Welcome to

ABE 370 Biological and Microbial Kinetics and Reaction Engineering

Fall 2017
Monday, Wednesday, and Friday
12:30 – 1:20 PM
LYNN G167

Instructor

- Meng Deng, Ph.D.
  - Department of Agricultural and Biological Engineering
  - School of Materials Engineering
  - Weldon School of Biomedical Engineering
  - Bindley Bioscience Center
  - Biomaterials, Cell Engineering, and Regenerative Engineering
  - *www.regenerativematter.com*
  - Office
    - ABE 319
    - Tel: 765-494-1190
    - Email: deng65@purdue.edu
  - Office Hours: Fridays from 3:00 – 5:00 pm and by appointment

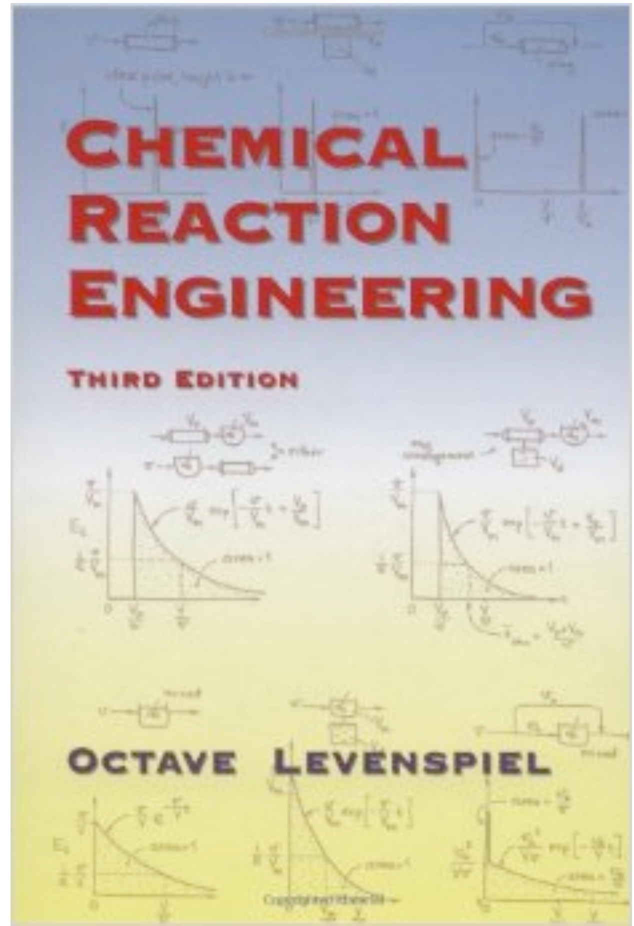
TA

- Jessica Zuponcic
- ABE PhD Student
- Email: jzuponci@purdue.edu
- Office hours: Mondays from
  10:00 – 11:00 am
- Office hour location: ABE 306

