TO:	The Faculty of the College of Engineering
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FROM: The School of Agricultural and Biological Engineering

RE Curriculum Changes - Biological Engineering Plan of Study

The faculty of the School of Agricultural & Biological Engineering has approved the establishment of three majors for students in the Biological Engineering degree program: Food and Biological Process Engineering (FBPE), Pharmaceutical Process Engineering (PPE), and Cell & Biomolecular Engineering (CBE). Currently all students in our Biological Engineering degree program have a major of Biological and Food Process Engineering. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Differences in requirements for the three majors: The primary differences among the three majors are summarized in the table below and include core biology, science, core engineering, and r ecommended t echnical el ectives as well as project to pics within shared core courses as summarized below. These changes would apply to students entering the School of Engineering in the Spring 2012 and thereafter.

	FBPE	PPE	CBE
Biology Core	BIOL 11000 Fund. Of Biology I (4)	BIOL 11000 Fund. Of Biology I (4)	BIOL 23000 Cell Biology (3) OR BIOL 23100 Cell Biology OR BCHM 30700
	Biol 22100 Microbiology (4)	Biol 22100 Microbiology (4)	IT 22600 Biotechnology Lab (2)
		BCHEM 30700 Biomolecules (3)	Biology Elective (3)
Science Elective	FN 20500 Food Science (3)	IPPH 36200 Basic Pharmaceutical I (3)	CNIT 22700 Bioinformatics (2)
	Bio/Food Science Elective (4)	IPPH 36300 Basic Pharmaceutical II (3)	Life Science Elective (3)
	Bio/Food Science Elective (4)	IPPH 5620 Introduction to Mfg Process (3)	Life Science Elective (3)
Core Engineering	No changes	No changes	ABE 49500 Cell & Molecular Design Principles (3)
Engineering Selective*	Selected from*: ABE 45000 Finite Element Method in Design and Opt. (3) CE 35000 Environmental Engineering (3) IE 34300 Engineering Economics (3 cr.) ME 41800 Engineering of Environmental Systems and Equipment (3 cr.) ABE 53100 Instrumentation and Data Acquisition (3 cr.)	Selected from*: CHE 30600 Design of Staged Separation Processes (3) IE 34300 Engineering Economics (3) CHE 52500 Biochemical Engineering (3) CHE 53600 Particulate Systems (3) IE 37000 Manufacturing Processes I (3)	Selected from*: ABE 59100T Biophysics (3) ABE 59100 Engineering Approaches to Systems Biology (3) CE 35000 Environmental Engineering (3) ABE 56000 Biosensors (3) ABE 49800 Undergrad Research (3) BME 49500/MA49500 Comp. Cell Biology (3) BME 47000 Biomolecular Engr ABE 59100W/BME 59500U Nonlinear Dynamics in Biological Systems (3)
total	22 credits	23 credits	22 credits

* not a complete list

Justification: For many ye ars, ABE h as o ffered five-year dual m ajor programs with Pharmaceutical S ciences an d B iochemistry i n addition t o t he f our-year Biological a nd Food Process E ngineering major. G raduates ha ve w orked i n the f ood, p harmaceutical an d biotechnology industries. The significant growth of biological engineering as a field, along with a desire maintain a reasonable time to graduation for the majority of our students creates a need for four-year programs in these areas. In addition, the availability of only one major has limited the evolution, divergence and growth of the pharmaceutical and cell/biochemistry aspects of the degree program. The creation of three majors will enable this future growth and allow for four-year programs that serve our base industries. The retention of the Food and Biological Process major will maintain the visibility of the food program among current and potential students and sustain our linkages with the many food industry companies who regularly recruit at P urdue. Finally, the growth of the BE program has placed resource constraints on e xperiential courses (e.g. Biotchnology Lab) that were previously required for all students.

A rapid and steady growth of interest of the incoming class in Biological Engineering is constent with these wider industry and academic trends. The biological engineering sophomore class has roughly tripled in the last 6 years. When asked about their area of interest, 26% of the 2011 sophomore class said "Food Process," 25% said "Biological Engineering (generic)," and 23% said "Cell and Biomolecular."

