BioEng 1102 Spring, 2001 Syllabus (as of 1/29/01)
Fundamentals of Bioengineering II

Lecture: MF 12:25 – 1:45 101 EMCB
Discussion/Lab:
W 8:35 MEB 2569 (lab)
W MEB 2569 (lab)
Th 8:35 MEB 2569 (lab)
Th 9:40 MEB 2569 (lab)

Instructor: Joe Andrade 2460 MEB Ph: 581-4379
Office hours: W 12:25—1:45
M 9:40--11:35
joe.andrade@m.cc.utah.edu

Teaching Assistants:
Daniel Bartholomeusz: d.bartholomeusz@m.cc.utah.edu
Michael Anderson: M.C.Anderson@m.cc.utah.edu

Fundamentals of Bioengineering I and II (BIOEN 1101 and 1102) introduces students to the broad field of Biomedical Engineering and to some of the principles, tools and techniques used in the profession. The material is organized around unified concepts of flux, transport and conservation in biological and engineered systems. Fundamental laws of physics and chemistry are applied to the analysis of biological systems and to the design of biomedical devices. Calculus and chemistry should be taken concurrently. BIOEN 1101 focuses on physical principles; 1102 adds chemical and biochemical principles and deals with physico-chemical coupled phenomena.

Requisites: Concurrent with Chem 1210, Math 1250

Prerequisite: BioEng 1101 or consent of the instructor

Readings are available via Electronic Reserve; some will be (have been!) distributed in class. Copyright limits what we can put on E Reserve; that's why actual books (next paragraph) are on regular hard copy Reserve.

Reserve Books (at Marriott):

Berger… Introduction to Bioengineering by S.A. Berger, W. Goldsmith, and E.R. Lewis, Oxford Univ. Press, 1996 ISBN 0-19-856516X
Blum… Bio- and Chemi-Luminescent Sensors, L.J. Blum, World Scientific, 1997, 198 pp.
Brolin… Bioluminescence Analysis, S Brolin and G Wettermark, VCH, 1992
Bronzino… The Biomedical Engineering Handbook. Editor, Joseph D. Bronzino; CRC Press, 1995; ISBN 0-8493-8346-3.
Campbell… Chemiluminescence, A.K. Campbell, VCH, 1988, 608 pp
Eisenberg… Physical Chemistry, D Eisenberg and D Crothers, 1979 Benjamin/Cummings Publ., 868 pp
Enderle… Introduction to Biomedical Engineering by J.M. Enderle, S.M. Blanchard, and J.D. Bronzino, Academic Press, 2000; ISBN 0-12-238660-4
Feynman… Lectures on Physics, Feynman, et al., Vol. 1, Addison-Wesley, 1963
Kotz… Chemistry and Chemical Reactivity, 4th ed., Kotz and Treichel, Saunders,

1999. This is the U of U Freshman Chem text.

Mathews… Biochemistry, C.K. Mathews, K.E. van Holde, and K.G. Ahern, Addison Wesley Longman, 2000; ISBN 0-8053-3066-6

Michal… Biochemical Pathways, G. Michal, Wiley, 1999; ISBN 0-471-33130-9. Many of the pathways in this book are on the web at www.expasy.ch/cgi-bin/search-biochem-index

Voet… Fundamentals of Biochemistry, D. Voet, J.G. Voet, and C.W. Pratt, Wiley, 1999; ISBN 0-471-58650-1 (this is the major biochemistry text used at the U)

Wolfson… Physics, Wolfson and Pasachoff, Addison-Wesley, 1999. This is the U of U Physics text

The following are on electronic reserve (www.lib.utah.edu then to UNIS and instructor (Andrade)). You are advised to download all the E reserve entries for this class onto your computer or onto a Zip or other media so you have ready access to all the reradings at any time. See the recommended readings in the Schedule below.

