**BIOE 130: Biothermodynamics**
**Fall, 2021**

Required Text: **Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience, Ken Dill and Sarina Bromberg, Garland Science, 2010**

**Lecture Time and Location** **4 credits (3 lectures and 1 discussion)**

**Lecture, TR 4:30-5:45AM, CLSSRM 114**
**Discussion section 02D, T 9:30-10:20 AM, COB 262**
**Discussion section 03D, R 2:30-3:20PM, ADMIN 355**
**Discussion section 04D, M 1:30-2:20PM, ADMIN 114**

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**Overview:** Thermodynamics is the study of processes done on or performed by the system, and explains how the macroscopic parameters change. The subject of statistical mechanics is concerned with expressing thermodynamics and the macroscopic behavior in terms of the microscopic properties of its constituent particles (molecules). Thermodynamics and statistical mechanics, therefore, are essential for explaining the forces that drive various chemical and biochemical reactions, ligand binding, protein structures, the behavior of biological macromolecules, and many other biological phenomena (processes). A good understanding of biothermodynamics will help in the design and engineering of molecules (e.g. drugs) and devices that interact with living organisms.

**Course Objectives/Student Learning Outcomes:** *By the end of this course, students will be able to:*

1. explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, and cycle.
2. understand the concept of heat, work, and basic principles of thermodynamics.
3. know the molecular origins of the Boltzmann distribution, the Arrhenius rate law, and entropic forces. They will understand how thermal motion constrains in biological systems.
4. understand the thermodynamic background for diffusion, chemical reactions and chemical kinetics in biological systems.

5. apply the mathematical framework of thermodynamics to understand basic processes of self-assembly, binding and recognition for biological systems.
6. Students will be able communicate information and their knowledge in biothermodynamics.

Learning Outcomes will be assessed through quizzes, exams, and classroom discussion.

**Program Learning outcomes:**
The course relates to these following bioengineering program learning outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering;
5. An ability to identify, formulate, and solve engineering problems;
10. A knowledge of contemporary issues

**Prerequisites by Topic:** BIO 002 CHEM 010, CHEM 008, MATH 032

**Course Policies:**

**Grading**
80% Exams (two midterm exams 25% each and one final exam 30%)
20% Homework, Classroom discussion & Quizzes
100 % Total

**Academic Dishonesty Statement:** Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy.

**Disability Statement:** Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

**Diversity Statement:** At UC Merced we steadfastly uphold the concepts expressed in the University of California Diversity Statement including, "the variety of personal experiences, values, and worldviews that arise from differences of culture and circumstance. Such differences include race, ethnicity, gender, age, religion, language, abilities/disabilities, neurodiversity, sexual orientation, gender identity, socioeconomic status, geographic region, and more."
We affirm that a diverse campus furthers our mission to create, interpret, and disseminate knowledge and values. The manifold diversity of our community encourages each of us to reflect on intellectual and cultural orthodoxies, and thus stimulates the creativity at the heart of our academic mission as a research university. We take pride in serving a large population of

first-generation college students, including the broad representation of background on our campus as a Hispanic (HSI), Minority (MSI) and Asian American and Native American Pacific Islander (AANAPISI) serving institution. As a common goal, we will work together to ensure all members of our academic community reflect the multiplicity of identities in our region.

**Tentative Lecture Schedule (3 hours lecture/week)**

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| Week 1 | Introduction |
| | Probability |
| Week 2 | Equilibrium States |
| Week 3 | Heat, Work and Energy |
| Week 4 | Math Tools |
| Week 5 | Entropy and Boltzmann's Law and **Midterm 1** |
| Week 6 | Thermodynamic Driving Forces |
| Week 7 | The logic of Thermodynamics |
| Week 8 | Free Energies |
| Week 9 | Maxwell's Relations |
| Week 10 | The Boltzmann Distribution law and **Midterm 2** |
| Week 11 | Chemical Equilibria |
| Week 12 | Chemical Kinetics |
| Week 13 | Binding and Adsorption and Catalysis |
| Week 14 | Multi-site and cooperative Ligand Binding |
| Week 15 | Bio and Nano Machines |