# Course memo for CB1030 Theory and Methodology of Science with Applications in Biotechnology

2021, period 1, TIMBM (Master programme, Industrial and Environmental Biotechnology) year 1 of Batch HT21, TMBIM (Master programme, Medical Biotechnology) year 2 of Batch HT20.

## 1. Content and learning outcomes

### Course content *

Topics covered by the course.

- Scientific knowledge
- Hypothesis testing
- Observations and measurements
- Experiments
- Models
- Statistical reasoning
- Causes and explanations
- Research ethics

### Intended learning outcomes *

After completion of the course, the student should have:
Knowledge and understanding to:

- Identify definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories.
- Account for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases.

Skills and abilities to:

- Apply concepts and theories to examples from the field of biotechnology and conduct a critical discussion of the methodology of examples of biotechnology research

Values and approaches to:

- Critically discuss the definitions and applications of concepts and theories to specific cases of scientific research.

## 2. Teaching team

The course is developed through collaboration between the Philosophy division from ABE school and the CBH school. The teachers are Johan Berg (johan.berg@abe.kth.se), Martin Rissler (mrissler@kth.se), Henrik Lundvall (henrik12@kth.se), Adam Lundström Ramirez (adamlr@kth.se), Amparo Jimenez Quero (amparojq@kth.se), and Qi Zhou (qi@kth.se). The course responsible is Amparo Jimenez Quero and the examiner is Qi Zhou. If you have any questions regarding the course, please send email to Amparo Jimenez Quero

(amparojq@kth.se) and Qi Zhou (qi@kth.se). For specific question about the lectures content please contact Adam Lundström Ramirez (adamlr@kth.se).

## 3. Language of instruction

The course round is given in English - knowledge of Swedish is not required, teaching language, course information and examination are in English. Swedish terminology may be included in the course.

## 4. Schedule and Information

All course material (readings, assignments, instructions, link to Zoom class, etc.) can be found on the course page in Canvas. Canvas is also where you do all quizzes and submit all assignments.

The course schedule is available through TimeEdit at www.kth.se/schema, and at the student web and on your personal pages. These schedules include lecture (online), seminar (campus with classroom location), and exam information (home exam). The detail teaching activities with schedule, teacher names, and location are also listed in section 7 in this course memo.

For those who need help with exam registration, course registration or re-registration, please contact the student office or via email (studentexpedition@biotech.kth.se).

## 5. Lectures

In the lectures, important course concepts are introduced, explained, and discussed. By preparing for and attending the lectures, you are therefore also preparing for the seminars and the home exam. There are 1 online (Zoom) introduction lecture on how the course is structured and how intended learning outcomes are assessed, 8 pre-recorded online video lectures, and 2 online (Zoom) flipped classroom sessions. Most pre-recorded lectures are given by Prof. Till Grüne-Yanoff. The online course introduction lecture and two online flipped classroom sessions are given by Qi Zhou and Amparo Jimenez Quero.

8 pre-recorded lectures and associated quizzes

1. Scientific knowledge
2. Scientific inferences
3. Observation and measurement
4. Experiments
5. Models
6. Statistics
7. Explanations and causes
8. Research ethics

The video lectures are all segmented into several parts. They are available via Canvas and you can watch them at any time. To make it easier for you to plan your studies, we have indicated time slots in the schedule for when it might be suitable to watch them.
For each video lecture, there is an associated quiz, testing your understanding of the content.

## 6. Seminars (1.5 credits)

There are five online seminars (Zoom). The seminars target some of the topics introduced in the lectures. In the seminars, you will practice at engaging with these topics independently and in-depth, working in smaller groups with tasks provided by the teacher. At the end of the seminar, you and your peers will discuss your and other groups' suggested solutions to the tasks. You will be divided in 3 groups, Group A, Group B, and Group C, with ca. 26 students in each group. Please go to course Canvas page (under "People" and "Seminar Group") and register yourself to one of the 3 groups. Each group will be in a different Zoom classroom, please check in section 7 in this course memo.

