COMMONWEALTH GRADUATE ENGINEERING PROGRAM
DISTANCE LEARNING COURSE PLANNING SHEET
UNIVERSITY OF VIRGINIA

Course: CHE 647 – Biochemial Engineering Principles
Semester: Spring 2008
Instructor: Erik J. Fernandez
Phone No.: (434) 924-1351
Office Address: Room 122, Chemical Engineering, 102 Engineers Way, University of Virginia
Charlottesville, VA 22904-4741

E-Mail Address: erik@virginia.edu

Textbook(s): (Student to purchase)

M. L. Shuler, F. Kargi, *Bioprocess Engineering: Basic Concepts*, Second edition, Prentice Hall, 2002.

Reference(s): Limit 4

- J. E. Bailey, D. F. Ollis, *Biochemical Engineering Fundamentals*, 2nd edition, McGraw-Hill, New York (1986).
- H. W. Blanch and D. S. Clark, *Biochemical Engineering*, Marcel Dekker, 1996.

- J. D. Watson, *Molecular Biology of the Gene*, Benjamin/Cummings, Menlo Park, CA (2004).
- Voet and Voet, *Biochemistry*, Wiley, New York (1995).

Computer Needs:

Computer Capability:

Software required: Excel should be sufficient. We may do a little work with ordinary differential equation modeling (Runge Kutta ODE solving. Packages such as MATLAB, Maple, Mathematica, possibly even Excel will be sufficient.)

Provided?

Other:

CHE 347/647 - Biochemical Engineering Principles

Spring 2008
Lecture: T/Th 8:00-9:15 pm
THN A-119

NOTE: This syllabus is tentative. Some special topics and assignments will likely change.

Course Description: 3 credits. Pre-requisites: CHE 246 and CHE 321; co-requisites CHE 318 and CHE 322; or instructor permission. Quantitative aspects of industrial applications of biology: microbial or mammalian cell synthesis of commercial products such as antibiotics and therapeutic proteins. Emphasis on biocatalysis including both enzymes and whole cells and on engineering aspects of bioreactor analysis and design. Introduction to special topics in biopharmaceutical production such as vaccine manufacture, insect and plant cell culture, transgenic animals, tissue engineering and gene/cell therapy products.

Objectives

(1) Familiarize advanced undergraduates and graduate students in the life sciences and engineering with applications of biotechnology and introduce special topics in biotechnology.
(2) Review micro-, cell and molecular biology and biochemistry important to technology and bioreactor analysis with an emphasis on quantitative descriptions
(3) Develop engineering analyses and design of bioreactors for enzyme, microbial, and animal cells.

Instructor

Erik J. Fernandez
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924-1351
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Class home page: http://toolkit.virginia.edu/CHE347-1

Required Text:

M. L. Shuler, F. Kargi, *Bioprocess Engineering: Basic Concepts*, Second edition, Prentice Hall, 2002.

Supplemental Sources (on reserve in the Science and Engineering library (SCI) or Bio/Psych (BP) library):

Sci/Engineering library:

- J. E. Bailey, D. F. Ollis, *Biochemical Engineering Fundamentals*, 2nd edition, McGraw-Hill, New York (1986).
- H. W. Blanch and D. S. Clark, *Biochemical Engineering*, Marcel Dekker, 1996.

Bio/Psychology library:

- J. D. Watson, *Molecular Biology of the Gene*, Benjamin/Cummings, Menlo Park, CA (2004).
- Voet and Voet, *Biochemistry*, Wiley, New York (1995).

Biotechnology Journals with an Engineering Perspective:

Applied and Environmental Biotechnology
Bioprocess Engineering
Biotechnology and Bioengineering
Biotechnology Progress
Enzyme and Microbial Technology
Nature Biotechnology

Trade News:

Nature Biotechnology
Genetic Engineering News

Grading:

There will be homework, a midterm, a short research paper, and a final exam. For those taking 647, you will prepare a short lecture (half a class period) on a special topic of your choice. The weighting of the homework, quizzes, and final exam will be

	CHE 347	CHE 647
Homework	15%	15%
Midterm	30	25
Research paper	15	10
Mini Lecture (647 students only)		15
Final Exam	35	30
Class contributions	5	5

"Class contributions" will be based on quantity and quality of contributions to discussions during class as well as formal or informal office hours. While the quantity will be noted, quality will be emphasized in grading.

Homework

The homework assignments will be handed out approximately weekly. The homework will be discussed on the date due and graded. The homework will be discussed on the date due and graded simply by 0, 1 or 2 per question; 2 = substantially correct, 1=reasonable attempt and 0 = not much effort. You are encouraged to work together on homework, but must turn in your own solutions, and you are not allowed to consult solutions from prior years. **Late homework will not be accepted without prior permission of the instructor.**

Note on spreadsheets: You are welcome to use them, but make sure you indicate the formulas you used and your reasoning as well.

