Engineering Faculty Document No.29-03
January, 2004

TO: Engineering Faculty

FROM: The Faculty of Agricultural and Biological Engineering

RE: New Undergraduate Course

The faculty of the Department of Agricultural and Biological Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ABE 202 - Thermodynamics in Biological Systems II

Sem. 2, Class 3, cr. 3.

Prerequisites: ABE 201, MATH 261

Thermodynamic principles and their applications to biochemical and biological systems with emphasis on the second law of thermodynamics and use of molecular interpretations of energies and entropies. Concept of entropy balances and process efficiency. Free energy and chemical equilibrium. Equilibrium between phases, colligative properties, binding of ligands and formation of biological membranes. Molecular motion and transport properties and their application in biochemical analytical methods. Development of physical chemical problem solving skills using MathCad and Matlab software.

Reasons:

A background in thermodynamic principles is essential to understanding biological and biochemical processes. This course is the second in a consecutive two course series in biological thermodynamics.

Vince F. Bralts
Head, Department of Agricultural and Biological Engineering

ABE 202: Thermodynamics in Biological Systems II

Sem. 2, Class 3, cr. 3.

Prerequisites
ABE 201 & MATH 261

Textbook
Physical Chemistry. Principles and Applications in Biological Sciences. Tinoco, I., Sauer, K. and Wang, J.C. and J.D.Puglisi (ISBN 0-13-720459-0)

Course Handouts

Description
Thermodynamic principles and their applications to biochemical and biological systems with emphasis on the second law of thermodynamics and use of molecular interpretations of energies and entropies. Concept of entropy balances and process efficiency. Free energy and chemical equilibrium. Equilibrium between phases, colligative properties, binding of ligands and formation of biological membranes. Molecular motion and transport properties and their application in biochemical analytical methods. Development of physical chemical problem solving skills using MathCad and Matlab software.

Course Learning Objectives:

1. Application of basic thermodynamic concepts and relationships between thermodynamic properties to study biological systems
2. Apply phase and chemical equilibrium concepts to understand physical chemical phenomena in biological systems
3. Develop an understanding of models for ideal and non-ideal physical behavior of biological materials at equilibrium in multicomponent multiphase systems
4. Develop and apply predictive equations on the calculation of colligative properties of food and biological systems
5. Understand the role of transport phenomena in foods and biological systems

Course Outline

Week

1-2 Introduction, Review of the First Law of Thermodynamics and Application of Balance of Mass and Energy to Food and Biological Systems. Second Law of Thermodynamics. Definition of Entropy, concept of reversibility

3-4 Application of entropy balances to estimate the efficiency of food and biological processes and in cycles and pathways. Application of the Second Law to biological reactions, hydrophobic interactions and interactions between biological systems (e.g. proteins and acid nucleics)

5-7 Maxwell relationships, thermodynamic relationships. Free energy and chemical equilibria. Chemical reaction equilibrium. Effect of temperature on equilibrium constant. Biochemical applications of thermodynamics. Thermodynamics of metabolism. Electron transfer and biological redox reactions. Ligand binding

8-10 Free energy and physical equilibria. Transport phenomena in biological systems, concept of chemical gradients. Biological Membranes and Transport. Colligative properties, Boiling Point elevation, Freezing point depression, osmotic pressure, Donnan Effect. Concept on equations of state.

11-12 Fugacity concept. Fugacity calculations. Introduction to multicomponent systems. Partial molar properties, chemical potential and activity concepts. Ideal solutions. Vapor-liquid equilibrium. Dew point calculations.

13-14 Kinetics: Rates of Chemical Reactions. Diffusion-controlled reations, Phothochemistry and Photobiology. Ionic Reactions and Salt Effects, Dissociation constants, Debye-Huckel Theory, Salting in and Salting out effects on proteins.

15 Concepts on Molecular Motion and Transport Properties. Difussion, Sedimentation, Electrophoresis, Viscosity. Applications to determine molecular properties of biological molecules.