The seminars will be graded as Pass/Fail. To pass each seminar, you must do the following things:

- Read the assigned literature, watch the assigned videos, attend the relevant lectures, re-read the slides etc.
- Successfully complete the assigned seminar preparation quiz by getting minimum 14 points before your seminar. If you attend the seminar without having passed the seminar quiz, you will not be marked as attending and will have to re-take the seminar.
- Be prepared for in-class discussion of questions relating the course concepts.
- Be prepared to answer oral questions relating to the core concepts listed for each seminar (see below).
- Actively participate on the seminar by discussing with the teacher and your peers.

If you fail to do any of the above tasks, you will not get registered attendance for the seminar. Instead you should do written compensations.

In preparation for the seminar, make sure you understand and can account for, exemplify, and discuss the course concepts below. The teacher might ask you to answer questions such as "What are some differences between stipulative and lexical definitions?", "Give an example of an operationalization.", or "Does it matter if we use vague terms in a scientific hypothesis?"

In preparation you should also prepare answers to discussion questions relating the course concepts.

The seminar is a learning environment, but it also examines the oral aspect of the course intended learning outcomes. You should be able to account for the meaning of the seminar concepts, at the start of the seminar. However, do not worry if you think something is complicated or hard to understand. We primarily expect you to show that you have studied the material and tried to get a grasp of it.

You find more information about each seminar below and in the course memo. Texts are found in the Files-section.

### 6.1 Seminar 1 – Definitions, Operationalizations and Hypotheses

Texts

- Grüne-Yanoff, Till – Experiments, Models and Methodology: part 1, 2, 3, 12
- Hansson, Sven Ove – Art of Doing Science: sections 2.2-2.8, 3.1-3.2, 5.0-5.1, and 5.8

Concepts that you will be expected to be able to explain when you attend the seminar:

- Stipulative and lexical definitions
- Narrowness and broadness (as applied to definitions)
- Vagueness
- Hypotheses (and their quality criteria)
- Direct, aided and indirect observation
- Operationalization
- Accuracy and precision (as qualities of observations and measurements)
- Measurement error (random and systematic error)
- Convergent validity and divergent validity

Prepare answers for classroom discussion questions:

- You will get a few preparatory questions in a Canvas announcement before the seminar. Prepare answers for these to discuss with your assigned group at the seminar.

Quiz – on Canvas

## 6.2 Seminar 2 – Designing a scientific study

Texts

- Grüne-Yanoff, Till - Experiments, Models and Methodology, part 4
- Hansson, Sven Ove – Art of Doing Science: sections 3.7, 4.2-4, and 5.1-3

Concepts that you will be expected to be able to explain when you attend the seminar:

- Experiment, observational studies, and simulations
- Mill's method of difference
- Internal validity and external validity
- Experimental control
- Constancy, elimination, and effect separation
- Randomization
- Control group and treatment group
- Observer influence
- The interpretation problem
- Blinding

Prepare answers for classroom discussion questions:

- You will get a few preparatory questions in a Canvas announcement before the seminar. Prepare answers for these to discuss with your assigned group at the seminar.

Quiz – on Canvas

## 6.3 Seminar 3 – Interpretation, analysis and evidence

Texts

- Hansson, Sven Ove – Art of Doing Science : sections 1.6-7, 3.7, 3.9, 5.3-5, 5.7, 7, 8 and the box on p. 24
- Grüne-Yanoff, Till - Experiments, Models and Methodology: part 6, 7
- "Seminar 3 Cases", see below.

Concepts that you should be able to explain:

- Repeatability, reproducibility, and replicability
- Statistical evaluation (p-value, significance level, control group)
- Causal explanation

- Deductive-Nomological account of explanation
- Correlation and causality
- Hypothetico-Deductive method for hypothesis testing
- Duhem-Quine thesis
- Falsificationism (Popper)

Prepare answers for classroom discussion questions:

- You will get a few preparatory questions in a Canvas announcement before the seminar. Prepare answers for these to discuss with your assigned group at the seminar.