Blum Bio- and Chemi-Luminescent Sensors, World Scientific, 1997, 198 pp.
Chapter 4, pp 37-68; Light-emitting Reactions

Brolin Bioluminescence Analysis, S Brolin and G Wettermark VCH, 1992, 151 pp.
Chapter 1, pp. 1-17; Chemi and Bioluminescence

Bronzino Biomedical Engineering Handbook. Editor, Joseph D. Bronzino; copyright, CRC Press, 1995, 1st ed., 2862 pp.; ISBN 0-8493-8346-3.
Chapter 52, pp 764-778; Optical Sensors
Chapter 53, pp 779-787; Bioanalytic Sensors
Chapter 77, pp 1241-1248; Clinical Lab Methods I
Chapter 78, pp 1249-1257; Clinical Lab Methods II

Campbell Chemiluminescence, VCH, 1988, 608 pp
Chapter 5, pp. 267-314; Measurement of Enzymes and Metabolites

Cohn Biochemistry and Disease, R.M. Cohn and K.S. Roth, Copyright 1996 Williams and Wilkins, 587 pp.
Chapter 1, pp 3-61; Biochem and Medicine

deDuve A Guided Tour of the Living Cell, Vol. 2, Copyright 1984 deDuve Trust, WH Freeman Co. 422 pp.
Appendix I, pp 385-407; Building Blocks of Cells
Appendix II, pp 408-423; Bioenergetics

Eisenberg Physical Chemistry, D Eisenberg and D Crothers, Copyright 1979 Benjamin/Cummings Publ., 868 pp.
Chapter 1, pp 3-36; Systems
Chapter 3, pp 85-122; Second Law
Chapter 9, pp 367-397; Electrochem Equilibria

Enderle Introduction to Biomedical Engineering by J.M. Enderle, S.M. Blanchard, and J.D. Bronzino, Copyright Academic Press, 2000, 1062 pp

Chapter 1, pp 1-28; Biomed Engineering
Chapter 13, pp 657-696; Biotechnology

Feynman Lectures on Physics, Feynman, et al., Vol. 1, Copyright, 1963, Calif Inst Tech., Addison-Wesley, , approx. 500 pp.
Chapter 4, pp 4-1 thru 4-8; Conservation of Energy
Chapter 43, pp. 43-1 through 43-10; Diffusion

Harold The Vital Force, Copyright 1986, WH Freeman Co., 578 pp
Chapter 1 pp 1-26; Energy, Work, and Order
Chapter 3 pp 57-90; Energy Coupling by Ion Currents

Hobson Physics, Copyright 1995, Prentice Hall, 530 pp.
Chapter 6, pp 143-165; Conservation of Energy
Chapter 7, pp 166-194; Thermodynamics

Kotz Chemistry and Chemical Reactivity, 4th ed., Kotz and Treichel, Copyright Saunders, 1999, approx 1200 pp
Chapter 12, pp 538-581, Gases.

Mathews Biochemistry, C.K. Mathews, K.E. van Holde, and K.G. Ahern, Copyright Addison Wesley Longman, 2000, 3rd ed., 1186 pp; ISBN 0-8053-3066-6.
Chapter 1, pp 2-25; Scope of Biochem
Chapter 2, pp 26-56; Weak Interactions, Water
Chapter 3, pp 57-82; Energetics
Chapter 11, pp 360-413; Enzymes
Chapter 12, pp 414-445; Intro to Metabolism

Nichols Bioenergetics 2, D G Nichols and S J Ferguson Copyright 1992 Academic Press, 255 pp.
Chapter 1, pp 3-20, Chemiosmotic Energy Transduction

Stephanopoulos Metabolic Engineering, Copyright 1998 Academic Press, 725 pp.
Chapter 1, pp 2-20

Voet Fundamentals of Biochemistry, D. Voet, J.G. Voet, and C.W. Pratt, Copyright Wiley, 1999, 931 + 75 pp; ISBN 0-471-58650-1.
Chapter 1, pp 3-21; Life--Intro
Chapter 2, pp 22-38; Water
Chapter 13, pp 353-381; Intro to Metabolism

