CENTER FOR INTERNATIONAL PROGRAMS AND SUSTAINABILITY STUDIES
COURSE NAME: Biotechnology for Sustainability
COURSE CODE: ENV-4100
TOTAL CONTACT HOURS: 60
INSTRUCTOR: Dr. Francisco Gonzalez

COURSE DESCRIPTION

This course emphasizes the vast possibilities offered by biotechnology for sustainable development through the study of specific cases in Costa Rica. In this sense, Costa Rica, despite its comparatively small geographical size and population, has consolidated as the most advanced country in the region when it comes to biotechnological research. This course will explore the reasons why, and correlate them with the role of sustainable development in this process. Fundamental and applied concepts of biotechnology will be explored and discussed in terms of life, environmental and social sciences. This course will be heavily based on the study of cases in which biotechnology has become into the best solution for social and environmental situations through the visits and participation of companies, associations and experts related to this technology. Therefore, this course is aimed to any professional with an interest in biotechnology from an engineering, scientific and social sciences point of view.

This is a course of Environmental Sciences (theoretical and practical) and answers the following question:

How has biotechnology been applied to sustainable development in Costa Rica?

To answer this question the following aspects will be studied:

- Fundamental concepts of Biotechnology
- The story of biotechnology
- Biotechnology in Costa Rica
- Agricultural Biotechnology
- Medical Biotechnology
- Marine Biotechnology
- Biorremediation
- Biofuels
- Bioprocesses
- Bioprospecting
- Synthetic Biology and the future of Biotechnology

Along the course the following abilities and skills will be promoted:

- Analyze the historical perspectives of global biotechnology and the situation of Costa Rica.
- Recognition of different types of biotechnology and their characteristics.
- Understanding of the context, reasons and motivations in the search of biotechnological solutions.
- Recognition of the main tools used in biotechnology.
- Development of strategical thinking sensitive for sustainable development.

The following values and attitudes will be promoted in the students:

- Respect for the environment and human groups (farmers, aboriginal people).

- Logical and critical thinking.
- Innovation in a tropical setting.
- Goal-oriented thinking.
- Team work and leadership.
- Empathy and sensitivity.

Competencies, criteria and evidence

The following defines the competencies (specific and general), the criteria and the performance evidence for their evaluation in this course.

Competency type	Criteria	Performance evidence
Specific Understands the concept of biotechnology, its tools and the need for its application in sustainable development in a developing country, and at the same time can related this knowledge with his/her future career.	He/she i can explain the concepts of biotechnology.	Mind Maps
	He/she is able to explain how biotechnology has evolved along the years at global and regional level.	Mind maps
	He/she distinguish the different types of solutions offered by biotechnology, along with the intrinsic challenges	Round Table
	Identifies opportunities and threats related to biotechnology on his/her own profesional area as well as understanding the current state of several related areas.	Essay
	The students are able to recognize a problem and design a recommendation based on the acquired knowledge	Biotechnology Consultancy Report
General		
Integrate concepts, nomenclature and key elements from the course to be used in his/her upcoming professional life.	Learning to learn	Mind Maps / Round Table
Develops the skills and techniques to communicate and transfer knowledge through visual, oral and wrtitten forms.	Written, visual and oral communication.	Essay / Biotechnology Consultancy Report
Incorporates and shares knowledge interpersonally to achieve a common goal through team work and leadership.	Team work and leadership.	Biotechnology Consultancy Report
Integrates knowledge and logical thinking in a respectful way to review his/her own work and others.	Respect for others and empathy. Conflict solving. Sensitivity and assertive criticism. Logical thinking.	Round Table / Presentation Biotechnology Consultancy Report

Contents

Subject 1. What is Biotechnology?
- Definition of Biotechnology
- Biotechnological products in our daily life
- Classification of Biotechnology
- Tools of Biotechnology / Bioinformatics

Subject 2. History of Biotechnology
- Ancient use of biotechnology
- Historical discoveries that led to the current biotechnology concept
- Biotechnology in Costa Rica

Subject 3. Agricultural Biotechnology
- Transgenics and transgenic crops
- Transgenic crops and controversy
- Biotechnology and organic agriculture

