



POLITÉCNICA

INTERNATIONAL
CAMPUS OF
EXCELLENCE

COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



Etsi Agronómica, Aliment. y
Biosistemas

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

203000029 - Synthetic And Systems Biology

DEGREE PROGRAMME

20BC - Master Universitario En Biología Computacional

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	203000029 - Synthetic And Systems Biology
No of credits	3 ECTS
Type	Optional/elective
Academic year of the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	20BC - Master Universitario en Biología Computacional
Centre	20 - Etsi Agronómica, Aliment. Y Biosistemas
Academic year	2025-26

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Krzysztof Teodor Wabnik (Subject coordinator)		k.wabnik@upm.es	--

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

3. Skills and learning outcomes *

3.1. Skills to be learned

CE02 - Utilizar sistemas operativos, programas y herramientas de uso común en biología computacional, así como, manejar plataformas de cómputo de altas prestaciones, lenguajes de programación y análisis bioinformáticos

CE03 - Analizar e interpretar bioinformáticamente los datos que se derivan de las tecnologías ómicas, y proponer soluciones bioinformáticas en relación a dichos datos.

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

CE10 - Conocimiento de las técnicas de representación del conocimiento reutilizables y modelos de razonamiento en entornos centralizados y distribuidos a utilizar en la resolución de problemas que impliquen conducta inteligente.

CG01 - Poseer los conocimientos que constituyen la base científica y tecnológica de la Biología computacional, lo que permitirá el desarrollo de ideas originales en este campo, en un contexto de investigación o desarrollo.

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 área de la Biología Computacional.

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

CT08 - Tener capacidad de análisis y síntesis para interpretar datos relevantes y abordar los problemas desde diferentes perspectivas.

3.2. Learning outcomes

RA27 - Familiarizar a los estudiantes con los datos de biología molecular utilizados en biología sintética

RA28 - Conocer las aplicaciones de los principios de ingeniería a la ingeniería de sistemas biológicos

RA29 - Conocer las diferentes etapas del ciclo biológico de la biología sintética

RA30 - Conocer las teorías subyacentes que se aplican a los conceptos y técnicas de la biología sintética.

* 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.

4. Brief description of the subject and syllabus

4.1. Brief description of the subject

Synthetic Biology began as a discipline that aimed to program transcriptional circuits in bacterial cells with diverse dynamic behaviors (bistable switches, oscillators, excitability, etc.). This approach complemented Systems Biology by helping to profile some of the hypotheses about the functioning of natural biological systems through the construction of synthetic alternatives. Initial ideas have subsequently developed into other organisms (yeast, mammalian cells, plant cells) with the use of various molecular substrates (along with transcription factors, microRNAs, protein phosphorylation, etc.). Additional aspects that complement modern Synthetic Biology include genomic editing, accelerated evolution, and the notion of the minimal cell. The ultimate goal of this discipline is to combine the best understanding of natural systems with the rules for designing and implementing de novo biological systems.

4.2. Syllabus

1. Basic concepts in Systems and Synthetic Biology
2. Gene regulatory motifs, genome rewriting
3. Genetic circuits, biological "plug-and-play"
4. Applications and socio-economic impacts of Synthetic Biology

5. Schedule

5.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	Basic concepts in Systems and Synthetic Biology (I) Duration: 02:00 Lecture			
2	Basic concepts in Systems and Synthetic Biology (II) Duration: 02:00 Lecture			
3	Basic concepts in Systems and Synthetic Biology (III) Duration: 02:00 Lecture			Individual assignment: "Basic concepts in Systems and Synthetic Biology" Individual work Progressive assessment Not Presential Duration: 02:00
4	Motifs, regulatory networks and genome rewriting: from minimal cells to synthetic communities (I) Duration: 02:00 Lecture			
5	Motifs, regulatory networks and genome rewriting: from minimal cells to synthetic communities (II) Duration: 02:00 Lecture			
6	Motifs, regulatory networks and genome rewriting: from minimal cells to synthetic communities (III) Duration: 02:00 Lecture			Individual assignment: "Motifs, regulatory networks and genome rewriting: from minimal cells to synthetic communities" Individual work Progressive assessment Not Presential Duration: 02:00
7	Genetic circuits, biological "plug-and-play" (I) Duration: 02:00 Lecture			
8	Genetic circuits, biological "plug-and-play" (II) Duration: 02:00 Lecture			
9	Genetic circuits, biological "plug-and-play" (II) Duration: 02:00 Lecture			Individual assignment: In silico design and implementation of synthetic circuits Individual work Progressive assessment Not Presential Duration: 02:00

