

**CHBE 474/ BIOE 489T/ ENCH648D**  
**Biopharmaceutical Process Development and Manufacturing**  
Department of Chemical and Biomolecular Engineering  
University of Maryland  
Spring 2019

**COURSE INFORMATION**

**Prerequisites:** BIOE120 or equivalent and permission of instructor

**Class Meetings:** Monday/ Wednesday 12:30-1:45 pm, AJC 2119

**Credit Level:** 3 credits

**Instructor:** Dr. Deborah S. Goldberg  
Office: ChE 1223D  
Email: [dsgold@umd.edu](mailto:dsgold@umd.edu)  
Phone: 301-405-5575  
Website: [dsgoldberg.weebly.com](http://dsgoldberg.weebly.com)  
OH: Wednesdays, 2-3 pm

**UTF:** Mr. Anthony Chiu  
Email: [anthonychiu96@gmail.com](mailto:anthonychiu96@gmail.com)  
OH: Fridays, 10-10:50 am, ChE 1124

**Course Material:** No textbook required. Reading material will be posted to course website.

**Course Description (from testudo):**

*This course will cover the fundamental steps involved in process development and manufacturing of biopharmaceuticals. An overview of different classes of biopharmaceuticals as well as manufacturing requirements for clinical development and regulatory approval will be provided. In depth coverage of manufacturing steps including cell culture, purification and formulation as well as drug product manufacturing, analysis and stability will be covered. Scientific literature will be used to highlight current challenges and novel solutions in each step of the manufacturing process. Scale up considerations, GMP requirements and process economics will also be introduced.*

**LEARNING OUTCOMES**

**After successful completion of the course students will be able to:**

1. Articulate the unique therapeutic properties and manufacturing challenges of biopharmaceuticals.
2. Demonstrate understanding of the structure/ function of antibodies, appropriate characterization techniques and how product quality attributes relate to manufacturing, safety and efficacy.
3. Fully describe the steps and considerations in each stage of biopharmaceutical manufacturing using biochemistry, physics, math and engineering concepts.
4. Articulate the practical and business considerations which impact process development at different stages of clinical and commercial product development.
5. Demonstrate the ability to read, synthesize, evaluate and discuss current literature on biopharmaceutical development and manufacturing.

## COURSE EXPECTATIONS

### Faculty Expectations of Students:

- Review prerequisite course materials.
- Complete out of class assignments on time.
- Come to class prepared (having read the assigned material) and on time.
- Participate in the classroom by asking and responding to questions and engaging in group activities.
- Get help and feedback from the instructor and teaching assistant, as needed.
- Treat instructor, teaching assistant and fellow students professionally, and with respect.
- Follow the university code and departmental policy on Academic Integrity.
- Write out and sign the University of Maryland Honor Pledge on all assignments and examinations, as well as abide by its principles.

### Student Expectations of Faculty:

- Provide written documentation and dialog on what is expected of students, course objectives and content, and performance criteria and evaluation procedures.
- Be available for office hours or by appointment.
- Put course material in context by relating it to life experiences, career related problems and applications, contemporary issues in engineering research and practice, and the content of other courses.
- Respect students and be receptive to their questions and opinions.
- Treat students fairly and equitably.
- Come to class prepared and on time.
- Return graded material in a timely fashion.
- Set examinations appropriately for the material being tested.
- Provide continual feedback on student performance.

## COURSE POLICIES

This course will adhere to university policies relevant to Undergraduate Courses are found here:

<http://ugst.umd.edu/courserelatedpolicies.html>

In addition, links to full policies on excused absences and academic dishonesty can be found below. Students are expected to read and understand these policies.