Quiz – on Canvas

## 6.4 Seminar 4 – Research ethics

Texts

- ”On Being a Scientist: Responsible Conduct in Research“, National academy of Sciences
- Ahlin, Jesper, “Ethical Thinking”
- Grüne-Yanoff, Till - Experiments, Models and Methodology, part 11
- Hansson, Sven Ove - Art of Doing Science: Section 9

Concepts that you should be able to explain:

- Gift authorship and ghost authorship
- Informed consent
- Falsification, fabrication, and plagiarism
- Precautionary principle
- Descriptive/normative distinction
- Deontology, consequentialism, and virtue ethics

Prepare answers for classroom discussion questions:

- You will get a few preparatory questions in a Canvas announcement before the seminar. Prepare answers for these to discuss with your assigned group at the seminar.

Quiz – on Canvas

## 6.5. Seminar 5 – critical discussion of examples of biotechnology research

In the 5th seminar, you will evaluate cases of scientific studies in the biotechnology field by using methodological concepts and considerations. After the seminar you should be able to apply the seminar concepts to an example case of biotechnology research, as well as critically discussing such cases from a methodological perspective.

<u>Perform an Empirical Study</u>

Your task is to design a master thesis project including hypothesis (scientific question), intended methods (methodology/kind of study), expected outcome, and some expected data analysis. Draft your project design on the answer sheet during your group discussion. Try to consider all the following questions when designing your study.

1.Does the hypothesis for the master thesis good according to the quality criteria? How to improve? Any auxiliary hypothesis?

2.Account for the operationalizations of the features of interest in the case. How to make a good operationalization. What type of study (experiment and/or simulation experiment) will you implement? In case of simulation experiment, can you explain how could you test it?

3.How would you design your experiments in this project? What is your expected outcome? How could you test the internal and external validity of your design?

4.Do you need a control in your experiment? Could randomization be used in your experiment and for what purpose? Should blinding be implemented in your study and why?

5.Which kind of experimental errors (artefacts) can appear? How could you reduce them?

## 7. List of teaching and learning activities, schedule, and location

| **Date/time** | **Activity** | **location** | **teacher** |
|---|---|---|---|
| Mon 30/8 15-17 | Course introduction and Lecture 1. Introduction and scientific knowledge | Zoom<br><br>Canvas/video | Amparo /Qi |
| Fri 3/9 10-12 | Lecture 2. Scientific inferences | Canvas/video | Pre-recorded |
| Mon 6/9 13-15 | Lecture 3. Observation and measurement | Canvas/video | Pre-recorded |
| Wed 8/9 15-17 | Lecture 4. Experiments | Canvas/video | Pre-recorded |
| Fri 10/9 10-12 | Lecture 5. Models | Canvas/video | Pre-recorded |
| Mon 13/9 13-15 | Seminar 1 | Zoom:<br><br>Group A<br><br>Group B<br><br>Group C | <br>Henrik<br><br>Martin<br><br>Johan |
| Wed15/9 10-12 | Lecture 6. Statistics | Canvas/video | Pre-recorded |
| Fri 17/9 10-12 | Lecture 7 & 8. Explanations and causes/Research ethics | Canvas/video | Pre-recorded |
| Mon 20/9 13-15 | Seminar 2 | Zoom:<br><br>Group A<br><br>Group B<br><br>Group C | <br>Henrik<br><br>Martin<br><br>Johan |

| | | | |
|---|---|---|---|
| Wed 22/9 10-12 | Flipped classroom session 1 | Zoom | Amparo/Qi |
| Thu 23/9 8-10 | Seminar 5 | Zoom:<br>Group A | Amparo/Qi |
| Wed 29/9 8-10 | Seminar 5 | Zoom:<br>Group B | Amparo/Qi |
| Wed 1/10 10-12 | Seminar 5 | Zoom:<br>Group C | Qi/Amparo |
| Mon 4/10 13-15 | Seminar 3 | Zoom:<br>Group A<br>Group B<br>Group C | Henrik<br>Martin<br>Johan |
| Fri 8/10 10-12 | Flipped classroom session 2 | Zoom | Amparo/Qi |
| Fri 15/10 13-15 | Seminar 4 | Zoom:<br>Group A<br>Group B<br>Group C | Henrik<br>Martin<br>Johan |
| Wed 27/10 14-18 | Exam (Home exam) | Canvas/Quiz | Qi/Amparo |
| Mon 21/12 8-12 | Re-exam (Home exam) | Canvas/Quiz | Qi/Amparo |

