Universidad Carlos III de Madrid
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COURSE: Informatics and Biotechnology to Support Tissue Engineering (257 - 15567)		
DEGREE: Biomedical Engineering	**YEAR: 2018**	**TERM: 2nd semester**

The course has 24 sessions along 14 weeks.

WEEKLY PLANNING

WEEK	SESSION	DESCRIPTION	GROUPS (mark X)		SPECIAL ROOM FOR SESSION (Computer class room, audio-visual class room)	Indicate YES/NO If the session needs 2 teachers	WEEKLY PROGRAMMING FOR STUDENT		
			LECTURES	SEMINARS			DESCRIPTION	CLASS HOURS	HOMEWORK HOURS (Max. 7h week)
1	1	**0. Overview of the subject** **I.Omic technologies and applications in biomedicine** **Introduction to omics I.** The omics era. The concept of omics in modern biomedicine, a holistic view. Different omic technologies and the omics cascade. **Introduction to omics II.** Common characteristics of omic technologies. Data integration and challenges in biomedicine. Gene onthology. Functional analysis.	X		Class room	NO		1,6	6

2	2	**Genomics.** Introduction. The Human Genome Project. Concepts and definitions in genomics. **Genomics instrumentation.** Genome sequencing. Concepts and evolution of DNA sequencing methods. Shotgun sequencing. Next generation sequencing.	X		Class Room	NO		1,6	6
2	3	**Genomics data analysis and quality control.** Practice FastQC		X	Computer Room	NO		1,6	
3	4	**Transcriptomics.** Introduction. Gene expression. Review of molecular biology concepts in gene expression. Concepts and definitions in transcriptomics. Gene regulation. **Transcriptomics instrumentation.** DNA microarrays, Gen-chip, Serial analysis of gene expression (SAGE), RNA-Seq. cDNA libraries.	X		Class room	NO		1,6	6
3	5	**Transcriptomic data analysis.** Babelomics practical exercise		X	Computer room	NO		1,6	
4	6	**Proteomics and metabolomics.** Introduction. Proteome and metabolome complexity. Biomarkers of disease. Human Proteome and Metabolome projects. **Proteomic instrumentation.** Mass spectrometry. Proteome and metabolome profiling. Quantification of the proteome and metabolome.	X		Class Room	NO		1,6	6
4	7	**Proteomic and metabolomic data analysis.** Metaboanalyst practical exercise		X	Computer room	NO		1,6	
5	8	**Other omics.** Fluxomics, nutrigenomics, the human diseaseome. Omics and cancer. Microbiome **Omic applications in biomedicine**. Genetic variation and disease. Disease diagnosis and therapeutics using genomic approaches. Personalized medicine.Functional pathway analysis. Drug discovery and development. Biomarker discovery and applications for early diagnosis. Development of targeted therapeutics from proteome or metabolome data.	X		Class room	NO		1,6	6

5	9	**II. Systems Biology and molecular networks. Introduction.** Omics paradigm in Molecular Biology. Molecular networks. Complex systems in Biology. Reductionism vs. holism. Systems Biology. Overview of the subject program. **Network Reconstruction:** From part list to molecular networks, from Networks to in-silico models: genome-scale metabolic models as of case of study; Databases and resources	X		Class room	NO		1,6	
6	10	**Graph Theory (I).** Introduction to Graph Theory. Formal definition of graph. Graph elements: nodes and edges. Graph classification based on the characteristics of nodes and edges. Computational representation of graphs. Main topological parameters. Classification of graphs based on topological parameters. Main graph-related algorithms. **Introduction to complex Networks:**	X		Class room	NO		1,6	6
6	11	**Protein interaction networks (I).** Protein-protein interactions. "Interactome". Experimental techniques for the high-throughput determination of protein interactions. Characteristics of the experimental data on protein interactions. Uses of PPIs networks	X		Class room	NO		1,6	
7	12	**Handling, visualization and topological calculations on molecular networks with Python.** Python plugins for handling networks. Importing and generating networks. Calculating topological parameters. Exploring the characteristics of biological networks: clustering coefficient, "small-world", "scale-free".		X	Computer Room	YES		1,6	6
7	13	**Protein interaction networks (II).** Analysis of protein interaction networks. Topological features of the interactome. Topological hierarchy. Scale-free topology. Topological motifs in protein	X		Class Room	NO		1,6	

		interaction networks. Central nodes. Combination with dynamical information. Interaction-based function prediction.							
8	14	**Topological and functional characteristics of gene regulatory networks.** Introduction - Regulation of gene transcription. High-throughput generation of data on transcriptional regulation. Network representation. Topological properties of gene regulatory networks. Topological motifs. Dynamics of gene regulatory networks. From genotype to phenotype and back. Examples and applications. **Other Biological Networks:** Genetic interaction networks, phosphorylation networks, metabolomic networks, residue contact networks in protein 3D structures, chromatin interaction networks, comparison with non-biological networks **Review on networks discussed so far.**	X		Class room	NO		1,6	6
8	15	**Visualizing and handling molecular networks with Cytoscape**. Introduction. Basic aspects of Cytoscape. Importing networks. Visualization/layouts. Incorporating gene expression data. Filters. Functional analysis.		X	Computer Room	YES		1,6	
9	16	**Metabolic Modeling in Systems Biology:** Representation of metabolic information as graphs. Topological features of metabolic networks (review). **Constraint-Based Modeling of Metabolic Networks:** Metabolic Reconstruction (review), Network Properties, Prediction of functional state using optimization: Flux Balance Analysis, Applications **Closing remarks on the subject.**	X		Class room	NO		1,6	6

