

**CHE 192: Introduction to Biochemical Engineering**  
Fall 2008  
TR 1630 - 1745  
Engr. 395  
claire.komives@sjsu.edu

**Dr. Claire Komives**  
Engr. 385J, 924-4002  
**Office hours:**  
W 8:50 - 11:50 am  
W 1:20 – 3:45 pm  
by appointment

**Text:** Bioprocess Engineering Basic Concepts (2nd Edition), Michael L. Schuler and Fikret Kargi, Prentice Hall, 2002.

**Prerequisites:** Bio 3 and Chem 112A, or Chem 55, or Chem 135 or CHE 158 (concurrent)

**Purpose of Course:** To introduce students to the fundamentals of biochemical engineering. Consideration will be given to enzyme kinetics, protein isolation and purification, cellular regulation, microbial kinetics and energetics, and design and operation of bioreactors. Biochemical engineering is a multi-disciplinary subject and students are expected to gain an appreciation for the multi-disciplinary nature of the subject.

**Course Website:**

<http://www.engr.sjsu.edu/ckomives/Courses/Introduction%20to%20Biochemical%20Engineering/index.htm>

**Web Supplements:**

- Course Greensheet
- Lecture Notes
- Homework Solutions

**Course Policies:**

- The course will begin promptly at 16:30 on Tuesdays and Thursdays. To facilitate beginning on time, students are encouraged to arrive early to the class to turn in homework, etc.
- Material covered during class will build upon reading assignments. Hence, students are expected to attend the lectures.
- Reading assignments are listed on the attached syllabus and should be completed prior to the lecture.
- You are encouraged to study together, but your grade will depend on your own mastering of the material.
- Drop policy: Tuesday, September 14 is the last day to drop this class without a petition. Petitions will not be approved for the following reasons: Taking too many units; missing prerequisites; poor advising; low grade in this class.
- A course grade of incomplete will be given in the most compelling non-academic circumstance, which must be documented in writing and approved by me no later than 24 hours before the scheduled final examination date.
- Exam scores and course grades will not be given over the phone, as this is a violation of confidentiality.

**Grading:**

homework	10%
material balance problem	15%
midterm	25%
paper/presentation	15%
final	25%
participation	10%
<b>total</b>	<b>100%</b>

**Course Structure:**

- The first day of class there will be a brief examination which will not count as part of the course grade. The result of the exam will be used to place students in teams based on their knowledge of biology and engineering. These teams will work together throughout the semester during class on problems requiring a multi-disciplinary approach to their solution.
- Every class will consist of a lecture, and some group work or quiz. Quizzes may or may not be announced, and the purpose of these quizzes is for students to demonstrate their knowledge of the

material at a conceptual level. Problem solving will be reserved for homework, and the midterm and final exams.

- Presentations of the project will consist of 40% of the project grade. These will be made during the class period towards the middle to end of the semester. Presentations will be limited to 15 minutes of presentation followed by 5 minutes of question/answer.
- A field trip to a bioprocess facility will be organized. A best effort will be made to accommodate everyone's schedule, but no guarantees. This trip will most likely not be scheduled during the regular class time.
- Students are encouraged to supplement course reading with current biotechnology journals: Nature Biotechnology, Biotechnology Progress, Science (articles related to biotechnology), Biotechnology & Bioengineering, Applied Microbiology and Biotechnology, Enzyme and Microbial Technology. Students can earn extra credit points by making a presentation (up to 5 minutes) of some subject of current impact. Once you have read something you would like to present, contact the professor to arrange a time for your presentation.

#### **Homework, Classwork and Quizzes:**

- One quiz will be weighted the same as one homework and be included in homework grade
- Homework will be collected at the beginning of the class. Homework cannot be turned in late for credit. No exceptions will be made for this.
- Credit for solutions of calculational homework problems will be based on problem definition, solution development and numerical answer. Credit for essay problems will be based on grammar, logic and answer.
- Problems requiring a computer solution will be assigned. Students should develop their own answer, however, discussion with each other is not discouraged.
- Problem solutions will not be discussed in class. Answers will be posted on the course website. Homework will be discussed in office hours prior to the due date only when a student brings in a written attempt on the problem.

#### **Exams:**

- The midterm and final exams are open book, open notebook. Problems on the exams will NOT be like the ones in homework or class work.
- Students must show complete solutions and write legibly to receive credit for a problem.
- Cases of academic dishonesty will result in an F on the exam, and a note to appropriate personnel on campus, including your advisor for addition to your file, and may result in an F in this course. Please review the College of Engineering Academic Dishonesty code, as that will be followed in this course.
- If you must miss an exam due to emergency, notify me as soon as possible. If possible, notify me prior to the exam. If you cannot reach me personally, a message may be left on my answering machine (office phone) indicating your name and the reason for your absence. I reserve the right to require a doctor's excuse, where applicable. You may or may not be able to take a make-up exam.
- You are encouraged to arrive on time for exams. If you are late, come anyway. If you do not attend the exam and have not been excused, you may not have the opportunity to take a make-up.

