CHBE 480 **Bionanotechnology: Physical Principles**

Catalog Data: Physics at nano/micro scales. Biomolecular building blocks. Simplest biomolecular assembly: protein folding. Nanoscale intermolecular interactions important in biology. Protein-ligand binding. Protein higher-order assembly: filaments, networks. Protein filaments and motility. DNA, RNA and their assembly assisted by proteins. Viral capsid assembly. Lipid assembly into micelles, bilayers. Lipid-protein co-assembly in membranes. Lipid and polymer-based carriers useful in medicine. Antimicrobial therapies. Targeted cancer therapy. Ideal properties of nanocarriers in terms of size, charge, and surface chemistry.

Instructor:
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Class Schedule: Tu-Th.......3:30 pm – 4:45 pm (CHE 2110) (Lectures)

Textbooks (Optional): *Bionanotechnology: Physical Principles* by David S. Goodsell, Wiley (2004).

Physical Biology of the Cell by Rob Phillips et al. (2003).

Prerequisites: A basic class in molecular biology or cell biology or biophysics. Familiarity with biomolecules, intracellular structures.

Contribution of the Course to Meeting Professional Component:

The design of materials and structures that take inspiration from biology is becoming increasingly important for engineers from all disciplines and chemical engineers in particular. To accomplish such design, it is useful to learn a set of essential physical principles that govern the design of biological structures. Students who take this course will thus be trained to exploit biomolecular design principles in developing new products and materials in a wide range of technologies, including, in particular, biomedical technologies ("nanomedicine").

Relationship of course to program objectives:

Relevant ABET outcomes include 2 (identifying and solving specialized problems in chemical engineering), 4 (broad knowledge to understand the impact of engineering solutions in a global and societal context) and 14 (an understanding of technological issues related to chemical engineering).

Objectives:

1. To present a *physical* perspective on biomolecular nanostructures and the nanoscale environment that is relevant to biology.

2. To identify *common unifying themes* that underpin biomolecular assembly at various hierarchical length scales (nano-micro-macro).

3. To describe how *biological function* is connected with the structure of biomolecular assemblies, and how abnormalities in structure lead to diseased states.

4. To provide a perspective on how *biomimetic and bio-inspired design* at the nanoscale are actively being exploited in nanotechnology, materials design, and in medicine.

Topics:

1. Physics at nano/micro scales: Dominance of viscous forces, Brownian motion
2. Biomolecular building blocks: Polymers, amphiphiles
3. Simplest biomolecular assembly: Protein folding: Analogy to coil-globule transition in polymers.
4. Protein folding: Interactions: hydrophobic, H-bonding
5. Protein folding: Interactions: van der Waals, electrostatic, crowding
6. Protein-ligand binding: Co-operative vs. non-co-operative
7. Protein higher-order assembly: Filaments and fibrils, motor proteins, force generation by filaments
8. Protein higher-order assembly: Filament stiffness, gels and networks, gel elasticity and swelling
9. Protein higher-order assembly: Connection to disease, amyloid plaques, sickle cell anemia
10. DNA, RNA and their assembly aided by proteins, DNA condensation, DNA origami
11. DNA-protein higher-order assembly: Viral capsids, osmotic ejection of DNA
12. Lipid assembly: Formation of micelles and vesicles based on molecular geometry
13. Lipid assembly: Membranes and the role of cholesterol; steric stabilization by polymers
14. Glycoprotein assembly into cell walls in microbes; basics of antimicrobial therapies
15. Cellular assembly: blood cells and their properties; cells of the immune system
16. Lipid and polymer-based nanocarriers useful in medicine: Comparisons
17. Ideal properties of nanocarriers in terms of size, charge, surface chemistry; fate after injection
18. Cancer biology and ways for nanocarriers to target cancer

Prepared by : Raghavan, S. R. **Last revised**: February 1, 2019