9	17	**III. Synthetic Biology: Introduction.** What is it, differences and similarities with Genetic engineering. The 3 roots of SynBio. SynBio vs SysBio. Adoption of metaphores and explicit SynBio languages. **Practical organization of the SynBio part of the Course.** Formation of teams and distribution of tasks and literature for reading and discussion. **The jargon of SynBio**. Parts, devices, modules, systems. Harware and software in Biological systems. Standards: Physical assembly vs functional assembly. Chasses and implants. **The logic and the need of standards**. Can biological systems and biological measures be standardized? Biological Units. Transfer functions.	X		Class room	NO		1,6	
10	18	**The prokaryotic gene expression flow.** The mechanics of transcription and translation. Spatial organization of the gene expression machinery. Redesigning cell compartiments. Definition of PoPs (polymerase per second) and RiPs (Ribosome per second). Modeling the whole gene expression flow **Orthogonal gene expression systems.** phage RNAPs, alternative genetic codes, codon reassignment and codon emancipation, artificial expansion of natural biodiversity, creation of new-to-nature activities. **Selection and exploitation of alternative codons.** The unique pyrrolysin codon / tRNA /tRNA synthetase. Genetic methods for changing codon identity.	X		Class room	NO		1,6	6
10	19	**Genome engineering.** Tools for editing extant genomes. Posfai's methods for insertions, deletions, corrections. Automated bio-engineering of re-written genomes. Emergent properties of edited genomes. The roadmap from entirely natural to entirely non-natural organisms. Barriers to horizontal gene transfer and designing certainty of containment	X		Class room	NO		1,6	

		DNA assembly methods. Traditional cloning and its spinoffs: BioBricks, BglBricks. Gibson's assembly, uracyl excision. Complete chemical synthesis of the Mycoplasma genome. **The repository of biological parts.** The BioBrick Foundation, the SynBERC initiative & registry. Towards a sharing SynBio global community							
12	20	**Deployment of Synthetic constructs:** The Standard European Vector Architecture (SEVA). Plasmid vectors, transposon vectors, expression systems, reporter genes. **Environmental mining of synthetic parts.** Surface / ectopic display of biomolecules on the cell envelope. Assembling microbial communities. **Metabolic engineering.** Organization of the metabolic network. Metabolic Economy and metabolic currencies ATP and NADP(H). Retroactivity chassis-implant. The DNA-metabolism interplay. Rational switching of the physiological regime of environmental bacteria (eg aerobic to anaerobic). Engineering production of bioplastics.	X		Class room	NO		1,6	6
12	21	**Design and testing of genetic circuits.** Inputs and outputs. Biological logic gates. Binary logic. Toggle switches, repressilators, discriminators, pulse generators, pattern development. Biosensors. Developing effector-specific transcriptional factors. TALENs. Applications of super-sensitive switches in metabolic engineering	X		Class room	NO		1,6	
13	22	**Synthetic operative systems in live organisms.** coding and de-coding information. Engineering memory. Uni-cellular and multi-cellular logic. Recombination-based recording of past events. Bacteria as computers making computers. The machine and the replication of the machine. Errors and anti-fragility.	X		Class room	NO		1,6	6
13	23	**But … what is all this for? Biotechnological applications of Synthetic Biology**. Biocatalysis.	X		Class room	NO		1,6	

		Artemisin. Biofuels. Domesticating environmental and comensal bacteria through Syn Bio. Towards a C-neutral society. The role of SynBio in sustainability. Low-cost high-tech for democratic medicine and environmental conservation. **The iGEM competition and its spinoffs.** Organization and objectives. The process. Intelectual property issues. The DIY (do it yourself) SynBio community. ELSA (ethical, legal, social aspects) of Syn Bio. Enthusiasm vs skepticism in scientific & technological progress. Social rejection of biological engineering: the GMO controversy.							
14	24	**Minimal Cells and Synthetic Life.** Alternative information-bearing molecules. Life without DNA. Self-sustaining biochemical systems. XNAs. Xeno-biological systems The Andromeda strain syndrome. SynBio and the arts. Inventing the future. Extending the community of stakeholders. **The business of Syn Bio.** How to create a Synthetic Biology Company. The global market for Synthetic Biology: key players, investment, expectations. The Open Access/Open Source controversy From genetic engineering to enginering genetics. The bacterium is the product. The Bacmine SL experience in Spain.	X		Class room	NO	**(05/05)** Victor de Lorenzo	1,6	6
							Subtotal 1	**38.4**	**90**
							Total 1 *(Hours of class plus student homework hours between weeks 1-14)*	128.4	

15		Tutorials, handing in, etc						1.4	
16		Assessment						3	
17									
18									6
							Subtotal 2	**4.4**	**6**
							Total 2 *(Hours of class plus student homework hours between weeks 15-18)*	10.4	

TOTAL *(Total 1 + Total 2)*	**138.8**