Course memo for BB2165 Biomolecular structure and function HT21

Course contents

The structure and function of biomolecules (structural biology) is a cornerstone in modern biotechnology. The course aims offer deepened theoretical and practical knowledge about the relationship between structure and function of macromolecules. The focus is on proteins and nucleic acids, as well as biomolecules that are functionally relevant to the macromolecular systems that are being addressed.

In medical biotechnology, the relationship between the structure and function of proteins is an important basis for modern drug development, and in industrial biotechnology, the use and rational design of enzymes for sustainable bioprocesses are widely implemented approaches.

Structural biology is a young science and research in this area is moving forward rapidly. The precise topics and exercises covered are subjects of change to appropriately reflect the research frontier. Topics covered in the course range from the foundations of macromolecular structure to experimental and theoretical methodology of structure determination and validation, and the application of knowledge about structure-function relationship.

Intended learning outcomes

After completion of the course the student should be able to

- Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.
- Based on knowledge and concepts acquired during the course, be able to propose, discuss and evaluate strategies for answering scientific questions in biology and biotechnology related to the structure and function of biomolecules.
- Use computer software tools and relevant databases to visualize, examine, analyze, evaluate and validate structures and function of macromolecules.
- Design, plan, implement and present in written and oral form an independent project in the field of biomolecular structure and function. A key aspect is to be able to critically evaluate one's own and others' chosen strategies for solving scientific problems from a biomolecular structure perspective. This also includes being able to evaluate and discuss biomolecular structure based on its importance for sustainable development.

Add-on

The course is mandatory for students admitted to the master's programs Industrial and Environmental Biotechnology and Medical Biotechnology.

Course literature

Recommended literature: Brändén C, and Tooze J., Introduction to Protein Structure, 2nd Ed. Garland Publishing Inc., 1999.

Other material: Handouts and selected articles.

Equipment

Personal computer for online elements.

Examination

LAB1 – Laboratory work, 1,5 hp, grades: P, F

LIT1 – Literature task, 2,0 hp, grades: P,F

TEN1 – Written exam, 4,0 hp, grades: A, B, C, D, E, FX, F

The written exam (TEN1) consists of two parts. The first part (part A) covers fundamental concepts in structural biology and is examined up to grade E. The second part covers more advanced knowledge such as strategies, critical analysis and evaluation (part B), and is graded up to grade A. To pass the written exam requires at least grade E on both parts.

Opportunity for supplementary examination is possible for a student that has received grade FX on the written examination. For computer exercises and project, complementary examination of a failed grade is only possible after consulting the examiner and is conditioned by practical circumstances.

It is possible to raise an already approved grade provided that this is done at a scheduled examination occasion.

The laboratory part (LAB1) is examined by mandatory active attendance during the computer exercises and a written report that is handed in at the end of the exercise, or at the time decided by the examiner.

The project (module LIT1) is presented at the end of the course in the form of a written report, peer review of another student's report, and a short oral presentation. Parts of the project are expected to be performed outside class.

Examiner

Christina Divne, divne@kth.se

Course coordinator and teacher

Christina Divne, divne@kth.se

Examination of learning outcomes

Learning outcome	TEN1	LAB1	LIT1	LIT1
1. Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.	X	X	X	X
2. Based on knowledge and concepts acquired during the course, be able to propose, discuss and evaluate strategies for answering scientific questions in biology and biotechnology related to the structure and function of biomolecules.	X	X	X	X
3. Use computer software tools and relevant databases to visualize, examine, analyze, evaluate and validate structures and function of macromolecules.		X	X	X
4. Design, plan, implement and present in written and oral form an independent project in the field of biomolecular structure and function. A key aspect is to be able to critically evaluate one's own and others' chosen strategies for solving scientific problems from a biomolecular structure perspective. This also includes being able to evaluate and discuss biomolecular structure based on its importance for sustainable development.		X	X	X

Possible grades for learning outcomes

Learning outcome	E	D	C	B	A
1. Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.	X	X	X	X	X
2. Based on knowledge and concepts acquired during the course, be able to propose, discuss and evaluate strategies for answering scientific questions in biology and biotechnology related to the structure and function of biomolecules.	X	X	X	X	X
3. Use computer software tools and relevant databases to visualize, examine, analyze, evaluate and validate structures and function of macromolecules.	X				
4. Design, plan, implement and present in written and oral form an independent project in the field of biomolecular structure and function. A key aspect is to be able to critically evaluate one's own and others' chosen strategies for solving scientific problems from a biomolecular structure perspective. This also includes being able to evaluate and discuss biomolecular structure based on its importance for sustainable development.	X				

