BPSC 208/CEE 208 - 2023
Product Design and Entrepreneurship for Agricultural and Biological Applications

3 hours lecture (3 units)
Meeting times: T/H, 12:00-1:20 PM, MSE 011

Instructors: Julia Bailey-Serres (serres@ucr.edu) and Ian Wheeldon (wheeldon@ucr.edu).
"Office Hours" by request.

Attendance and Participation: All students are expected to attend all lectures in-person to participate in active learning and discussion unless unable to do so because of health or a pre-approved absence (*e.g.*, due to attendance at a scientific conference). Send pre-approval requests for absences to both instructors.

Class Standing Restriction: Enrollment in an MS or PhD program in CNAS (*i.e.*, Plant Biology, Plant Pathology, Entomology, Genetics, Genomics & Bioinformatics, etc.) or BCOE (*i.e.*, Chemical and Environmental Engineering, Bioengineering, etc.). Recommended that students be active in research in biological science, engineering or another discipline and interest in bioprocessing, plant sciences, agriculture or synthetic biology.

COURSE OBJECTIVES AND ORGANIZATION

Objectives: This course examines the process of identifying, evaluating and commercializing biological and agricultural products. It provides students with the tools and methods for product design, production, and economic and market assessment. The course uses a convergence learning model whereby individuals with different knowledge and technical expertise come together to tackle a research challenge that requires integration across disciplines. This approach is fostered through case studies involving the application of synthetic biology for the exploitation of plant secondary metabolite pathways to produce specialty and commodity chemicals in microorganisms, and the manipulation of plant traits (*i.e.*, control of plant and crop metabolism to enhance resilience to pests and pathogens, drought, flooding, temperature extremes and nutrient deprivation) and production (*i.e.*, development of plant-based sensors). Students with differing expertise are stimulated to identify and address significant research challenges. They are provided opportunities to develop formal and informal oral and written communications and intellectual partnerships. A key goal is to broaden knowledge and enhance communication skills so that our graduate students are better prepared to translate basic knowledge into applications in an industrial or academic setting.

*This class is an interdisciplinary course of the NSF **Plants3D** National Research Traineeship program and CEE's MS program in **Industrial Biotechnology**.* The method and approach of this course will be evaluated by an Evaluation Team at the end of the quarter (the Team are participants in the Plants3D program). This is the fourth offering of a course that is continuously evolving through student feedback. *Your input matters.*

Course Advisors: This course engages UCR faculty as advisors for the case studies and members of UCR's Office of Research and Economic Development (RED) with expertise in intellectual property or business.

Course Overview: Lectures, group discussions, individual and team presentations. Students work in teams to foster cross-disciplinary learning and improve communication skills. Collaborative work includes the creation, presentation, and discussion of case studies in biotechnology and the generation of new ideas and bioproducts. Teams also develop an original design project that is presented orally and in a written report at the end of the course. Weeks 1-3 focus on the basics of engineering products and processes. Weeks 4-17 focus on case studies. The remainder of the course covers the development of a biotechnological product. This later section includes guest lectures on entrepreneurship and business that cover product development and feasibility studies, identification of stakeholders, matters related to intellectual property, regulation and ethics.

Learning approach: Students work in small teams (3-4 students), drawn from plant sciences and engineering, to develop and assess products for biological and applications. Students learn the basics of product and process selection, product manufacturing approaches, techno-economic analysis, intellectual property practices, and business model development. Student teams give five presentations to the class and instructors, learning and improving their communication skills. The first significant presentation is on a case study. As the Design Projects develop, there are briefs on the team's selection of a product (rationale, economic opportunity, intellectual property, process; one short presentation for each). The final presentation presents the product or process design to investors. It includes the concept, economics, marketing strategy and a decision on the likelihood of success. In addition to these presentations, all students will also participate in "idea exercises" that seek to develop new cross-disciplinary concepts in plant synthetic biology and bioprocessing.

Reading: Reading assignments and other resources are provided prior to lectures via the Canvas website. Recommended references: Material and Energy Balances: Introduction to Chemical Engineering Analysis, Russell, TWF and Denn, MM. Wiley (1972) (see also https://www.youtube.com/watch?v=C0JYSnW5Yio). Plant Biochemistry and Molecular Biology, Buchanan, R, Gruissem W and Jones R. Wiley (2015).

Working in Teams: Every individual will contribute to the team assignments and project. Leadership roles should rotate. Every individual needs to bring knowledge, ideas and perspective to the table. Students are provided exercises and guidance on how to do this effectively. An open dialog is fostered within and across teams. Teams are taught to provide one another with constructive feedback. Teams consult with the instructors and course advisors multiple times over the course. All ideas and writing is to be the original work of the teams:

Learning outcomes: Students will learn, practice and master the following:

1. Working collaboratively within and across disciplines to understand and address scientific challenges by identification and design of projects with a potential for positive impact on agriculture or human health;
2. Working collaboratively to evaluate varied information sources (i.e., primary literature, patents) to formulate plans to translate basic knowledge to an original application;
3. Working independently and collaboratively to evaluate stakeholder needs, materials and process costs, and business potential; and
4. Scientific oral and written communication for varied audiences.

