BAE 425/525

(SPRING, 2009)

Industrial Microbiology and Bioprocessing (3)

Mondays, Wednesdays and Fridays, 9.10 – 10.00 a.m., 143 Weaver Labs

Instructor: Ratna Sharma, Assistant Professor
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Office hours: open door policy and by appointment

Course Website: http://www.courses.ncsu.edu/bae425/lec/001/

This course caters to the needs of bioprocessing engineers and scientists, at the undergraduate and graduate level, who are interested in the basics and real world application of microbes to biological processes.

Course Pre-requisites:
MB 351 or graduate standing

Course Objectives:
This course aims at creating a learning environment that is open, challenging, engaging, and fun to achieve the following:

- Integrate biological and engineering principles involved in the production and recovery of commercial products
- Develop critical thinking skills and learn to employ a quantitative, scientific approach towards conversion of biological materials to value added products.
- Work in small groups for certain assignments and thereby acquire teamwork skills.
- Develop a research mind-set to solve problems and explore new opportunities as bioprocess engineers.
- Create awareness among students about the various opportunities available to them for conversion of biological material to add value.

Learning Outcomes/Student Objectives:
By taking this course, students will be able to:

- Appreciate the use of microorganisms for the production of value added commodities
- Understand the working of a fermentation system
- Identify suitable downstream processing methods
- To describe key industrial bioprocesses, from the traditional to the recently evolved.
- Discuss/predict possible future developments in microbially based industries in the context of developing technologies

Text Book:

Industrial Microbiology: An Introduction by M. K. Waites, N. L. Morgan, J. S. Rockey, and G. Higton. 2001. Blackwell Science Ltd.

Reference Books:

- Bioprocess Engineering Basic Concepts by M. L. Shuler and F. Kargi. 2002. 2nd edition. Prentice Hall, Inc.
- Biochemical Engineering Fundamentals by J. E. Bailey and D. F. Ollis. 1986. 2nd edition. McGraw-Hill, Inc.
- BAE 525: *Journals that cover articles on bioprocess engineering and industrial microbiology such as (but not limited to):*
    - *Biotechnology and Bioengineering*
    - *Applied Biochemistry and Biotechnology*
    - *Applied and Environmental Science*

POLICIES and PROCEDURES

Homework:

- Homework will be assigned on Wednesday and will be due at the beginning of class the following Wednesday.
- Submissions must be **legibly** hand written or typed on clean sheets of paper.
- You may work in teams but each student should submit his or her own homework.
- Submissions made after Wednesday will lose 15% of the grade on the first day (Th) and 30% on the second day (F). *No late homework will be accepted after Friday.*
- Submissions out of class may be kept in the instructor's mailbox (before 5.00pm) outside 280 Weaver Labs
- *Solutions to homework problems will not be posted*. It is your responsibility to make sure you find out how to solve the problems by getting help before the due date and/or asking about them in class.

Quizzes, Exams:

- There will be announced and unannounced quizzes in class over the course of the semester. Scores from these quizzes will count towards the final grade. The lowest score will be dropped from overall grading.
- There will be two in-class exams and a final exam, with questions focusing on the learning outcomes/course objectives of the class.
- Students enrolled for BAE 525* will be graded for leading and participating in journal club. Grades will be based on the score sheet turned in each week. A proposal will be due at the end of the semester for evaluation. The final score will be the average of all the weeks converted to a base of 15.

Missed quizzes and exams:

- If you miss an exam without either a certified medical excuse or prior instructor approval, you will be allowed one comprehensive make up exam in the last week of the semester. No make up quizzes will be offered.
- Tests missed with certified medical excuse or prior instructor approval will be dealt with individually.

***Graduate Credit**:

- To obtain graduate credit students will have to actively participate in one hour of journal club discussion per week and prepare a project on product development through bioprocessing. The time for meeting will be decided during the first class.
- One student will be responsible for selecting an article and leading the discussion each week journal club is held.
- Discussion papers should be handed over to the group at least a week before discussion.