Cell & Biomolecular Engineering is the design, modification, and analysis of microorganisms from all domains of life (Eukaryota, Bacteria, and Archaea) and the integration of these cells into devices, reactors, and processes to produce fuels, cell products, and biotech products, along with biosensors, that can be used to meet global challenges in the environment, agriculture, energy, health, and sustainability. Students in this field will pursue careers in bio-based products, biologics, bioenergy, biotechnology and graduate school.

Pharmaceutical Engineering. Our Department established a dual degree with Pharmaceutical Sciences in 1996 and a significant number of our ABE graduates are currently working in the pharmaceutical industry. The establishment of a *Pharmaceutical Process Engineering* major provides a four-year option for students who want to work in the pharmaceutical industry.

Food and Biological Process Engineering major will allow us to maintain the visibility of this program among current and potential students. We have a large number of graduates currently working in R&D, manufacturing, quality control, and entrepreneurship in the food industry. Retention of the major will help us to sustain the connections our Department has established with the many food industry companies who regularly recruit at Purdue.

Credit Hours Required for Graduation					
<u>Present</u>	Total Credit Hours	135	<u>Proposed</u>	Total Credit Hours	135
Course	25	Credit Hours	Cou	rses	Credit Hours
Mathematics and H	Basic Sciences		Mathematics an	d Basic Sciences	
Calculus: MA16500, 166 26600	00, 26100, 26500,	18	Calculus: MA16500, 1 26600		18
Chemistry: CHM 11500, 11600, 257	00	12	Chemistry: CHM 11500, 11600, 2	5700	12
Physics: PHYS 17200, 24	4100	7	Physics: PHYS 17200	, 24100	7
Biological and Food S	ciences		Biological and Foo	d Sciences	
Biological Sciences: BIOL 22100, 23000, IT 2	2600	9	Biological Sciences: BIOL 11000, 22100		8
BCHM 22100 or FN 205	00	3	FN 20500		3
Biological or Food Scient	ce Selectives	7	Biological or Food Sci	ience Selectives	8
Engineering Tools and			Engineering Tools		
ENGR 13100, ENGR 132		7	ENGR 13100, ENGR		7
Professional Developr	nent		Professional Develo	opment	
ABE 29000, 49000		2	ABE 29000, 49000		2
Communication			Communication		
English Composition:		4	English Composition:		4
ENGL 10600			ENGL 10600		
Speech: COM 11400 Humanities and Socia	10	3	Speech: COM 11400 Humanities and So		3
General Education Must be chosen in accord approved general education help of a faculty advisor. hours, 6 must meet Colleg international understandin must be an additional com elective, and 3 must be ex-	ance with the on list and with the Of the 18 credit ge of Agriculture ng requirements, 3 nmunication	18	General Education Must be chosen in acc approved general educ help of a faculty advise hours, 6 must meet Co international understar must be an additional of elective, and 3 must be	ordance with the eation list and with the or. Of the 18 credit llege of Agriculture ading requirements, 3 communication e economics	18
Core Engineering Con	urses		Core Engineering (Courses	
Thermodynamics: ABE 20100, 20200, 3010	-	13	Thermodynamics: ABE 20100, 20200, 30		13
Momentum, Heat and Ma CHE 37700, 37800		8	Momentum, Heat and CHE 37700, 37800		8
Kinetics and Reaction En ABE 37000		3	Kinetics and Reaction ABE 37000		3
Sensors and Process Cont		3	Sensors and Process C		3
Transport Processes: ABI		4	Transport Processes: A		4
Unit Operations: ABE 55		4	Unit Operations: ABE		4
Biological and Food Proc ABE 55600		4	Biological and Food P ABE 55600	-	4
Process Engineering: AB	E 58000	3	Process Engineering: A		3
Technical Electives		3	Technical Electives		3

Minimum Degree Requirements for Food and Biological Process Engineering Major Credit Hours Required for Graduation