Vogel Cats' Paws and Catapults, Copyright 1998 WW Norton, 379 pp;
Chapter 3, pp 39-56; Magnitude

Vogel Life's Devices, Princeton, 367 pp.
Chapter 15, pp. 298-315; Energy

Wolfson Physics, Wolfson and Pasachoff, 3rd ed. Copyright 1999 Addison-Wesley--Longman, 1250 pp
Chapter 19, pp 471-495; Temperature and Heat

Chapter 20, pp 496-516; Thermal Behavior

Grading and Evaluation:

Discussion and Lecture Participation	5%
Homework	15%
Five quiz scores	25%
Project(details later)	30%
Final	25%

Six 30 minute quizzes will be given during the Monday or Friday periods at the BEGINNING of class (Quiz #1 is a take home). Your five highest quiz scores will be used to compute your total quiz grade. If you are absent or miss a quiz for any reason, a score of zero will be assigned. We encourage students to study together and help one another with the material. Homework and answers on quizzes, however, must be your original work – copying is not allowed and may result in failure or expulsion. Late homework will not be accepted after solutions have been discussed in class or posted (usually the day after the homework is due).

Homework will be closely coupled to the lab/project experience; Quizzes will largely reflect lecture material. Lectures and Lab will be closely coupled.

Discussion/participation refers to class and discussion/lab section active participation, attendence at relevant seminars (announced in class), and email/WebCT discussions and interactions.

Major Project:

A major project is a key component of the course and is designed to integrate and connect the topics in the course to practical engineering design and development activities; this project will also utilize many of the topics and skills from BioE 1101and from courses in Physics, Chemistry, and Biology.

Each student is considered a virtual employee of a new company (virtually!) whose task is to design and prototype a 50 channel ChemChip, a device to measure the concentrations of up to 50 different biochemicals (‘analytes’) in blood and/or urine. Each student’s ‘job’ is to design, develop, and test one analyte channel for the overall ChemChip. A bioluminescence output—based specific enzyme assay will be used for the analysis. The major project will be discussed extensively in class and will consist of the following components:

Weeks 1-3: Selection/assignment of analyte biochemical; background work on its general structure and chemistry; background work on its role in metabolism, health, disease, nutrition, etc.; also considerations of safety and toxicity.

Weeks 4-7: Enzyme reactions appropriate to the measurement of analyte using the enzyme bioluminescence readout system (provided). Application of enzyme kinetic modeling to assess the feasibility of the analytical reactions for practical measurement; available from the web: and www.gepasi.org.

Weeks 8-10: Laboratory (test tube) experiments to develop and test the analytical method; ; selection of blanks, calibrants, etc.; luminometer studies; revision of process, if necessary; estimation of analytical precision, range, etc.

Weeks 11-14: Method testing and evaluation; how to present the data; how to optimize the analysis; knowing what you know now, how would you approach this problem differently – next time! Final Report.

Major Project Report format and contents will be distributed and discussed in class.