### *Excused Absence Policy:*

<http://www.president.umd.edu/sites/president.umd.edu/files/documents/policies/V-1.00G.pdf>

### *Academic Dishonesty Policy:*

<http://www.president.umd.edu/sites/president.umd.edu/files/documents/policies/III-100A.pdf>

### *A Special Note on Plagiarism*

During this course students will be asked communicate and synthesize information based on primary sources. **All original sources must be properly cited and students must paraphrase content in their own words.** Blatant plagiarism will result in submission to the honor council.

## **COURSE FUNDAMENTALS**

### **Course website**

The course website is on ELMS: <https://myelms.umd.edu/login> . The course website will be used for posting course material, announcements, and grades. Ensure the email address you have associated with ELMS is current, as course information will be communicated through the ELMS messaging system.

If you are having difficulty with ELMS/Canvas, do not contact the instructor for technical support. The University has professional 24-hour support for students: 1-877-399-4090

### **Classroom Environment**

Students are expected to contribute to a classroom environment that is conducive for learning and discussion. As such, please observe the following during class:

- Participate in all in class activities and discussions fully. This includes being prepared for discussions by reading assigned material prior to class, engaging with classmates in a discussion on the designated topic and appreciating different academic backgrounds.
- Interact with all instructors and classmates in a respectful and professional manner. Behaviors and remarks perceived to constitute teasing or harassment will not be tolerated.
- Questions and comments on student presentations should be reserved for the end of the presentation so as not to disrupt the flow. Questions should be genuine, inquisitive and discussion-provoking, not designed to intentionally expose weaknesses or embarrass fellow classmates.
- Use of electronic devices is not permitted except for times and purposes specifically designated by the instructor. Using electronic devices during class time is distracting and disrespectful. Please leave the classroom if you need a device (in emergencies only).

### **Attendance & Class Participation**

Regular attendance and class participation is expected and part of your grade (see “Evaluation” for more details).

### **Lectures Slides, Supplemental Information and Reading Assignments**

Paper copies of lecture slides will be provided so that students can take notes on the slides during class. It is important to attend lecture and pay close attention since not all information will be written explicitly on the slides. Electronic copies of the slides will be posted on Canvas after class along with supplemental reading to support the lecture. Reading assignments will also be assigned prior to certain classes. You will not be able to engage in class discussions without reading the assigned material.

### **Communication with the Instructor:**

Email is the best way to reach the instructor outside of office hours. A reply to email can be expected within two business days. Email should be used to notify the instructor of planned and/or excused absences, ask questions on assignment requirements, team issues, etc. Any questions regarding grading or student progress should be addressed in person. Course content questions should be addressed in person.

### **Arrangements for Students with Disabilities:**

The University is legally obligated to provide appropriate accommodations for students with disabilities. Please contact Disability Support Service (DSS) Office (301) 314 – 7682 or Dissup@umd.edu or visit their website: <http://www.counseling.umd.edu/DSS/> If you have an accommodation letter from DSS indicating that you have a disability which requires academic accommodations, please present it to the instructor by the end of the schedule adjustment period so we can discuss the accommodations that you might need in this class.

### **University Closures or Delays**

If class is affected by a University closure or delay, the instructor will email the class concerning the impact of missed class meeting and will distribute an updated course schedule as needed.

### **Copyright Statement**

All materials presented or provided in class and on the course website (e.g., lectures, handouts, videos, slides) are copyright protected. Students may not copy, record, or distribute these materials without the instructor's permission.

## **EVALUATION**

### **Grading Policy**

There will be a total of 1000 points from during the semester for undergraduate students (CHBE474, BIOE489T)\*. Each item will contribute to your final grade as follows:

Homework (5 @ 25 pts):	125 points
Exams (2 @ 250 points):	500 points
Group Project	240 points
Engagement	135 points
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TOTAL	1000 POINTS

\*Graduate students (ENCH648D) will be required to complete an additional literature analysis assignment worth 100 points. ENCH648D final grades will be calculated based on 1100 total points.