	Cre	edit Hours	Required for Grad	uation	
<u>Present</u>	Total Credit Hours	135	Proposed	Total Credit Hours	136
Courses	3	Credit Hours	Courses		Credit Hours
Mathematics and B	asic Sciences		Mathematics and	l Basic Sciences	
Calculus: MA16500, 1660 26600	00, 26100, 26500,	18	Calculus: MA16500, 1 26500, 26600	6600, 26100,	18
Chemistry: CHM 11500, 11600, 2570	0	12	Chemistry: CHM 11500, 11600, 2	5700	12
Physics: PHYS 17200, 24	100	7	Physics: PHYS 17200	, 24100	7
Biological and Food So	ciences		Biological &Pharm Sciences	aceutical	
Biological Sciences: BIOL 22100, 23000, IT 22	2600	9	Biological Sciences: BIOL 11000, 22100		8
BCHM 22100 or FN 2050		3	BCHM 30700		3
Biological or Food Science		7	IPPH 36200, 36300, 5		9
Engineering Tools and			Engineering Tools		
ENGR 13100, ENGR 132		7	ENGR 13100, ENGR		7
Professional Developm	nent		Professional Develo	opment	-
ABE 29000, 49000		2	ABE 29000, 49000		2
Communication			Communication		
English Composition: ENGL 10600		4	English Composition: ENGL 10600		4
Speech: COM 11400		3	Speech: COM 11400		3
▲	a .	<u> </u>	Humanities and So	cial Sciences	
Humanities and Social General Education Must be chosen in accorda approved general educatio help of a faculty advisor. O hours, 6 must meet Colleg international understandin must be an additional com elective, and 3 must be eco	ance with the n list and with the Df the 18 credit e of Agriculture g requirements, 3 munication pnomics	18	General Education Must be chosen in accuration approved general educe the help of a faculty accredit hours, 6 must m Agriculture internation requirements, 3 must be communication elective economics	ordance with the vation list and with lvisor. Of the 18 eet College of nal understanding be an additional re, and 3 must be	18
Core Engineering Cou	rses		Core Engineering (Courses	
Thermodynamics: ABE 20100, 20200, 30100		13	Thermodynamics: ABE 20100, 20200, 30		13
Momentum, Heat and Mas CHE 37700, 37800		8	Momentum, Heat and CHE 37700, 37800		8
Kinetics and Reaction Eng ABE 37000		3	Kinetics and Reaction ABE 37000		3
Sensors and Process Contr		3	Sensors and Process C		3
Transport Processes: ABE		4	Transport Processes: A		4
Unit Operations: ABE 555		4	Unit Operations: ABE		4
Biological and Food Proce ABE 55600	_	4	Biological and Food P ABE 55600		4
Process Engineering: ABE	E 58000	3	Process Engineering: A		3
Technical Electives		3	Technical Electives		3

Minimum Degree Requirements for Pharmaceutical Process Engineering Credit Hours Required for Graduation

C	redit Hours	s Required for Gradu	ation	
Present Total Credit Hours	135	ProposedTotal Credit Hours		135
Courses	Credit Hours	Cours	es	Credit Hours
Mathematics and Basic Sciences		Mathematics and	Basic Sciences	
Calculus: MA16500, 16600, 26100, 26500, 26600	18	Calculus: MA16500, 16 26500, 26600	6600, 26100,	18
Chemistry: CHM 11500, 11600, 25700	12	Chemistry: CHM 11500, 11600, 25	700	12
Physics: PHYS 17200, 24100	7	Physics: PHYS 17200, 2	24100	7
Biological and Food Sciences		Biology and Life Sci		
Biological Sciences: BIOL 22100, 23000, IT 22600	9	Cell Biology: BIOL 23(or BCHM 30700 Microbiology/Virology/ Biology: IT 22600, 3 cr	/Molecular	8
BCHM 22100 or FN 20500	3	Life Science selectives		6
Biological or Food Science Selectives	7	Bioinformatics/Genomi	cs: CNIT 22700	2
Engineering Tools and Skills		Engineering Tools a	nd Skills	
ENGR 13100, ENGR 13200, CHE 32000	7	ENGR 13100, ENGR 1	3200, CHE 32000	7
Professional Development		Professional Develop	oment	
ABE 29000, 49000	2	ABE 29000, 49000		2
Communication		Communication		
English Composition: ENGL 10600	4	English Composition: ENGL 10600	4	
Speech: COM 11400	3	Speech: COM 11400		3
Humanities and Social Sciences General Education Must be chosen in accordance with the approved general education list and with the help of a faculty advisor. Of the 18 credit hours, 6 must meet College of Agriculture international understanding requirements, 3 must be an additional communication elective, and 3 must be economics	18	Humanities and Soci General Education Must be chosen in accor approved general educa the help of a faculty adv credit hours, 6 must mer Agriculture internationa requirements, 3 must be communication elective economics	rdance with the tion list and with risor. Of the 18 et College of I understanding an additional , and 3 must be	18
Core Engineering Courses		Core Engineering Co	ourses	
Thermodynamics: ABE 20100, 20200, 30100, 30300	13	Thermodynamics: ABE 20100, 20200, 301		13
Momentum, Heat and Mass Transfer: CHE 37700, 37800	8	Momentum, Heat and M CHE 37700, 37800		8
Kinetics and Reaction Engineering: ABE 37000	3	Kinetics and Reaction E ABE 37000	ingineering:	3
Sensors and Process Control: ABE 460000	3	Sensors and Process Co		3
Transport Processes: ABE 45400	4	Transport Processes: AI		4
		Cellular Design Princip		3
Unit Operations: ABE 55500	4	Unit Operations: ABE 5		4
Biological and Food Process Design: ABE 55600	4	Biological and Food Pro ABE 55600	ocess Design:	4

