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

3 hours lecture (3 units)
Meeting times: Tuesday and Thursdas, 4-5:30PM
Class Meeting Location: Via Zoom in 2021

Instructors: Julia Bailey-Serres (serres@ucr.edu) and Harvey Blanch (hwblanch@engr.ucr.edu)
Office and Office Hours: TBD

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

COURSE DESCRIPTION and OBJECTIVES

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 course is the capstone interdisciplinary course of the NSF Plants3D National Research Traineeship program. The method and approach of this offering should be readily applicable to other topics and graduate student cohorts.

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

Course Overview: Weeks 1-6 focus on the basics of engineering products and processes. Students work in teams to foster cross-disciplinary learning and improve communication skills. Collaborative work includes introductory problem sets and the development and presentation of case studies. Teams also develop an original design project that is presented orally and in a written report at the end of the course. Weeks 7-10 cover the development of a biotechnological product. This 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), drawn from plant sciences and engineering, to develop and assess products for biological and agricultural 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 four presentations to the class and instructors, learning and improving their communication skills. The first presentation is on a case study. The second and third presentations are briefs on the team's selection of a product (rationale, economic opportunity, process). The fourth is a final presentation of the product or process design, that includes the economic analysis, marketing strategy and a decision on the likelihood of success.

Reading: Reading assignments and other resources are provided prior to lectures via the course website. The recommended reference for chemical engineering is Material and Energy Balances: Introduction to Chemical Engineering Analysis, Russell, TWF and Denn, MM. Wiley (1972). The recommended reference for plant biology is 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 ASSIGNMENTS, ACTIVITIES AND GRADING

Assignments	**Percentage of Final Score of 100**
Problem Set #1 Material Balances	5
Problem Set #2 Economic Analysis	5
Written #1: Evaluation of other Team's Case Study	15
Written #2: Business Plan IP, Regulatory Assessment	10
Written #3: Project Design Final Report	10
Presentation #1: Case Study	20
Presentation #2: Brief on the Project Design Concept	10
Presentation #3: Brief on the Project Economics	10
Presentation #4: Final Design Project	15

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

Grading

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.

Attendance and Participation: All students are expected to attend all lectures to participate in active learning and discussion unless unable to do so because of health or a pre-approved absence (i.e., due to attendance to a scientific conference).

Problem Sets:
Two Problem Sets focus on chemical engineering and are completed in teams, with students working individually and then collectively and with the instructor, as necessary.

Case Study Assignments:

Written #1: Team-to-Team Evaluation of a Case Study & Concept Development. As part of the convergent learning process and communication skill development, each team will evaluate another team's Case study presentation. *The goal of this assignment is for a team to (i) constructively evaluate a Case Study presentation that is of value to the presenters and the rest of the class; (ii) further the sharing of ideas in a topic area for classmates, (iii) develop a concept for a project in the general topic area; and (iv) to share ideas and knowledge with one another and with other class members to broaden collective knowledge and understanding.* The assignment has three sections. (1) **Presentation Feedback**. Teams are provided specific instructions for providing constructive positive and critical feedback to another team after their presentation of a case study. (2) **A second published or commercialized example of knowledge translation in the topic area.** The evaluating team identifies and summarises another example in the realm of the presented case study. Specific instructions are provided. (3) **A new concept in the topic area.** The team presents a design concept in the topic area. The assignment includes instructions for brainstorming (sharing knowledge), concept development, and concept evaluation (including a techno-economic evaluation, using knowledge from weeks 1-2).

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.* The description may consider specialized materials and instrumentation. These should be integrated into the presentation in an appropriate place. Teams are provided specific instructions about the assignment requirements, including a bibliography, reading assignment for other students, a slide template, and suggested presentation components. Each team is provided a specific topic area (see syllabus) and a faculty advisor. Written advice is provided on how to manage the assignment and presentation.

Team Design Project Assignment:

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. Ideally, could 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.

Written #2: Business Plan, Intellectual Property and Regulatory Assessment. Teams are provided a format for a business plan and associated marketing analysis. 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.

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 #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.

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.

plants 3d

Product Design and Entrepreneurship for Agricultural and Biological Applications

PROGRAM FROM 2020 COURSE

Lecture Topcs and Team Activity Schedule

Wk	Topics	Lecturers & Advisors	Team Activity
1	**Introduction to Mass and Energy Balances**		
	Introductions and Course Objectives	JBS	In class: Form teams
	Mass and Energy Balances	HB	Problem Set 1: Material balances
2	**Bioprocesses**		
	Tools for Product and Process Design	HB	Teams survey agricultural & biological products
	Economic Analysis of Bioprocesses	HB	Problem Set 2: Economic analysis
3	**Case Study: Artemisinin**		
	Metabolic routes and host selection.	HB	Teams survey and prepare for presentations
	Process design. Production economics.	HB	Tutorial: Process Software
4	**Crop Protection (Case Study Team 1)**		
	Overview. Case study. Translation strategies.	Advisor Cutler	**Team 4: Crop Protection Study Evaluation** (Written Assignment #1)
	Comparison of Breeding/GMO/Editing. Consideration of costs.	JBS	
5	**Plant Secondary Metabolite Production in Yeast (Case Study Team 2)**		
	Overview. Case study. Economics.	Advisor Y. Li	**Team 1: Secondary Met. Production Study Evaluation.** (Written Assignment #1)
	Moving plant metabolism to yeast. Fermentative production.	JBS	
6	**Harnessing Chemicals from Algae (Case Study Team 3)**		
	Algal metabolism. Case Study. Process design.	Advisor Jinkerson	**Team 2: Chemicals from Algae Evaluation.** (Written Assignment #1)
	Product separation and purification.	HB	In class: form design teams and begin
7	**Commodity Chemical Production in Microbes (Case Study Team 4)**		
	Overview. Case study on production of 1,4 butanediol by *E. coli* (Genomatica process)	Advisor Wheeldon	**Team 3: Chemicals from Microbes Evaluation.** (Written Assignment #1)
	Metabolite production and purification. Economic analysis.	HB	
8	**Biotech Business**	Ken Gruys RED/HB	
	Estimates, detailed process costing	RED Guests	Develop design and begin economic analysis. (Written #2)
	Business Plans and Marketing Strategies	RED Guests	
9	**Intellectual Property**	Ken Gruys RED/JBS	
	Identifying IP, Disclosures, Patents vs. Trade Secrets. Infringement. Ethics.	RED Guests	IP disclosure; summary of ethics and regulatory matters (Written #3)
	Mini-presentations of Concept (5 min per group; 2 slides)	JBS/HB	
10	**Entrepreneurship**		
	Guest Entrepreneur: The 3Ds: from the lab to start-up	Faculty Guest	
	Mini-presentations on Economics (5 min per group; 2 slides)	JBS/HB	Final Design Report (Written #4)
	Formal Team Design Presentations	JBS/HB	

RED: UCR's Office of Research and Economic Development staff (i.e., Ken Gryus (ag biotech specialist), Jay Gilberg (entrepreneur) and Brian Suh (intellectual property and tech transfer lead). The RED staff and Advisors listed participated in the pilot of this course in Sp20.