Course memo for BB2560: Advanced Microbiology and Metagenomics

VT22 – last updated 2022-01-17

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, the wet labs will go ahead in person, but lectures and exercises will take place online via Zoom. 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

2022-01-18 Course starts at 0815 online in Zoom. All subsequent lectures (föreläsningar) and exercises (övningar) will also be online. Zoom links will be added to the Canvas Schedule page.

2022-01-24 Last day to pass the online skills quiz for the R programme. This is **mandatory** to pass the **LAB1** assignment.

2022-01-25; 2022-01-31; 2022-02-01 Introduction to analysing metagenomic data in R computer exercises. This is called "First R exercise (LAB1)" in the schedule page on Canvas. You will have to attend one of these online 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** assessment. 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 online session, but you are welcome to work on your own to complete the exercise.

2022-01-28 Students present proposals for the wet lab project so we can plan the sample collection field trip!

2022-02-01; 2022-02-15; 2022-03-02 Student peer teaching presentations for the **mandatory ÖVN1** assessment. All sessions are compulsory for all students to attend.

2022-02-07 Sample collection field trip – details to be determined.

2022-02-08; 2022-02-09; 2022-02-10 Wet lab sessions for DNA extraction and PCR 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 will work in pairs for the lab work, but you will write individual reports for the **TEN1** assessment.

2022-02-14 Submission deadline for the **LAB1** assignment (report on Introduction to R exercise).

2022-02-23; 2022-02-24; 2022-02-25 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 will work in pairs for the lab work, but you will write individual reports for the **TEN1** assessment.

2022-03-17 Main assignment deadline: submission of the lab reports, which form the **TEN1** assessment. These lab reports will be graded and represent your final exam.

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 analyze 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 2-4 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-2022 we will be following safety guidelines regarding the Covid-19 pandemic, and will aim to maintain social distancing at all times. Apart from the wet lab sessions and the sample collection field trip, all course moments will be online, and we strongly recommend that you stay home to attend the online sessions. **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, and the deadline to complete the quiz will be January 24th.

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 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 February 1st. The presentations for T3 will be held on February 15th. And the presentations for T5 will be held on March 2nd. Full details for these exercises will be provided on Canvas soon. Students who are unable to attend these compulsory presentation sessions will be required to submit alternative written assignments.

The final examination for the course will be the lab report. Students will work in paris for the lab exercises, but will submit individual lab reports. These will be graded, and you will have only one chance to submit. If you fail, there will be a make-up examination in the summer.

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 R exercises and the data analysis part of the lab report, you will be asked 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 few students who cannot install R on their own computers, but we insist that as many students as possible stay home for this work, to keep the number of students on campus low, so we can stay safe and comply with Covid-19 social

distancing guidelines. We will arrange a session 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 report from data lab**), 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 the group's work. On examination, each student must honestly report help received and sources used. At oral examination, each student should be able to account for the entire assignment and the entire solution.

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, and can be defined like this: 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 external circumstance.	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.
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 external circumstance.	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 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 external circumstance.	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 or clarity in some respects.	Figures are chosen well and produced in high quality. Data are presented in a clear, appropriate, and professional way.
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 external circumstance.	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.	The data generated in the lab project are discussed in detail, with extensive reference to the literature.

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. Details will follow.

LAB1 assessment criterion	**F**	**P**
Demonstrate understanding of and ability to use the R programme for analysis of a metagenomic dataset.	The student does not complete the online quiz, and/or does not take part in the Introduction to R computer labs, and/or does not submit a report. **OR:** the report submitted is largely incorrect.	The student takes part in the Introduction to R computer labs, and writes a full report answering all 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, participates in group work and the presentation, and submits a summary report to Canvas.
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, participates in group work and the presentation, and submits a summary report to Canvas.
Explain with examples from literature how sequencing can be used to study plants and the environment		

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, Meike Latz.

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.