Course policy on academic ethics and dishonesty: Plagiarism will not be tolerated. All written and presented work is to be original and not synthesized sentences from the writings of others. All information obtained from other sources should be cited in an appropriate manner. Sources of images should be given for oral and written work. Academic Dishonesty will not be tolerated, including the facilitation of academic dishonesty by knowingly helping another student to commit an act of academic misconduct or by allowing another student to duplicate all or part of an assignment that was expected to be independent work. In this course, we encourage teamwork and therefore teams are expected to work together so that knowledge is shared.

Diversity Statement: We are committed to promoting diversity and inclusion in education and research in this course. We expect all participants in this course to maintain respect for these principles in all course-related activities and interactions.

COURSE ASSIGNMENTS, ACTIVITIES AND GRADING

Assignments	100 points total
Ideas Exercises (5 points each)	10
Discussion Participation	7
Written #1: Concept Development on Case Topic	15
Written #2: Business Plan IP, Regulatory Assessment	6
Written #3: Project Design Final Report	15
Presentation #1: Case Study	15
Presentation #2: Project Design Concept	8
Presentation #3:Brief on IP	6
Presentation #4 Brief on Project Economics	6
Presentation #5: Final Design Project	12

Grading basis: Letter grade or S/NC based on instructor approval.

What will be evaluated:

Teamwork: Due to the interdisciplinary nature of the assignments and course, all assignments are collaborative. All presentations include contributions from each team member. Contributions of individuals or of the group will be recognized by attributions provided for each assignment. This includes several mini-presentations developed by 2 or more students (depending on presentation).

Idea Exercises: *Goal: Students working together will come up with a product concept to be presented on a single slide in no more than 3 minutes.* After researching the technologies of one or more start-up companies, teams of two students will develop a new idea for product commercialization. This is a brainstorming exercise meant to foster cross-disciplinary interactions, teamwork, getting to know one another's expertise, and developing new ideas.

Case Study Assignments:
Presentation #1: Case Study. *Goal: Each team will increase the breadth and depth of knowledge by providing a distillation of information in a specific area to the interdisciplinary group.* Each team is provided a specific topic area and a faculty advisor. Teams are provided specific instructions about the assignment requirements, including a bibliography, reading assignment for other students, a slide template, and suggested presentation components. The technology or bioprocess may involve specialized materials and instrumentation. These should be integrated into the presentation in an appropriate place.

Written #1: Case Study Concept Development. As part of the convergent learning process and communication skill development, a second team will expand on the Case study presentation. *The goal of this assignment is for a team to (i) further the sharing of ideas in a topic area for classmates, (ii) develop a concept for a project in the general topic area; and (iii) to share ideas and knowledge with other class members to broaden collective knowledge and understanding.* For this the team identifies and summarizes another example in the realm of the presented case study, based on published or commercialized examples. The team then develops a new concept

that they present in the written report. The assignment includes instructions for brainstorming (sharing knowledge), concept development, and concept evaluation (including a techno-economic evaluation, using knowledge from weeks 1-2). *Instructions are provided. This is a major writing assignment that requires teamwork.*

II. Team Design Project Assignments:
Goal: To develop a product concept that bridges between plant or plant-microbial science and engineering. The project should be original and marketable. Teams will consider economic feasibility, intellectual property, ethics and regulatory opportunities and constraints. Ideal projects can be carried out within two years and potentially commercialized. Each team will develop an organization that maximizes involvement of all members and the convergence of knowledge, ideas and creativity across team members. Aim for originality and integration of knowledge and disciplines. Teams are encouraged to take advantage of the instructors, guest scientific advisors, as well as our business, IP and entrepreneurship experts. It is acceptable to discuss ideas with other UCR faculty, especially if they may be ultimate mentors on a project. Knowledge of others should be credited in the presentation/report, as appropriate.

Presentation #2*:* **Brief on the Project Design Concept.** *Each team presents the first draft of their concept using a standardized template; 2 slides, 5 minutes, all members present.*

Presentation #3: Brief on Project Economics. *Each team presents the first draft of their market and techno-economic analyses following specific instructions; 2 slides, 5 minutes, all members present.*

Presentation #4: Final Design Project. *Each team presents their design project; 8 slides max., 15 minutes, all members present.* Components will include an overview of the product and challenge it addresses, process flow diagram, mass and energy balance summary, techno-economic analysis, summary of IP, ethics, regulatory and environmental considerations, and a recommendation of whether the project should move forward (yes/no) or if a modified approach should be considered.

Written #2: Business Plan, Intellectual Property and Regulatory Assessment. Teams are provided a format for a business plan and associated marketing analysis for their project. A RED speaker has them prepare a draft of an Invention Disclosure. They also perform a short Regulatory Assessment. Each team member drafts one task and others participate in implementing improvements. This is a component of the Team Design Project Final Report; teams may improve after feedback.

