DIGIT~Bio~TECH

2019-1-BG01-KA203-062371

M.Sc. PROGRAMME "GREEN BIOTECHNOLOGY AND ICT"

SYLLABUS

COURSE:

SYSTEMS BIOLOGY AND OMICS TECHNOLOGIES

AUTHORS:

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Academic work	Type	Number of classes
In-class work	Lectures	30
	Seminars	20
Total in-class work		**50**
Out-of-class work	Presentations	25
	Projects	20
	Self-guided library/database work	30
Total out-of-class work		**75***
Total of academic work		**125**
ECTS credits in-class work		**2.0**
ECTS credits out-of-class work		**3.0**
Total ECTS credits		**5.0**

№	Grading	% of the grade
1.	Workshops/discussions of reports and papers	20 %
2.	Case studies	20 %
3.	Homework assignments and tests	10 %
4.	Exams	50 %

* One credit corresponds to 25 hours of work.

Outline of the course
The educational material in LO1 covers the main concept and objectives of contemporary systems biology as an integrative scientific discipline and the adopted methodologies used in the system-level analysis of a cell or an organism. This "big data science" studies the complexity of biological systems using integrated multi-omics experiments data. An introduction to the structure and function of different types of omics molecules (DNA, proteins, lipids, etc.) involved in cellular processes and their interactions within individual layers is presented. Special emphasis is given to the relevant omics techniques underlying experimentation in systems biology: genomics, epigenomics, transcriptomics, proteomics, metabolomics, lipidomics, and economics. Some of the most often used data types are also overviewed: sequences, molecular structure, gene expression, binding sites and domains, protein-protein interaction, etc. The variety of big biological databases created for the curation of biological data and algorithms for analyzing resultant data are also described. The advantages and disadvantages of the omics technologies are revealed, and a comparative review of combined omics approaches vs. traditional reductionist approaches is given. The educational material in LO1 presents the most advanced applications of "omics sciences" in different fields of Biotechnology. Examples are presented of how data integration could be used to better understand, diagnose, and inform the treatment of diseases. Technical and other challenges to the clinical implementation of integrative omics are discussed. Part of the educational materials is focused on the use of integrative molecular approaches in the comprehensive understanding of the effects of toxic substances at different levels of biological organization. Different approaches for the discovery of new species, pathways, and genes are also described. The potential of 'omics technologies for restoring ecosystems and biodiversity is highlighted. LO1 covers many aspects of research in the area of bioinformatics and systems biology in bioengineering. Special attention is given to the emerging Lab-on-a-chip technology and its potential applications. Various examples of omics-based approaches that contribute to the broadened application of omics in food science are described. Special attention is given to the up-to-date studies on how nutrition is related to a state of health or disease. In addition, useful information is provided on how genome information has boosted approaches to study the role of genetic variation and explain individual differences in responses to nutrition, underlying the susceptibility to nutrition-related disorders.

Educational goals

Systems biology is an interdisciplinary research discipline whose main aim is to provide a comprehensive picture of the behavior of biological systems rather than the behavior of their components in isolation. This "big-data biological science" encompasses different omics technologies thus producing various biological datasets integrated into a broad range of research areas. For that reason, the educational goal of LO1 is to provide comprehensive background information on:

- the importance of the system`s level approach for understanding the complexity of biological processes
- the different omics levels in the cell and the relevant omics technologies
- the strengths and limitations of each omics technology.

The educational goal of this LO is to present the latest applications of OMICS approach for a better understanding of the behavior of cells, tissues, organs, and the whole organism at the molecular level. It summarizes the new insights on "omics sciences" and their impact in several generic fields: molecular medicine, toxicology, environment and biodiversity, biotechnology, and bioprocess engineering, as well as nutrigenomics research. It includes advanced tools and methodologies for dealing with the data generated and provides an excellent reference for applications of advanced omics techniques.

Expected outcomes

Knowledge and Skills:

As a result of the training students will be able to:

- understand the basic concept of systems biology – its roots and aims as an experimental science and its special relationship with other scientific disciplines
- acquire knowledge on different biological processes, pathways and molecules, structure and function, regulation and interaction with the environment
- apply omics-related techniques for the purpose of problem-solving and reporting results
- choose suitable bioinformatics tools and databases for data analysis
- processing and interpretation of experimental data
- present the advantages and disadvantages of omics technologies
- differentiate omics approaches and their possible uses
- understand how computational systems can be used for the analysis of different data sets
- apply omics approaches to accelerate discoveries in different areas of research
- match the suitable bioinformatics tool with the specific research area
- process and interpret experimental data

Problem-solving skills: Decision making, creative thinking, analytical, research and interpreting skills

Digital competencies and skills: strategic web and database searching; data analysis and presentation; data management and preservation; digital communication; networks and file management.

Personal skills: initiative and independence, time management, good oral and written communication skills, teamwork.

Syllabus

№	Topic	Number of classes
1.	**Unit 1 BL - Systems Biology and Omics Technologies: The Big Picture**	**25 h**
1.1	Systems biology of the cell: from single-omic to multi-omic experiments data.	3 h
1.2	Different branches of omics – challenges to combine biological information. Genomics.	2 h
1.3	Different branches of omics – challenges to combine biological information. Epigenomics.	2 h
1.4	Different branches of omics – challenges to combine biological information. Transcriptomics.	2 h
1.5	Different branches of omics – challenges to combine biological information. Proteomics.	2 h
1.6	Different branches of omics – challenges to combine biological information. Matabolomics.	2 h
1.7	Advantages and disadvantages of omics technologies	2 h
1.8	Seminars	10 h
2.	**Unit 2 AL - OMICS technologies towards improving the quality of life**	**25 h**
2.1	OMICS Technologies and Molecular Medicine: OMICs technologies in diagnostics. OMICs analysis for revealing genetic architecture of common disease. Application of OMICs approach in disease treatment. OMICs technologies for disease prevention - future prospects.	4 h
2.2	Application of OMICS Technologies in Toxicology: Toxicological studies via OMICs analysis. OMICs applications for toxicology risk assessment and regulatory submissions.	4 h
2.3	Environmental OMICS and Biodiversity. Single-cell genomics.	2 h
2.4	Omics Approaches in Industrial Biotechnology and Bioprocess Engineering. Omics-Guided Biotechnology.	2 h
2.5	Nutri-omics Research: Genomics and nutrition. Trascriptomics and nutrition. Proteomics and nutrition. Matbolomics and nutrition. Nutrition and other OMICs.	3 h
2.6	Seminars	10 h