### **Grading Scale**

This course will use a +/- grading system with letter grades equivalent to the following point values: 895-1000 points (90-100%): A-/A/A+; 795-894 points (80-89%): B-/B/B+; 695-794 point (70-79%): C-/C/C+; 595-694 points (60-69%): D-/D/D+; <595 points (<60%) = F. The instructor reserves the right to lower grade cutoffs.

### **Homework (125 points)**

Five homework assignments worth 25 points will be assigned throughout the semester. Tentative due dates are included on the schedule at the end of the syllabus and will be confirmed when assigned. Homework problems will be updated after each lecture so that students can work on them progressively.

Homework is expected to be completed individually. Although it is acceptable to discuss homework problems with your classmates, you must turn in (and understand) your own solutions. Turning in solutions that are not your own is a violation of department and university academic integrity policies, and violations will be referred to the Honor Council.

Many homework questions will be open ended and may have more than one correct answer. You are expected to combine your knowledge gathered from the course, external research from literature/ other reputable sources and your own engineering judgement to provide a rational and properly justified answer. You must always cite your sources to avoid plagiarism. The process of thinking about these questions and formulating a thoughtful response is much more important than “getting the right answer.” Homework solutions will not be posted, but students will receive feedback when their homework is graded and may discuss homework approaches with the UTF or instructor in office hours to gain further clarification.

#### **Follow these guidelines for homework assignments.**

- Include a cover page with your name, student ID number, date, course number, assignment number and honor pledge.
- Start each problem on a new page.
- **Homework will be submitted through canvas as a pdf and must either be typed or neatly written and scanned. Free scanning is available in all university libraries. Photographs of written solutions are not acceptable.** Combining digital and scanned PDFs into one document is easy and free (<https://www.sejda.com/visually-combine-reorder-pdf>)
- Write out a reasonable amount of work to address the problem. Graders are not obligated to giving full credit if large gaps are present and the thought process is not clear.
- Homework assignments will be graded partially for completion and partially for accuracy. Problems that are only partially completed or do not show sufficient work will not earn any points.

#### **Exams**

There will be two in-class exams (75 min). Exams must be promptly turned in at the end of each class/exam period. For each exam, you may prepare and use one hand-written 8½ in. x 11 in. sheet for reference (both sides). This reference sheet must be turned in along with your exam and will be returned to you after the exam is graded. Department calculators will be provided if calculations are required. You may also use your own scientific calculator up to TI-36x Pro. No unauthorized materials or tools may be visible during exams, and students must stop working on the exam promptly when informed the exam is over; violation of these policies is a violation of the Code of Academic Integrity.

Exam Dates are as follows. Material covered on the exam will be confirmed 1 week prior to the exam. The exam may be moved to a different room or split into multiple rooms. This will be communicated at least 1 week prior to the exam.

**Exam 1:** Wednesday, March 27, 12:30-1:45 pm

**Exam 2:** Wednesday, May 6, 12:30-1:45 pm

#### **Re-grade Requests**

Any questions (or complaints) regarding grading of homework or exams must be brought up within one week of the graded item being returned. Requests for reconsideration after this time will not be accepted. Questions (or complaints) regarding homework should be directed to the undergraduate teaching fellow and those regarding exams should be directed to the instructor. All exam re-grade requests must be submitted in writing while homework regrade requests may be done over email.

### **Project**

All students must complete a team project. Details of the projects will be provided in the assignment description. Project teams will be assigned by the instructor using the CATME team tool. Team contributions will be assessed through a survey after each presentation or project. The CATME team contribution score will be used to scale the final grade of team members if they did not contribute sufficiently. If there is a concern about a team member not contributing equally to the team projects, this should be brought to the attention of the instructor in a timely manner so that appropriate feedback can be given and the issue corrected.

### **Engagement**

Course engagement will be measured through completion of reflection assignments, literature pre-work and class participation. Additional details for each are provided below.

