ANX-PR/CL/001-01
LEARNING GUIDE

SUBJECT

203000028 - Modelization And Simulation Of Biosystems

DEGREE PROGRAMME

20BC - Master Universitario En Biologia Computacional

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	203000028 - Modelization And Simulation Of Biosystems
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	20BC - Master Universitario en Biologia Computacional
Centre	20 - E.T.S. De Ingenieria Agronomica, Alimentaria Y De Biosistemas
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Jesus Israel Pagan Muñoz (Subject coordinator)		jesusisrael.pagan@upm.es	- -

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

2.3. External faculty

Name and surname	Email	Institution
Jaime Iranzo Sanz	jaime.iranzo@upm.es	Centro de Biotecnología y Genómica de Plantas

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

- Basic notions in dynamic systems (recommended)

- Programming (any language)

4. Skills and learning outcomes *

4.1. Skills to be learned

CE01 - Comprender las bases moleculares y las técnicas experimentales estándares más comunes en las investigaciones ómicas (genómica, transcriptómica, proteómica, metabolómica, interactómica, etc.).

CE04 - Utilizar diferentes bases de datos (incluidos los bigdata), conocer sus estructuras y ontologías, aplicar la estadística a su análisis, siendo capaz de utilizar herramientas de representación y visualización.

CE05 - Utilizar herramientas de biología computacional para el análisis genómico, incluida la genómica comparativa y biología evolutiva.

CG03 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con el area de la Biología Computacional.

CG05 - Que los estudiantes sean capaces de integrar conocimientos en el area de la Biología Computacional, de formular conclusiones, hipótesis o líneas de trabajo a partir de la información disponible, y de formarse una opinion fundamentada sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos.

4.2. Learning outcomes

RA22 - Describir cuantitativamente los sistemas celulares, su forma de procesar e intercambiar información con el medio externo y los mecanismos de diferenciación celular y desarrollo

RA23 - Utilizar herramientas computacionales para analizar y extraer información cuantitativa de los sistemas celulares

RA24 - Integrarlas las herramientas computacionales con aproximaciones experimentales

RA25 - Explicar funcionamiento y estructura globales a partir de su organización en módulos o unidades funcionales más simples, y destacando principios de diseño y optimización celular

RA20 - Adquirir una visión global de la Biología de Sistemas y sus aplicaciones

RA21 - Adquirir un visión integradora de los sistemas y redes biológicas en organismos y poblaciones

RA26 - Conocer los métodos matemáticos y computacionales de Modelización y Simulación de Sistemas Biológicos.

* 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

The main goal of this course is to develop the ability to design, evaluate and criticize evolutionary dynamical models based on empirical and observational evidence.

To this end, students will follow a number of topic lectures, with biological examples as threads, that will allow us to introduce multiple transversal concepts. Each lecture will be associated to (i) one or a few research papers that have dealt with the topic; (ii) learning specific techniques applied to the topic; (iii) exercises to be individually developed/solved; (iv) several ideas to discuss from a critical viewpoint related to the applicability and limitations of the associated models.

Topic lectures will be complemented with the development and discussion of inverse models. The starting point will be the qualitative description of a biological problem and related empirical data gathered from experimental protocols or observational data. The goal is the design of quantitative models that take into account those

mechanisms deemed essential in the process. We will attempt to disentangle the dominant dynamical or evolutionary mechanisms through the simulation of the dynamical model and the comparison of the outcomes with data.

The performance of students will be subjected to steady evaluation. Exercises corresponding to every topic should be delivered as soon as possible, preferably before the next lesson (50% of course mark). Students will be given the opportunity to amend and improve the exercises along the course. Before each lesson, students will be given a scientific article to read, introducing the main concepts that will be later developed during the lecture. Every student or small working group will orally present one of these articles, and the rest of the class will answer questions related to it (30% of course mark). Participation in class and the course forum will complete the final mark (20%).