#### **Material Balance Problem:**

The goal of this assignment is to generate an original biochemical engineering problem to be PUBLISHED with your name as author on the BioEMB website (<http://www.bioemb.net>). The website is a source of solved problems for faculty in chemical engineering departments all over the world to incorporate bio-based problems in their undergraduate chemical engineering courses.

What do you need to do:

1. Choose a paper from the ones identified or find a different paper of your choice but get it approved by professor

(<http://www.engr.sjsu.edu/~ckomives/Courses/Introduction%20to%20Biochemical%20Engineering/papers/>). The papers include research on the production of some protein or chemical from a biocatalytic process.

2. Read the paper and identify key information such as production rates, amounts of substrates, type of organism, process characteristics, etc.
3. Identify which species can be balanced in the process (at least carbon, possibly nitrogen and oxygen).
4. Develop the process flow sheet and show the input and exit streams. Standard rules for process flow diagrams apply - for reference on this, check Felder & Rousseau (Elementary Principles of Chemical Processes).
5. Generate a problem statement that provides enough information to solve the problem. Try yourself to solve it to be sure the balance is correct. If you are producing a protein, look up the amino acid composition and identify the stoichiometry of the protein as  $\text{CH}_x\text{O}_y\text{N}_z$ . The problem should be challenging for junior level chemical engineering taking the material and energy balance course. Note that students in this course have learned about fractional conversion (f),

$$f = (\text{mols a exiting reactor} - \text{moles a entering reactor}) / \text{moles a entering reactor}$$

but they have not learned about kinetics in the reactor. If you need to relate the concentration of the species exiting the reactor to the concentration entering, you should provide the relationship for them as they won't know how to relate it themselves. Likewise, they have not learned about mass transfer relationships, so those must also be provided if it is essential to the calculation.

Turn in a type-written problem together with a printed copy of your paper. The flow diagram should not be an image file but should be drawn in word with the drawing tools. The problem will be graded according to the following rubric:

30% accuracy of the calculation

1 = more than 2 errors; 3 = one or two minor errors; 5 = no errors

20% faithfulness to the chosen paper

1 = altered substrates, 3 = same substrate and product but altered productivity (if given), 5 = process uses same substrate, product, productivity or titers presented in paper

30% difficulty of the problem

1 = less than 6 calculations required; 3 = 7-10 calculations required, 5 = 11 or more calculations required. (calculations include appropriate (meaningful) unit conversions, molecular weight determinations, balances, process conversion calculations, productivity calculations, degree of freedom analysis, etc.)

20% presentation of the problem

1 = missing any of the following: title, abstract, problem statement, process flow diagram (does not need to have all the numerical values, just variables), solution.

3 = complete problem includes all parts but has significant grammatical errors or confusing statements

5 = clear and complete problem without grammatical errors.

#### Paper:

- To facilitate further development of a particular topic of your own interest, a project paper will be due on Thursday, November 13. The paper is an individual assignment and is not intended to be done in a group.
- The content of the paper is as follows: You must include a bibliography and you must cite your references throughout the paper.
  1. Introduction: describes the relevance of the technology to current biotechnology research and development. Focus on the engineering aspects of the technology (1-2 pages)

2. Historical development of a particular technology describing the critical paths to initiate the technology and develop it to its current state of the art. (2-3 pages)
  3. Current status of research is a review of recent literature on the topic from 1995 - present. You should reference the original literature papers, this cannot be copied from published reviews. Your first paragraph should mention the published literature reviews you will use for this portion of the paper. (3-4 pages)
  4. Summary should be 1-2 paragraphs to end the paper.
  5. References cited. No more than 2 internet cites should be used for this paper. Cite the references in the order they appear in the paper.
- Your paper (specifically, #'s 1-4 above) should be at least 6 pages and no more than 10 pages single-spaced, 12 pt font. Figures can be included in an appendix and are not included in the 8 pages. The paper will be graded based on the depth of your development of the topic, including accuracy in your interpretation of the technology. If your paper has more than three (3) grammatical errors, it will be turned back to you and you will lose 10% credit. Each time you turn it in and it is turned back to you, you will lose another 10% credit. If English is not your first language, you should get your paper professionally edited for grammar prior to turning it in. This policy will be strictly followed.
  - You should choose a topic no later than Thursday, September 23. You must present your topic to me - 1 paragraph description with literature review- on or before that date or you will lose 10 points from your paper score. The topic must have applications in or have involved engineering, not strictly biological science oriented. You will be required to describe how the topic is related to engineering in the introduction to the paper.
  - The paper will be turned in as hard copy and through [www.turnitin.com](http://www.turnitin.com). The course ID is 1159659 and the password is "greatbugs".

