ENBE 603
Transport Processes in Biological Systems
3 Credit Hours

A study of the transport processes of fluid flow, heat transfer, and mass transfer applied to biological organisms and systems. Analogical and systems approaches used. Credit cannot be obtained for ENBE 454 and ENBE 603.

Text: Johnson, A. T., 1999, Biological Process Engineering, John Wiley, New York, New York.

References: Geankoplis, C. G., 1983 Transport processes and Unit Operations (Allyn and Bacon: Boston, MS

Objectives:

Goals for this course include:

1. Analysis of physical processes such as heat transfer, fluid flow, and mass transfer, used to modify physical characteristics, placement, or general usefulness of biological products or systems.

2. Impart an appreciation for analogic thinking.

3. Exercise the ability to research material on a chosen topic.

Instructional Procedures:

Two 1 hour lecture-discussion periods and one 1 hour recitation/laboratory per week are devoted to the topics listed in the syllabus. Students will be expected to have r read the assigned material prior to the class. Lecture/discussion in the scheduled class period will be used to clarify items not understood from the reading material. Short quizzes will be administered about once per week to test the students' retention of material in class. Potential quiz questions will be posted on the web at the beginning of the semester. All quiz questions will come form this list.

Homework problems will be assigned throughout the semester. Each person will be responsible for knowing how to solve each of the problems. Homework problems may be submitted in neat handwriting written in ink. Pencil-written homework will not be accepted.

Students in the class will be assigned to groups. Homework problems, laboratory reports, and design problems will be completed and graded on a group basis. Each group member should feel responsible that all other group members perform to their maximum abilities. Groups will be reconstituted for each chapter of the text. Graduate students in ENBE 603 will be expected to act as consultants for design problems assigned to students in ENBE 454. They do not have to produce designs or participate in report writing, but they are expected to generate ideas, pursue research, and advise their groups.

A major part of this course will be application of transport processes to biological systems. A series of biological applications examples will be discussed in class to illustrate the broad range of material application.

Grades will be based on:

Homework Problems	25%
Midterm Exam	15%
Quizzes	10%
Final Exam	25%
Biological Applications (4)	25%

The biological application examples will be written by the student and should illustrate the application of some aspect of transport phenomena to some part of biology. The application examples should be drawn from a current problem in medicine, food, the environment or other biological segment and should include background information and terminology important for the understanding of the example. Each example must have numerical calculations with realistic values. Grading will consider background material accuracy, usefulness, writing clarity, and graphical illustrations.

There will be four application examples required, illustrating: 1) systems, 2) fluids, 3) heat, and 4) mass transfer. Each example must:

*Give an explanation of biological system under consideration
*Include pertinent terminology
*Properly explain application of engineering
*Present numerical calculations using typical values
*Draw conclusions
*Be properly illustrated.

If you have a documented disability and wish to discuss academic accommodations, please contact Dr Johnson (301-405-1184) as soon as possible.

Cyberinfo:

Course information can be found at http://www.ajconline.umd.edu. You will need an email address at the University of Maryland to access this information. Book errata and supplemental material can be found at http://www.bre.umd.edu/johnson.htm

Prohibitions:

Cell phones are not welcome in class. If you have one, please make sure it does not ring during class time. There will be no calculators necessary or allowed for answering quiz questions.

ENBE 603
SYLLABUS

Class	Date	Topic	Text (Sections)	Recitation
1	**Jan** 28	Introduction	--	
2	30	Problem Solving	1.1-1.3	Tech Writing
3	**Feb** 4	Effort and Flow Variables	1.4-1.6	
4	6	Balances	1.7	Tech Writing
5	11	Transport Processes Applications	1.8-1.9	
6	13	Systems Review	--	Systems Lab
7	18	Conservation of Mass Conservation of Energy	2.1-2.3	
8	20	Conservation of Momentum Flow Velocity Profiles	2.4	Problem Session
9	25	Pipe Energy Losses	2.5	
10	27	Compressible Flow Distensible Tubes Open-Channel Flow NonNewtonian Fluids	2.6-2.7	Viscosity Lab
11	**Mar** 4	Power Calculation, Pumps	2.8	
12	6	Fluid-Flow Review	--	Pump Lab
13	11	Conduction Heat Transfer	3.1-3.2	
14	13	Conduction Heat Transfer	3.3	Tech Writing
15	18	Radiation Heat Transfer	3.4	
16	20	Heat Storage, Heat Generation	3.5-3.6	Thermal Conductivity

Spring Break (3/24-3/30)

