SYLLABUS BIOTECH3

-

FALL SEMESTER

Article Analysis & Hands-on Work

Total instructional hours: 30-60

Credits: 8 ECTS credits

Pre-requisites/Bibliography references

- Knowledge of scientific English
- Solid foundation in biology
  - Molecular Biology
  - Biochemistry
  - Microbiology
  - Cellular Biology
- Ability to use a search engine

Course objectives

- Understanding life science research and the research work that is required for publication.
- Understanding the structure and organization of scientific articles and journals.
- Completing an in-depth study of a scientific article and a journal, presented to a jury.
- The objective of the hands-on work is:
  -Learning to work independently or with a partner.
  -Understanding each stage of an experimental protocol.
  -Critically analyzing and discussing results and writing a report in a lab notebook.
  -Managing one's time and workspace.
  -Learning to use theoretical knowledge applied in a practical way, and vice versa.

Specific objectives and skills

- Understanding how major academic research entities are organized (units, teams, groups, etc.).
- Understanding modern life science research as a combination of scientific work and the necessary funding.
- Demonstrating the stages of submitting a scientific publication to a peer-reviewed scientific journal.
- Conducting bibliographic research using the PubMed and Google Scholar databases.
- Understanding the structure of a scientific article and each party's role: introduction, materials and methods, results, and discussion.
- Knowing how to use multiple approaches to study an article and read more efficiently.
- Knowing how to distinguish a scientific article from a journal article, and understanding the appeal of each of those for a project.
- Studying a journal and articles in a group of two or three students, focusing on one of the major biotechnology areas: health, agri-foods, environment.
- Knowing how to present a topic to a jury using a scientific journal, and presenting the key points from a scientific article selected from that journal.

<u>Hands-on work</u>

- Pipetting and Dilution: Manipulation of micropipettes, Calibration test, serial dilutions, food colorant dosing, statistical analysis of the results.
- PCR and cartography: Setting up of PCR reactions and appropriate controls, Preparation of agarose gel, Plasmid DNA manipulation, Role and activity of restriction enzymes, .
- Protein analysis by dosing and electrophoresis: Bradford and BCA assays, Acrylamide gel preparation, SDS-PAGE.
- Protein purification by chromatography and glycerol assay: Separation of hemoglobin and cytochrome c by gel filtration, Enzymatic assay.
- RNA extraction and analysis: RNA isolation from human cell cultures, RNA quantification by absorbance measurement, RNA quality analysis by electrophoresis.
- Microbiology: Preparation of culture media, Inoculation and bacterial culture, Microscopic observation of living cells, Cell numbering using absorbance and Malassez cell.
- Cell culture: preparation of culture medium, Cell trypsinization, Cell count, Cell replating, Cell freezing.
- Introduction to bio-production: *Saccharomyces cerevisiae* fermentation, Formation to the functioning of the bioreactors and of the controlling software, Measurement of biomass production.

Course outline

1. Current life science research
   1.1 Major research entities
   1.2 Research work and funding
   1.3 Submitting a publication to a scientific journal with a scientific review committee
2. Organizing and structuring a scientific article and a journal article
   2.1 Formatting the first page (references, order in which authors' names appear, etc.)
   2.2 Formatting sections, and the role of sections (introduction, materials and methods, etc.)
   2.3 Efficiently reading an article
   2.4 Overview of a journal article, using journal articles to launch projects and study them in depth
3. Hands-on work: completing a project
   3.1 Proposal: five project topics (Examples: New sources of DHA; Most relevant biomarkers for Alzheimer's disease; Outlook for micro-organism "bioremediation," etc.)
   3.2 Journal is distributed after student groups select a topic.
   3.3 Students select three articles from the journal and present them during a mid-term defense
   3.4 Jury members select articles
   3.5 Selected article is presented during the final defense

Topics addressed through analysis and interpretation of scientific articles:

- Metabolism
- Cellular Engineering
- Molecular Biology
- Microbiology

Assessments

1) Project identifying common themes in a selected article/Final defense, evaluated as follows:
- Presentation of the context for the study addressed in the article, and the issues associated with it
- Presentation of experimental approaches
- Presentation of results, and correlation with the initial issue or question
- Responses to questions

2) Written summary of biological knowledge gained through articles, focusing on each topic addressed (end-of-semester exam)
3) Evaluation for each small-group session is based on four criteria (the evaluations' average grade is a test grade):
    a. Individual preparation work
    b. Quality of individual experimentation work completed
    c. Individual behavior
    d. Report written with a partner

    Evaluation of a written (individual) exam, on the following theoretical topics: principles of methods and techniques dealt with in small group sessions, description and analysis of experimental results, calculations.