Subject 4. Medical Biotechnology
- Diagnostics of human and animal diseases
- Biomedical engineering

Subject 5. Marine Biotechnology
- Molecular tools applied to marine biology problems
- Industrial needs solved by marine biotechnology

Subject 6. Biorremediation
- Soil biorremediation
- Oil spills biorremediation
- Waste cleanup

Subject 7. Biofuels
- Definition of Biofuels
- Biofuel controversy
- Biotechnology applied to solve biofuel controversy

Subject 8. Bioprocesses
- Biofactories
- Bioproducts

Subject 9. Bioprospecting
- Pharmaceutical exploitation of biological products
- Sustainable approach to bioprospecting

Subject 10. Synthetic Biology and the future of Biotechnology
- Pros and cons of synthetic biology
- Future of Biotechnology in sustainable societies

Methodology

This is a course of active interaction between the students and the professor, where knowledge is developed through the participation of both parts. Attendance is compulsary, although two unexcused absences are allowed.

Assistance to visits is compulsary. Emergency absence will be excused when proper documentation is provided.

This course utilizes the PBL (problem-based learning) and the TBL (team-based learning) as educational strategies. This means that students are expected to solve research questions individually and in groups through the different activities planned by the professor. Additionally, students will learn and perform critical analysis of their own as well as others work.

Attendance

Students are only allowed a total of 2 nonconsecutive (back to back) absences. The student will fail the course if he/she has more than **two absences**. Students will have a 0 on any assignment evaluated in class (presentations, evaluations, field trips, etc.) if he/she is absent unless the student presents an official document no later than one week after the absence. If the student presents an authoritative report to excuse the absence, he/she must submit the missed assignment on that same day. An unjustified absence to a field trip will immediately mean losing all of the points assigned to the field trip. If an official document is presented for the field trip absence students will have to present a research assignment to obtain 50% of the points. The only exception to this rule is when two-course field sessions collide in programming. Students can then opt for doing a research assignment not to lose any points on the field trip they don't attend but it must be coordinated ahead of time with the professors.
Three late arrivals to class (within the first 15 minutes) are treated as one absence. If you come to class 30 minutes late without an official justification document, it will also count as an absence.

Performance activities

The following activities will be used as evaluating evidence of student performance :

- Mind Maps: the students will prepare, summarize, extract and present the most important aspects related to the subject assigned.
- Round Tables: the students will prepare arguments and questions to participate in each one of subjects designated as controversial presenting different aspects of the same subject.
- Essay: each student will correlate the acquired knowledge with his or her own studies and predict applications on their professional careers.
- Biotechnology consultancy report: students will analyze, gather literature, consult experts, prepare and present a consultancy report that will provide suggested biotechnological solutions to a problem assignated by the teacher. In parallel, they will study the assignment of other students of the class and prepare to be their reviewers during the final presentation date.

Educational Resources

Lessons will take place in a laboratory/classroom with the essential equipment for teaching and learning of this subject. Visits will also include most of the essential elements for learning. Reading material will be provided by the professor and the university. In case of other needed literature for the literature consultancy report, essays, etc., the student will have the availability of the university library to check books and online resources.

Evaluation

The evaluation of the course will be based on the performance evidence (items) produced by the student and the examination by the teacher using the criteria mentioned above. The following shows the details of each one.

The following extends on the evaluation criteria of each part:

Items	Percentage
Mind Maps	10%
Round Tables	10%
Essay	20%
Class assignments and participation	30%
Consultancy Report	30%
TOTAL	100%

Mind Maps

This strategy helps to learn, summarize, code, organize, memorize, analyze and discrimate among the different aspects of new knowledge. Mind maps will be produced in small groups and will be presented to the class. This activity will take place twice and the subjects will be given by the teacher. Each mind map session will have a value of 5% and the evaluation criteria will be the following:

