1SC2210 – Life sciences

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Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 22,50

Description

The general principles that define life, presented as a complex system, will be addressed via a multi-scale approach from the cell to the population : macromolecule, intracellular organelle, cell, population of cells (e.g., cell tissue, microorganisms in suspension and immobilized).

The general objective of this course is to introduce the basic concepts of life necessary to better understand it and finally to be able to exploit it for a given objective : 1) to repair it (health challenge), 2) to purify an ecosystem (environmental challenge) and 3) to produce molecules of interest (industrial challenge).
The principles will be presented through a multidisciplinary approach at the interfaces of biology, biochemistry, bioprocesses, mechanics and mathematics in order to obtain a global and integrated vision of life systems.

Quarter number

ST2

Prerequisites (in terms of CS courses)

none

Syllabus

- Part 1: The Cell:
o The bricks of life
o Prokaryotic/eukaryotic cell
o Cellular organelles
o The general functioning of the cell: from gene to protein
o Cellular metabolism (anabolism and catabolism)
o Computational approach to life.
- Part 2: Cell Population :
o Suspended and immobilized microorganisms (biofilm). Bioprocess

applications (production of molecules of interest and environmental applications).
o Bone tissue.

Part 1: The Cell
Understanding life is essential for the engineer of tomorrow. Whether it is handling it to produce drugs or fuels industrially, or to cure pathologies. Modern biology uses all the techniques of engineering (mathematics, physics, chemistry, thermodynamics, computer science, etc.). It is inherently multidisciplinary. This course is an introduction to living organisms. Life as we define it is only a set of chemical reactions assisted by enzymes and energy. The molecules used in the cells come from the primitive ocean. We will see how they have been used to generate the cells we now know, including amino acids, sugars, lipids, up to DNA. We will see that there are different types of cells, some of which are already used on an industrial scale.
The focus of the course will be on how cells make the molecules they need, using genetic coding. In addition, the genetic code can be manipulated to use living organisms for specific purposes.
To make everything work, energy is required. Particular attention will be paid to the mitochondria, a real factory supplying energy to many cells.
Finally, we will discover how computational approaches are used to better understand and control living organisms.

Part 2 : Cell Population
Microorganisms, such as bacteria, yeasts and microalgae, are widely used in industry, particularly in the food, pharmaceutical, cosmetics, waste treatment and energy production sectors. They can be suspended or immobilized, aggregated in the form of flocs or on a support (biofilm). Biofilms are the microbial way of life par excellence and are ubiquitous. They develop in natural, industrial and hospital environments and are responsible for the fouling of heat exchangers, cooling towers and catheters. They are also used for the production of molecules of interest and wastewater treatment.
In this course, we will cover these two microbial lifestyles and their associated applications in industry and the environment.
This course is also an introduction to bioprocesses. The basic principles (the different stages of bioreactor production up to the recovery of products of interest, the different ways of operating bioreactors) will be illustrated with real industrial examples and applications. Bioprocess modeling will also be discussed.

Bone : an evolving biological tissue - The human skeleton is made up of different types of bones. These are made up of two major tissues : trabecular bone and cortical bone, which are in constant evolution. Indeed, under the effect of the mechanical environment, bone adapts its density and architecture. In this course, we will discuss the microstructure of bone, its relationship to the mechanical environment and the bone remodeling process initiated at the cell level. Then we will see how studying the mechanical-biological link can help to consider innovative regeneration therapies.

Class components (lecture, labs, etc.)

Lectures (70%) and training classes (30%)

11 lectures of 1h30 each and 3 training classes of 1h30 each

Grading

Intermediate examen (30% of the final grade) and final written examen (70% of the final grade).

Course support, bibliography

- The presentations of the various speakers.
- Books :

- Madigan, M. (2007). Brock Biology of microorganisms;
- Meyer, A., Deiana, J., & Bernard, A. (2004). Microbiology course with problems and corrected exercises - 2nd edition;
- Doran, P. M. (1995). Bioprocess engineering principles. Academic press;
- Marsily, G., Quantitative Hydrogeology Ed. Masson Paris (1981)
- Marsily, G., Quantitative Hydrogeology. Groundwater Hydrology for Engineers Ed. Academic Press, New York (1986)
- Bear J., Dynamics of Fluids in Porous Media, Elsevier Publishing Company, Inc.

Resources

- Teaching team : C. BERNARD, C. PUENTES, E. VENNAT, T. BOUCHEZ and F. LOPES.
- Size of the training classes : 30.

Learning outcomes covered on the course

1. Define the different bricks of life : amino acids, sugars, bases and their assembly method.
2. Describe the method of protein coding: genetic code, DNA, RNA and protein transcription and translation.
3. Explain the basics of enzymatic reactions and energy processes in the cell.
4. List and explain the different steps of the bioprocess.
5. Estimate the growth rate of a microbial population and discuss the factors impacting it.
6. Define biofilms and list associated impacts.
7. Write the material balances within the bioreactor.

Description of the skills acquired at the end of the course

C1 - Analyse, design and implement complex systems made up of scientific, technological, social and economic dimensions