Biomimicry

Total instructional hours: 12 hours

Credits: 2 ECTS credits

Pre-requisites/Bibliography references

Nature is a high-tech library. Biomimicry is the science that allows us to read nature's books. Biomimicry, or "bio-inspiration" is the art of extracting knowledge from nature. Biomimicry is part of the knowledge economy, which provides an endless amount of knowledge, and contrasts with the primary materials economy.

At present, society is confronting the planet's physical and biological limitations. There are many urgent issues to be dealt with: water, energy, resources, pollution management, climate change, differences between the Northern and Southern hemispheres, biodiversity, and human health.

The next generation of engineers and experts has a major role to play. They will develop the technological solutions of tomorrow; those are critical to progress and innovative solutions, while including and managing many other facets of these ever-more-complex problems.

This is the context in which Sup'Biotech is offering an introduction to biomimicry forecasting methods in the Bachelor's degree program. These are part of our Sustainable Development commitment, which is highlighted in the school's charter, and discussed in various places in the school's self-evaluation guide.

The pre-requisite for this module is completion of the L2 level in biology.

Overall objective

Developing cross-disciplinary skills to apply the most effective strategies from the life sciences to sustainable innovation in an economy undergoing a transition to new forms of energy, through technical, economic, environmental, and social compromises.

Specific objectives

A systemic analytic process, to examine the interactions of a specific need with its environment and identifying innovative solutions (functional analysis).

Course plan

Lectures:

- Introduction to biomimicry/background
  - Issues with definitions, challenges, and changes
  - History of biomimicry
  - A holistic approach to biomimicry
  - Current state of biomimicry, outlooks for the future
  - Biomimicry: research and process tools
    - From biology to design

        - From design to biology
    - References

Small group work:

- Phase 1: Identifying the question or problem Identify a challenge or specific problem (if possible, outside the student's biology skills) and describe it in a general way. Put the problem in context and identify functional keywords.

- Phase 2: Biological research Know how to create combinations of keywords, prepare a research equation. Accelerate the iterative process of an equation with text imaging tools. Use bibliography management tools and tools for creating heuristics maps, to look for potential solutions.

- Phase 3: Biological analyses Extracting biological phenomena and identifying the underlying biological mechanism. Selecting the operating principle.

- Phase 4: Design principles Making connections/Transferring between the biological operating principle and designing a solution. Sketching out the concept.

- Phase 5: Generating the concept/integrating the concept into the solution environment: Is the problem being addressed? What are the limitations and advantages of the proposed solution? Summary of the integration or use of the bio-inspired technology. Is there a connection in terms of reducing the environmental footprint? (Concept of lifecycle analysis)

Skills assessments

The evaluation lasts eight hours. Students will apply their knowledge to a real-world case study outside their area of expertise (biology).

They are assessed based on:

- Their ability to create an appropriate process for finding bio-inspired solutions.
- The relationship of the biological solution and the problem or issue that was uncovered or identified.
- An assessment of the appropriateness of their bio-inspired solution as it would be realistically implemented, and the bio-innovation's ability to reduce the environmental footprint.

Synthetic biology

Total instructional hours: 10 hours

Credits: 2 ECTS credits

Pre-requisites/Bibliography references

Knowledge of molecular biology: classical cloning technique using restriction enzymes, plasmides, promoters, ORFs, and terminators.

Overall objective

This course's overall objective is to provide an overview of the complex topic of synthetic biology and its various applications. This is done through examples.

Specific objectives

- Ability to seek out information.
- Group work.
- Ability to present, discuss, and write a report in English on a scientific topic.
- Learning the major principles of synthetic biology: the BioBricks system; standardization; modeling and prediction; optogenetics; metabolic path engineering; gene expression regulation systems; genetic pathways; advanced cloning techniques (Golden Gate, Gibson, AQUA cloning, etc.).
- Knowledge of industrial applications in various areas: WatchFrog, Glowee, GoldenRice, Généthon, Pili, etc.
- Reflections on the ethics of synthetic biology.

Course plan

- Overview of synthetic biology: what is it? Challenges, examples of its application, and the moral and ethical issues it raises.
- Class discussions using individual opinions.
- Group work and distribution of various iGEM projects to be presented (E. Chromi, Arsenic Biosensor, Banana Flavor, etc.).
- Presentation of new cloning techniques (Gibson, Golden Gate, etc.) and new tools for altering the genome (TALen, CRISPR, etc.).
- Before finishing the course, a final debate based on students' personal opinions of the use of synthetic biology to solve larger problems: world hunger, energy, ecology, etc.

