Advanced Synthetic Biology Course (22148)

Academic year 2013-14

1. Teaching activity identification

The Advanced Synthetic Biology course is an 4 ETCS optional subject in the Biomedical Engineering degree that will be offered in the first three-month period of the year.

2. Coordination and teaching staff

The teaching activities will be coordinated by Javier Macía. Additional teachers will be Baldo Oliva, Jordi Garcia-Ojalvo, Romilde Manzoni, Carlos Rodriguez-Caso and Raul Montañez. The language of the course will be English, but optionally Catalan and/or Spanish can be used as well.

3. Competences

a. To know the state-of-the-art in synthetic biology at multiple scales, from molecules to multicellular consortia.
b. To know the basic tools for protein engineering.
c. To know the basic tools for metabolic engineering.
d. To know how to design and/or analyze genetic circuits in prokaryote organisms based on transcriptional regulations.
e. To know how to design genetic circuits in eukaryote organisms based on transcriptional and post-transcriptional regulations.

4. General objectives

The teaching project addresses fundamental aspects related with biological elements, at different scales levels (molecules, genes and cells) from an engineering point of view. How to modify natural systems to create synthetic devices is at the core of this course. The students must be able to manage theoretical/computational (dry lab), and experimental (wet lab) tools in order to design and create these new synthetic devices. The main goal of the course is to teach the students in a way that they are able to understand the concepts more than memorize details. It should strengthen their critical thinking and enable them to integrate these concepts with others from different scientific disciplines.

5. Teaching methodology

A main aim of the course is to spark the student's interest and curiosity in Synthetic Biology and related disciplines and to promote their active participation during the lectures

The proposed teaching activities are as follows:

5.1 Lectures

Graphic support will be used in some of the lectures (Powerpoint slides).

5.2 Seminars

Some important topics in Synthetic Biology or technical information will be given within seminars.

5.3 Practical work

Practical work will complement some of the topics learned in the theoretical classes. These practical works will include computational analysis and experimental practices.

6. Course Program (4 ECTS)

6.1 Protein engineering

Basic principles of physics and chemistry applied in biomolecules

Brief introduction to the key elements involved in the structure of proteins and their reactivity.

Protein structure

Introduction to protein structure: from sequence to 3D.

Classification of folds and principles of protein homology.

Protein function associated with folds: biomolecular interactions. Protein docking. Protein-protein and protein-DNA interactions. The protein interaction network.

Protein folding

Statistical potentials of protein folds. Protein design and improvement of fold stability with mutations.

Seminar on protein structure analysis (visualization and evaluation of folds), data storage of protein information and prediction of protein-function.

Protein function and enzyme reactivity

Chemical reactions. Activation energy and transition state. Catalysis and enzymes. Mechanisms of action of enzymes: nucleophilic attack, electrophilic addition and oxidoreduction. The enzyme code.

"Lock and key" model and induced fit. Enzyme specificity and enzyme kinetics. Examples of mechanisms of action: aldolase, proteases, isomerases, kinases.

6.2 Metabolic engineering

Metabolic control flux analysis. Flux Control Coefficients

Metabolic control analysis

Flux Balance Analysis.

Control structures in metabolism. Feedback inhibition, branch pathways, "futile" cycles

6.3 Genetic Circuits in Prokaryotes

Design and synthesis of genes and circuits in Synthetic Biology: software and applications.

Synthetic feedback systems: switches and engineered stability

Synthetic oscillators: the repressilator, activator-repressor circuits

Synthetic quorum sensing circuits: programmed collective behavior, multicellular oscillators

Hybrid synthetic-natural systems: bacterial excitability

Applications of synthetic prokaryotic circuits

6.4 Genetic Circuits in Eukaryotes

How to build genetic circuits in yeast
Logic gates in yeast
Scale up to mammalian cells

Introduction to non-coding RNAs
- Historic overview
- Kinds of ncRNAs
- Characteristics, biogenesis and activities each one
- Rolls in cell physiology and developmental process
- Examples

Application of ncRNAs on circuit designs
- Riboswitches
- microRNAs
- siRNAs
- Examples

7 Evaluation

7.1 Practical works evaluation (35% of the final qualification). The students must present a report for each practical work. Attendance the practical sessions and reports presentation on time are compulsory to pass the course.

7.2 Theoretical evaluation (65% of the final qualification). A test will be performed at the end of the course that will include assay questions related to the concepts studied in the lectures, seminars and practical sessions.