Minimum Degree Requirements for Cell & Biomolecular Engineering Credit Hours Required for Graduation

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cess Engin	eering: ABE 58000	3	Proces	s Engineerin	g: ABE	58000 3
chnical E		3		nical Electi [,]		3
Support	ing Documentation – Biol	ogical H	Engineer	ring Plan o	of Stud	ly revisions (FBPE major)
Present				Pro	oposed	l - FBPE
Freshma						
First Seme	ster					
(4) CHM	11500 General Chemistry I			(4) CHM	11500	General Chemistry I
. ,	10600 English Composition I			(4) ENGL	10600	English Composition I
(2) ENGR	13100 Transforming Ideas to In			(2) ENGR	13100	Transforming Ideas to Innovation I
(4) MA	16500 Plane Analytic Geometr	y and Cal	culus I	(4) MA	16500	Plane Analytic Geometry and Calculus
				(3)		General Education Elective
14				17		
Second Ser					11600	Conoral Chamister II
	11600 General Chemistry II	Commu	niantions			General Chemistry II
(3) COM (4) MA	11400 Fundamentals of Speech 16600 Plane Analytic Geometr					Fundamentals of Speech Communication Transforming Ideas to Innovation II
	17200 Modern Mechanics	y and Car		(2) ENGR (4) MA		Plane Analytic Geometry and Calculus I
	R 13200 Transforming Ideas to It	novation	п			Modern Mechanics
<u>(2)</u> ENGE 17	C 15200 Transforming fueas to m	movation	11	<u>(4)</u> 1113 17	17200	
Sophomo	ore Year					
Third Sem	ester					
(4) ABE	20100 Thermodynamics of Bio	logical Sy	ystems I	(4) ABE	20100	Thermodynamics of Biological Systems
(4) MA	26100 Multivariate Calculus			(1) ABE	29000	Sophomore Seminar
	25700 Organic Chemistry I			(4) BIOL	11000	Fundamentals of Biology I
(3) BIOL	23000 Biology of the Living Co	ell		(4) CHM	25700	Organic Chemistry I
(2) IT	22600 Biotechnology Laborato	ry I		<u>(4)</u> MA	26100	Multivariate Calculus
(1) ABE	29000 Sophomore Seminar			17		
18						
Fourth Sei	nester					
(3) ABE	20200 Thermodynamics of Bio		ystems II	(3) ABE		Thermodynamics of Biological Systems
(3) BCHM	122100 Analytical Biochemistry	y OR	Ł	(3) CHE	32000	Statistical Modeling
	FN 205 Food Science			(3) FN	20500	Food Science
	26500 Linear Algebra			(3) MA	26500	Linear Algebra
(3) MA	-	uations		(3) MA	26600	Ordinary Differential Equations
(3) MA (3) MA	26600 Ordinary Differential Ec					-
	-			(3)		General Education Elective
(3) MA	26600 Ordinary Differential Ec 32000 Statistical Modeling General Education Elect	ive		<u>(3)</u> 18		General Education Elective

