INTRODUCTION TO BIOCHEMICAL ENGINEERING (CBE:5205); FALL 2016

General Course Policy

This course is given by the College of Engineering. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Engineering. Students wishing to add or drop this course after the official deadline must receive the approval of the Dean of the College of Engineering.

Accommodations for Disabilities

If you feel that you may need an accommodation based on the impact of a disability please contact Prof. Murhammer privately to discuss your specific needs. You may also contact the Office of Student Disability Services (319/335-1462 or sds-info@uiowa.edu) to discuss the accommodations that are available for students with documented disabilities.

Classroom Behavior

You are expected to be respectful of the course instructor and other students in the course. Thus, the following is expected during class time:

- Turn off cell phone – no texting, etc.
- No reading newspapers, etc.
- No talking except during Q & A and discussions.
- Please ask questions! Raise your hand and wait to be acknowledged.

1. Time and Place of Course
   Lecture: 11:30 a.m. – 12:20 p.m. on Mondays, Wednesdays, and Fridays in 22 Schaeffer Hall (SH)
   Discussion (Problem Solving Session): 6:30 p.m. on Wednesdays in 3505 SC

2. Course Web Site
   Course information can be found on the course web site that is found on the ICON system (http://icon.uiowa.edu).

3. Instructor
   David W. Murhammer
   Office: 4132 Seamans Center (SC)
   Phone: 335-1228
   Email: david-murhammer@uiowa.edu
   Office Hours: W 1:30-2:30 p.m. and Th 2:00-3:00 p.m.

4. Teaching Assistant
   Kayla Racinowski
   Email: kayla-racinowski@uiowa.edu

5. Textbook
   "Bioprocess Engineering: Basic Concepts", 2nd ed., Shuler and Kargi, 2002, Prentice Hall, Inc.

6. Course Learning Goals
   By the end of the course, the student will:
   - Have a fundamental understanding of pharmaceutical and biotechnology businesses, including the range of products produced and how products get to the marketplace.
   - Have a fundamental understanding of cell chemistry, cell metabolism (including yield coefficients and metabolic quotients), recombinant DNA methods, and cell structure and function.
   - Be able to choose and apply the simple models of enzyme kinetics, cell growth, and product formation that yield accurate results for the problem under consideration, including the Michaelis-Menten Equation with and without inhibition and the Monod growth equation.
   - Be able to evaluate mass transfer limitations in immobilized enzymes and cell reactors.
   - Have a fundamental understanding of chemostats and their applications, and be able to perform the corresponding calculations.
   - Be able to formulate a medium for a specific application and to design the corresponding sterilization process.
   - Have a fundamental understanding of mixing and oxygen transport in agitated bioreactors and be able to perform corresponding calculations.

- Be able to scale up agitated bioreactors based on various criteria.
- Have a basic understanding of the major issues and techniques involved with purifying biologics and be able to perform corresponding calculations.
- Be able to collect and analyze experimental data.
- Have a fundamental understanding of batch and continuous processes involved in producing fermentation (e.g., antibiotics and biofuels) and recombinant products (e.g., recombinant proteins).
- Have had opportunities to further his/her professional development through practicing written communication skills.

7. Tentative Course Outline (Suggested readings are from Shuler and Kargi textbook)

	Date	Topic	Reading
August	22	Introduction/Pharmaceutical and Biotechnology Products and Business	Chapter 1
	24	Cell Chemistry	Chapter 2 & 4
	26	Cell Chemistry	
	29	Cell Metabolism/Metabolic Control	Chapter 5
	31	Cell Metabolism/Metabolic Control	
September	2	Media Formulation/Sterilization	Handout & Chapter 10
	5	**Labor Day – No Class**	
	7	Media Formulation/Sterilization	
	9	Media Formulation/Sterilization	
	12	Analytical Tools Used In Biotechnology	Handout
	14	Analytical Tools Used In Biotechnology	
	16	Strain Development/Recombinant DNA Technology	Chapters 8 & 14
	19	Strain Development/Recombinant DNA Technology	
	21	Strain Development/Recombinant DNA Technology	
	23	Experiment 1/Enzymes and Enzyme Kinetics	
	26	Enzymes and Enzyme Kinetics	Chapter 3
	28	Enzymes and Enzyme Kinetics	
	30	Enzymes and Enzyme Kinetics	
October	3	Cell Structure and Function	Chapter 2
	5	Cell Structure and Function	
	7	Cell Growth/Product Formation	Chapters 6, 7 & 14
	10	Cell Growth/Product Formation	
	12	Cell Growth/Product Formation	
	14	Biofuels Production	Appendix
	17	Common Fermentations	
	19	Common Fermentations	
	21	Experiment 2/Common Fermentations	
	24	Immunology/Antibodies/Vaccines	Handout
	26	Immunology/Antibodies/Vaccines	
	28	Animal and Plant Cell Culture/Product Production	Chapter 12 & 13
	31	Animal and Plant Cell Culture/Product Production	