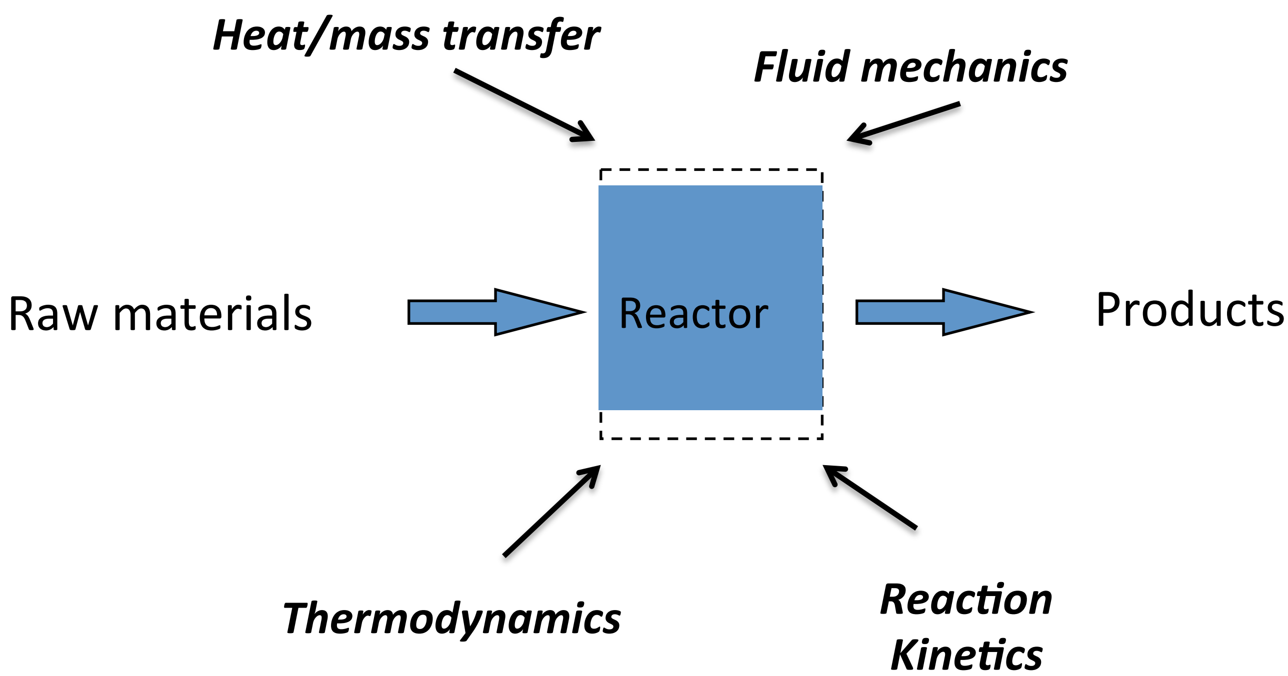
TextBook

- Chemical Reaction Engineering, 3rd Edition, O. Levenspiel, Wiley & Sons

- Supplemental readings will include handouts



Typical Chemical Process



The two fundamental questions are:
(1) what changes are expected to occur and (2) how fast will they occur?