Indicator	**Excellent (100-90%)**	**Very Good (89%-80%)**	**Good enough (79%-70%)**	**Insufficient (69% or less)**
The main idea and concepts are represented by clear images and relations Value 3	The full image is direct, relevant and unambiguously represent the main idea and concepts	The full image is close to represent the main idea and concepts	The full image contains related concepts but their relation is not clear	The full image does not represent the assigned main idea and concepts
Starts from the centre and then irradiates the concepts and ideas related to the main subject Value 2	Full agreement with the indicator	Follows the idea of the indicator but some sides are not evenly distributed	The main idea is not in the centre, but some other ideas are properly distributed	The main idea is not centred and the others are not properly distributed
There is a clear hierarchical organization of the ideas and concepts Value 1	Full agreement with the indicator	Most of parts follow a clear hierarchy	At some parts the hierarchy is not clear	The hierarchy is not properly used
Uses lines, arrows, icons, images or any others to differentiate and clarify different categories and to form relationships among ideas Value 2	Full agreement with the indicator	Most of visual aids are properly used and transfer a sense of organization	Some of the visual aids cause confusion or are not used properly	The visual aids cause confusion and are not used properly making the map unintelligible

The quality of the final map is of the best standards: visually attractive, with no spelling mistakes, organized and clear Value 2	Full agreement with the indicator	Design and contents are attractive but there are spelling mistakes	Design and contents are not in their best form, there are multiple spelling mistakes, unknown acronyms and instead looks like a draft	Design and contents are not inviting at all and there are multiple spelling mistakes, acronyms and others that are unintelligible

Round Tables

This strategy promotes research techniques, logical and critical thinking and oral transfer of knowledge among peers. There will be three round tables that will allow students to comprehend and to participate in the discussion of controversial subjects related to biotechnology. The week previous to the session, the teacher will provide basic literature for the students to prepare, but each group is responsible to extend in the knowledge for better performance during the round table. Each round table session will have a value of 5% and the evaluation criteria will be the following:

Indicator	**Excellent (100-90%)**	**Very Good (89%-80%)**	**Good enough (79%-70%)**	**Insufficient (69% or less)**
The students read the literature and further read other associated literature that they found Value 3	The student has a clear knowledge of what scientific literature has to say about the subject (assigned and self-found)	The student has a wide knowledge of the assigned literature and some other references	The student read the assigned literature but did not look for anything else	The student did not read any material for the round table
All the students of the group have discussed the subject and know the most important aspects of their participation in the round table Value 2	Full agreement with the indicator	Most of students discussed the subject and know the main points of their participation in the round table	Students read the literature but did not discuss among them the participation in the round table	The students did not read and did not discuss the subject
Students have prepared appropriate questions for other groups and are able to	Students respectfully and critically formulated questions to discuss with other	Students have prepared questions for others and can defend	Students have prepared questions but are not able to	Students did not prepare for the questions round.

argument against or in favour of each position Value 5	groups and are able to formulate positions about the subjects	their own positions	defend a position	

Essay

This assignment aims to make students reflect, integrate and think logically of the relevance of the course in respect to their own professional careers. This essay will be individual and will have a value of 20% of the final mark. The criteria will be evaluated as follows:

Indicator	**Excellent (100-90%)**	**Very Good (89%-80%)**	**Good enough (79%-70%)**	**Insufficient (69% or less)**
The essay includes 10-12 pages that contain: cover page (1 page), introduction (1 page) essay body (7-9 pages), conclusions (1 page) and references (as many pages as needed) Value 1	The essay fully includes all the necessary parts	All the most relevant information is included	Some less important information (such as some references) might be missing	Any fundamental part is missing
The introduction clearly states the main facts of the background, the research question that the essay aims to answer and the objectives of the essay Value 2	Full agreement with the indicator	Some aspects of the background and research questions are not completely clear at the beginning	Although the background is not so clear, the main question and objectives are clear	The background, research question and objectives are not clear
The essay follows a logical order with interconnected ideas that respond to the objectives of the essay Value 5	Full agreement with the indicator	Most of parts follow a clear hierarchy	At some parts the hierarchy is not clear	The hierarchy is not properly used