- The leader for the week will be graded by the participants for his/her ability to lead the discussion, ask questions from the group and reach a conclusion on possible variations in the research presented. A short write up (preferably half a page) summarizing the paper discussed and the research variations suggested should be submitted by the day after the discussion.
- The participants will be graded by the leader based on their preparedness for discussion of the paper, participation in class, overall enthusiasm, and suggestions on possible research variations.
- Grading will be done on a scale of 1 - 5.
- The semester project will be worth 10 points. The students will be expected to submit a project (in the form of a grant proposal) and make a formal presentation open to students registered for the class and the instructor. For details on the format and evaluation of the proposal please refer to 'Proposal Format'

Grading Policy:

Basis:

BAE 425:	%	BAE 525:	%
Homework	20	Homework	20
Quizzes and class participation	15	Quizzes and class participation	15
Exams	30	Journal club and project	15
Final Exam	35	Exams	25
	100	Final Exam	25
			100

This course is not graded on a curve nor are individual submissions and exams curved.

Scale:

A+	97.0 – 100.0
A	93.0 – 96.9
A-	90.0 – 92.9
B+	87.0 – 89.9
B	83.0 – 86.9
B-	80.0 – 82.9
C+	77.0 – 79.9
C	73.0 – 76.9
C-	70.0 – 72.9
D+	67.0 – 69.9
D	63.0 – 66.9
D-	60.0 – 62.9
F	< 59.9

Instructor's commitment:

You can expect the instructor to be courteous, respectful, and punctual; be prepared for lecture and other class activities; answer questions in a non-negative fashion and as clearly as possible; be available to address student concerns or notify you beforehand if she is unavailable; try to accommodate suggestions that might improve the teaching-learning process; and grade uniformly and consistently according to posted guidelines.

Others:

A class visit to a brewery and/or waste water treatment facility may be organized if conditions permit.

Students with special needs:
Reasonable accommodations will be made for student with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653.
http://www.ncsu.edu/provost/offices/affirm_action/dss For more information on NC State's policy on working with students with disabilities, please see
http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html. For additional information on NC State's policy on working with students with disabilities, please see the Handbook for Teaching and Advising (http:www.ncsu.edu/provost/hat/current/index.html).
It is requested that a student requiring accommodations inform the instructor in time for necessary action to be taken.

Academic Integrity:
Students are expected to be familiar with and honor the NCSU Code of Student Conduct. The honor pledge, which follows, pretty much spells out what is expected of the student – "I have neither given nor received unauthorized aid on this test or assignment". It is the instructor's understanding and expectation that the student's signature on any test or assignment means that the student neither gave nor received unauthorized aid. While there will be times when students will be encouraged to talk and participate in class discussions, students should refrain from extraneous conversations with each other when the instructors or other students are presenting information. Talking at inappropriate times violates academic integrity since you are interfering with another students' desire to hear and see what is going on in class. Code of Student Conduct
(http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php).

Field Trips
Transportation for one or more field trip during the course will be provided by the university. If students choose to provide their own transportation, they do so at their own risk. Students are encouraged to use the transportation provided by the university.

Course Outline/Layout:

Week	Lecture	Topic	Reading Assignment
1	1 (Jan 7)	*Introduction to course syllabus and policies* Overview	 pp. 1 – 4
	2 (Jan 9)	Review of microbial classifications Nutritional classification and nutrients required	Ch 1 Ch 2 (pp. 21 – 23)
2	3 (Jan 12)	Microbial growth kinetics - Batch growth: kinetics and application	Ch 2 (pp. 23 – 28)
	4 (Jan 14)	Microbial growth kinetics - Continuous growth kinetics Enumeration methods and quantitative estimation *Distribute discussion paper 1* (BAE 525)	Ch 2 (pp. 28 – 32) _____
	5 (Jan 16)	Factors affecting microbial growth Inhibition of microbial growth – physical agents	Ch 2 (pp. 32 – 36) Ch 2 (pp. 36 – 38)
3		No class (Martin Luther King Jr. day)	
	6 (Jan 21)	Inhibition of microbial growth –chemical agents Introduction to protein synthesis	Ch 2 (pp. 38 – 44) _____
	7 (Jan 23)	Brief overview of major metabolic pathways Mechanisms of regulation and secondary metabolism *Paper presentation, discussion and critical review* *Distribute discussion paper 2*	Ch 3 (pp. 46 – 58, 67 – 70)
4	8 (Jan 26)	Isolation of microbes Industrial strain characteristics Strain improvement: introduction to nucleic acids	Ch 4 (pp. 75 – 85)
	9 (Jan 28)	Fermentation media - Nutrients provided - Sources of nutrients	Ch 5 (pp. 86 – 93) _____
	10 (Jan 30)	Fermenter design and construction Types of fermenters *Paper presentation, discussion and critical review* *Distribute discussion paper 3*	Ch 6 (pp. 94 – 99)
5	11 (Feb 2)	Fermentation process development Factors affecting scale up *Lecture by Dr. Stewart McNaull, Diosynth*	Ch 6 (pp. 107 – 108)
	12 (Feb 4)	Fermenter operating modes Fermentation process control Solid state fermentation (SSF) - Parameters affecting SSF - Bioreactor design for SSF	Ch 6 (pp. 101 – 104) Ch 6 (pp.105 – 107)
	13 (Feb 6)	Factors affecting fermentation : heat and mass transfer, aeration kinetics, agitation *Lecture by Dr. Stewart McNaull, Diosynth*	Ch 6 (pp. 99 – 101) Handout

