Syllabus: BIOE 111 (Spring 2015)

Course Number: BioE 111
Course Title: Functional Biomaterials Development and Characterization

Instructor: Seung-Wuk Lee, Assistant Professor of Department of Bioengineering
1-220 Donner Lab
Department of Bioengineering,
Univeristy of California, Berkeley
Berkeley, CA 94720
Phone: 510-486-4628
e-mail: leesw@berkeley.edu
Office Hours: 1-2 PM on Fridays at 220 Donner Lab.

Units: 4
Course format: 1.5 hours and 2 lectures in a week and 1 hour discussion
Class Room: 102 WURSTER
GSI: Malav Desai, mdesai@berkeley.edu
GSI Office Hours: 4-5 PM (or later) on Thursdays at 458 Donner Lab.
Prerequisites: Chemistry 1A or 4A, Biology 1A or 1AL, MCB C100A/Chem C130 or MCB 102
Grading: Letter

Bioengineering content: Design of the biomaterials and physical methods of quantitative measurement of the biological phenomena and biomolecules, and their quantitative characterization methodology for engineer.

Core Specialization:
Biomaterials, Biomechanics, Biomedical Devices, Cell & Tissue Engineering and Biomedical Imaging

Text book: Scanned copy or E-Textbook will be posted.

Reference books (Necessary chapters will be uploaded in the course website)
Bioanalytical chemistry
Author: Manz, A. (Andreas)

Published: London : Imperial College Press ; Hackensack, NJ : Distributed by World Scientific Pub., c2004.

Bioanalytical chemistry
Author: Mikkelsen, Susan R., 1960-
Published: Hoboken, N. J. : John Wiley & Sons, c2004.

Principles of physical biochemistry
Author: Kensal E. van Holde, W. Curtis Johnson, P. Shing Ho.
Published: Upper Saddle River, N.J. : Pearson/Prentice Hall,

Important Date:
Mid Term Exam: TBD
Final Exam: TBD
Term Paper due: TBD

Course structure and assignments:

Grading:

Home works	10%
Term paper	10%
Term projects	10%
One mid-term exam	30%
Final exam	35%
Attendance:	5%

Late submission policy of homework and term papers:
Late submission is allowed within a week with 25% deduction of the points;
No submission is allowed after posting the answer sheet.

Term Projects: TBA
Term Paper: TBA

Course description:

Three hours of lecture and one hour of discussion per week. This course is intended for the upper level engineering undergraduate students interested in acquiring knowledge about the development of novel functional proteins and peptide motifs and their characterization of physical and biological properties using various instrumentation tools in quantitative manners. First the course will cover the physical chemistry and molecular biology of DNA, RNA, proteins and peptides which are essential to understand the directed evolutions process or rational design of the protein based materials. Then, the course will introduce various methods to develop novel functional proteins including phage display, bacterial display, mRNA display, SELEX and yeast two hybrid systems. Then, the course will focus on how to characterize the basic and novel biological and physical properties of the proteins and peptide motifs that isolated from the library screening techniques using various analytical instrumentations including UV-visible, IR spectroscopy, NMR, X-ray crystallography, light scattering, mass spectroscopy, circular dichroism, electron microscopy, isothermal calorimeter, electrophoresis. The course also covers the physical chemistry related to the functional protein characterizations which are used in each analytical instrument. Through this course, student will be familiar with recent development of the biotechnology for functional protein developments and their quantitative characterization using various instrumentation.

(1) Outline of topics to be covered (week-by-week or other detailed format)

1. Biomolecules:
The biomolecules that are most commonly analyzed in quantitative biology and biochemistry will be discussed:

DNA/RNA:
Chemical and physical properties of DNA and RNA
Central dogma of biology will be discussed.
Measurement of hybridization and dehybridization kinetics of Watson-Crick base pairing
Determination of common motifs and, triple helices, tetraloops, pseudoknots
DNA sequencing technology

Amino acids, peptide and proteins:
Determination of primary, secondary, tertiary and quaternary structures of

proteins
Measurement of protein folding thermodynamic and kinetics
Protein sequencing technology

II. Identification and development of functional proteins and peptide motifs

2-3. Directed evolution of proteins and peptide library.
Protein and peptide library display
The principles of directed evolution will be introduced and discussed including
phage display, bacterial display, mRNA display, yeast two hybrid systems.

III. Purification, separation and molecular weight determination:

4. Separation: Chromatography and electrophoresis.
Chromatography & Electrophoresis
The principles of separation in chromatography and electrophoresis, basic theory, methods which are commonly applied to the separation of biomolecules

5. Molecular Weight Determination: Mass spectrometry
The basic principle and instrumentation of mass spectrometry will be introduced.
MALDI-TOF/MS and ESI-MS methods will be discussed.
How mass spectrometry can be used to obtain structural information about biomolecules will be discussed.

IV. Spectroscopic characterization of functional proteins

6: UV-Visible spectroscopy/Fluorescence spectroscopy
The basic principle of the spectroscopy will be introduced. UV-vis, fluorescence, phosphorescence, bioluminescence, GFP, FRET will be discussed.

7: Circular dichroism
The basic principle and instrumentation of circular dichroism will be introduced. Thermodynamic of the protein folding will be discussed.

8: IR/Raman spectroscopy
The basic principle, instrumentation of IR/Raman spectroscopy will be discussed. Examples of functional group determination will be discussed.

9: NMR
The basic principle and instrumentation of NMR will be discussed. Examples of structure determination using NMR will be discussed.

V. Structure determination of functional proteins

10: X-Ray crystallography
The basic principle, instrumentation will be introduced. Examples of structure determination will be discussed.

11: TEM/SEM/Electron microscopy tomography
The basic principle and instrumentation of electron microscopy will be introduced, Examples of structure determination using electron microscopy

12: **Molecular recognitions assays**
Commonly used bioassays will be introduced.
Example of diagnostic biosensor will be discussed.
Surface plasmon resonance spectroscopy will be introduced.
Isothermal titration calorimetry will be introduced.

VI. Single molecule characterization of functional proteins

13: Atomic force microscopy & Near-field scanning optical microscopy
The basic principle of atomic force microscopy and NSOM will be introduced. The example of single molecule characterization will be discussed.

Student project conference for the functional protein developments:
TBA