The cronogram shown in Section 6 of this guide follows a plan for presential classes, but this may be subjected to modifications during the course derived from the COVID-19 situation.

5.2. Syllabus

1. The logistic equation. A paradigm of complexity in simple models.
   1.1. Workshop: Macroevolutionary dinamics.
2. Infectious diseases and epidemic spread. SIR model.
   2.1. Woirkshop: Viral dynamics in vitro.
3. Oscillations and synchronization in biological systems.
   3.1. Workshops: Fast-forwarding evolution.
4. Extended biological processes: the role of space.
   4.1. Workshop: Vegetation patterns.
5. Extended biological processes: the role of networks.
   5.1. Workshop: Ecological networks.
6. Genotype-phenotype maps and the architecture of genotype spaces.
   6.1. Workshop: Mobile genomic elements and gene-sharing networks.
7. Viral dynamics.
   7.1. Workshop: Deep sequencing data of viral populations: time samples.
8. Games and evolutionarily stable strategies.
   8.1. Workshop: Ecological dynamics: Canadian lynx.

9. Stability and complexity of model ecosystems.

9.1. Workshop: Social systems: Cities and human languages.

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1		**Introduction to modeling of biological systems** Duration: 02:00		
2		**Macroevolutionary dinamics.** Duration: 01:00 **The logistic equation. A paradigm of complexity in simple models.** Duration: 02:00		**Exercises of lesson 1** Continuous assessment Presential Duration: 00:00
3		**Viral dynamics in vitro.** Duration: 01:00 **Infectious diseases and epidemic spread. SIR model.** Duration: 02:00		**Exercises of lesson 2** Continuous assessment Presential Duration: 00:00
4		**Fast-forwarding evolution** Duration: 01:00 **Oscillations and synchronization in biological systems.** Duration: 02:00		**Exercises of lesson 3** Continuous assessment Presential Duration: 00:00
5				**Cooperative work on specific aspects of Lessons 1, 2 and 3. Students will work in groups of 2 or 3. Work will be presented orally to the class.** Continuous assessment Presential Duration: 02:00
6		**Vegetation patterns.** Duration: 01:00 **Extended biological processes: the role of space.** Duration: 02:00		**Exercises of lesson 4** Continuous assessment Presential Duration: 00:00

7		**Ecological networks.** Duration: 01:00 **Extended biological processes: the role of networks.** Duration: 02:00		**Exercises of lesson 5** Continuous assessment Presential Duration: 00:00
8		**Mobile genomic elements and gene-sharing networks.** Duration: 01:00 **Genotype-phenotype maps and the architecture of genotype spaces.** Duration: 01:00		**Exercises of lesson 6** Continuous assessment Presential Duration: 00:00
9				**Cooperative work on specific aspects of Lessons 4, 5 and 6. Students will work in groups of 2 or 3. Work will be presented orally to the class.** Continuous assessment Presential Duration: 02:00
10		**Deep sequencing data of viral populations: time samples.** Duration: 01:00 **Viral dynamics.** Duration: 01:00		**Exercises of lesson 7** Continuous assessment Presential Duration: 00:00
11		**Ecological dynamics: Canadian lynx.** Duration: 01:00 **Games and evolutionarily stable strategies.** Duration: 01:00		**Exercises of lesson 8** Continuous assessment Presential Duration: 00:00
12		**Stability and complexity of model ecosystems.** Duration: 02:00		**Exercises of lesson 9** Continuous assessment Presential Duration: 00:00
13		**Social systems: Cities and human languages.** Duration: 02:00		
14				**Cooperative work on specific aspects of Lessons 7, 8 and 9. Students will work in groups of 2 or 3. Work will be presented orally to the class.** Continuous assessment Presential Duration: 02:00

15		**Summary of the course. Question-answer dynamics** Duration: 02:00		
16				
17				**Exercises to be solved theoretically.** Final examination Presential Duration: 03:00