Skills assessments

- Oral participation grade
- Oral and written presentation grade
- Exam grade: theoretical knowledge and an essay question

Organic chemistry

Total instructional hours: 22 hours

Credits: 4 ECTS credits

Pre-requisites/Bibliography references

- Understanding the basics of organic chemistry through detailed study of major functions and major molecular families.
- Understanding the study of reaction mechanisms to deepen understanding of total synthesis methods.
- Understanding certain principles of general chemistry taught in the first year (electronegativity, aromaticity, limit structures, etc.)

Course objectives

- Mastering the basics of organic chemistry through detailed study of major functions and major molecular families.
- Resuming the study of reaction mechanisms to deepen understanding of total synthesis methods.

Specific objectives and skills

- Mastering nomenclature, structure, and physical properties (optics, if applicable) of alkenes, alkynes, aromatic compounds, (benzene and derivatives), aromatic amines, aliphatic amines, alkyl halides, organomagnesiums, alcohol, and carbonyl compounds.
- Mastering the reaction mechanisms in which thse molecules can be involved: aldolization, halogenation, etc.
- Ability to define isomerism.

Detailed ourse outline

1 Nomenclature and organic functions
1.1 Nomenclature: IUPAC rules
1.2 Organic compounds
1.2.1. Hydrocarbons
1.2.2. Organic functions: oxygenated derivatives, nitrogen derivatives, halogenated derivatives.

2 Stereochemistry
2.1 Writing organic molecules
2.2 Representation of molecules
2.3 Isomerism
2.3.1. Definitions
2.3.2. Composition isomerism
2.3.3. Structural stereoisomerism
2.3.4. Configuration stereoisomerism
2.3.5. Tree structure
2.4 Importance of isomerism

3 Reactivity and mechanisms
3.1 Electronic effects
3.1.1. Inductive effects and mesomeres

3.1.2. Stability of reactive intermediates
3.1.3. Acids/bases- comparison of pKa.
3.2 Reactive conditions
3.2.1. Kinetic and thermodynamic monitoring
3.2.2. Properties and role of solvents
3.3 Reactions in organic chemistry
3.3.1. Types of reagents
3.3.2. Types of reactions
3.4 Primary mechanisms
3.4.1. Nucleophile substitutions (NS)
3.4.2. Elimination (E)
3.4.3. Addition

4 Reactions of primary organic functions
4.1 Halogenated derivatives
4.2 Alcohols
4.3 Alkenes
4.5 Carbonylated derivatives (aldehydes and ketones)
4.5.1. Nucleophilic additions
4.5.2. Oxydation and reduction reactions
4.5.3. Carbonyl α reactions: reactivity of enols and enolates
4.6 Acids and derivatives
4.6.1. Carboxylic acid reactions
4.6.2. Nucleophilic addition reactions on acid derivatives
4.6.3. Reactions involving α carboxyl hydrogen mobility
4.6.4. Nitrile reactions
4.7 Organomagnesiums

Skills assessments

- During the semester: two in-class assignments of one half hour and one assignment of one hour, during class.
- Final exam: one, three-hour exam

Bioinformatics

Total instructional hours: 30 hours

Credits: 4 ECTS credits

Pre-requisites/Bibliography references

Mathematics:

- Matrices and basics of linear algebra, by the end of the course

References and media:

- http://www.dsimb.inserm.fr/~fuchs/python/cours_python.pdf : interesting courses related to the ideas presented, but with gaps and in a different order.
- Internal course media are available.

Course objectives

This course's objective is to introduce beginning students to Python, bringing them up to the same level as students who took bioinformatics courses during their first two years. Thus, we revisit general concepts, with particular emphasis on deepening fundamental concepts. IT topics are illustrated through uses related to biology. Specific attention is given to practical application of concepts on the computer. The goal is for students to write code independently if needed, after this course.

Specific objectives and skills

The primary goal is to bring students up to the level of the first two years of the bioinformatics program.

Detailed course outline

1. **General functioning of a computer**
    a. Hardware components
    b. Operating systems
    c. Software: compiled versus interpreted
    d. The Spyder text editor
2. **The Python language**
    a. History
    b. Python "software" versus the Python language
    c. The Python interpreter versus code files
3. **Basic concepts of programming**
    a. Basics
        i. Values
        ii. "Simple" types (complete, floating, Boolean)
        iii. Variables

iv. Operators (arithmetic, comparison, logical)
v. Practice with calculations

b. Structure of a Python code
   i. Stream execution
   ii. Code blocks
c. Simple constructions
   i. If, elif, else constructions
   ii. While constructions
d. Sequence types
   i. Character chains
   ii. Lists
   iii. Slicing
   iv. The for construction
e. Functions and recursion
   i. Definition and use of functions
   ii. Structuring code by using functions
   iii. Recursion
f. Files
   i. Opening/closing
   ii. Reading (various methods)
   iii. Writing
   iv. Useful functions