Topic Outline and Course Schedule

Date	**Topic**	**Assignment**	**Laboratory Section**	**Readings* (: Chapters)**
Dec. 6	Intro; Syllabus; Biochemistry and Bioengineering	Send email to Joe.andrade @m.cc.utah.edu		Vogel hand out Chem: Intro, 1-9; App. A-I Phys: 1, App. A-D; Ende:1
Jan. 8	Welcome: Hard Rules—Soft Rules; Evolution; Scaling (Powers of 10); Chemistry	Read Chemistry		Vogel hand out Vogel: 3 Matt: 1; Voet: 1
Jan. 12	From Simple Chemistry to Metabolism; Glucose; Diabetes	Take home Quiz		Matt: 2-3; Voet: 2 Cohn: 1
Jan. 15	Holiday—no class	work on Quiz	Solutions and Dilutions	
Jan. 19	Welcome to ChemChip, Inc. Measuring and modeling metabolism; H2O; Strong and Weak Bonds; Ions, pH;	Quiz #1 Due;		Matt: 12; Voet: 13;Kotz: 12;
Jan. 22	Energy, Systems, Work, and 'Bean Counting'; Disorder; 2nd Law;		Glucose and Glucometers	Eise: 1; Vogel: 15 Feyn: 4, 43; Hobs: 6 Matt: 3;
Jan. 26	The Grand Yin-Yang: Free Energy; from Thermo to Biochem --Chem Reactions;	Check off #1 TODAY		Hobs: 7; Haro: 1 Matt: 3; Kotz: 12;Voet:1 Eise:3; Wolf: 19
Jan. 29	Reactions; Activation Energies; Catalysts; Enzymes	HW #1 out	Statistics, Excel, Data Analyses	Matt: 11; Wolf: 20
Feb. 2	Simulating Enzyme Reactions; Enzyme charts and pathways; ATP and Luciferase; Gepasi	Quiz #2		Handout: P. Mendes, "Biochemistry by Numbers—", TIBS, 9/97, 361-3. Matt: 11;
Feb. 5	From Metabolism to Coupled Reactions to Enzyme Assays		Seeing Enzyme Reactions	Matt:12; Voet: 13

Feb. 9	Enzyme Sensors; Photon Biosensors -- Bioluminescence	HW #1 Due		Brolin: 1;Blum: 4; Bron: 52, 53, 77, 78
Feb. 12	NADH and Bioluminescence		Measuring ATP via Luciferase	Camp: 5
Feb. 16	R. Davies:An Engineer's Approach to Kidney Biochemistry; I-Stat Demo	Quiz #3 HW #2 out		
Feb. 19	Holiday—no class	Keep studying!	Simulating Enzyme Reactions-- Gepasi	Mendel handout; Gepasi Help
Feb. 23	Dr. Taki Matsuda			
Feb. 26	NADH-Based Sensors	HW #2 Due	Seeing NADH -- the Bacterial Luciferase Reaction	Bron: 52, 53
Mar. 2	Electrons, Protons, Ions: Mr. Nernst's Potentials			Eise: 9; Haro: 3;Matt: 3
Mar. 5	More Nernst; Electrochemical Sensors	Quiz #4 HW # 3 out	Simulating YOUR Analytical Method	Nich: 1; Bron: 53, 78
Mar. 9	Dr. Dan Urry			
Mar. 19	Real World Enzymes; Protein Stability and Stabilization; Dry Reagent Sensors		Minimizing Lab by Simulation, Modeling	Bron: 77-78; Ende: 13
Mar. 23	Designing Tougher Enzymes	HW #3 Due		Step: 1
Mar. 26	Measuring Photons, Electrons, Protons, Ions	Quiz #5 HW #4 out	Measuring your Analyte--	Bron: 52,53,77,78
Mar. 30	Array Devices;			
Apr. 2	Fluidics and 'Chips'		Final Data-Calibration, Reliability	
Apr. 6	New Ways of Seeing-- Handling and Visualizing Multi-Parameter Data--			Cohn: 1
Apr. 9	Tissues, Materials, and Tissue 'Engineering'	HW #4 Due	Data Analysis Help	Ende: 12
Apr. 13	Proteins as Machines and Devices	Quiz #6		
Apr. 16	Listening to Tissues (Sensing)		Report Help	
Apr. 20	Talking to Tissues (Stimulation)	Major Project DUE TODAY		

Apr. 23	Tying it all Together (Thinking)	Last Date for Major Project Submittal		
Apr. 27	Optional Review			
May 2	Final Exam 11:30—1:30	Closed Book; one 8 1/2 x 11 allowed; turn in with final exam		*1st 4 letters of 1st authors' name; refer to E Reserve li above

1/29/01