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
2	Exercises of lesson 1		Face-to-face	00:00	7%	5 / 10	CG05 CE04 CG03 CE05 CE01
3	Exercises of lesson 2		Face-to-face	00:00	8%	5 / 10	CG03 CE05 CE01
4	Exercises of lesson 3		Face-to-face	00:00	7%	5 / 10	CE04 CG03 CE05 CE01
5	Cooperative work on specific aspects of Lessons 1, 2 and 3. Students will work in groups of 2 or 3. Work will be presented orally to the class.		Face-to-face	02:00	10%	5 / 10	CG05 CE04 CG03 CE05 CE01
6	Exercises of lesson 4		Face-to-face	00:00	8%	5 / 10	CE04 CG03 CE05
7	Exercises of lesson 5		Face-to-face	00:00	8%	5 / 10	CG05 CG03 CE01
8	Exercises of lesson 6		Face-to-face	00:00	8%	5 / 10	CG05 CE05 CE01
9	Cooperative work on specific aspects of Lessons 4, 5 and 6. Students will work in groups of 2 or 3. Work will be presented orally to the class.		Face-to-face	02:00	10%	5 / 10	CG05 CE04 CG03 CE05 CE01
10	Exercises of lesson 7		Face-to-face	00:00	8%	5 / 10	CG05 CG03

11	Exercises of lesson 8		Face-to-face	00:00	8%	5 / 10	CG05 CE04 CG03 CE05
12	Exercises of lesson 9		Face-to-face	00:00	8%	5 / 10	CG05 CG03 CE05 CE01
14	Cooperative work on specific aspects of Lessons 7, 8 and 9. Students will work in groups of 2 or 3. Work will be presented orally to the class.		Face-to-face	02:00	10%	5 / 10	CE04 CG03 CE05 CE01 CG05

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Exercises to be solved theoretically.		Face-to-face	03:00	100%	5 / 10	CG05 CE04 CG03 CE05 CE01

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Problems, plus exercises to be theoretically solved.		Face-to-face	03:00	100%	5 / 10	CG05 CE04 CG03 CE05 CE01

7.2. Assessment criteria

Continuous evaluation: Exercises corresponding to each lesson should be submitted before the following one (50% of the final grade). At the beginning of each lesson, groups of 2-3 students will orally present a scientific article related to the topic of that lesson (10 min), and a small test (4-5 multiple-choice questions) will be conducted to evaluate the degree of understanding by the class. This activity will contribute to 30% of the final grade. Participation in class and the course forum will complete the final mark (20%).

Only Final and Extraordinary evaluation: This evaluation is composed of two parts. First, a selection of exercises will have to be solved following approaches similar to those suggested and developed along the course. Second, one exercise will have to be solved theoretically, following guidelines as proposed for the Final Evaluation.

The results will follow the scheme established by the UPM in 2012 as A: Excelent, B: Advanced, C: Satisfactory, D: Not satisfactory.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
R. V. Solé y S. C. Manrubia, "Orden y caos en sistemas complejos: Fundamentos". Ediciones UPC, 342 pp., 2000	Bibliography	
R. V. Solé y S. C. Manrubia,"Orden y caos en sistemas complejos. Aplicaciones". Ediciones UPC, 234 pp., 2001	Bibliography	

9. Other information

9.1. Other information about the subject

This course aims at conveying some poorly unknown aspects of dynamical systems through the analysis of representative case-examples. Two main objectives are to develop an intuition for non-linear behaviour and to train the ability to perform critical assessments. The first objective is related to important SDGs as how our actions affect climate change or environmental features: the latter are complex systems whose response to perturbations is highly nonlinear, meaning that small causes might have large effects, as the course demonstrates. The second objective aims at educating a general-purpose attitude which should help developing critical and equalitarian thought (be it related to gender, discrimination or institutional policies). As a specific example, the course addresses epidemics and therefore touches on questions related to vaccination and public health.