## 8. Home exam (2 credits)

The final part of the course is a home written exam. More information will be available on the course page in Canvas. The exam consists of two parts. The first part of the exam primarily tests your ability to account for, or describe, course concepts as well as the ability to apply these concepts to biotechnology example cases. This part contains two questions of this nature and invite brief essay style answers. The second part of the exam is intended at testing your ability to critically analyse and discuss course concepts and their application. You will be asked to evaluate a summary of some hypothetical scientific research in the field of biotechnology. You do this by pointing out and discussing strengths and weaknesses of the presented case, and by motivating why these are strengths and weaknesses, as well as by suggesting, and provide justification for, possible improvements.

The home exam will be graded as Pass/Fail. The grade criteria can be found in section 12 of this course memo. No submission or a failed submission will result in grade Fail.

## 9. Course literature

The course literature consists in slides from the video lectures, the course manuscript "Experiments, Models and Methodology" by Till Grüne-Yanoff, which is adapted from the lectures, and some supplemental articles and text. "The Art of Doing Science" by Sven Ove Hansson is optional reading treating the same topics as "Experiments, Models and Methodology".

- Introduction and Scientific Knowledge
    - Grüne-Yanoff - Experiments, Models and Methodology, part 1
    - Video Lecture Slides - Background for Introduction Lecture
    - *Optional: Sven Ove Hansson The Art of Doing Science, Chapters 1, 2 and 9.*
- Scientific Inferences
    - Grüne-Yanoff - Experiments, Models and Methodology, part 2
    - Sven Ove Hansson The Art of Doing Science, Chapter 5
    - Video Lecture Slides - Scientific Inferences
- Observation and Measurement
    - Grüne-Yanoff - Experiments, Models and Methodology, part 3
    - Video lecture slides - Observation and measurement
    - *Optional: Sven Ove Hansson The Art of Doing Science, Chapter 3*
- Experiments
    - Grüne-Yanoff - Experiments, models and methodology, part 4
    - Video Lecture Slides - Experiments
    - *Optional: Sven Ove Hansson The Art of Doing Science, Chapter 4*
- Models
    - Grüne-Yanoff - Experiments, models and methodology, part 5
    - Video Lecture Slides - Models
- Statistics and How to Interpret It
    - Grüne-Yanoff - Experiments, models and methdology, part 6
    - Video Lecture Slides - Statistics
- Explanations and Causes
    - Grüne-Yanoff - Experiments, models and methodology, part 7
    - Video Lecture Slides - Explanations and Causes
    - *Optional: Sven Ove Hansson The Art of Doing Science, Chapter 7 & 8*
- Research Ethics
    - Grüne-Yanoff - Experiments, models and methodology, part 11
    - Excerpt from National Academy of Sciences et al., On Being a Scientist: Responsible Conduct in Research
    - Jesper Ahlin, Ethical Thinking
    - Video Lecture Slides - Research Ethics

## 10. Disabilities

If you have a disability, you can get support through Funka:
https://www.kth.se/student/studentliv/funktionsnedsattning

In addition, inform the course responsible if you have special needs since Funka does not automatically inform the teacher. Then show the certificate from Funka.

## 11. Examination and completion

### Grading scale *

P, F

### Examination *

- HEM1 - Written home exam, 2.0 credits, Grading scale: P, F
- SEM1 - Seminars, 1.5 credits, Grading scale: P, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students. The course is examined with seminars and a written home exam.

If the course is discontinued, students may request to be examined during the following two academic years.

### Other requirements for final grades *

In order to pass the course, **active participation in lectures (correctly complete all quizzes to the video lectures) and a pass for seminars and an approved (pass) written home examination are required.**

### Examiner

Qi Zhou (qi@kth.se)

### Ethical approach *

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.

