Synthetic and systems biology

Academic Year: (2024 / 2025) **Review date: 24-04-2024**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: QUILEZ LOPEZ, CRISTINA

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is strongly advised to have completed Cell and Molecular Biology, Biochemistry, Bioinformatics.

SKILLS AND LEARNING OUTCOMES

RA3: Be able to carry out conceptual designs for bioengineering applications according to their level of knowledge and understanding, working in a team. Design encompasses devices, processes, protocols, strategies, objects and specifications broader than strictly technical, including social awareness, health and safety, environmental and commercial considerations.
RA4: Be able to use appropriate methods to carry out studies and solve problems in the biomedical field, commensurate with their level of knowledge. Research involves conducting literature searches, designing and carrying out experimental practices, interpreting data, selecting the best approach and communicating knowledge, ideas and solutions within their field of study. May require consultation of databases, safety standards and procedures.
RA5: Acquire intermediate/advanced knowledge of engineering and biomedical sciences and demonstrate an understanding of the theoretical and practical aspects and methodology of work in their field of study.
CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3: Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4: Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5: Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2: Ability to design, draft and develop scientific-technical projects in the field of biomedical engineering.
CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG6: Knowledge of current standards, regulations and legislation and ability to apply them to bioengineering projects. Bioethics applied to biomedical engineering.
CG7: Drafting, representing and interpreting scientific-technical documentation.
CG8: Ability to solve mathematical, physical, chemical and biochemical problems that may arise in biomedical engineering.
CG12: Ability to solve mathematically formulated problems applied to biology, physics and chemistry, using numerical algorithms and computational techniques.
CG14: Acquire a global vision of the basic functioning of biological systems. Ability to model such systems using mathematical and computational tools.
CG16: Ability to handle and mine data obtained through "omics" technologies using bioinformatics techniques. Applications in biology and medicine.
CG17: Ability to apply engineering, micro-engineering, nano and biotechnology techniques to solve

complex biomedical problems in regenerative medicine.
CG18: Ability to apply knowledge of human anatomy and physiology to the resolution of problems in medicine from the point of view of bioengineering. Ability to identify medical problems that can be treated by means of techniques encompassed in Biomedical Engineering.
CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised audiences.
CT2: Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.
CT3: Ability to organise and plan their work, making the right decisions based on the information available, gathering and interpreting relevant data in order to make judgements within their area of study.

OBJECTIVES

Fundamental knowledge and capabilities developed by cellular engineering scientists allows us to move beyond toward systematic mechanisms for predictable modulation of cell proliferation, migration, communication, and the production of small molecules and biologics. Modern biomedical science includes Systems Biology and Synthetic Biology, two new and complementary fields that constitute the basis of innovation. In this course, students will learn about the foundational technologies and theory behind engineering biology. Students will study strategies for engineering cellular and molecular systems as well as, will explore current and future applications for synthetic biology and system biology approaches. Students will study how to build novel synthetic biological systems that solve practical biomedical problems. They will incorporate elements from many different disciplines including chemistry, biology, mathematics, physics and engineering.

DESCRIPTION OF CONTENTS: PROGRAMME

Gene and protein sequencing, gene expression analysis, protein expression and interaction analysis, genomic and proteomic analysis . protein-protein Interaction networks, metabolic networks and disease networks, quantitative tissue analysis, modeling biological systems: synthetic biology circuits, data analysis techniques and clinical computing interfaces.

The course is divided mainly in two parts:

SYSTEMS BIOLOGY AND OMIC TECHNOLOGIES:

- Fundamentals of genomics, proteomics and metabolomics
- How do normal cellular functions such as cellular division, cell activation, differentiation, and apoptosis emerge from the interaction of genes
- How to examine whole cell functions corresponding to observable phenotypes.
- How to generate network reconstructions, followed by the synthesis of in silico models describing functionalities.
- Systems Analysis of Complex Diseases.
- Systems Pharmacology: Understanding Drug Action from a System Perspective.
- Systems Pharmacogenomics: Personalized medicine.

SYNTHETIC BIOLOGY:

- Design and construction of new biological parts, devices, and systems, and the re-design of existing natural biological system for better application.
- Build artificial biological systems for engineering applications.
- Draw powerful techniques for the rapid assembly of DNA.
- Engineer biological system: modify the behaviour of organisms and engineer them to perform new tasks. Create bioengineered microorganisms that can produce pharmaceuticals and repair damaged genes.

LEARNING ACTIVITIES AND METHODOLOGY

The program will be divided into master classes and computer practical classes (cases). Students are required to read or resolve assigned chapters, articles, problems, etc., before the corresponding classes. The seminars will contain the discussion of relevant scientific articles and problems that will be presented by the students.

ASSESSMENT SYSTEM

% end-of-term-examination:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

Teaching methodology will be mainly based on lectures, seminars and practical sessions.
Students may be required to read assigned documentation before lectures and seminars. Lectures will be used by the teachers to stress and clarify some difficult or interesting points from the corresponding lesson, previously prepared by the student.
Grading will be based on two continuous evaluation practices and several exercises, together with a final exam covering the whole subject. Help sessions and tutorial classes will be held prior to the final exam upon student's request.
Attendance to lectures and seminars is not compulsory. However, failure to attend any test will result in a mark of 0 in the corresponding continuous evaluation block (see below).

GRADING:
Total score: 10 points
Continuos evaluation: 5 points out of 10 (project poster 2.5 points, project paper discussion 1.5 points and exercises 1 point)
Final exam: 5 points out of 10
FINAL EXAM: The final exam will cover the whole subject (and may include practical cases) and will account for the 50 % of the final score. The minimum score in the final exam to pass the subject is 4 over 10, not with standing the mark obtained in continuous evaluation.
EXTRAORDINARY EXAM: The mark for students attending any extraordinary examination will be:
a) 100% exam
b) 50% exam and 50% continuous evaluation if it is available in the same course
ACADEMIC CONDUCT: Unless specified all exams will be closed-book, closed-notes, no PC or mobile phone, or anything else other than a writing implement and the exam itself. Plagiarism, cheating or other acts of academic dishonesty will not be tolerated. Any infractions what so ever will result in a failing grade.

BASIC BIBLIOGRAPHY

- Natalie Kuldell PhD., Rachel Bernstein, Karen Ingram, Kathryn M Hart Synthetic Biology in the Lab, BioBuilder, June 2015

- Uri Alon An Introduction to Systems Biology: Design Principles of Biological Circuits , Chapman & Hall/CRC Mathematical and Computational Biology, Jul 2006