

Academic Year of Degree: 2025/26

## 24050 - Biocomputing

### Teaching Guide Information

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**Academic Course:** 2025/26

**Academic Center:** 337 - Engineering School

**Study:** 3378 - Bachelor's degree in Biomedical Engineering

**Subject:** 24050 - Biocomputing

**Credits:** 6.0

**Course:** 3

**Teaching languages:**

Theory: Group 1: English, Spanish

Practice: Group 101: English, Spanish

Seminar: Group 101: English

**Teachers:** Jorge Garcia Ojalvo, Gustavo Ricardo Deco

**Teaching Period:** First term

### Presentation

*Biocomputing* is a compulsory course of the third year of the BSc Degree in Biomedical Engineering of the Universitat Pompeu Fabra. It consists of 6 ECTS credits, corresponding to 54 hours of face-to-face teaching distributed in 30 hours of theory lectures/seminars and 24 hours of practical work. The main objective of the course is to present the basic principles that govern the processing of information in living systems, from the level of biomolecules to the brain.

### Associated skills | General learning outcomes

Generic competences:

- Ability to be critical and self-critical
- Ability to plan and manage time
- Capacity to generate new ideas (creativity)
- Ability to search for, process and analyse information from a variety of sources
- Ability to identify, pose and resolve problems
- Ability to work in a team

Specific competences:

- Model mathematically gene and protein regulation circuits
- Identify the roles of feedback and feedforward circuits in cells
- Understand the concept of network motifs
- Identify motifs in cellular regulatory networks
- Recognize situations in which cells process information, and characterize this phenomenon
- Model mathematically the behavior of neurons

## Learning outcomes | Specific learning outcomes

After following this course, students will be able to understand the principles that allow cells to process information from their environment, and to model mathematically different genetic circuits that enable such information processing.

### Contents

#### 0. Introduction.

The cell as a computer.

Detection and processing of biochemical signals.

Gene and signaling networks, circuits, and modules.

#### 1. Feedback circuits

Negative feedback. Robustness. Sensitivity coefficient.

Positive feedback. Bistability, hysteresis, and irreversibility. Mutual regulation.

Mixed feedback. Oscillations.

#### 2. Feedforward circuits

Coherent feedforward circuits. Asymmetrical delay lines, filters.

Incoherent feedforward circuits. Pulse generation.

Other applications. Fold-change detection, perfect adaptation.

#### 3. Network motifs

Single-input motif. LIFO response (last-in first-out).

Multiple output feedforward circuit. FIFO response (first-in first-out).

Densely overlapping regulons.

#### 4. Cellular computation

Finite state machines and Turing machines.

Universal computation with biochemical reactions.

The *chemical barebones* programming language.

#### 5. Biological information processing

Entropy and information.

Genetic information.

Information processing by genetic circuits.

#### 6. Computation in the brain

Neuronal impulses.

Synaptic dynamics.

Dynamics of neural networks.

Cortical networks.

### Sustainable Development Goals

3 - Good Health and Well-being

14 - Life below water

15 - Life on land

### Evaluation and grading system

The final grade of the course will be distributed as follows:

1. Theory (30%): the conceptual knowledge of the course will be evaluated in a final exam at the

end of the course, which will contain both multiple choice questions and open-ended questions.

2. Problems (30%): the ability to solve problems about the topics of the course will also be evaluated in a final exam.
3. Practicals (20%): 3/4 of this grade will correspond to reports of the results obtained in the practical sessions, which will have to be submitted periodically. The remaining 1/4 of the grade will be determined by several short questions that will be posed during the final exam.
4. Class participation (20%): this grade item consists of three parts, weighted equally: (i) review quizzes, (ii) assignment submissions, and (iii) participation in the discussion (Q&A) forum of the Aula Global.

A training quiz in the middle of the trimester will provide extra grade. Active participation in the theory sessions (asking questions and making comments during the lectures), in the seminar sessions (solving problems in the blackboard), and in 1-1 tutoring sessions, will also provide extra grade. These activities, weighted equally, will provide a maximum of one extra point, and will only be considered if they change the grade qualitatively (from fail to pass, from pass to good, or from good to excellent).

The following considerations must be taken into account:

- Attendance to the practicals sessions is mandatory.
- A minimum score of 3 points (out of 10) in **each** of the items 1-3 listed above will be necessary to pass the course.
- Students who have not passed the course will have the option to do a retake exam in July, where the theory, problems and practical questions will be reassessed. The practical reports and the class participation grade cannot be reevaluated.