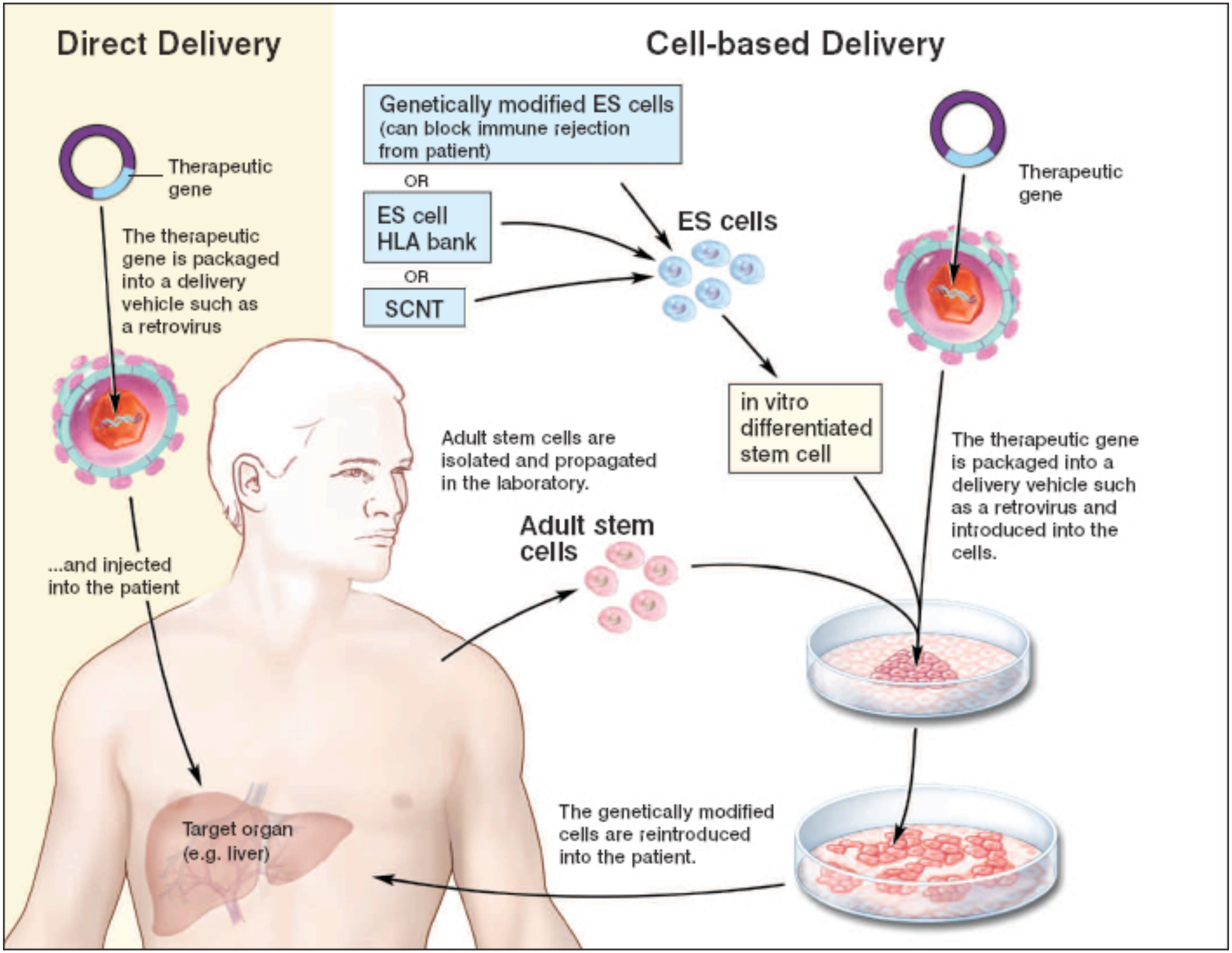
Chemical Reaction Engineering

- "…is the synthesis of all these factors with the aim of properly designing a chemical reactor."

---Octave Levenspiel

Fife Ethylene Plant


The Man Behind Obama's Plan to Rescue the Economy
Why Banks Are Broke— And What to Do
The Oscar Race: How Slumdog Became Top Dog
TIME
Diabetes. Heart Disease. Parkinson's.
How the Coming Revolution in
STEM CELLS
Could Save Your Life
BY ALICE PARK



http://stemcells.nih.gov/info/Regenerative_Medicine/pages/2006chapter4.aspx

Cell Culture Systems

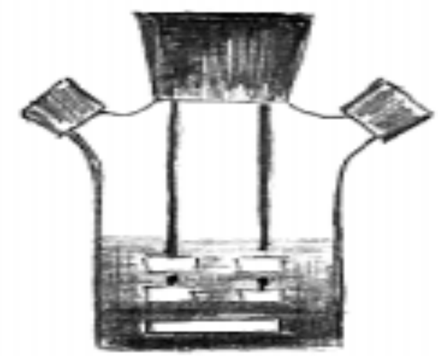
- Types of cell culture systems:

(a) Static culture

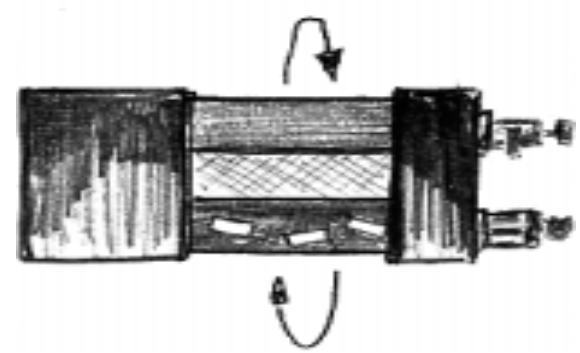
Dynamic culture
- (b) spinner flask
- (c) rotating wall vessel
- (d) perfusion reactor

a)

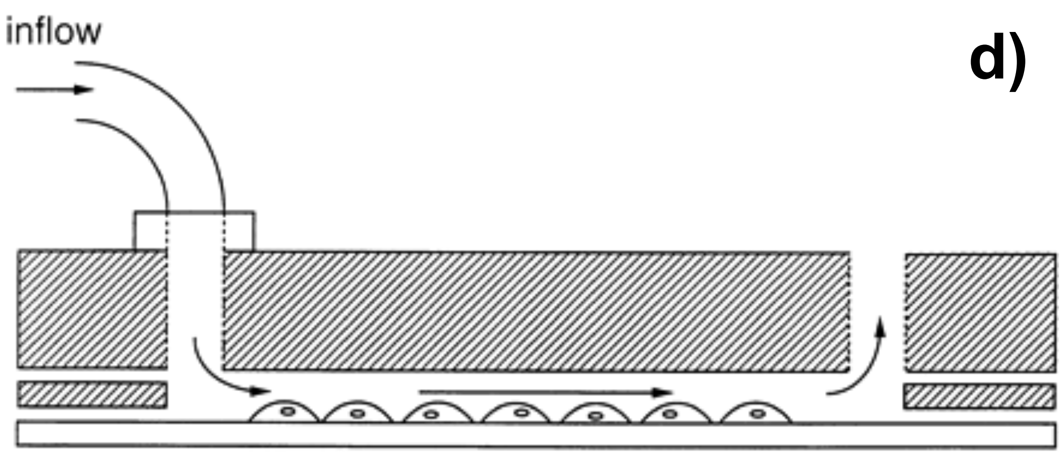
b)



c)



d)