There is a clear argumentative input that correlates literature, theory and the personal learning experience of the student Value 5	Full agreement with the indicator, the student manifests an opinion based on literature and own observations whenever possible	The student the student manifests an opinion based on literature and own observations in some particular cases	There is some input of personal opinion at some level	There is not personal argumentative opinion or the opinion does not have a verifiable base
Grammar and spelling follow high standards Value 2	Full agreement with the indicator	There are some grammatical or spelling mistakes	There are multiple grammatical and spelling mistakes	There are many grammatical and spelling mistakes that make reading difficult
Conclusions are fact-based, clear and reflect the opinion, findings and position of the author Value 5	Full agreement with the indicator	Conclusions reflect at some degree authors opinion in the light of the findings	Conclusions are fact based but do not state the opinion of the author	Conclusions do not indicated the opinion of the author and are not logical from the findings of the essay
References are properly cited (APA format) and all references are from verifiable, serious sources (preferably scientific journals, books, avoiding websites) Value 3	References are properly cited on text, properly described in the references section and all sources are from scientific sources (natural and social sciences books and journals)	Most of references are properly cited and obtained from scientific sources	At least the most important sources in which the essay is based on are properly cited and obtained from scientific sources	The student based his/her essay in a non-scientific reference and/or did not follow the citation format (APA)

The essay follows the following specifications: Font Arial 10, 1.5 spacing, titles and subtitles properly categorized following a logical order (bold, capital letters, italics, etc.), scientific names are italics, figures and tables properly presented Value 2	Full agreement with the indicator	There are a few of format changes but do not compromise the understanding of the document	Some changes in the format compromise the understanding of the document	The student did not follow the recommendations of format

Biotechnology Consultancy Report

This assignment aims to familiarize students with real-life cases of problems that can be solved through sustainable biotechnological solutions. At the same time, it promotes cooperative work and constructive criticism. To do this, the teacher will give a reality-based problem to groups of students and the students will take notes along the course of different elements that they can use to come up with a sustainable biotechnological solution that will be presented in a report and an oral presentation to the rest of the class. This is a team-based project and will have a value of 30%. It will be evaluated as follows:

Indicator	**Excellent (100-90%)**	**Very Good (89%-80%)**	**Good enough (79%-70%)**	**Insufficient (69% or less)**
The report includes: cover page (1 page), introduction (1 page), methodology (1-2 pages), recommendations (1-5 pages), supporting information and references (as many pages as needed) Value 1	The report fully includes all the necessary parts	All the most relevant information is included	Some less important information (such as some references) might be missing	Any fundamental part is missing
The introduction clearly states the main facts of the background and the main problem to solve Value 2	Full agreement with the indicator	Some aspects of the background and the main problem to solve are not completely clear at the beginning	Although the background is not so clear, the main question and objectives are clear	The background, and the main problem to solve are not clear

The methodology states clearly what was the strategy followed to find solutions to this problem Value 5	The methodology details all the resources used to come up with solutions (experst consulted, literature, data bases, online tools, etc.)	The methodology is detailed in some aspects but not in others	The methodology at least mentions (with no details) the main sources used to come up with solutions	The methodology does not state the sources for the solutions proposed
The recommendations are realistic, ready to implement, detailed but explicit, are based on scientific sources and demonstrate analysis, discussions and extensive use of the available resources Value 5	Full agreement with the indicator	Most of recommendations are explicit and ready to implement with verified scientific sources	Some recommendations are not clear, realistic or ready to implement, but most are based on scientific sources	The recommendations are not relevant or based on scientific sources
Grammar and spelling follow high standards Value 2	Full agreement with the indicator	There are some grammatical or spelling mistakes	There are multiple grammatical and spelling mistakes	There are many grammatical and spelling mistakes that make reading difficult
Supporting information provides all the necessary data for the client to proceed. For example, if microorganisms, genes or tools are recommended, the most important information must be provided in this section (sequences, similar studies, specific protocols, etc) Value 5	Full agreement with the indicator, all the recommendations are supported with a wide range of supporting data	Supporting information is extensive in the most important recommendations	There is some relevant supporting information	There is not supporting information

