BIOCATALYSIS AND METABOLIC ENGINEERING

ChBE 4760/6760, CHEM 4760/6760 Spring 2008

LECTURES: Tuesday/Thursday, 9:30-11:00 am; classroom: ES&T L1125

INSTRUCTOR: Dr. Andreas Bommarius, IBB 3310, x5-1334, andreas.bommarius@chbe.gatech.edu, office hours: TTh 11-12

TEACHING ASSISTANT: Thomas Rogers, IBB 3412, x5-3089 thomas.rogers@chbe.gatech.edu; office hours: MW 3-4

WEBSITE: https://swiki.chbe.gatech.edu/biocatalysis

COURSE DESCRIPTION: Biocatalysis and Metabolic Engineering are in the process revolutionizing the areas of pharmaceuticals, fine chemistry, and biofuels over the next years, as biologically derived synthesis and processes will diffuse across ever more industries. This course for graduate and advanced undergraduate students provides an in-depth coverage of various topics in biocatalysis. The only requirements are prior knowledge in biochemistry as well as kinetics and/or reactor design. The course provides an in-depth coverage of various topics in biocatalysis and metabolic engineering. Goals of this course are the development of an understanding of proteins as catalysts, their functioning in metabolic networks, their application in various industries, and recognition of their potential for addressing future challenges in science and engineering.

REQUIRED TEXTS: *Biotransformations in Organic Chemistry*, Kurt Faber Springer, 5th edition, **2004**, ISBN 3-540-20097

RECOMMENDED TEXTS: *Biocatalysis – Fundamentals and Applications*, A.S. Bommarius and B.R. Riebel, Wiley-VCH, **2004**, ISBN: 3-527303-448

Biochemistry, Donald Voet and Judith G. Voet, John Wiley & Sons, New York, 3rd edition, **2004**, ISBN: 0-471-25090-2

Structure and Mechanism in Protein Science, Alan Fersht Freeman, New York, **1999**, ISBN 0-7167-3268-8

Metabolic Engineering, Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, and Jens Nielsen Academic Press, San Diego, **1999**, ISBN: 0-12-666260-6

COURSE GRADING: Homework (20%), Midterm exam (25%), Term project (25%), Final exam (30%)

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Course Outline

No.	Date	
	01/08	*no class* (instructor at conference)
1	01/10	Purpose, status, perspective, and challenges of biocatalysis
2	01/15	Why and how do enzymes work? What is a good biocatalyst?
3	01/17	Features of a biocatalyst: sequence, structure, type of reaction, mechanism, rate
4	01/22	Metabolic engineering basics: metabolic pathways
5	01/24	Metabolic engineering basics: fluxes and networks
6	01/29	Important biocatalytic reactions I: hydrolases
7	01/31	Important biocatalytic reactions II: oxidoreductases, lyases, isomerases
8	02/05	Activity: advanced enzyme kinetics
9	02/07	Selectivity: chemo- & regiospecificity, enantioselectivity (E-value)
10	02/12	Stability: thermo vs kinetics: unfolding and deactivation
11	02/14	Stability: enzyme denaturation, aggregation, instability factors
12	02/19	Medium engineering: biocatalysis in non-aqueous media
13	02/21	**Mid-term (open book, open notes)**
14	02/26	Enzymes as products in detergents, textiles, and pulp and paper
15	02/28	Biocatalysis in biofuels: hydrolysis of cellulose
16	03/04	Biocatalysis in the synthesis of pharmaceutical intermediates I
17	03/06	Biocatalysis in the synthesis of pharmaceutical intermediates II
18	03/11	Biocatalysis in agriculture and in the food industry
19	03/13	Biocatalysis in fine chemicals and specialties
		03/18,20: ***no class*** **(Spring break)**
20	03/25	Optimization of biocatalytic reactions: synthesis vs hydrolysis
21	03/28	Optimization of biocatalytic reactions: reaction engineering tools
22	04/01	Advanced Metabolic Engineering: overcoming challenges of pathway regulation
23	04/03	Advanced Metabolic Engineering: designed metabolic pathways (**Term projects due**)
24	04/08	**Presentations of term projects I**
25	04/10	**Presentations of term projects II**
26	04/15	Protein engineering: rational vs combinatorial vs data-driven design
27	04/17	Evolution of enzyme activity: creation of novel functions
28	04/22	Biocatalysis on surfaces : cellulase revisited
29	04/24	Review; Unsolved problems and challenges in biocatalysis

Mon, 04/28; 8:00 - 10:50 am: Final (comprehensive; open book, open notes)

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HOMEWORK ASSIGNMENTS:

20% of total grade, 20 points per problem set; no late homework accepted except in emergencies

Problem set topic	**Hand-out date**	**Due date**
1. Basics in enzyme catalysis	01/15	01/22
2. Basics in Metabolic Engineering	01/22	01/29
3. Important biocatalytic reactions	01/29	02/05
4. Biocatalytic activity and selectivity	02/05	02/12
5. Biocatalytic stability	02/12	02/19
6. Biocatalysis in biofuels, pulp & paper, and textiles	02/26	03/04
7. Biocatalysis in pharma	03/04	03/11
8. Optimization of biocatalytic reactions	03/25	04/01
9. Advanced Metabolic Engineering	04/01	04/08
10. Protein engineering	04/15	04/22

TERM PROJECT:

Critical, suitably in-depth review of a biocatalysis-based topic agreed upon between student and instructor. The purpose of the term project is i) exploration of a topic in more depth than possible during class hours, ii) creation of excitement within the student's mind, and iii) honing of written and oral presentation skills.

Requirements: topic of term project must be based:
- i) on ≥ 1 papers with original experimental data or model, i.e. not just on reviews;
- ii) not cover any previous paper or any topic of past or current research.

6760 sections: pick your own topic
4760 sections: pick from a list of suitable topics with one paper suggested as a starting point

Timeline: suggestions for topics due: 03/06, agreement on topics by: **03/13**
3-page critique and Powerpoint presentations due: 04/03
presentations to class (15 min, incl. Q&A)**: 04/08,10**

Deliverables: **due 04/03**: i) ≤ 3 (incl. cover!) pages of critique, single-sided, 12pt font, 1 in margins,
ii) Powerpoint slides, in "handout, 3 slides per page" format

MIDTERM EXAM: Thu, 02/21, 9:30-11:00 am (open book, open notes)
FINAL EXAM: Mon, 04/28; 8:00 - 10:50 am (comprehensive; open book, open notes)