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Junior Ye	ear		
Fifth Seme	ster		
(3) ABE	30100 Modeling & Computation Tools in Biol.	(3)ABE	30100 Modeling & Computation Tools in Biol.
	Engr.		Engr.
(3) ABE	30300 App of Phys Chemistry to Biol. Processes	(3)ABE	30300 App of Phys Chemistry to Biol. Processes
(4) CHE	37700 Momentum Transfer	(4)CHE	37700 Momentum Transfer
(3) PHYS	24100 Electricity and Optics	(3)PHYS	24100 Electricity and Optics
(3)	General Education Elective	(3)	General Education Elective
16		16	
Sixth Seme	ester		
(3) ABE	37000 Biol./Microbial Kinetics & Reaction Engr.	(3) ABE	37000 Biol./Microbial Kinetics & Reaction Engr.
(4) ABE	45400 Transport Processes in Biological and Food Process Systems	d (4) ABE	45400 Transport Processes in Biological and Food Process Systems
(4) CHE	37800 Heat and Mass Transfer	(4) BIOL	22100 Microbiology
(4) BIOL	22100 Microbiology	(4) CHE	37800 Heat and Mass Transfer
(3)	General Education Elective	(3)	General Education Elective
18		18	

Senior Year

gr (1)ABE	49000 Professional Practice in Agric. & Biol.
	Engr
(4)ABE	55500 Biological & Food Processing Unit
	Operations
(4)	Biological or Food Science Elective
(3)	Engineering Selective
(3)	General Education Elective
15	
(3)ABE	46000 Sensors and Process Controls
(4) ABE	55600 Biological and Food Process Design
(3)ABE	58000 Process Engineering of Renewable
	Resources
(4)	Biological or Food Science Elective
(3)	General Education Elective
17	
<u>Total</u>	
135	
	n of Study revisions (PPE major)
	(4) (3) (3) 15 (3)ABE (4) ABE (3)ABE (4) (3) 17 Total 135

Second Semester (4) CHM 11600 General Chemistry II (4) CHM 11400 Fundamentals of Speech Communications (3) COM 11400 Fundamentals of Speech Communications (3) COM 11400 Fundamentals of Speech Communications (4) CHM 11600 Fundamentals of Speech Communications (4) CHM 11600 Fundamentals of Speech Communications (4) PHY 17200 Modern Mechanics (4) MA 16600 Plane Analytic Geometry and Calculus II (4) PHY S 17200 Modern Mechanics (4) PHY S 17200 Modern Mechanics (4) ABE 20100 Thermodynamics of Biological Systems I (4) ABE 20200 Thermodynamics of Biological Systems I (4) ABE 20200 Thermodynamics of Biological Systems I (3) ABE 20200 Thermodynamics of Biological Systems II (3) ABE 20200 Thermodynamics of Biological Sy	Present		Pro	oposec	I - PPE
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(2) ENGR 13100 Transforming Ideas to Innovation I (2) ENGR 13100 Transforming Ideas to Innovation I (4) MA 16500 Plane Analytic Geometry and Calculus I (3) Transforming Ideas to Innovation I (4) MA 16500 Plane Analytic Geometry and Calculus I (4) MA 16500 (4) CHM 11600 General Chemistry II (4) CHM 11600 General Chemistry II (3) COM 11400 Fundamentals of Speech Communications (4) CHM 11400 Fundamentals of Speech Communications (4) MA 16600 Plane Analytic Geometry and Calculus II (4) CHM 11400 Fundamentals of Speech Communications (2) ENGR 13200 Transforming Ideas to Innovation II (4) PHYS 17200 Modern Mechanics (2) ENGR 1300 Transforming Ideas to Innovation II (4) PHYS 17200 Modern Mechanics (2) ENGR 1300 Transforming Ideas to Innovation II (4) PHYS 17200 Modern Mechanics (5) ENGR 1300 Transforming Ideas to Innovation II (4) PHYS 17200 Modern Mechanics (4) ABE 20100 Thermodynamics of Biological Systems I (4) ABE 20100 Fundamentals of Biological Systems I <th>. ,</th> <th>-</th> <th></th> <th></th> <th>5</th>	. ,	-			5
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(3) General Education Elective 18		, ,		20000	
		-			
	<u>(3)</u> 18	General Education Elective	10		