4. Advanced concepts

a. Modules
   i. Importing variables and functions
   ii. Breaking code down into files
b. Programming errors
   i. Understanding the different types (methodical, logical, syntax)
   ii. "Understanding" the interpreter
   iii. Methods of resolving errors
c. Defining a problem
   i. Understanding when, where, and why IT is useful
   ii. Translating a problem into code
d. Vectors and matrices (the numpy module)
   i. Math review
   ii. Building matrices in Python
   iii. Use
   iv. Examples of algorithms on the matrices

Guided work (on paper):

1. Recursion (class 3.e.iii)

Hands-on work (on the computer):

1. Manipulating values: calculations, defining variables, using the interpreter (course 2 and 3.a)
2. Manipulating sequences: creation, workflow, modification/transformation, use of code files (class 2.c, 3.c, and 3.d)
3. Manipulating matrices (course 4.d)

QCM to verify that the course materials have been mastered:

1. Basics and simple constructions (class 2.c and 3.a-c)
2. Classic sequences and functions (class 3.d-e)
3. Files, modules, and matrices (class 3.e-f and 4.d)

Homework to apply concepts:

1. Mastering Python: values, operators, if, while (course 3a-c)
2. Manipulating sequences: chains, lists, and problem solving (course 3.d and 4.c)

Midterm exam on paper (not open book, no calculators):

1. Class portion (approximately 6 points)
    a. QCM
    b. Course application exercises
2. Python exercises (writing code) (approximately 6 points)
    a. Sequence manipulation
    b. Recursion
    c. Files
    d. Matrices
3. Problem (approximately 8 points)
    a. Reflection on a new question
    b. Identifying a problem

Human and social sciences: biotechnology in society

Total instructional hours: 20 hours

Credits: 3 ECTS credits

Pre-requisites/Bibliography references

Course intended for students admitted in parallel into the third year. As HSSs were not introduced in courses during the first two years, this class provides a summary of what was covered during the first two years.

Overall objective

- To teach students to prepare investigational and reasoning models related to biotechnologies in society. Developing their skills in terms of identifying, posing, and analyzing questions and issues related to biotechnologies in relation to society.
- Teaching students methodological knowledge for designing and writing papers (investigational) and reports (internship reports), as well as documentary research (differentiating sources, referencing).
- Familiarizing students with HSS survey methods (questionnaires, interviews, observations). Learning to analyze the resulting empirical data. Exploring biotechnologies, relying on these methods and analyses.
- Developing knowledge of current questions and issues raised by biotechnologies (in medicine, concerning the environment, with respect to ethical challenges-bioethics, ethics of nature).

Specific objectives

- Familiarizing students with the realities of biotechnology and introducing them to HSSs (sociology, anthropology, history, etc.) through exercises using documents, analytical work and summary work.
- Knowing how to summarize and research information on a given topic.
- Knowing how to use the information gathered on a certain subject to develop an analysis.
- Know-how: being aware of the diversity of HSS methods, differentiating between qualitative and quantitative methods, interpreting empirical data from the two types of methods. Adopting the analytical mindset. Articulating the social and technical dimensions of biotechnology.
- Know-how/mindset: developing one's listening, discussion, and dialogue skills.

Course plan

- Depending on the session, small exercises to be done in class (bibliographic research using the Internet, differentiating between sources, building a categorized bibliography, formulating questions, etc.).
- Oral presentations
- Research done at home (preparing a paper)
- Article study (reaching sheet to be returned)
- Learning to design and formulate questions and issues (in the context of the paper)
- Participating in discussions on current topics related to biotechnology.

Skills assessments

- Writing a study paper.
- Oral presentation on various aspects of the paper (topic, question or issue, and study plan: detailed plan, oral presentation with PowerPoint on the content of the student's paper)
- Reading sheets
- Exam

English

Total instructional hours: 30 hours

Credits: 3 ECTS credits

Pre-requisites/Bibliography references

English level equivalent to IELTS of 6.0 or TOEFL of 70.

Course objectives

Improving oral and written expression and comprehension of the English language, in general and professional situations.

Specific objectives and skills

- Working on writing skills, using articles.
- Learning public speaking in English, using oral presentations with PowerPoint slides.
- Learning to analyze texts and news articles, discussing them in English.
- Expanding one's vocabulary by reading, listening to recordings, and watching instructional videos.
- Beginning to listen to audio recordings and watch videos to develop oral comprehension.
- Familiarizing oneself with various English accents.

Detailed course outline

1. Working on news articles
2. Discussing articles in English.
3. Oral presentation on current events topics
4. IELTS practice
5. Listening to recordings (i.e. BBC) and watching short videos (i.e. Ted talks)
6. Exercises using Rosetta Stone (1 hour/week)

Skills assessments

- Graded oral presentation
- Exam