Pledged Research Paper Assignment

Investigate the key engineering challenge associated with a biotechnology. You will report on a biotechnology product or process of interest to you. You will describe the technology, and then identify a key engineering challenge in the development of the technology. You will complete this assignment in two-person teams of your choosing. More details forthcoming.

Lecture Assignment (647 students only)

Create and present lecture on a biochemical engineering/biotechnology topic related, but not directly covered in the lecture material of the course. To give you practice with independent learning and presentation, you will prepare a 20-minute lecture on a special topic of relevance to the class. The lectures will help enrich the course coverage and will be subject to testing on the final exam. **You must claim your topic by Feb 15** by sending an email to the instructor**.** The topic must be approved by the instructor; some possibilities are listed on the following page. I will be available for consultation on the presentations. PowerPoint visuals should be provided to the instructor prior to your lecture, so that handouts can be prepared for the class.

Tentative Syllabus

- Introduction to biochemical engineering
- Proteins
  - Structure, function, and stability
  - Sequence analysis

- Enzymes
  - Catalytic mechanisms
  - Selectivity
  - Rate laws, Michaelis-Menten kinetics
  - Batch kinetics
  - Inhibition
  - Determining rate parameters
- Immobilized enzymes
  - Surfaces
  - Porous materials
  - Mass transfer vs. Reaction rate limitations
- Cellular kinetics
  - Batch growth kinetics
  - Product formation kinetics
  - Nutrient limitation
  - Continuous culture
  - Modeling approaches
- Bioreactor design
  - Batch vs. CSTR
  - Alternatives to CSTR
- Immobilized biocatalysts
- Scale-up issues
  - Oxygenation
  - Mixing
  - Sterilization
- Animal cell culture and for therapeutic proteins
- Metabolic engineering
- Protein engineering
- Special topics / mini-lectures by 647 students – could include
  - Plant cell culture
  - Transgenics
  - Genetic instability
  - Tissue engineering
  - Gene therapy
  - Drug discovery technology
  - Vaccines

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Education

B. S., Chemical Engineering, California Institute of Technology, 1984.
Ph. D., Chemical Engineering, University of California, Berkeley, 1989.

Professional Experience

2006	*Visiting Professor,* Department of Chemical and Biomolecular Engineeering Johns Hopkins University, Baltimore, Maryland.
2005 – present	*Professor,* Department of Chemical Engineering University of Virginia, Charlottesville, Virginia.
1997 - 2005	*Associate Professor,* Department of Chemical Engineering University of Virginia, Charlottesville, Virginia.
1999	*Visiting Professor,* Department of Pharmaceutical Chemistry University of California, San Francisco, California.
1991 - 1997	*Assistant Professor,* Department of Chemical Engineering University of Virginia, Charlottesville, Virginia.
1989 - 1990	*Postdoctoral Fellow,* Departments of Medicine and Radiology University of California, San Francisco. Advisors: Michael W. Weiner and Andrew A. Maudsley

Honors and Awards

2006	Fellow of American Institute of Medical and Biological Engineering
2003	Aydelotte Faculty Fellow (U. Virginia)
1999	Rodman Scholars Award for Excellence in Teaching (U. Virginia)
1997 - 1998	University Teaching Fellow (U. Virginia)
1995 - 1999	National Science Foundation CAREER Award
1990 - 1991	NIH/Cardiovascular Research Institute Postdoctoral Fellow
1985 - 1988	NSF Graduate Fellow

Research Interests

- Biomolecular engineering with applications to protein and other biopharmaceuticals:
  - Protein unfolding and adsorption
  - β-Amyloid structure (Alzheimer's disease)
  - Biophysical analysis of protein aggregation and impact on protein formulation
  - Virus-like particle structure, assembly, and misassembly
- Engineered biointerfaces for biomedical science and drug delivery
- Continuum mechanics of compressible chromatography media and column packing

Prof. Fernandez completed his Ph.D. at Berkeley (Thesis advisor, Prof. Douglas Clark), focusing on metabolic and reaction engineering analysis of mammalian cell culture. During a postdoc at the University of California, San Francisco, he helped develop new techniques for metabolic imaging with MRI. Since beginning at the University of Virginia in 1991, Prof. Fernandez' research interests have focused on purification of protein pharmaceuticals, including structural, kinetic, and thermodynamic mechanisms of protein denaturation during adsorption, aggregation, and formulation. More recently, Prof. Fernandez has begun investigating peptide aggregation in the context of human disease as well as developing engineered surfaces for biological applications.