ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

105000395 - Introduction To Biocomputing

DEGREE PROGRAMME

10II - Grado En Ingenieria Informatica

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	105000395 - Introduction To Biocomputing
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	Fourth year
Semester of tuition	Semester 7
Tuition period	September-January
Tuition languages	English
Degree programme	10II - Grado en Ingenieria Informatica
Centre	10 - Escuela Tecnica Superior De Ingenieros Informaticos
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Alfonso Vicente Rodriguez-Paton Aradas (Subject coordinator)	DIA 2106	alfonso.rodriguez-paton@upm.es	Sin horario. make appointment by email

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Nuñez Berrueco, Elena	elena.nunez@upm.es	Rodriguez-Paton Aradas, Alfonso Vicente

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- no previous courses needed, just not to be afraid of biological terms and notions

4. Skills and learning outcomes *

4.1. Skills to be learned

CG-1/21 - Capacidad de resolución de problemas aplicando conocimientos de matemáticas, ciencias e ingeniería.

CG-19 - Capacidad de usar las tecnologías de la información y la comunicación.

CG-2/CE45 - Capacidad para el aprendizaje autónomo y la actualización de conocimientos, y reconocimiento de su necesidad en el área de la informática.

CG-24/25/26/27 - Capacidad para trabajar en el contexto internacional, comunicándose en lengua inglesa y adaptándose a un nuevo entorno.

CG-5 - Capacidad de gestión de la información.

CG-6 - Capacidad de abstracción, análisis y síntesis

4.2. Learning outcomes

RA280 - Obtención de las competencias lingüísticas comunicativas (comprensión, expresión, etc.) habladas y escritas en entornos académicos/profesionales nacionales/internacionales.

RA286 - Experiencia de estudio y trabajo en un contexto internacional.

RA278 - Desarrollar la solución matemática y algorítmica mas apropiada a un problema informático que requiera un tratamiento especialmente complejo, analizando y exponiendo su viabilidad.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

In this course we will study the basic concepts and topics of DNA Computing, Synthetic Biology and Programmable Biology.

Biomolecular computing: is the term used for information processing encoded in biological macromolecules. A bio-molecular computer is a device made with these biomolecules that processes biological information, and use DNA, RNA, proteins, or their combination. We will describe only a few of the most relevant DNA and RNA-based computers developed so far and applied to in vivo diagnostic and drug delivery. The engineering of programmable biomolecular automata applied to the diagnosis and treatment in vivo of a disease is a promising application in the area of intelligent in situ drug delivery. This field started in 2001 with the first design of a DNA-based automaton operating in vitro (Benenson et al. 2001) applied to biomedical diagnosis in 2004 (Benenson et al. 2004). An automaton is a device with memory that can operate in an autonomous way, sensing inputs, processing those inputs and emitting an output without external human interaction. Another important and widely used nucleic acid sensing technique is the so-called "competitive hybridization" or "DNA strand displacement" (Seelig et al., 2006). This technique is used in the design of DNA logic circuits for the intelligent sensing and processing of DNA and RNA molecules.

What is Synthetic Biology? It is the engineering of biology: the application of the engineering principles in biology to design and build biological systems.This field considers biology as a technology that can be programmed to manufacture new synthetic biological devices and systems. This field was born in 2000 in MIT Artificial Intelligence Lab where engineers, computer scientists, and physicists started to work jointly with biologists. Engineers asked this question: can we combine natural living hardware components (mainly genes) to build new synthetic biological systems? Can we design and write genetic programs in DNA (the software) to be run in a cellular processor (the hardware)? The answer was yes. The biotechnology and genetic engineering tools were already available. The first synthetic devices were developed in 2000: a genetic memory (Gardner, Cantor, & Collins, 2000), an oscillatory genetic circuit (Elowitz et al. 2000) and several genetic Boolean logic gates (Hasty, McMillen, & Collins, 2002; Weiss et al., 2003).

Programmable Biology and open-source portable biology labs: LIA group is developing code for programming portable biology labs run by Arduino cards. We want to make these biolabs easy to program and easy to engineer. This is why we are using BioBlocks language (a drag-and-drop visual language based on Scratch and Blockly). We want to develop open-source versions of Bento.bio, Amino.bio and Feles One. We will discuss some recents works using deep learning tools in computational microbiology.