### Course Learning Objectives

1. Model and analyze simple bioreactor systems, including chemostats and enzyme batch reactors, using first principles models.
2. Analyze metabolic pathway models for application to chemostat reaction systems.
3. Application of heat and mass transfer concepts to laboratory- and pilot-scale bioreactors.
4. Design procedures for expression of foreign genes in *E. coli* using principles of cellular chemistry.
5. Develop a historical exposition of a bio-technology.
6. Use Excel, Matlab and other software for analysis of batch bioreactor data.
7. Work with multi-disciplinary teams to solve relevant problems in biotechnological research and development.
8. Identify necessary components for control of bioreactor systems to achieve a specified objective.
9. Evaluate separations systems for cell separation and purification of intracellular and secreted compounds from bacterial and animal cell cultures.
10. Evaluate emerging and new technologies in the field of biotechnology and their impact on chemical process engineering.

### Class Schedule for Fall 2008

Class date	Subject	Reading assignment	Homework due (subject to change)
T Aug 26	Introduction - green sheet		assignment of material balance prob
Th Aug 28	Intro to cells	Chapter 1 & 2	

T Sep 2	Enzyme kinetics	Chapter 3	
Th Sep 4	Enzyme kinetics		
T Sep 9	DNA Replication and Protein Production	Chapter 4	Mat'l bal prob due
Th Sep 11	Microbial Kinetics & Energetics	Chapter 5	
T Sep 16	Microbial Kinetics & Energetics, cont'd	Chapter 5	Homework I
Th Sep 18	Cell growth in flasks	Chapter 6	
T Sep 23	Chemostats	Chapter 6	deadline for paper topic
Th Sep 25	Stoichiometry of Microbial Growth	Chapter 7	
T Sep 30	Modified Chemostats/fed-batch fermentation	Chapter 9	Homework II
Th Oct 2	Bioreactor mixing, oxygen transfer and scale-up	Chapter 10	
T Oct 7	midterm I cells, cell culture and bioreactors		
Th Oct 9	Intro to flux analysis & metabolic engineering I		
T Oct 14	Intro to flux analysis & metabolic engineering II		Homework III
Th Oct 16	Cloning	Chapter 8	
T Oct 21	Intro to separations	Chapter 11	
Th Oct 23	Ultrafiltration, microfiltration, cont'd		
T Oct 28	Protein purification: protein stability and solubility(salting out),		Homework IV
Th Oct 30	Protein purification, cont'd chromatography	Homework handout	
T Nov 4	Animal Cell Culture	Chapter 12	
Th Nov 6	Gene shuffling/protein engineering		
T Nov 11	No class: Veterans Day		
Th Nov 13	Applications: biosensors	Chapter 14	Paper due: turnitin.com
T Nov 18	Good manufacturing practices: guest lecture		
Th Nov 20	Guest lecture: Ion Exchange Chromatography		
T Nov 25	Guest lecture: TBA		Homework V
Th Nov 27	No class: Thanksgiving		
T Dec 2	Class presentations		
Th Dec 5	Class presentations		
T Dec 9	Class presentations		
T Dec 16	Final exam: comprehensive	1715-1930	

**a) Academic integrity statement (from Office of Judicial Affairs):**

“Your own commitment to learning, as evidenced by your enrollment at San José State University and the University’s Academic Integrity Policy requires you to be honest in all your

academic course work. Faculty are required to report all infractions to the Office of Judicial Affairs. The policy on academic integrity can be found at <http://www2.sjsu.edu/senate/S04-12.pdf>

**b) Campus policy in compliance with the Americans with Disabilities Act:**

“If you need course adaptations or accommodations because of a disability, or if you need special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities register with DRC to establish a record of their disability.”

**c) Cell Phones:**

Students will turn their cell phones off or put them on vibrate mode while in class. They will not answer their phones in class. Students whose phones disrupt the course and do not stop when requested by the instructor will be referred to the Judicial Affairs Officer of the University.

**d) Evacuation Plan:**

Room 395: Turn left or right upon leaving classroom, down the staircase. Meet in front of the main entrance of the Engineering Building to be counted.