Learning Objectives

- Gain an understanding of the basic concepts of reaction kinetics for chemical and biochemical systems
- Gain an understanding of basic engineering reactor design models
- Gain an understanding of the application of kinetic models to reaction processes involving diffusive and convective mass transport

Learning Objectives

- Understand how kinetic reaction and reactor design models are applied to food and biological engineering processes

- Be able to apply mathematical skills to developing analytical and numerical solutions

Topics to be covered

- Basic reaction rate concepts
  - Reaction constants, rates of reaction
  - Reaction rate models
  - Enzymatic rate models
  - Fitting models to data
- Ideal reactor types
  - Reactor performance/design
  - Multiple ideal reactor systems
  - Recycle reactors
  - Reactor selection criteria

Topics to be covered

- Non-ideal flow reactor concepts
  - Residence time distribution curves
  - Convolution
  - Reactor output analysis
- Heterogeneous reactions
  - Fluid-solid reactions
  - Heterogeneous catalytic reactions

Grading

• Classroom participation:	10%
• Homework:	20%
• In-class quizzes:	10%
• In-class exams:	
– 4 x 10% each =	40%
• Final exam:	20%
	100%

Grade	**GPA Value**	**Numerical Range**
A+, A	4.0	93-100
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3.0	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2.0	73.0-76.9
C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1.0	63.0-66.9
D-	0.7	60.0-62.9
F	0.0	<60.0

- Check the Blackboard Learn for course notes and other announcements

EMERGENCY PREPAREDNESS – A MESSAGE FROM PURDUE

To report an emergency, call 911. To obtain updates regarding an ongoing emergency, sign up for Purdue Alert text messages, view www.purdue.edu/ea.

There are nearly 300 Emergency Telephones outdoors across campus and in parking garages that connect directly to the PUPD. If you feel threatened or need help, push the button and you will be connected immediately.

If we hear a fire alarm during class we will immediately suspend class, evacuate the building, and proceed outdoors. Do not use the elevator.

If we are notified during class of a Shelter in Place requirement for a tornado warning, we will suspend class and shelter in [the basement].

If we are notified during class of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in the classroom, shutting the door and turning off the lights.

Please review the Emergency Preparedness website for additional information.
http://www.purdue.edu/ehps/emergency_preparedness/index.html

Material Balances with Chemical Reactions

Concept

Mass Balances with chemical reactions are very similar to mass balances with mixing and separation.

The only difference between the two is that a reaction takes place and it may change the form of the components. Keep in mind that the **mass** will still be conserved.

Stoichiometry

When chemical reactions occur in a process, a balanced chemical equation or a **stoichiometric equation** can be written to represent the actual ratios of the quantities that exist in the products and the reactants.

The atoms of these molecules will be in equal amounts when they enter and leave the process. They may be re-distributed in the system but they will be conserved.

Stoichiometry
(cont'd)

To start, lets consider the burning of ethanol in the presence of oxygen which produces carbon dioxide and water. Is this a balanced stoichiometric equation?

$$C2H5OH + O2 \longrightarrow CO2 + H2O$$

Reactants - Limiting and Excess

The reactants of a process may not always be in their stoichiometric amounts. A reaction may only go until one of its components runs out. The reaction then stops and you might have one of your reactants in ***excess.*** The reactant that is entirely used is the ***limiting*** reactant.

Let's assume you react 1 mole of ethanol with 5 moles of oxygen.

C2H5OH + 5O2

Are these 2 components present in stoichiometric amounts?

Extent of Reaction

Two parameters, the fractional conversion (f) and the extent of reaction (ξ) are used to describe the amount of reaction that occurs.

extent of reaction = ξ = (Ni - Nio)/vi

fractional conversion = fi = (Nio-Ni)/Nio

Ni - number of moles present

Nio - number of moles initially present

νi - stoichiometric coefficient of balanced equation

Note: νi will be *negative* if dealing with a reactant
νi will be *positive* if dealing with a product

These factors are vital because they must be used to account for production or consumption.

For example, consider the reaction

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

what are the stoichiometric coefficients?

Extent of Reaction (cont'd)

Consider the following reaction in which 1 mole of ethanol and 4 moles of oxygen are reacted, resulting in 1 mole of carbon dioxide, 1.5 moles of water, and 1/2 mole of ethanol and 2.5 moles of oxygen.

$$C2H5OH + 4O2 \longrightarrow 1CO2 + 1.5H2O + 0.5\ C2H5OH + 2.5O2$$

Calculate the fractional conversions and extents of reaction for oxygen and ethanol.