Jı	unior	Year

Fifth Seme	ester		
(3) ABE	30100 Modeling & Computation Tools in Biol.	(3)ABE	30100 Modeling & Computation Tools in Biol.
	Engr.		Engr.
(3) ABE	30300 App of Phys Chemistry to Biol. Processes	(3)ABE	30300 App of Phys Chemistry to Biol. Processes
(4) CHE	37700 Momentum Transfer	(4)CHE	37700 Momentum Transfer
(3) PHYS	24100 Electricity and Optics	(3)IPPH	36200 Basic Pharmaceutical I
(3)	General Education Elective	<u>(3)</u> PHYS	24100 Electricity and Optics
16		16	
~ ~ ~			
Sixth Seme	ester		
(3) ABE	37000 Biol./Microbial Kinetics & Reaction Engr.	(3) ABE	37000 Biol./Microbial Kinetics & Reaction
			Engr.
(4) ABE	45400 Transport Processes in Biological and Food	l (4) ABE	45400 Transport Processes in Biological and
	Process Systems		Food Process Systems
(4) CHE	37800 Heat and Mass Transfer	(4) BIOL	22100 Microbiology
(4) BIOL	22100 Microbiology	(4) CHE	37800 Heat and Mass Transfer
(3)	General Education Elective	<u>(3)</u> IPPH	36300 Basic Pharmaceutical II
18		18	

Senior Year

Seventh Se	mester		
(1) ABE	49000 Professional Practice in Agric. & Biol. Eng	r (1)ABE	49000 Professional Practice in Agric. & Biol.
			Engr
(4) ABE	55500 Biological & Food Processing Unit	(4)ABE	55500 Biological & Food Processing Unit
	Operations		Operations
(4)	Biological or Food Science Elective	(3)IPPH	56200 Introduction to Mfg Process
(3)	Engineering Elective	(3)	Engineering Selective
(6)	General Education Elective	(6)	General Education Elective
18		17	
Eighth Sen	nester		
(3) ABE 5	58000 Process Engineering of Renewable	(3)ABE	46000 Sensors and Process Controls
	Resources	(4) ABE	55600 Biological and Food Process Design
(4) ABE 5	55600 Biological and Food Process Design	(3)ABE	58000 Process Engineering of Renewable
			Resources
(3) ABE 4	46000 Sensors and Process Controls	(6)	General Education Elective
(3)	General Education Elective		
(3)	Biological or Food Science Elective		
16		16	
<u>Total</u>		<u>Total</u>	
135		136	
Supporti	ing Documentation - Biological Enginee	ring Plan	of Study revisions (CBE major):
		-	

Present		Pre	oposed	I - CBE
Freshma	n Year			
First Seme	ster			
(4) CHM	11500 General Chemistry I	(4) CHM	11500	General Chemistry I
(4) ENGL	10600 English Composition I	(4) ENGL	10600	English Composition I
(2) ENGR	13100 Transforming Ideas to Innovation I	(2) ENGR	13100	Transforming Ideas to Innovation I
(4) MA	16500 Plane Analytic Geometry and Calculus I	(4) MA	16500	Plane Analytic Geometry and Calculus I
		(3)		General Education Elective
14		17		
Second Ser	nester			
(4) CHM	11600 General Chemistry II	(4) CHM	11600	General Chemistry II
(3) COM	11400 Fundamentals of Speech Communications	(3) COM	11400	Fundamentals of Speech Communications
(4) MA	16600 Plane Analytic Geometry and Calculus II	(2) ENGR	R 13200	Transforming Ideas to Innovation II
(4) PHYS	17200 Modern Mechanics	(4) MA		Plane Analytic Geometry and Calculus II
(2) ENGR	R 13200 Transforming Ideas to Innovation II	<u>(4)</u> PHYS	17200	Modern Mechanics
17		17		
Sophomo	re Year			
Third Sem	ester			
(4) ABE	20100 Thermodynamics of Biological Systems I	(4) ABE	20100	Thermodynamics of Biological Systems I
(4) MA	26100 Multivariate Calculus	(1) ABE	29000	Sophomore Seminar
(4) CHM	25700 Organic Chemistry I	(3) BIOL	23000	Biology of the Living Cell OR BIOL 23100 OR BCHM 30700
(3) BIOL	23000 Biology of the Living Cell	(4) CHM	25700	Organic Chemistry I
(2) IT	22600 Biotechnology Laboratory I	(4) CIIM (2) IT		Biotechnology Laboratory I
(1) ABE	29000 Sophomore Seminar	(4) MA		Multivariate Calculus
18		18		
Fourth Sen	noter			
	20200 Thermodynamics of Biological Systems II	(3) ARF	20200	Thermodynamics of Biological Systems II
	22100 Analytical Biochemistry OR	(3) CHE		Statistical Modeling
(5) Derina	FN 205 Food Science			-
(2) MA		(2) CNIT		Bioinformatics++
(3) MA	26500 Linear Algebra	(3) MA		Linear Algebra
(3) MA	26600 Ordinary Differential Equations	(3) MA	20000	Ordinary Differential Equations
(3) CHE	32000 Statistical Modeling	(3)		General Education Elective**
(3)	General Education Elective	17		
18				

