

Introduction to Biochemical Engineering

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Office: Discovery Park K240K

Office hours: Friday 1:00 – 3:00 pm

Lecture hours: Tuesday and Thursday 9:05 AM – 10:25 AM

Classrooms: NTDP D207A

Prerequisite(s): Senior standing in biomedical engineering (BMEN 3310 and/or BMEN 3321) or permission of instructor.

Catalog Description:

Introduction to fundamental biochemical engineering concepts primarily to biomedical engineers. This course covers three major topics in biochemical and bioprocess engineering, including enzyme technology (enzyme kinetics, inhibition, stability, and immobilization techniques), cell culture and bioreactor design (cell growth models, media formulation, aseptic techniques, bioreactor design, etc.) and bioseparation for protein purification (centrifugation, filtration and ultrafiltration, chromatography, electrophoresis, etc.).

Course Description:

This is a course developed for senior students in biomedical engineering. However, it may be useful for a diverse student body, including engineers with formal training in high-level mathematics and engineering design, and biologists and chemists with formal training in biochemistry and molecular biology. This course will introduce the basics of biochemistry, biology, microbiology, and chemical engineering with applications in biopharmaceutical industry and explain how biochemical engineering is used for the analysis, control, and development of biological, biochemical, and industrial processes. Quantitative, problem-solving methods in biochemical engineering will be introduced. Emphasis for this course will be on the bioprocesses necessary for the production and purification of biopharmaceutical drugs, including small molecules and proteins. Students will learn enzyme technology, including enzyme kinetics, inhibition, stability, and immobilization techniques, for the enzymatic production of small molecules. In addition, students will learn how to formulate cell culture media, culture mammalian cells for the production of therapeutic proteins, design bioreactors for large-scale cell culture, and understand downstream separation processes of biologics. A student who wishes to pursue a career in biopharmaceutical industry or one who intends to continue graduate studies will benefit the most from the course.

* Cell phone use in class is strongly prohibited.

* **There will be no make-up exam.** In case a student cannot take the midterm/final exam for medical reasons with official documents provided by hospitals, 75% of the score the student obtained from the other exam will be used instead of the missing exam.

* During the exam, phones and bio-breaks are not allowed.

* All purses and bags must be completely zipped up and closed during the exam.

* **Students are required to pull back all head coverings to display their ears during exams to prevent academic misconduct.** As part of the University's ongoing efforts to prevent cheating, and based on evidence of increased use of headphones and earpiece devices to permit cheating on exams, all students are required to display their ears for the duration of any exam. The policy may require adjustment to hair or clothing. Any student not complying with this policy will, after a warning, be issued a zero on the exam. Students with concerns about their compliance with this policy, please contact Academic Integrity Officer at academic.integrity@unt.edu or 940-565-2856.

Course Goal:

- Understand basics of biopharmaceutical and biotechnology processes
- Introduce simple models of enzyme kinetics and inhibition
- Learn mass transfer limitations in immobilized enzymes and cell reactors
- Understand basics of mammalian cell culture
- Learn how to formulate cell culture media and design the sterilization process
- Learn how to design bioreactors (batch and continuous) and understand mixing and oxygen transport in bioreactors
- Learn how to scale up bioreactors based on various criteria
- Overview major issues in downstream processing of biologics (bioseparations)

Course Materials:**Textbooks**

- Bioprocess Engineering: Basic Concepts, 3rd ed., Michael L. Shuler, Fikret Kargi, and Matthew DeLisa, Pearson, ISBN: 9780137062706 (2017)
- Essentials of Chemical Reaction Engineering, 2nd Ed., Fogler, Scott H., Prentice Hall, ISBN-10: 0-13-466389-6 (2018)

Reference books

- Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists, 2nd ed., Shigeo Katoh, Jun-ichi Horiuchi, Fumitake Yoshida, Wiley, ISBN: 9783527338047 (2015)

These books are only suggestions, and there is no need to purchase them. All materials covered in the course will be drawn from the textbooks, the reference book, and other sources, and lecture notes will be provided to students.