Written #3: Team Design Project Final Report. (5 pages) Teams are instructed on what to include for the non-technical audience of the report. Components include the project goal and challenge it addresses, the stakeholders and market, the development steps (processes) including a techno-economic analysis that considers costs for development, infrastructure, raw materials, and consumables. Teams will also consider environmental impact, the intellectual property potential, ethics and regulatory issues. They will also critically evaluate whether or not the design project is worthy of moving forward. Written Assignment #2 and Presentations #2 and #3 provide text and figures for this report.

No Written Final. *The "final" is the* ***Design Project Presentations*** *(***Presentation #5***) in the Genomics Auditorium. Date to be scheduled by consensus.*

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Lecture Topics and Team Activity Schedule

Wk	Topic	Leaders	Team Outside Activity
1	**Industrial Biotechnology: Products and Processes**		
4/4	Introductions and Course Objectives	JBS/IW	Groups meet to share expertise
4/6	Biotechnology Applications & Bioprocess Design	IW/JBS	Students pair for *Ideas Exercise 1* and start identifying companies for ag & biological products
2	**Tools for Analysis of Biotechnology Processes**		
4/11	*Pairs: Ideas exercise 1*	IW	Regrouping and prep for *Ideas Exercise 2*
4/13	*Pairs: Ideas exercise 2*	JBS/IW	*Define Teams for* ***Case Studies;*** Teams email case study mentor, to initiate contact
3	**Lectures**		
4/18	Crop challenges and technologies	JBS/IW	Prep for case studies (Presentation #1) and concept development (Written #1)
4/20	Ag Biotech, Business Plans and Marketing Strategies	JBS/Guests	Agent Orange case study provided for
4	**Case Studies**		
4/25	Case Study 1: **Commodity Chemical Production in Microbes (Case Study Team1): Team Presentation of Case Study**. *Genomatica process. E. coli* production of petro- and other chemicals.	Advisor I. Wheeldon	**Team 4: Chemicals from Microbes Concept** (Written #1, due 5/2)
4/27	Case Study 2: **Commodity Chemical Production in Microbes (Case Study Team2): Team Presentation of Case Study**. *Amryis farnesene process.* Yeast production of petro- and other chemicals.	Advisor I. Wheeldon	**Team 5: Chemicals from Microbes Concept** (Written #1, due 5/4)
5	**Case Studies**		
5/2	Case Study 3: **Plant Secondary Metabolite Production in Yeast (Case Study Team 3). Team Presentation of Case Study**: Yeast metabolite engineering. *Include an economic analysis.*	Advisor Yanran Li	**Team 6: Plant metabolites in alternative production host Concept** (Written #1, due 5/9)
5/4	Case Study 4: **Producing Chemicals from Algae (Case Study Team 4). Team Presentation of Case Study**: Algal bioprocesses. *Include an economic analysis.*	Advisor R. Jinkerson	**Team 7: Chemicals from Algal Concept** (Written #1, due 5/11)
6	**Case Studies**		
5/9	Case study 5: **Plant/Crop Engineering (Case Study Team 5) Team Presentation of Case Study:** Product addressing challenge in ag or plant biotech. *New Technologies.*	Advisor Bailey-Serres	**Team 1: Crop Engineering Concept** (Written #1, due 5/16)
5/11	Case study 6: **Crop Protection (Case Study Team 6) Team Presentation of Case Study:** Product addressing challenge in ag or plant biotech. *Regulatory issues.*	Advisor Bailey-Serres	**Team 2: Crop Protection Concept** (Written #1, due 5/18)
7	**Case Studies and Biotech Business**		
5/16	Case study 7: **Agrochemical control of plant traits:** Product addressing challenge in controlling crop phenotypes. *Translational biology.*	Advisor Sean Cutler	**Team 3: Chemicals from Yeast Concept** (Written #1, due 5/22)
5/18	Stakeholder and Market Discussion	Ken Gruys Jay Gilberg	In class: *Re-form teams for Design Project if desired by majority*
8	**Intellectual Property**		
5/22	Identifying IP, Disclosures, Patents vs. Trade Secrets, and Infringement	Brian Suh	*Teams: Work on IP disclosure (Written#2, Part B, due 5/29)*
5/24	*Mini-presentations of Concept (5 min per group; 2 slides)*	IW/JBS	
9	**Entrepreneurship**		
5/29	Guest Entrepreneur: The 3Ds: from the lab to start-up	TBD	
6/1	Ethics Discussion: Agent Orange (case study provided in wk3). Teams: prepare to consider ethical challenge of your project	Dena Plemmens	*Teams work on final report including Economic Analysis. (Written #3: Final Report, due 6/9)*
10			
6/6	*Mini-presentations on Project IP (5 min per group; 2 slides) and Discussion*	IW/KG/JBS	
6/8	*Mini-presentations on Economics (5 min per group; 2 slides) and Discussion*	IW/KG/JBS	
6/16 If ok	**Formal Team Design Presentations and Social** *(Final Design Project Report due 6/17, midnight)*	IW/JBS Plants3D	Genomics Auditorium Date and time may be changed