	Date	Topic	Reading
November	2	Animal and Plant Cell Culture/Product Production	
	4	Chemostats	Chapters 6 & 9
	7	Chemostats	
	9	Chemostats	
	11	**NO CLASS –AIChE Meeting**	
	14	**NO CLASS –AIChE Meeting**	
	16	Transport in Bioreactors	Chapter 10
	18	Transport in Bioreactors	
	21-25	**No Class – Thanksgiving Break**	
	28	Bioreactor Design	
	30	Bioreactor Design	
December	2	Introduction to Bioseparations	Chapter 11
	5	Introduction to Bioseparations	
	7	Special Topics (as time permits)	
	9	Special Topics (as time permits)	

8. Homework
   Homework assignments will be due on Fridays and should be handed in at the beginning of the period it is due. Late homework will not be accepted. You are also encouraged to work together on homework assignments; individual solutions must be handed in, however.

9. Quizzes
   There will be a quiz every Monday following a Friday on which homework is due, with the exception of the first quiz. Due to Labor Day, the first quiz will be on Friday, September 2nd, which is also the date on which the first homework assignment will be due. The quizzes will generally be closed book and will cover material contained in the corresponding homework.

10. Laboratory Component
    There will be laboratory experiments conducted in groups, including a recombinant DNA experiment (held the week of September 26th at times to be determined) and a cell growth/metabolism experiment (held the week of October 24th at times to be determined). Each experiment will include brief individual laboratory reports. Details to come.

11. Project Report (Due December 9th)
    This will be a group project describing the design of a process to produce a specified amount of a given product (fermentation product, recombinant protein, etc.) as given in a previous AIChE Design problem. This will consist of (1) consulting the literature to determine all currently known information pertinent to the problem and (2) using this information along with the procedures (e.g., bioreactor design, medium formulation, genetic engineering, etc.) learned in class to develop the requested design. The design should include all pertinent steps from genetic engineering through product purification, including medium development, medium sterilization, etc. All of the equipment through product production should be properly sized (to the extent possible), etc., by using the techniques learned in our course (cost estimations should not be included). Product purification only needs to include the equipment used and the sequence thereof (i.e., no sizing or cost estimates). The final report should have the following format:
    (a) Title Page – which includes the names of all group members, project title, course number and course name, and date.
    (b) Abstract – which summarizes the overall conclusions of the project.
    (c) Introduction – which briefly describes the project, including the goals and approach used to achieve these goals and a summary of all pertinent literature.

(d) Process Design – which includes the results of the design (obtainable with literature information and the techniques learned in class), including figures, diagrams, etc. This section should also include a Process Flow Diagram (PFD), preferably drawn with use of the ChemCad or similar software.
(e) Safety and Environmental Issues - This should include identification of major hazards, including toxicity, flammability, reactivity, biological hazards, environmental hazards and how these can be addressed (e.g., PPE, procedures, training, control systems, sensors, relief devices, etc.) for the entire process. Compatibility of chemicals should also be evaluated, e.g., through use of the CRW software, and a HAZOP should be conducted.
(f) Inherently Safer Design – a discussion of applying inherently safer design principles (minimize, substitute, moderate, and simplify) to the process. This should include (i) designing the plant for easier and effective maintainability, (ii) designing the plant with less waste, (iii) designing the plant with special features that demonstrate inherent safety, and (iv) incorporating design concepts that take into account the entire life cycle.
(g) Conclusion – which includes all the conclusions, including potential market value of the proposed design.
(h) Appendix – which includes sample calculations, etc.

12. Examination Schedule

	Material Covered	Date	Place
Exam 1	Aug. 22 – Oct. 7 lectures	Wednesday, October 12 (6:30-8:30 p.m.) [tentative]	TBD
Final Exam	All Material in Course	TBD	TBD

Exams will be a combination of closed book and open book. No excuses for missed exams will be accepted other than certified medical excuses. If you cannot take the exam at the scheduled time, then please contact Professor Murhammer at least one week prior to that date so that an alternative exam time can be scheduled.

13. Grading

Letter grades will be assigned on a curve. However, there will be a "gray area" between each two letter grades in the final distribution, so that two people getting the same weighted average grade could get different letter grades. If you are in one of these gray areas, whether you get the higher or lower grade depends on two factors: (i) your performance on the homework and (ii) whether your exam and homework performance has been improving (your grade goes up) or declining (your grade goes down). The weighting of the various components of the course is as follows:

(a) Attendance	50 points
(b) Homework	100 points
(c) Quizzes	250 points
(d) Lab Reports	100 points
(e) Project	100 points
(f) Midterm Exam	100 points
(g) Final Exam	200 points
TOTAL	**900 Points**