Topical Outline:

- Introduction to Biochemical Engineering
- **Part A. Enzyme Technology**
 - ✓ Introduction to Proteins and Enzymes; Industrial Applications of Enzymes
 - ✓ Principles of Enzyme Catalysis
 - ✓ Enzyme Inhibition
 - ✓ Enzyme Stability
 - ✓ Introduction to Immobilized Enzyme Technology
- **Part B. Bioreactor Design and Cell Culture**
 - ✓ Chemical Reaction and Rate Laws
 - ✓ General Mole Balances
 - ✓ Conversion and Reactor Sizing
 - ✓ Stoichiometry
 - ✓ Isothermal Bioreactor Design
 - ✓ Basics of Mammalian Cell Culture
 - ✓ Media Formulation and Sterilization
- **Part C. Bioseparations**
 - ✓ Introduction to Bioseparations
 - ✓ Overview of Critical Issues in Downstream Processing
 - ✓ Centrifugation, Filtration and Ultrafiltration
 - ✓ Precipitation of Proteins; Chromatography; Electrophoresis and Crystallization

Grading Policy:

The course grading will consist of two parts. Part 1 is the two exams. These exams are not cumulative and will test knowledge gained through the indicated lectures. Part 2 is homework, which will be due periodically throughout the semester. I will prepare the homework, yet it will be graded solely by the TA.

I will allow study groups to discuss homework assignments; however, the homework that you submit must be your own. The following is a breakdown of the grading:

- Class attendance: 5%
- Homework assignments: 30%
- Midterm exam: 30%
- Final exam: 35%

Total: 100%

All scores on class attendance, assignments, and exams will be based on 100 points. The final score will be calculated by the percentage given above.

The final letter grade will be determined by a grading guideline chosen by the instructor. The following grading guideline exemplifies the relationships between the final score calculated from the formula above and the letter grade assigned. Final grades will be balanced between the grading guideline and a student grade distribution.

- A: 89.5 – 100%
- B: 79.5 – 89.4%
- C: 69.5 – 79.4%
- D: 59.5 – 69.4%
- F: below 59.4%

Registration, Drop and Withdrawal Policy

Drop: It is the student's responsibility, and not the instructor's, to drop the course. You may find important details about how dropping a class can affect your GPA and your Financial Aid here: <http://registrar.unt.edu/registration/dropping-class>

Withdrawal: It is the student's responsibility to withdraw from the course by either going to their academic advisor's office (which should be the first stop when considering a withdraw), the Registrar's office, or the Department. If you can't complete the course, you must withdraw for a "W" (after this date, you'd receive either a "WP" or a "WF"). Withdrawing from a course is a formal procedure which YOU must initiate. I can't do it for you. If you simply stop attending and do not withdraw, you will receive a performance grade, usually an "F." All deadlines can be found at: <http://registrar.unt.edu/registration/fall-registration-guide>

University Policy on Academic Misconduct

Academic Misconduct (Sec. 3.4 from the Student Handbook): Any act that violates the academic integrity of the institution is considered academic misconduct. The procedures used to resolve suspected acts of academic misconduct are available in the Office of Academic Deans and the Office of Campus Life. Specific examples include, but are not limited to:

Cheating: Copying from another student's test paper, written assignment, other report, or computer files and listings; Using, during any academic exercise, material and/or devices not authorized by the person in charge of the test; Collaborating with or seeking aid from another student during a test or laboratory without permission; Knowingly using, buying, selling, stealing, transporting, or soliciting in its entirety or in part, the contents of a test or other assignment unauthorized for release; Substituting for another student or permitting another student to substitute for oneself.

Plagiarism: The appropriation, theft, purchase or obtaining by any means another's work, and the unacknowledged submission or incorporation of that work as one's own offered for credit. Appropriation includes the quoting or paraphrasing of another's work without giving credit (especially online resources). Turnitin will be utilized to ensure online resources are not misappropriated.

Any work not meeting this standard will be evaluated and subject to either a re-write, if the Instructor concludes that the assignment was unintentionally plagiarized or a zero for the assignment. Egregious forms of academic conduct are subject to a formal hearing. For more information on paper writing, including how to avoid plagiarism, and how to use citations, see <http://anthropology.unt.edu/resources->

writingpaper.php. For information on the University's policies regarding academic integrity and dishonesty, see the UNT Center for Student Rights and Responsibilities, <http://www.unt.edu/csrr/>.

Collusion: The unauthorized collaboration with another in preparing work offered for credit.

Personal Distress

Excerpts from <http://studentaffairs.unt.edu/care> "The University of North Texas cares about our students' success, not only academically, but emotionally and physically.... Because of our commitment, we provide literally hundreds of departments and services across campus that respond to our students' unique needs.... UNT believes it is important to foster an environment that encourages students to maintain a standard of responsibility for self-care which includes the ability to respond adequately to one's emotional, physical, and educational needs. If you are experiencing physical or emotional distress which adversely affects your ability to succeed in class, please see me as soon as possible. Together, we will point you towards the appropriate resources.