Class	Date	Topic	Text (Sections)	Recitation
17	**Apr** 1	Mixed Mode Heat Transfer, Heat Exchangers	3.7-3.7.1	Problem Session
18	3	Transient Heat Transfer	3.7.2-3.9	
19	8	Heat System Design	--	Heat Exchanger Lab
20	10	Heat Transfer Review	--	
21	15	Molecular Diffusion	4.1-4.3.2	
22	17	Reverse Osmosis Membranes and Films	4.3.3-4.3.4	Problem Session
23	22	Mass Generation and Storage Convection	4.5-4.6	
24	24	Mixed Mode Transfer, Transient Transfer	4.4	
25	29	Psychrometrics	4.7	Reverse Osmosis Lab
26	**May** 1	Drying, Mass Transfer Design	4.8-4.8.1	
27	6	Mass Transfer Review	4.8.2-4.9	Psychrometics Lab
28	8	Ethics/Professionalism	--	
29	13	Student Presentations	--	

Biological Application Examples

4 total:

1 systems
1 fluids
1 heat
1 mass

Each example must:

*give an explanation of biological system under consideration
*include pertinent terminology
*properly explain application of engineering
*present numerical calculations using typical values
*draw conclusions
*be properly illustrated

Biological Example Suggested Topics

1. Glaucoma – pressure build-up in the eye
2. Flow through a catheter – delivery of drugs
3. Electrode current density – avoiding burn
4. Artificial kidney
5. Reverse osmosis
6. Heart/lung machine - heat transfer to maintain body temp
7. Transdermal drug administration
8. Encapsulated fertilizer – rate of release
9. Oxygenation of closed-cycle aquatic systems
10. Denitrification of aquatic systems
11. Irrigation to deliver pesticides and nutrients
12. Cooling of a cup of coffee
13. Heating of a snake in the sun
14. Diffusion of nutrients through a microbial membrane
15. Diffusion biosensors
16. Packaging of fresh fruit and vegetables – use of plastic films to modify the atmosphere
17. Limestone scrubbing of sulfur dioxide
18. Pumping wastewater sludge
19. Atherosclerosis – affects on flood velocity and pressure
20. Jet propulsion of aquatic animals
21. Sodium an potassium conductance in neural membranes
22. Determination of cardiac output: thermal dilution of Fick method
23. Moisture diffusion in stored grain due to temperature gradients

24. Cardiovascular adaptations of a giraffe to prevent blood pooling
25. Viscoelastic models of the human chest to reduce injury in automobile accidents
26. Air delivery to insects to breathe
27. Calorimetry of food or animals
28. Dispersion of intramuscularly or subdermally injected medicine
29. Stray voltages
30. Respiratory heat and moisture losses
31. Heat transfer from mushrooms
32. Rate-controlling resistances in mass-transfer pathways of fermenter microbes
33. Oxygen transfer from bubbles
34. Heat transfer from blood vessels
35. Measurement of thermal properties of foods
36. Kinetics of water vapor desorption from apples
37. Diffusion of species in ecological domains
38. Moisture uptake in pine roots
39. Cleansing affect of saliva flow between teeth
40. Gas diffusion into leaf stomata
41. Dissolving pills
42. Producing apple juice
43. Freezing of food materials
44. Heat loss from feet and heads of birds
45. Oxidation browning in fruits
46. Two-stage drying of pistachios
47. Pharmacokinetics and diffusion of drugs

48. Bioremediation of oil and grease spills

49. Mass transfer in biochemical reactors

50. Specific dynamic action of foods

51. Metabolic heat loss and body size

52. High frequency ventilation

53. Energy exchange of insect larvae

54. Increased mass transfer to microorganisms with fluid motion.

55. Countercurrent multistage fluidized bed reactor for immobilized biocatalysts

56. Fermented ethanol recovery with vacuum

57. Controlling micropropagation environment

58. Supercritical Co2 extraction of biomaterials

59. Recovery and concentration of apple juice aroma compounds by pervaporation

60. Lung diffusion in exercising foxes

61. Monitoring of anaerobic methane fermentation processes

62. Electrophoresis

63. Muscle contractile properties in fish with temperature

64. Freeze protection in poikilothermic species

65. Determination of cardiac infarct tissue by acoustic impedance measurements

66. Water & nutrients uptake in plant roots

67. Absorption of lipids in the digestive tract

68. Slow pyrolysis of hardwood chips

69. Membrane dynamics in relation to fluid absorption in reptilian proximal renal tubules

70. Measuring quality of goat milk cheese

71. Steam blanching of green beans

72. Heat transfer in winter clusters of honey bees

73. Optimization of Escherichia coli growth by controlled addition of glucose

74. Determinants of milk flow through nipple units

75. Airflow resistance through granular products

76. Osmotic diffusion

77. Sphygmomanometry

78. Neural transmission

79. Stream monitoring downstream from discharge sites