CHEN 4801- Pharmaceutical Biotechnology
MWF 9:30 AM – 10:25 AM JSCBB A104

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Pharmaceutical Biotechnology Zoom
https://cuboulder.zoom.us/j/94682209607
Meeting ID: 946 8220 9607
Passcode: biosepzoom

## Syllabus

| *Week* | *Date* | *Day* | *Subject* | *Notes* |
|---|---|---|---|---|
| 1 | Jan 10, 12, 14 | M | Intro to Pharmaceuticals | |
| | | W | Molecule to Drug Overview – Discovery, Preclinical, Clinical Trials | |
| | | F | Cost of pharmaceuticals | |
| 2 | Jan 17 19,21 | M | MLK Day | Reading: Ch 1, 10<br>Reading Homework due Wed Jan 19<br>HW1 due Jan 20<br><br>See also Handout on Canvas |
| | | W | Thermodynamics of Interfaces | |
| | | F | Surfaces II- Capillary Thermodynamics/ Gibbs eqn. | |
| 3 | Jan 24, 26, 28 | M | Experimental Measurement of surface tension | Reading: Ch 2<br><br>Reading Homework due Monday Jan 24 |
| | | W | Protein Solutions: Conformational instability/ Timasheff mechanism | |
| | | F | Experimental Measurement of Protein Stability | |
| 4 | Jan 31, Feb 2, 4 | M | Application: Protein Aggregation Kinetics | HW 2 due Feb 3<br>Reading Ch 9 |

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|---|---|---|---|---|
| | | W | The FDA | Reading Homework due Monday Jan 31 |
| | | F | Regulatory Requirements for Approval | |
| 5 | Feb 7,9,11 | M | IP Considerations | HW 3 due Feb 10 |
| | | W | Clinical Trial Ethical Issues | |
| | | F | Case Studies | |
| 6 | Feb 14, 16, 18 | M | Exam review | 2/16 Exam I- 7:30-9:00 pm , location to be announced. (likely online) |
| | | W | PK ADME | |
| | | F | PD- Binding constants, ED50, etc. | |
| 7 | Feb 21, 23, 25 | M | Animal Models / Allosteric Design | Reading Ch. 5<br><br>Reading Homework due Mon Feb 21 |
| | | W | Kinetic Models | |
| | | F | Controlled Release Strategies | |
| 8 | Feb 28 Mar 2, 4 | M | Transdermal Delivery<br>Iontophoresis<br>Microneedle Delivery<br>Ultrasound<br>Blood Brain Barrier<br>Ocular Delivery | HWK 4 due Mar 3<br>Reading Homework due Mon Feb 28<br>Reading Ch 4 |
| | | W | | |
| | | F | | |
| 9 | Mar 7,9, 11 | M | Pulmonary Delivery, Parenteral Delivery | HWK 5 due Mar 10 |
| | | W | Pulmonary Delivery: Exubera case study | |
| | | F | Nasal / Exotic Delivery | |
| 10 | Mar 14, 16, 18 | M | Antibodies | Reading: Ch 7<br><br>Reading Homework due Mon Mar 14 |
| | | W | Antibody-drug conjugates (ADC's) | |
| | | F | Antibody Delivery Issues | |
| 11 | Mar 21, 23, 25 | F | Spring | |
| | | | Break | |
| | | | | |
| 12 | March 28,30, April 1 | M | Vaccines | HWK 6 due Mar 31<br>Reading Ch 22<br><br>Reading Homework due Mon Mar 28 |
| | | W | Adjuvants | |
| | | F | Vaccine Ethics | |
| 13 | April 4,6,8 | M | Generics / Biosimilars | 4/8 Exam II in class<br>Reading: Ch 6<br><br>Reading Homework due Mon Apr 4 |
| | | W | Immunogenicity | |
| | | F | Exam II | |
| 14 | April 11, 13, 15 | | Intro to Nucleation Rate Theory | |
| | | | Crystal Growth kinetics | |
| | | | Polymorphism / Bioavailability | |
| 15 | April | M | Ostwald Ripening Application: Organ | Reading: Ch 3 |

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|---|---|---|---|---|
| | 18, 20,22 | | Preservation | Reading Homework due Apr 18 |
| | | W | Lyophilization: Materials Science of Glassy States | |
| | | F | Heat and Mass transfer in lyophilization | |
| 16 | Apr 25, April 27 | M W | Tba | Homework 7 Due **Monday** April 25 |
| Final ?TBA | | | Final Paper | turn in final paper |

CHEN 4801- Pharmaceutical Biotechnology

**Introduction**
Pharmaceutical Biotechnology is a course that is designed to acquaint students with the engineering challenges associated with the process of converting molecules into drugs. In this course, we will focus on the engineering principles needed to bring therapeutic products derived from living organisms (e.g., proteins, peptides, DNA, RNA) from the production plant to the patient. We will learn about the challenges of keeping these products "active" as they are stored, shipped, and administered to patients. Specific topics will include:

- Regulatory hurdles for commercial biotechnology-derived pharmaceutical products
- Physical stability of biopharmaceuticals
- Chemical stability of biopharmaceuticals
- Material properties of biopharmaceuticals
- Physics of surface interactions applied to drug delivery systems
- Engineering of freeze drying
- Advances in controlled drug delivery technology
- Protein folding and refolding
- Pharmacokinetics
- Pharmacodynamics

**Where does this course fit in?**
The current course focuses on what happens *after* a biopharmaceutical product is made and purified. This course is one of the three main "focus electives" in the Chemical and Biological Engineering degree. [The other two are Metabolic Engineering, which focuses more on bioprocessing and fermentation engineering, and Tissue Engineering/Medical Devices, which focuses on the creation artificial organs and the interplay between physiology and various devices]. All three courses are designed to use and build on a foundation of chemical engineering science learned in other courses such as thermo, separations/bioseparations, fluids, kinetics and heat transfer.

**A note on the schedule**
The syllabus should be considered a "work in progress". Depending on class interest levels, some topics may be added/expanded and others dropped/shortened.

**We will use the book "Pharmaceutical Biotechnology: Fundamentals and Applications"**
by Daan J. A. Crommelin (Editor), Robert D. Sindelar (Editor), Bernd Meibohm (Editor)

ISBN-13: 978-1461464853 ISBN-10: 1461464854 Edition: 4th ed. 2013

This textbook covers some of the aspects that apply to pharmaceutical biotechnology products. It does not cover the full span of subjects that we'll touch on in class. Because much of this material is quite new, some of it hasn't made its way into a book form. Other parts of the course do appear in other books, but there isn't a single book

that unifies it all, and it seemed rather brutal to make you pay for several books and use only small parts of them. So… what we'll do is the following. Regulatory information, information on patents and the drug development process in general are covered in the book. We'll highlight some of the most critical sections in the reading assignments. As you can see from the syllabus, we won't be approaching the subjects in the same order as the book presents them. For other subjects, many of the references that we'll work from can be downloaded directly as PDF files from the web. We'll either simply put the files up on the class webpage, or post links there to other pages. We suggest creating your own course book by printing out information downloaded from the webpage and assembling it into a course folder.

Because you don't have the advantage of a textbook that covers everything, and because some of the material is difficult, don't let yourselves get lost. Ask questions! We have plenty of flexibility to make sure everyone is able to understand the material.

**What background is required of me?**
The real world doesn't neatly separate into subjects- so there may be pieces that some of you haven't seen before. Don't worry, ask questions!

**Grading**
We will have two types of homework: one based on reading chapters of the book, and one based on the lectures. It is expected that the "reading" homework can be answered essentially by using material in the book. Please turn in the "reading" homework" individually; typically it will be due at the beginning of class on Mondays. The "lecture" homework may require you to look up data, read articles from the literature, and recall concepts and methods you've seen in previous classes (material & energy balances, thermos, kinetics, chemistry, biochemistry, fluids…). There will be a "lecture" homework set due roughly every week. Typically they will be due Thursday nights at midnight. "Lecture" homework can be turned in in groups of no more than three people. We'll use Gradescope for turning in homework asignments.

We will also have two midterm exams and a final group report (roughly 4 people per group).

The weighting will be:
Homework (lecture) – 20%
Homework (reading) - 10%
Midterm Exams - 25% each
Group report final - 20 %

***Final Paper***
***(10-15 ages, Hand in as Groups of 3)***

1. ***Pick a disease***
   suggestions (by no means not a complete list of possibilities!):
   Covid
   Alzheimers
   Malaria
   Diabetes
   Rheumatoid Arthritis
   Cancer (pick one)
   Tuberculosis
   Multiple Sclerosis
   …
2. ***Describe disease in detail***
   pathology
   progression
   mode of transmission
   populations affected
   morbidity/mortality statistics
   challenges for treatment
   …
3. ***Describe current therapies***
   type of drugs used
   mechanism of drug action
   estimated costs of treatment
   intellectual property
   clinical trials underway

**The fine print**:

**Classroom Behavior**

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior and the Student Conduct & Conflict Resolution policies.

**Requirements for COVID-19**

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and

all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu).

**Accommodation for Disabilities**

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

**Preferred Student Names and Pronouns**

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

**Honor Code**
All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu; 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

**Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation**
CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. The university will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by or against members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and the support resources can be found on the OIEC website.
Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

## *Religious Holidays*

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please let me know as soon as possible if you have any such conflicts. See the campus policy regarding religious observances for full details.