CHEN E4740x: Biological Transport and Rate Phenomena II (3)
T-R 1:10 – 2:25 E. F. Leonard, 834 Mudd.

Prerequisites: Any two of the following: CHEN E3110; BIOL C2005; CHEN E3210 or BMCH E3500.

Analysis of transport and rate phenomena in biological systems and in the design of biomimetic transport-reaction systems for technological and therapeutic applications. Modeling of homogeneous and heterogeneous biochemical reactions. The bases of biological transport: roles of convection, ordinary diffusion, forced diffusion. Systems where reaction and transport interact strongly. Applications to natural and artificial tissue beds, tumor modeling, controlled release, natural and artificial organ function.

Syllabus:

Homogeneous and heterogeneous biochemical reactions. Pseudo-homogeneous models. Free energy changes during reaction; reversibility, coupled reactions. General approach to modeling molecular binding to receptors, carriers, and enzymes. Cooperativity, Hill functions. Competition and inhibition in binding reactions. Regulation and regulatory time constants of enzyme activity. Modeling of polymerases during transcription and ribosomes during translation.

Bases of biological transport: roles of convection, ordinary diffusion, forced diffusion. Membranes: transport of electrically neutral and charged species across membranes; selective membrane transport mechanisms: permeases (uniport, comport, antiport), carriers, endo- and exocytosis. Diffusion in deep stationary media: transient diffusion with application to controlled release systems; steady-state diffusion in reacting media with application to metabolizing tissue beds and tumors. Convective diffusion. Leveque and Leveque-like formulations with application to blood-tissue exchange, thrombogenesis, hollow-fiber therapeutic devices.

Molecular transformation systems involving both transport and reaction. Rate-limiting step. Non-equilibrium steady states; the resting cell. Mitochondrial kinetics. Simple models of cellular operons.

This is an advanced course which contains more theory and applications than BMCH E3500. It is intended as an elective for upper-level undergraduates and beginning graduate students in chemical and biomedical engineering.

efl: 6/6/07, rev: 8/5/07

Date	Topic
September	
4	Quantification of chemical, biochemical reaction rates
6	Reaction thermodynamics, chemical potential, equilibria
11	Complex equilibria, CO_2, O_2/hemoglobin; cooperativity, Hill functions
13	Enzyme reactions, pseudo steady state and equilibrium assumptions
18	Inhibition, regulation of enzyme reactions, receptor kinetics, permeases
20	Polymerases and ribosomes in gene transcription and translation
25	Operon models, trp
27	Reaction networks. Rate-limiting step
October	
2	Biological transport: convection, ordinary, forced diffusion
4	General equations, simplifications, boundary conditions
9	Membrane transport of uncharged and charged species
11	Models of the resting cell
16	Role of permeases and vesicles in membrane transport
18	Equilibrium at phase boundaries. Gas diffusion in artificial lungs
23	Steady-state diffusion in thick layers, cylinders, spheres, tumor necrosis
25	Transient diffusion in semi-infinite media, error functions, drug penetration
30	Transient diffusion in finite media, heat-transfer analogy, controlled release
November	
1	Midterm Examination
8	Election Holiday
10	Diffusion with homogeneous chemical reaction
15	Convective diffusion, macroscopic models, transport coefficients
17	Concentration polarization, axial dispersion, intra- interphase phenomena
22	Concurrent, countercurrent complex flows, Artificial organs, Sorbents
24	Léveque model, transport to tissue-engineered constructs.
29	Thanksgiving Holiday
December	
4	Perfused tissue: Krogh cylinder. Embelished models. Other geometries
6	Transport in the kidney, the “countercurrent multiplier”

27 lectures