presented in poorly prepared or insufficient numbers of figures/tables, and/or poor choice of type of data visualisation. | There are some good figures/tables and text describing the results but they lack quality, clarity, or creativity in some respects. | Figures are chosen well and produced in high quality. Data are presented in a clear, appropriate, and professional way. Innovative means of data presentation or highlighting are in evidence. |
| Discussion of results

ILO: Explain and investigate the roles of microbes in natural ecosystems such as soils | Student participates in the lab but is unable to complete a lab report due to unavoidable circumstances e.g. illness supported by a doctor's note. A make-up report can be submitted and graded later. | Student does not participate in the lab, and/or does not submit a report, without any justification. | There is no or limited discussion of what the data mean. | There is some discussion of what the data mean, but this is not well connected with literature. Conclusions may be limited to describing how well the study was performed. | The data generated in the lab project are discussed in detail, with extensive reference to the literature the student has found independently. Conclusions are scientific in nature, and may give recommendations for future work. |

If you fail (F) you will be offered a timed written examination (5 hr) based on the contents of the lectures in the course. If you have a provable illness and do not submit a report (Fx) you will be given another chance to submit the report when you are well. You must submit the report the same year you do the lab exercise – it is not possible to "plussa" this examination by writing the report a year after taking the course.

For LAB1, students will take a Canvas-based quiz about the programme R, take part in a data analysis computer exercise ("First R exercise"), and write a short report about their findings.

LAB1 assessment criterion	F	P
Demonstrate understanding of and ability to use the R	The student does not complete the online quiz, and/or does not take part in the	The student takes part in the Introduction to R computer labs, and writes a full report answering all

programme for analysis of a metagenomic dataset.	Introduction to R computer labs, and/or does not submit a report. **OR:** the report submitted is largely incorrect.	questions. The student also passes the online quiz.

Students will contribute to in-class presentation and discussion exercises. Students will read articles related to a certain theme, and share their findings with the class.

ÖVN1 assessment criteria	F	P
Explain the roles of human microbiota in health and disease.	The student does not take part in the exercise.	The student reads the assigned article, and participates in group work and the presentation, OR submits a summary report to Canvas if they miss the class session.
Explain with examples from the literature how metagenomics can be used for enzyme discovery.	The student does not take part in the exercise.	The student reads the assigned article, and participates in group work and the presentation, OR submits a summary report to Canvas if they miss the class session.
Discuss with reference to literature how new antibiotics can be discovered.	The student does not take part in the exercise.	The student reads the assigned article, and participates in discussions in class, OR submits a summary report to Canvas if they miss the class session.
Explain with examples from literature how sequencing can be used to study plants and the environment	The student does not take part in the exercise.	The student reads the assigned article, and participates in group work and the presentation, OR submits a summary report to Canvas if they miss the class session.

Other information

Learning platform

The course will be delivered and administrated via Canvas. Contact studentexpedition@biotech.kth.se with questions about admittance and registration.

Responsible teacher

Lauren McKee. Contact me at mckee@kth.se with any questions about the course.

Teachers

Lauren McKee, Anders Andersson, Gunaratna Kuttuva Rajarao. Contact us via Canvas with questions during the course. You can also feel free to email us.

Course evaluation and analysis

At the end of the course, students will complete an evaluation of the course. This will be used for future development and improvement of the course. You are invited to give detailed feedback on any and all aspects of the course. Your comments help us to improve the course every year.