More introductory info at: http://www.lia.upm.es

Also: Alfonso's talk in Valencia, Spain, in ISBBC Summer School, June 2017: "Synthetic Biology for computer scientists in 2 hours"

Slides available at: https://drive.google.com/file/d/0B1K8p9umsfI4WWhUd1lMLTA0OVE/view

Towards programmable antibiotics and in silico microbiota: https://www.youtube.com/watch?v=b4ECvhXD5kg

Decrypting bacterial virulence networks: https://youtu.be/tPZ36vyzAUM

¿Co?mo funcionan los fa?rmacos programables? https://youtu.be/RwAUjSLwXOc

5.2. Syllabus

1. DNA Computing
    1.1. DNA structure and operations
    1.2. DNA strand-displacement-based biocircuits
    1.3. Molecular automata
    1.4. Adleman experiment
    1.5. DNA storage
2. Synthetic Biology: designing genetic circuits
    2.1. Gene expression and regulation
    2.2. Genetic Boolean logic gates
    2.3. Basic genetic circuits: A toggle switch and an oscillator.
    2.4. CRISPR-based devices and gene drives
3. Programmable Biology
    3.1. Automation in Biology
    3.2. Simulating bacterial colonies with IBM: Gro simulator
    3.3. Engineering portable biolabs with Arduino cards and software blocks

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**DNA Computing** Duration: 02:00 Lecture			
2	**DNA Computing** Duration: 02:00 Lecture			
3	**DNA Computing** Duration: 02:00 Lecture			
4	**DNA Computing** Duration: 02:00 Lecture			
5	**DNA Computing** Duration: 02:00 Lecture			
6	**Synthetic Biology** Duration: 02:00 Lecture			
7	**Synthetic Biology** Duration: 02:00 Lecture			
8	**Synthetic Biology** Duration: 02:00 Lecture			
9	**Synthetic Biology** Duration: 02:00 Lecture			
10	**Synthetic Biology** Duration: 02:00 Lecture			
11	**Programmable Biology** Duration: 02:00 Lecture			
12	**Programmable Biology** Duration: 02:00 Lecture			
13				**Oral presentation** Group presentation Continuous assessment and final examination Presential Duration: 00:10

14				**Final work (written assay or practical work)** Individual work Continuous assessment and final examination Not Presential Duration: 30:00
15	**Oral presentations** Duration: 02:00 Additional activities			
16				
17				**Exam** Written test Continuous assessment and final examination Presential Duration: 02:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
13	Oral presentation	Group presentation	Face-to-face	00:10	20%	6 / 10	CG-1/21 CG-2/CE45 CG-5 CG-6 CG-19 CG-24/25/26/27
14	Final work (written assay or practical work)	Individual work	No Presential	30:00	80%	5 / 10	CG-2/CE45 CG-1/21 CG-5 CG-6 CG-19 CG-24/25/26/27
17	Exam	Written test	Face-to-face	02:00	%	5 / 10	

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
13	Oral presentation	Group presentation	Face-to-face	00:10	20%	6 / 10	CG-1/21 CG-2/CE45 CG-5 CG-6 CG-19 CG-24/25/26/27
14	Final work (written assay or practical work)	Individual work	No Presential	30:00	80%	5 / 10	CG-2/CE45 CG-1/21 CG-5 CG-6 CG-19 CG-24/25/26/27
17	Exam	Written test	Face-to-face	02:00	%	5 / 10	

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Oral presentation: choose a paper from the list and make a short presentation (10 minutes). The presentations can be done in groups up to 3 people.

Final work: written essay (se puede redactar en español) or practical work simulating a biological process: Average workload dedicated to the final written work: 30 hours. The student should read at least 1-2 relevant (good journal) papers on the chosen research topic/problem and some other needed introductory material. The essay topic must be related (or closed) to the topics of the course and must be chosen by the student. It can be also an extension of the work chosen for the oral presentation. Remember that the most valuable topics are those related with novel processing information encoded in biomolecules (by living organisms or in vitro), DNA storage, and the mathematical and programming tools used to model and simulate those biological processes. Recent bio-inspired computing models (and some novel artificial life models) could also be eligible. In case of doubt about the feasibility of the topic chosen and the papers selected please consult me. The essay must be original (plagiarism of even a single paragraph means automatic failing the course) and contains at least the following sections: Abstract, Introduction, Conclusions and all the bibliographical references used for its elaboration.

Length of the essay: no restrictions but a normal essay would contain no less than 7 pages and no more than 15 pages.

The essay will be evaluated taking into account mainly: the understanding level acquired and shown by the student on the topic analyzed, and the depth of the reasoning, the novelty, originality and relevance of the new ideas (if any) proposed by the student. The quality in the writing and the synthesis capacity will be also positively assessed. Any novel and original idea, a deep critical thinking or a creative contribution from the student will be highly valued. As conclusions please avoid general superficial phrases as: "this field is starting but it's very interesting", "the future is very promising", "I like it very much", etc. I want deeper reflections from you.

Exam: Exam evaluating basic concepts of the course. Only two evaluations: pass or fail. If fail, there is the possibility of recover at the end of the course.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Scientific papers	Web resource	Scientific papers and slides will be given to the students

9. Other information

9.1. Other information about the subject

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

The 17 SDGs are integrated?they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability.

In UPM the relevant text about SDGs is at: https://sostenibilidad.upm.es/wp-content/uploads/sites/759/2021/03/Sostenibilidad-estudios-oficiales-UPM-2020.pdf

The SDGs covered incidentally or partially by this class are: 3, 4, 5, 6, 9, 11, 12, 13, 14, 15