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Junior Ye	ear		
Fifth Seme	ster		
(3) ABE	30100 Modeling & Computation Tools in Biol.	(3)ABE	30100 Modeling & Computation Tools in Biol.
	Engr.		Engr.
(3) ABE	30300 App of Phys Chemistry to Biol. Processes	(3)ABE	30300 App of Phys Chemistry to Biol. Processe
(4) CHE	37700 Momentum Transfer	(4)CHE	37700 Momentum Transfer
(3) PHYS	24100 Electricity and Optics	(3)PHYS	24100 Electricity and Optics
(3)	General Education Elective	(3)	General Education Elective
16		16	
Sixth Seme	ester		
(3) ABE	37000 Biol./Microbial Kinetics & Reaction Engr.	(3) ABE	37000 Biol./Microbial Kinetics & Reaction Engr.
(4) ABE	45400 Transport Processes in Biological and Food	d (4) ABE	45400 Transport Processes in Biological and
	Process Systems		Food Process Systems
(4) CHE	37800 Heat and Mass Transfer	(4) CHE	37800 Heat and Mass Transfer
(4) BIOL	22100 Microbiology	(3) BIOL	24100 Genetics & Molecular Biology
(3)	General Education Elective	<u>(3)</u> ABE	49500Cell & Molecular Design Principles
18		17	
Senior Ye	ear		
Seventh Se			
(1) ABE	49000 Professional Practice in Agric. & Biol. Engr	(1)ABE	49000 Professional Practice in Agric. & Biol.
()		(-)	Engr

(4) ABE	55500 Biological & Food Processing Unit	(4)ABE	55500 Biological & Food Processing Unit
	Operations		Operations
(4)	Biological or Food Science Elective	(3)	Biology or Science Selective
(3)	Engineering Elective	(3)	Engineering Selective
(6)	General Education Elective	(6)	General Education Elective
18		17	

Eighth Semester

(3) ABE 58000	Process Engineering of Renewable	(3)ABE	46000 Sensors and Process Controls
(4) ABE 55600	Resources Biological and Food Process Design	(4) ABE (3)ABE	55600 Biological and Food Process Design 58000 Process Engineering of Renewable
(1)		(-)	Resources
(3) ABE 46000	Sensors and Process Controls	(3)	Biology or Science Selective
(3)	General Education Elective	(3)	General Education Elective
<u>(3)</u> 16	Biological or Food Science Elective	16	
<u>Total</u>		<u>Total</u>	
135		135	

Same Enge

Bernard A. Engel Professor and Head Agricultural and Biological Engineering Department

Date: April 11, 2011

Supplemental Material: Course Syllabus for ABE 49500 Cell and Molecular Design Principles

ABE 495 - Cell and Molecular Design Principles

Spring 2012Instructor:Dr. Jenna Rickus rickus@purdue.eduOffice:MJIS 2029Phone:494-1197Office Hours:

Catalog Description. The design principles underlying mechanisms of cellular functions such as cell architecture, energy storage and conversion, sensing and signaling, communication, time keeping, molecular synthesis, memory, and motility. Emphasis will be placed on the chemical, physical, and mathematical features that determine the performance of the biological device. Topics cover both cellular/biochemical processes and molecular/genetic circuits. Examples are presented from reverse engineering of natural systems and design of new synthetic systems.