Criteria for grades

Learning outcome	Criteria for grade E
1. Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.	The student can describe a number of the concepts in structural biology covered during the course at a basic and mostly correct level.
2. Based on knowledge and concepts acquired in the course, be able to propose, discuss and evaluate the role of biomolecular structural biology to advance understanding of biological and biotechnological scientific problems.	The student can suggest at least one strategy for a given problem that is in theory realistic but not necessarily entirely optimal, complete and/or correct. The student knows that structural biology can be used to target biological and biotechnological scientific problems, and can give at least one relevant example.
3. Use computer software tools and relevant databases to visualize, examine, analyze, evaluate and validate structures and function of macromolecules.	The student can use the computer softwares and databases used in the course to visualize and investigate macromolecular structure information. The student can also perform basic analysis and evaluation of structure information and validate the models using relevant validation criteria.
4. Design, plan, implement and present in written and oral form an independent project in the field of biomolecular structure and function. A key aspect is to be able to critically evaluate one's own and others' chosen strategies for solving scientific problems from a biomolecular structure perspective. This also includes being able to evaluate and discuss biomolecular structure based on its importance for sustainable development.	The student is able to apply course knowledge to read, understand and analyze a biomolecular structure. The student hands in on time a written report that is in most parts correct and reasonably well formulated from a factual and linguistic perspective. The student is also able to give an oral presentation that highlights the most important messages of the project. The student is able to reflect and formulate questions on other students' project presentations. When presenting, the student is able to provide feedback to the questions raised.
Learning outcome	**Criteria for grade C**
1. Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.	The student can describe most of the concepts in structural biology covered during the course correctly, and formulate questions and hypotheses relating to structural biology, as well as performing simpler evaluation and validation of structural biology information.
2. Based on knowledge and concepts acquired in the course, be able to propose, discuss and evaluate the role of biomolecular structural biology to advance understanding of biological and biotechnological scientific problems.	The student can suggest and motivate, at least one strategy for a given problem that is in theory realistic and correct. The student is able propose and discuss, at a basic level, at least one relevant example of how structural biology can be used to target a specific scientific problem.
Learning outcome	**Criteria for grade A**
1. Explain in detail, formulate, analyze and evaluate fundamental concepts in structural biology.	The student can describe correctly most of the concepts in structural biology in detail. The student shows an excellent ability to assimilate, integrate and evaluate structural biology information, and can easily extrapolate and existing knowledge to new problems and situations.
2. Based on knowledge and concepts acquired in the course, be able to propose, discuss and evaluate the role of biomolecular structural biology to advance understanding of biological and biotechnological scientific problems.	The student can suggest different strategies for a given problem, and motivate why a particular strategy is realistic and correct. The student is also able to discuss and evaluate own and others strategies form a critical perspective. The student is able to propose, discuss and evaluate a number of examples of how structural biology can be used to target specific scientific problems. The student can also from existing knowledge propose own solutions to new problems.

Course disposition

The course comprises approximately 200 full-time study hours, which corresponds to 7,5 ECTS credits. The course uses an interactive pedagogical concept to enhance and deepen the perception and understanding of 3D structure and structure-function relationships. To achieve this, lectures are intimately coupled to self-studies using interactive computer exercises known as kinetic images (kinemages) where structures can be viewed and analyzed in 3D. Acquired theoretical and practical knowledge and skills are further consolidated by each student performing a project that runs throughout the course. Additional details about the course disposition can be found in the course memo for this course offering.

Course structure for the autumn 2021

As of July 2021, the President of KTH has decided that education during the autumn semester should be conducted as on-campus teaching with certain restrictions regarding the extent of attendance in the lecture and exercise rooms. A lecture rooms may be filled to one third of its capacity, and an exercise room up to half of its capacity.

Lectures

The first half of the lecture on August 30 will provide important course information, followed by the actual lecture. The course information is mandatory but not the lecture. Since a large number of students is expected, the first lecture is given online in Zoom.

Other lectures will be given on campus (Albanova) up to 1/3 of the capacity of the lecture room, which means that if a majority of the students wish to attend the lectures on-campus, a schedule will be needed to allow students to take turn. All lectures will be pre-recorded and available in the course canvas for those who are not able to come to Albanova. For practical reasons, the lectures will not be streamed online when given on campus, and each pre-recorded lecture will be made available in canvas for viewing at the scheduled time for that lecture.

Exercises (LAB1, 1.5 credits)

There are three mandatory exercises (E1, E2, E3). The exercises are given on campus in the computer room RB33 at Albanova. Because of the restrictions regarding attendance (max half of the places), each exercise is given at four separate occasions (occasion A-D). It is mandatory to attend one of these occasions for each exercise E1-E3. Each scheduled occasion is two hours and some homework will be required. A brief written report is required for each mandatory exercise. One exercise session (Sep 24, 15:00-17:00) will be offered online due to RB33 being unavailable that time.