References are properly cited (APA format) and all references are from verifiable, serious sources (preferably scientific journals, books, avoiding websites) Value 3	References are properly cited on text, properly described in the references part and all sources are from scientific sources (natural and social sciences books and journals)	Most of references are properly cited and obtained from scientific sources	At least the most important sources in which the essay is based on are properly cited and obtained from scientific sources	The student based his/her essay in a non-scientific reference and/or did not follow the citation format (APA)
The biotechnology consultancy report uses the following specifications: Font Arial 10, 1.5 spacing, titles and subtitles properly categorized following a logical order (bold, capital letters, italics, etc.), scientific names are italics, figures and tables properly presented Value 2	Full agreement with the indicator	There are a few of format changes but do not compromise the understanding of the document	Some changes in the format compromise the understanding of the document	The student did not follow the recommendations of format
The students are able to confidently present their recommendations, including background, main problem to solve, their methodology to find answers and the recommendations, as well as being able to review the research assignment of another group of students Value 5	All the students are able to properly show and defend all the parts of their assignment in a talk, and at the same time to evaluate, review and give feedback to another group	Students can show and defend their assignment, but are not properly evaluating the research of the classmates, or the other way around	Students can barely show and defend the logic behind their research and can barely evaluate others	Students cannot properly defend their research or evaluate others

Bibliography:

Sittenfeld, A., Espinoza, A. M., Muñoz, M., & Zamora, A. (1999). Costa Rica: challenges and opportunities in biotechnology and biodiversity. In *Agricultural Biotechnology and the Poor: Proceedings of an International Conference, Washington, DC* (pp. 21-22).

Moreno, E., Lomonte, B., & Gutiérrez, J. M. (2008). Computational biology in Costa Rica: The role of a small country in the global context of bioinformatics. *PLoS Comput Biol*, *4*(3), e1000040.

Schedule

Weeks	Competency criteria	Content	Teaching strategy
1	He/she i can explain the concepts of biotechnology.	What is Biotechnology? • Definition of Biotechnology	Course introduction Assignment of biotechnology consultancy report projects and essay projects

		• Biotechnological products in our daily life • Classification of Biotechnology • Tools of Biotechnology	Lectures and discussion / Mind Maps
2	He/she is able to explain how biotechnology has evolved along the years at global and regional level.	History of Biotechnology • Ancient use of biotechnology • Historical discoveries that led to the current biotechnology concept • Biotechnology in Costa Rica	Lectures and discussion / Mind Maps
3		**VISIT 1. Centre of Research in Biotechnology (Cartago, Costa Rica) / VISIT 2. CIBUS 3.0**	1. Students will learn about projects, possibilities and constraints of biotechnology in general 2. Students will learn about projects, possibilities and constraints about biofuels
4	He/she distinguish the different types of solutions offered by biotechnology, along with the intrinsic challenges	Agricultural Biotechnology • Transgenics and transgenic crops • Transgenic crops and controversy • Biotechnology and organic agriculture	Lectures and discussion Round Table 1
5		Medical Biotechnology • Diagnostics of human and animal diseases • Biomedical engineering	Lectures and discussion
6		Biorremediation • Soil biorremediation • Oil spills biorremediation • Waste cleanup	Lectures and discussion
7		**VISIT 3. Laboratory of Biotechnology San Mateo High School**	Students will learn about projects, possibilities and constraints about

			agricultural biotechnology
8	Identifies opportunities and threats related to biotechnology on his/her own profesional area as well as understanding the current state of several related areas.	Biofuels • Definition of Biofuels • Biofuel controversy • Biotechnology applied to solve biofuel controversy	Lectures and discussion Round Table 2 / Essay
9		Bioprocesses • Biofactories • Bioproducts Bioprospecting • Pharmaceutical exploitation of biological products • Sustainable approach to bioprospecting	Lectures and discussion / Essay
10	Identifies opportunities and threats related to biotechnology on his/her own profesional area as well as understanding the current state of several related areas.	Synthetic Biology and the future of Biotechnology • Pros and cons of synthetic biology • Future of Biotechnology in sustainable societies	Lectures and discussion Round Table 3
11		**VISIT 4. Bioinformatics Costa Rica, San José**	Students will learn about projects, possibilities and constraints about bioinformatics
12	The students are able to recognize a problem and design a recommendation based on the acquired knowledge	Biotechnology Consultancy Report	Biotechnology Consultancy Report Presentation