Prerequisites. MA 265 AND MA 266 AND BIOL 230 (or BIOL 231 or BCHM 307)

Textbook

1. Instructor Compiled Online Textbook in "Scitable" by Nature Education. http://www.nature.com/scitable/groupjoin/cellular-design-principles-22413806/48811

2. An introduction to systems biology

Additional Readings and References:

3. Rafelski and Marshall "Building the Cell: design principles of cellular architecture". Nature Reviews. 2008. 4. "Design principles of biochemical oscillators." Bovak, Tyson. Nature Reviews Molecular Cell Biology. 2008.

Week 1	 Cell Architecture & Self-Assembly. Determinants and Regulation of Size and Shape of Cells and Organelles. Design Principle: Controlling size and number by molecular rulers, quantal synthesis and dynamic balance. Example. Organelle synthesis, turnover, and number
Week 2	Transport/Diffusion . Passive versus active intracellular transport. Design Principles: Transport limitations/pressures on cell size and impact on energy needs. Example. How specialized cells transport over long distances.
Week 3	Energy Storage and Conversion. Electrochemical gradients. High energy molecules. Design principle: gradients versus discrete storage Example: Why are proton gradients universal?
Week 4	 Signaling. Introduction to signaling. Why multiple levels of regulation? Design advantages, times scales and choices of multiples levels of regulation. Kinase/Phosphatase Design Principle. Multi-step Ultra sensitivity. Zero order Ultra sensitivity Example. Monitoring Cellular Energy State
Week 5	 Sensing & Signaling. Introduction to external inputs to cells. Design Principles. Amplification in signaling cascades, chemical sources of background noise, adjustable dynamic range (adaption to inputs) in signaling networks. Example. Photoreceptors as near perfect photon detectors. Insect detection of signals across miles.
Week 6	Biological Circuits . Intro to Transcriptional Networks. Mathematical representation of activators, repressors, multi-input systems.
Week 7	Biological Circuits. Network Structure. Network Motifs. Gene and Protein Network Analysis. Design Principles: Structural effects on robustness. Connectivity and lethality. Case Study. Systematic knockouts in yeast and mycobacteria.

Week 8	Biological Circuits. Graphical Analysis of Biochemical Circuit Dynamics. Time domain, frequency domain, phase plane, stability diagrams		
Week 9 Gene	Circuits. Feed-Forward Loop Network Motif. Design Principles. Performance Implications of Negative and Positive Auto regulation Motifs.		
Week 10	 Biochemical Oscillators. Significance and function of biochemical oscillations in nature and engineered systems. Design Principles. General requirements for natural biochemical oscillators. Negative feedback, time delay, nonlinearity, balance of production/consumption time scales. 		
Week 11	Time Keeping. Cellular Clocks and Gene Oscillations. Design Principles: inherent oscillations, entrainment Example: <i>period</i> and <i>timeless</i> oscillations with light entrainment in drosophila. Mutants		
Week 12	Biochemical Switches . Simple Gene Switches, Bistability, Design Principle(s). Advantages & disadvantages of simple inducers/repressors versus circuit (bistable switch) on toggle switch performance. Role of stoichiometry / cooperativity in creating a biostable toggle switch Example. Genetic toggle switch in E. coli.		
Week 13	Motility. Mechanisms and Decision making in Cellular locomotion Design Principle. Robustness Example. Bacterial Chemo taxis		
Week 14	Synthetic Systems. Synthetics Biology. Standard Registry of Biological Parts, Safety and Ethics Design Principles. Abstraction, hierarchy, standardization		
Week 15	 Ground Up Cellular Design. Approaches to genome synthesis. Alternative codes. Nuclear transfer for cell "boot up". Design Principles. Minimum Gene Set. Watermarking. Identification of synthetic versus native. Engineering Safety Mechanisms. Case Study. First synthetic bacterial genome. 		

Grading:	25%	Weekly Homework Assignments	
	25%	Exam 1	
	25%	Exam 2	
	25%	Final Exam	

Grading Scale:	grade	gpa value	% range
	А	4.0	93-100
	A-	3.7	90.0-92.9
	B+	3.3	87.0-89.9
	В	3.0	83.0-86.9
	B-	2.7	80.0-82.9
	C+	2.3	77.0-79.9
	С	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