Chem 6180 Special Topics Course

Wednesday 7th period; Thursday 7th and 8th periods

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Instructor: Dr. Weihong Tan
Department of Chemistry
E-mail: tan@chem.ufl.edu
846-2410
114 Leigh Hall

This is a selective course designed for graduate students in Chemistry, Materials Sciences, Biophysics and Biotechnology Program. Students in other areas are also welcome to register for this course. The goals of this course are to provide students an opportunity to actively learn at the frontier of science and get to know the important developments in bioanalytical chemistry and nanotechnology. This is a discussion type course, where active participation by the students is expected. There are two major activities in this course: Lectures and Problem Based Learning (PBL) projects. Here are the descriptions for each.

A. Lectures:

The goals of the lectures are to provide students an opportunity to get to know the most recent advancements in modern chemistry and nanotechnology. Topics will cover the frontier of optical spectroscopy, bioanalysis and nanosciences and their potential applications in biomedicine. There will be about 25 lectures to cover some important areas of frontier science. The major lecture topics in this course are listed below (more will be added depending on student demands))

1. **Advanced optical spectroscopy**: Optical instrumentation; fluorescence lifetime; fluorescence anisotropy; fluorescence resonance energy transfer; multiple photon excitation; optical trapping; etc.
2. **Scanning probe microscopy**: scanning tunneling microscopy; atomic force microscopy; near-field scanning optical microscopy; scanning magnetic force microscopy; etc.
3. **Nanotechnology and nanomaterials**: nanoparticles; quantum dots; nanochannels; biomedical applications of nanomaterials and nanotechnologies; molecular nanomotors (DNA and proteins); bio/nano interface; molecular wires and molecular electronics; etc.
4. **Biosensor**: biosensor and bioanalytical challenges; biosensor design and development; optical and electrochemical biosensors; thermal biosensors; biosensor applications in point-of-care; etc.
5. **Molecular engineering for signal transduction**: molecular probe design; molecular aptamers; combinatorial chemistry; fluorescent amplifying polymer; dendrimer and its applications in drug/gene delivery and bioanalysis; etc.
6. **Current interesting research topics**: single molecule studies; proteomics; genomics; cancer research and nanomaterials; etc.

B. Problem Based Learning

The goals for the Problem Based Learning are to increase our student's learning ability (acquiring knowledge; Critical thinking; Communication; Presentation; Critical reviewing; Organization). Our students will be given interesting and practical problems to stimulate their active learning. Students will develop research plans, give presentations, lead discussions and write critical reviews about current research topics.

Goals for Problem based learning (PBL)

- **Identifying the key issues in the specific problem.**
- **Familiarization with the state of the art researchers in the expertise areas.**
- **Putting together a research team and defining each person's role.**
- **Learn what specific aims are and how they define a research project.**
- **Definition of the specific aims for each member.**

Problem Based Learning (PBL)

Topic #1: Optical measurements and imaging inside living cells

Monitoring proteins and genes inside living cells has always been very difficult in biomedical studies. As we move into the era of "Molecular Medicine", there is a clear need for new technologies. In this Problem Based Learning exercise, you are asked to learn the basic knowledge essential in this field. Based on what you have learnt, you will then develop efficient technologies for gene/protein monitoring inside living specimen. The techniques will have to be in the general area of optical microscopy and spectroscopy. It has to be efficient, reproducible and with minimal damage/perturb to the biological systems.

Topic #2: Real time monitoring of small particles in atmosphere

There are many small particles in the air we breathe. Monitoring these particles in real time will provide us accurate information regarding air quality and ways to prevent air pollution. In this Problem Based Learning exercise, you are asked to develop efficient technologies for real time monitoring of particles in air. The techniques will have to be in the general area of optical microscopy and spectroscopy. It has to be efficient, reproducible and fast (in real-time).

Topic #3: Efficient energy delivery for nanodevices

Much as microfabrication technologies have revolutionized the electronics industry, nanotechnologies are now poised to revolutionize biotechnology and the biomedical fields ranging from basic studies to disease diagnosis and treatment. Nanotechnology, the processes to generate, manipulate and deploy nanomaterials, represents an area holding significant promise for new materials, new energy source, health care and biotechnology in the next 50 years. Understanding the principles of nanotechnology may provide insights into critical biological systems related to disease control, correction of genetic disorders and longevity. Delivery of nanotechnology has mostly been done in the form of nanomaterials and nanodevices.

More topics will be added.