Course memo for BB2560: Advanced Microbiology and Metagenomics

<u>VT20</u>

This 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-omics analysis of environmental and human-associated microbial communities.

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 (OVN1)

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, OVN1)
- 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, OVN1)

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 two lectures and one exercise. The exercises will involve mandatory student-led discussions, short presentations on current research topics, or peer teaching exercises. In addition, a lab project will be undertaken throughout the course. At the beginning of the course, students will work together and with their teachers and teaching assistants to design metagenomic investigations of their chosen environment. They will sample microbial community DNA from a real-world setting, and sequence the DNA of this community for their course research project. At the end of the course, students will submit a lab report on their work. This course presents a reasonable work load 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

Attendance at the first lecture session on January 15th is mandatory. Here we will introduce the course contents and activities in detail, and we will begin as a class to discuss your plans for the lab project. We will present the different types of microbial environment you might want to study by metagenomic sequencing, and help you begin to formulate some project ideas. On January 23rd, student groups will present their project ideas and select one or two environments for the whole class to visit on a sampling trip.

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 deadline for this quiz will be January 20th.

We expect to have a high number of students on this course, and so the class will be divided into two groups for the lab work. The sampling trips will take place on January 27th (for lab Group A) and January 30th (for lab Group B). Group A will perform DNA extraction and other experimental steps on January 28th and 29th. Group B will perform the same tasks on February 5th and 6th.

For T2 and T3 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 class in sufficient detail that everyone feels they read the paper. We will use your presentations to write questions for the final exam. The presentations for T2 will be held on February 4th. The presentations for T3 will be held on February 11th. Students who are unable to attend these compulsory presentation sessions will be required to submit alternative written assignments.

The final exam will be held on March 10th, and there will be a possibility to take a re-exam on June 5th.

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.

Equipment needed

For the data analysis part of the lab report, you may use your own computer with the R programme, but computers will be provided during the scheduled data analysis labs.

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.

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 (**lab project**), 2.5, grading scale: P, F

TEN1 – Tentamen (**final exam**), 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 (lab report) and to PASS the in-class exercises (OVN1) 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 the lab report and exercises, final grades for the course are determined by the grade achieved on the final exam, and can be defined like this: E – basic fulfilment of every objective; A – excellent fulfilment of every objective.

In the lab experiments, students will collect a sample relevant to their interest (i.e. medical biotechnology or environmental biotechnology). They will extract DNA and perform a metagenomic study of the microbial community. The lab report will be submitted a short time later (likely 1-2 weeks), and should give a full accounting of their experimental design, supported by scientific literature. They should present their results and critically analyse the success of the experiment, including suggestions for improving their methods. We will assess students on experimental design, choice of methodology, quality of data generated, execution of laboratory work, and depth of discussion in the written report.

Lab Report assessment criteria	**F**	**P**
Explain and investigate the roles of microbes in natural ecosystems such as soils	Student does not participate in the lab, and/or does not submit a report. **OR:** The lab report contains no discussion of the meaning or relevance of the data generated.	The data generated in the lab project are discussed in detail, and with reference to the literature.
Plan and conduct a microbial community analysis, with discussion of safe handling and ethical concerns.	Student does not participate in the lab, and/or does not submit a report. **OR:** The student follows a simple protocol as given, but offers no explanation of the methods utilised, and shows no understanding of the techniques involved. The lab report includes no discussion of safe and ethical handling of samples.	The aims of the lab project are clearly explained. The choice of methodology is supported by reference to literature. **AND:** The report includes a discussion of how samples were collected and stored safely and in an ethical way.

Students will participate in in-class exercises, each followed by a short submission to Canvas. Students will read articles related to a knowledge theme, and share their findings with the class. This is a peer teaching exercise, as we will create exam questions based directly on these student presentations.

Exercises 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.
Discuss the societal and scientific challenges associated with antimicrobial resistance.	The student does not take part in the exercise.	The student submits a question for the guest speaker, takes part in in-class discussions, 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.

Students will take a final exam that tests their knowledge on all five themes. The exam will consist of two parts, described below. Students must be given advance awareness of the grading criteria for the exam, especially so that they understand that they need to pass both parts of the exam.

- **Part A**, multiple choice (P/F). Two multiple-choice questions from each theme, for a total of ten questions. Students must achieve at least 60 % correct answers to PASS part A.
- **Part B**, extended written answers (A-F). One question from each theme (may have multiple parts) requiring longer written answers (short sentences/paragraphs or longer mini-essays). The final exam grade (A-F) will be determined by the student's score on part B.

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.

In the previous course round, some students mentioned that they found the work-load at the end of the course too heavy, and that the lab reports required too much work. We have therefore reduced the scope of the lab report and taken some of that work into a computer exercise at the beginning of the course. Some students also mentioned that they struggled with using the computer programme R during the lab project, so we have added an extra training quiz on R, which you will complete at the beginning of the course.