Project (LIT1, 2.0 credits)

There is a mandatory structure project running over the entire course. There are three mandatory scheduled sessions for the project work (P1, P2, P3). The project sessions are given on campus in the computer room RB33 at Albanova. As for the exercises, each project session is given at four separate occasions (occasion A-D). It is mandatory to attend one of these occasions for each project session P1-P3. Each scheduled occasion is two hours. A considerable part of the structure project is also performed outside scheduled hours.

The project includes writing an individual project report, peer-reviewing one other student's report, presenting the project at the end of the course and also acting opponent on the presentation of the peer whose report has been peer-reviewed. The presentations take place during three days at the end of the course (S1, S2, S3). Each presentation session is three hours and it is only mandatory to attend one of these sessions (S1, S2 or S3), which is the day of ones own presentation.

All presentations are held online in Zoom. For the presentations, students are divided into smaller groups (breakout rooms) with 8-10 students in each virtual room. Each student then presents their work only to those in that group.

Course canvas

All study material and information will be available in the course canvas. The canvas opens at the course start.

Detailed schedule for the autumn 2021

August 30
- 13:00-15:00 Course information. Mandatory.
  Lecture L1 - Fundamentals of protein structure I (Zoom).

September 1
- 08:00-10:00 Lecture L2 - Fundamentals of protein structure II (FD5)
- 13:00-15:00 Exercise E1 (group A) - Fundamentals of protein structure (RB33)
- 15:00-17:00 Exercise E1 (group B) - Fundamentals of protein structure (RB33)

September 2
- 10:00-12:00 Lecture L3 - Folding and stability (room FD5)
- 13:00-15:00 Exercise E1 (group C) - Fundamentals of protein structure (RB33)
- 15:00-17:00 Exercise E1 (group D) - Fundamentals of protein structure (RB33)

September 7
- 10:00-12:00 Lecture L4 - Folding diseases, amyloids (FD5)
- 13:00-15:00 Project P1 (group A) - Project work (RB33)
- 15:00-17:00 Project P1 (group B) - Project work (RB33)

September 9
- 10:00-12:00 Lecture L5 - Experimental macromolecular structure determination (FD5)
- 13:00-15:00 Project P1 (group C) - Project work (RB33)
- 15:00-17:00 Project P1 (group D) - Project work (RB33)

September 15
- 08:00-10:00 Lecture L6 - Experimental structure determination cont. and validation (FR4)
- 13:00-15:00 Exercise E2 (group A) - Experimental map analysis and validation (RB33)
- 15:00-17:00 Exercise E2 (group B) - Experimental map analysis and validation (RB33)

September 16
- 10:00-12:00 Lecture L7 - Biomolecular structure and function I: Immune-system proteins and viruses (FD5)
- 13:00-15:00 Exercise E2 (group C) - Experimental map analysis and validation (RB33)
- 15:00-17:00 Exercise E2 (group D) - Experimental map analysis and validation (RB33)

September 23
- 10:00-12:00 Lecture L8 - Biomolecular structure and function II: Nucleic-acid-binding proteins (FD5)
- 13:00-15:00 Project P2 (group A) - Project work (RB33)
- 15:00-17:00 Project P2 (group B) - Project work (RB33)

September 24
- 10:00-12:00 Lecture L9 - Biomolecular structure and function III: Signal transduction (FD5)
- 13:00-15:00 Project P2 (group C) - Project work (RB33)
- 15:00-17:00 Project P2 (group D) - Project work (Zoom)

September 29
- 10:00-12:00 Lecture L10 - Structure prediction by homology modeling (FD5)
- 13:00-15:00 Project P3 (group A) - Project work (RB33)

15:00-17:00 Project P3 (group B) - Project work (RB33)

September 30

10:00-12:00 Lecture L11 - Biomolecular structure and function IV: Enzymes for sustainable development (FR4)

13:00-15:00 Project P3 (group C) - Project work (RB33)

15:00-17:00 Project P3 (group D) - Project work (RB33)

October 6

10:00-12:00 Lecture L12 - Biomolecular structure and function V: Fibrous proteins, molecular machines (FD5)

13:00-15:00 Exercise E3 (group A) - Structure prediction by homology modeling (RB33)

15:00-17:00 Exercise E3 (group B) - Structure prediction by homology modeling (RB33)

October 7

10:00-12:00 Lecture L13 - Protein engineering and drug design (FD5)

13:00-15:00 Exercise E3 (group C) - Structure prediction by homology modeling (RB33)

15:00-17:00 Exercise E3 (group D) - Structure prediction by homology modeling (RB33)

October 12

09:00-12:00 Seminar S1 - Project presentations (Zoom)

October 13

13:00-16:00 Seminar S2 - Project presentations (Zoom)

October 14

13:00-16:00 Seminar S3 - Project presentations (Zoom)

October 25

14:00-17:00 Written examination TEN1 (FA31, FA32, FB42, FD41, FP21, FP41)

December 22

14:00-17:00 Written re-examination TEN1 (FB54)