6	14 (Feb 9)	Factors affecting fermentation : heat and mass transfer, aeration kinetics, agitation (contd.) *Revision/question session* *Paper presentation, discussion and critical review*	Ch 6 (pp. 99 – 101) Handout
	15 **(Feb 11)**	**EXAM 1 (9.10 – 10.00)**	
	16 (Feb 13)	Introduction to downstream processing - unit operation used Sedimentation, Centrifugation	Ch 7 (pp. 109 – 115)
7	17 (Feb 16)	Filtration Cell Disruption *Start proposal on product development*	Ch 7 (pp. 115 – 119)
	18 (Feb 18)	Product recovery: chromatography, distillation Crystallization, drying Role of genetics in downstream processing	Ch 7 (pp. 119 – 123)
	19 (Feb 20)	Commercial enzyme production and use	Ch 9 (pp. 137 – 143)
8	20 (Feb 23)	Enzyme kinetics Applications of microbial enzymes	Ch 9 (pp. 133 – 137), Handout
	21 (Feb 25)	*Problem Session*	
	22 (Feb 27)	Fuels: Biodiesel	Handout
9		SPRING BREAK	
10	22 (March 9)	Fuels: Alkanes, butanol Industrial ethanol production Hydrogen, Electricity	Ch 10 (pp. 144 – 155), Fig 10.3
	24 (March 11)	Future of fuels and energy Amino Acids, Organic Acids	Inclass activity Ch 10 (pp. 152 – 155)
	25 (March 13)	Antibiotics, Bacterial vaccines,	Ch 11 (pp. 165 – 169, 171 – 173)
11	**26** **(March 16)**	**EXAM 2 (9.10 – 10.00 a.m.)**	
	27 (March 18)	Therapeutic agents Beer Brewing	Ch 11 (pp. 173 – 177) Ch 12 (pp. 179 –180)
	28 (March 20)	Unit operations for brewing beer	Ch 12 (pp. 180 – 187)
12	29 (March 23)	All about yeast *Submit outline of proposed product development project*	Ch 12 (pp. 187 – 191)

	30 (March 25)	Post fermentation treatments and maturation of beer Wine production	Ch 12 (pp. 192 – 199)
	31 (March 27)	Dairy products and other traditional fermented foods	Ch 12 (pp. 203 – 209)
13	32 (March 30)	Food additives	Ch 13 (pp. 210 – 217)
	33 (April 1)	Microbial biomass production	Ch 14 (pp. 218 – 227)
	34 (April 3)	Waste water treatment - primary and secondary treatments - loading rates	Ch 15 (pp. 229 – 234)
14	35 (April 6)	Waste water treatment *Laptop activity*	
	36 (April 8)	Waste water treatment (Trickle bed….) Composting, Ensiling, Bioremediation	Ch 15 (pp. 234 – 239, 239 – 243)
		Spring Holiday	
15	37 (April 13)	Biomining, Desulphurization of Coal, Bioinsectides	Ch 15 (pp. 243 – 245)
	38 (April 15)	Biodeterioration of plant material	Ch 16 (pp. 247 – 252)
	39 (April 17)	Biodeteriotation of pharmaceuticals Factors affecting microbial spoilage and performance of preservatives *Present product development project to group*	Ch 16 (pp. 252 – 257)
16	**40** **(April 20)**	**COMPREHENSIVE EXAM (9.10 – 10.00a.m.)**	
	41 (April 22)	Product development and regulations - patents, HACCP, GMPs… Environmental safety - Containment, disposal	Ch 8 (pp. 124 – 129)
	42 (April 24)	Fermentation lab (*report due on April 27, 2009*) *Submit final report on product development project* *Closing comments*	
	April 27	**FINAL EXAM (8.00 – 11.00 a.m.)**	