10	Applications of Synthetic Biology (I) Duration: 02:00 Lecture			
11	Applications of Synthetic Biology (II) Duration: 02:00 Lecture			
12	Applications of Synthetic Biology (II) Duration: 02:00 Lecture			
13	Socio-economic impact of Synthetic Biology (I) Duration: 02:00 Lecture			Individual assignment: Propose new applications of synthetic biology and their implementation Individual work Progressive assessment Not Presential Duration: 02:00
14	Socio-economic impact of Synthetic Biology (II) Duration: 02:00 Lecture			
15				Exercises: Socio-economic impact of Synthetic Biology Individual work Progressive assessment Presential Duration: 02:00
16				
17				Final Exam Online test Global 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.

6. Activities and assessment criteria

6.1. Assessment activities

6.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Individual assignment: "Basic concepts in Systems and Synthetic Biology"	Individual work	No Presential	02:00	20%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08
6	Individual assignment: "Motifs, regulatory networks and genome rewriting: from minimal cells to synthetic communities"	Individual work	No Presential	02:00	20%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08
9	Individual assignment: In silico design and implementation of synthetic circuits	Individual work	No Presential	02:00	20%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08
13	Individual assignment: Propose new applications of synthetic biology and their implementation	Individual work	No Presential	02:00	20%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08
15	Exercises: Socio-economic impact of Synthetic Biology	Individual work	Face-to-face	02:00	20%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05

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6.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final Exam	Online test	Face-to-face	02:00	100%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08

6.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Writing of a short document about one of the subjects discussed in the course.	Individual work	Face-to-face	02:00	100%	5 / 10	CG03 CE05 CG01 CE02 CE03 CE10 CG05 CT08

6.2. Assessment criteria

Progressive evaluation: Discussions in class and individual assignments.

Global evaluation: exam

7. Teaching resources

7.1. Teaching resources for the subject

Name	Type	Notes
S. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering, 2nd Ed., Westview Press, 2014.	Bibliography	
Purnick, P. E. M., & Weiss, R. (2009). The second wave of synthetic biology: from modules to systems. Nature Reviews Molecular Cell Biology, 10(6), 410-422. https://doi.org/10.1038/nrm2698	Bibliography	
Cheng, A. A., & Lu, T. K. (2012). Synthetic Biology: An Emerging Engineering Discipline. Annual Review of Biomedical Engineering, 14(1), 155-178. https://doi.org/10.1146/annurev-bioeng-071811-150118	Bibliography	
E. Voit. A First Course in Systems Biology, 2nd Edition. Garland Science, 2018. ISBN-10: 0815345682	Bibliography	
S. Camazine et al. Self-Organization in Biological Systems. Princeton University Press, 2003	Bibliography	

8. Other information

8.1. Other information about the subject

La Comisión de Calidad del Centro en su reunión de 29 de mayo de 2023 acordó aprobar la propuesta de reasignación de competencias transversales en las asignaturas de los Grados en Biotecnología, Ingeniería Alimentaria, Ingeniería Agrícola, Ingeniería Agroambiental, Ciencias Agrarias y Bioeconomía, y en el Máster Universitario en Ingeniería Agronómica. En virtud de dicho acuerdo, este sujeto ha sido designado como Sujeto Punto NO de Control. Esto significa que si bien se puede seguir trabajando una o varias competencias transversales que se abordan en diferentes puntos y aspectos de la materia, dicha formación y evaluación no será objeto de recogida de evidencia por parte de los sistemas de acreditación de calidad del Centro.

La asignatura se relaciona con el ODS9, ODS11 y el ODS12. En esta asignatura se imparten conocimientos de vanguardia en bioingeniería y diseño de sistemas sintéticos. El aprendizaje de estos conocimientos dota al estudiante de las habilidades y competencias para comprender, seleccionar y aplicar las metas establecidas en el ODS9, ODS11 y el ODS12.