### ***Reflections***

Three short reflection assignments including participation in anonymous surveys will be assigned during the semester. The purpose of these reflections is for the instructor to get to know the students/ student needs better and to gather information on how to improve the course. In addition, they provide an opportunity for students to reflect on their own learning and learning processes.

### ***Literature Discussion Pre-work***

Prior to each literature discussion, students will be expected to read the assigned journal article and respond to questions on ELMS.

### ***Class Participation***

Students are expected to attend class on time and participate fully. Participation will be informally measured by students participating in small group discussions and asking/ responding to questions in lecture. Formal attendance will not be taken every class, but repeated absences will impact your class participation grade. University- excused absences and absences due to interviews and engineering conferences will be accepted with proper documentation. All planned absences should be communicated to the instructor prior to the end of schedule adjustment so that the presentation schedule can be set accordingly. If a student must miss a group presentation due to an unplanned excused absence, the student must contact the instructor to make alternate arrangements to complete a makeup presentation. If a student misses a presentation due to an unexcused absence, they will receive a grade of "0" for that assignment. A self-signed sick note may not be used for presentations or exams. Students are responsible for all information presented in class for an excused or unexcused absence.

### **Literature Analysis (Graduate students only)**

Students taking the ENCH648D version of the class will be expected to complete a literature analysis assignment to satisfy the graduate course component. Additional details will be provided in the assignment description.

### **Assignment Submission & Late Policies**

Homework and projects are due at the date and time specified on Canvas. Except in cases of university- excused absences, late assignments will not be accepted. As one exception, reflection assignments may be turned in up to 1 day late for half credit.

## COURSE SCHEDULE- TENTATIVE

Lecture #	Day	Date	Topic	Due
1	M	1/28/2019	Introduction to Biopharmaceuticals	
2	W	1/30/2019	Monoclonal Antibody Structure, Function and Instability	
3	M	2/4/2019	Biopharmaceutical Process Dev. & Manufacturing: Overview & Challenges	Reflection 1
4	W	2/6/2019	Clinical Trials, Material Supply & Product Specifications	
5	M	2/11/2019	Analytical Testing	
6	W	2/13/2019	Upstream Process Development	HW1 (2/15)
7	M	2/18/2019	Upstream Process Development	
8	W	2/20/2019	Upstream Process Development	
9	M	2/25/2019	Upstream Process Development & Literature Discussion	Lit pre-work
10	W	2/27/2019	Downstream Process Development	HW2 (3/1)
11	M	3/4/2019	Downstream Process Development	
12	W	3/6/2019	Downstream Process Development	
13	M	3/11/2019	Downstream Process Development & Literature Discussion	Lit pre-work
14	W	3/13/2019	Upstream and Downstream Scale-up Considerations	HW3 (3/15)
	M	3/18/2019	SPRING BREAK	
	W	3/20/2019	SPRING BREAK	
15	M	3/25/2019	Formulation Development	(LA Proposal- Grad)
	W	3/27/2019	<b>Exam 1</b>	
16	M	4/1/2019	Formulation Development	
17	W	4/3/2019	Formulation Development	Reflection 2
18	M	4/8/2019	Formulation Development & Literature Discussion	Lit pre-work
19	W	4/10/2019	Drug Product Development	HW4 (4/12)
20	M	4/15/2019	Drug Product Development	
21	W	4/17/2019	Drug Product Development	
22	M	4/22/2019	Drug Product Development & Literature Discussion	Lit pre-work
	W	4/24/2019	Process Economics & Beyond mAb's	HW5 (4/26)
20	M	4/29/2019	Bio Process Scale-up Facility Tour	(LA - Grad)
21	W	5/1/2019	CMC Team Planning & Strategy	
22	M	5/6/2019	<b>Exam 2</b>	
23	W	5/8/2019	In class project work day	Project Pre-work
	M	5/13/2019	In class project work day	Reflection 3
<b>Final exam period: Tuesday, May 21st : 8-10 am- Final Project Presentations</b>				