## 12. Grading criteria

### 12.1. Exam

Grades (P, F) for intended learning outcomes (ILOs) are shown in the table below.

| Intended learning outcomes | Grade | |
|---|---|---|
| | P | F |

| | | |
|---|---|---|
| Identify definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories. | *The student identifies **multiple** definitions and descriptions of concepts, theories, and problem areas, and identifies the correct application of these concepts and theories.* | *The student identifies at most a few definitions and descriptions of concepts, theories, and problem areas, or does not identify the correct application of these concepts and theories*. |
| Account for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases. | *The student provides **mostly correct and satisfactory** accounts of concepts, theories, and general problem areas, and provides **acceptable applications** of these concepts and theories to specific cases.* | *The student's accounts of concepts, theories and general problem areas are (substantially or completely) **incorrect or missing**. The student's applications of those concepts and theories are **largely incorrect or missing**.* |
| Apply concepts and theories to examples from the field of biotechnology and conduct a critical discussion of the methodology of examples of biotechnology research | *The student provides **acceptable applications** of concepts and theories to biotechnology field and presents a discussion of the definitions and applications of concepts and theories as they apply to specific cases of biotechnology research **without substantial errors or contradictions.*** | *The student's applications of those concepts and theories are **largely incorrect or missing** and the discussion presented by the student is **unclear, wrong, or contradictory**.* |
| Critically discuss the definitions and applications of concepts and theories to specific cases of scientific research. | *The student presents a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research **without substantial errors or contradictions.*** | *The student **does not present** a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research, or their discussion is **unclear, wrong, or contradictory**.* |

## 12.2. Seminars

For a passing grade, the student should orally provide…

- identifications of definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories.
- accounts for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases.
- critical discussions of the definitions and applications of concepts and theories as they apply to specific cases of scientific research.

## 12.3. Study techniques and the ILOs

The intended learning outcomes (below) are a great help in understanding what is required of you in your studies, so it might be a good idea to take some time to consider what they mean, and how to best fulfil them.

1. *Identify definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories*.

One learning outcome is to be able to *identify* terms and concepts related to the course. A main course component is the terminology used – and there are a lot of words to learn. We think the best way is to create your own word list, starting from lecture one or the first course text and then continue to write down every concept that is important in the course. Write down the meaning and the definition of the term and how it is used in the context. If you know all the course terms and what they mean, you have come a long way in learning what you are to know after finishing the course.

2. *Account for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases.*

However, just saying the right words doesn't get you all the way. You also need to be able to explain what they mean and how to use them. You can start with the word list you made before, and add after the formal definition an account of what it means. We think a good way is to give a pedagogical explanation: if you can explain something to someone else, you probably have good knowledge of what it means. The words are supposed be used in practice to communicate with others, so the final part of this learning outcome is being able to apply the concepts to a practical situation you have not seen before. Work with a friend, and come up with a situation you think a certain concept can be applied. You can take inspiration by analysing research in your own field. Show it to your friend and see if you friends agrees and applies it in the same way. If you disagree – discuss! You are always welcome to contact any of the teachers to explain it further.

3. *Critically discuss the definitions and applications of concepts and theories as they applies to specific cases of scientific research.*

The final part of the three intended learning outcomes that are common to all course codes, is being able to critically discuss the definitions and applications. An important part of the course – and philosophy in general – is to be able to take a step back and reflect on the words and concepts, and discussing exactly what they mean and how they should be applied. Philosophy is, at least to some degree, an activity, something that you do, and in this case you are to show that you are capable of performing a discussion of these concepts. A discussion features presenting arguments for or against one position and attempting to evaluate the strength of this argument, by comparing it with other arguments. This is something you will practice in the seminars, but one way to practice for yourself is to take one of the concepts and the definition and try to find one case where the definition does not hold. Another way is, of course, to discuss with others.

| **Intended learning outcomes** | **Seminars** | **Home exam** |
|---|---|---|

| | | |
|---|---|---|
| Identify definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories. | *x* | *x* |
| Account for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases. | *x* | *x* |
| Apply concepts and theories to examples from the field of biotechnology and conduct a critical discussion of the methodology of examples of biotechnology research | | *x* |
| Critically discuss the definitions and applications of concepts and theories to specific cases of scientific research. | *x* | *x* |