TO: Engineering Faculty
FROM: The Faculty of Biomedical Engineering
RE: New Dual Level Course

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

BME 570 Surface Science Techniques for Biomedical and Chemical Applications Sem. 2. Class 3, cr. 3. Prerequisites: senior or graduate standing in engineering or science.

Review of fundamental aspects of common surface science techniques. Course presents an integrated view of these techniques and their application to biomedical and biochemical problems. Emphasis will be placed on the practical aspects of each technique.

Reason: This course is essential for BME students trying to engineer surfaces and new types of biomaterials. Several faculty members in our department work in this area and the course provides the necessary knowledge for students to understand surface techniques.

George R. Wodicka
Professor and Head

Instructor: Albena Ivanisevic

Lecture Format for Surface Science Techniques for Biomedical and Chemical Applications

The class is organized in the following fashion: one lecture period is spent introducing a particular topic and the following lecture period is used to discuss literature papers that use the technique covered in the previous class. Students receive a copy of the powerpoint slides used by the instructor to describe and discuss the technique, as well as additional reading materials in the form of review articles, sample data and handouts. For the literature discussion part the class is divided into several groups and each group is assigned to read one paper and prepare a presentation that will help them describe to the entire class how the paper utilized a certain surface technique to address important biomedical and chemical problems. One member of the group makes a short presentation to the entire class, answers questions and leads a short discussion with the rest of the students.

Syllabus:

Week 1
- Introduction
- The Structure of Surfaces – clean surfaces
- The Structure of Surfaces – adsorbed monolayers

Week 2
- Holiday – No class
- Adsorbed complex "biomarkers" on surfaces
- Nano barcodes

Week 3
- The Surface Bond
- Contact Angle, Ellipsometry, Profilometry, Interferometry
- Contact Angle Measurements – Lab demo

Week 4
- Surface Techniques: Scanning Tunneling Microscopy (STM)
- Surface Techniques: STM (literature)
- Surface Techniques: Atomic Force Microscopy (AFM)

Week 5
- Surface Techniques: AFM (literature)
- Surface Techniques: Near-field Scanning Optical Microscopy (NSOM)
- Surface Techniques: NSOM (literature)

Week 6
- Surface Techniques: Surface Infrared Spectroscopy
- Surface Techniques: Surface Infrared Spectroscopy (literature)
- Surface Techniques: X-ray Photoelectron Spectroscopy (XPS)

Week 7
- Surface Techniques: XPS (literature)
- Surface Techniques: Surface Enhanced Raman Spectroscopy (SERS)

Surface Techniques: SERS (literature)

Week 8

Project 1 Presentations
Project 1 Presentations
Project 1 Presentations

Week 9

Surface Techniques: Auger Electron Spectroscopy (AES)
Surface Techniques: AES (literature)
Surface Techniques: Secondary Ion Mass Spectrometry (SIMS)

Week 10

Surface Techniques: SIMS (literature)
Surface Techniques: Scanning Electron Microscopy (SEM)
Surface Techniques: SEM (literature)

Week 11

Surface Techniques: Transmission Electron Microscopy (TEM)
Surface Techniques: TEM (literature)

Week 12

Surface Techniques: Temperature Programmed Desorption (TPD)
Surface Techniques: TPD (literature)
Surface Techniques: Electron Energy Loss Spectroscopy (EELS)

Week 13

Surface Techniques: EELS (literature)
Surface Techniques: Low-energy electron diffraction (LEED)
Surface Techniques: LEED (literature)

Week 14

Review

Week 15

Project 2 Presentations
Project 2 Presentations
Project 2 Presentations

Week 16

Finals Week: Final Exam

Description of Project I

Project I is a group assignment. Each group will receive a grade for their effort to write the paper associated with this assignment and present a 20 min talk on it in class.

When reading papers that deal with adsorption of (bio)molecules on surfaces one often encounters studies where the authors talk about conformation of adsorbates as well as their height. A number of studies assume that conformation is the same as height or that conformation can always be directly related to height. That is not necessarily true for all surfaces and adsorbates combinations. Furthermore, many of the techniques that are used to extract the height information have their limitations. Therefore, in many cases the information one gathers is a qualitative measurement rather than a quantitative (an absolute value) measurement. Your particular group will be assigned one of the following four systems to look at:

- DNA molecules on surfaces.
- Proteins on surfaces.
- Synthetic polymers on surfaces.
- Peptides/cyclic peptides on surfaces.

Your assignment is to:

- do a literature search and find a group of papers that deal with the system assigned to you. The papers will have to deal with adsorbing these (bio)molecules onto a surface and will have to discuss the possible conformation and height of the adsorbates.
- pick 5 papers that you think are closely related to one another or complement each other. Discuss how the authors define conformation and height. Do you agree or disagree with these definitions in the context of a particular system and why?
- objectively discuss the surface techniques data the authors gather to extract height and conformation information.
- discuss what is the best and most practical way to extract height and conformation data for the system assigned to you and why. When writing this part of the paper, think about these questions: when can height be directly related to conformation, or is that not feasible for your particular system? What is the best possible way to calibrate your system to a desired conformation and/or height?

Grading of the assignment:

- **Paper: ¾ of the total points**
- this should read like a review paper (therefore you must do a good job referencing different studies).
- full sentences, proper English and spelling is expected.
- address all questions in the assignment.
- the majority of the grade will be based on how thoroughly you read and analyzed the literature you chose to use for this assignment.
- length is not necessarily an indication that you read a lot – being concise, to the point, without leaving out important information is a difficult art! Therefore I am putting a limit of 15 single-spaced pages.
- **Presentation: 1/4 of the total points**
- format is open – main criteria is how clearly you managed to communicate your thoughts during the time allotted to you.

Description of Project II
This is an individual project. The paper is ¾ of the total points for this assignment and the presentation will be ¼ of the total points. The in-class presentation should be 10 min. You are required to e-mail me your presentation or bring it on a disc, so that I can refer back to your slides when I grade your project II efforts.

The Hanford site located in the rural southeastern parts of the state of Washington is considered the biggest disgrace in the United States' environmental practices. It is estimated to contain about 53 million gallons of variety of waste in the form of liquids and sludge. For this project you are to come up with an original research proposal to contribute to the Hanford research site clean-up. Your idea can deal with any aspect of the environmental, biomedical, chemical or engineering challenges we face when we try to correct what was done many years ago in the state of Washington. Your strategy should utilize at some stage of the work at least 3 of the surface techniques we have been discussing. Attached to this assignment are 3 general articles, which are intended to introduce you to the problems in Hanford and possible research projects. You may find it useful to visit the following web site: www.hanford.gov. Your assignment cannot exceed 7 typed pages. You should approach this assignment as a way to practice writing a small grant, therefore it is essential that it is clear in its scientific content, it is understandable to a wide range of scientists, and it is concise. Since most grants require that applicants follow a very specific format, please utilize the following guidelines:

Title of proposed work
Abstract (cannot exceed 300 words)
Background
Statement of the problem you propose to address and scientific significance
Plan of procedure
Potential benefits from the success of this project
References (this part is not included in the 7 page limit)
Any figures or tables you use are part of the 7 page limit.

I would like everybody to use this as a fruitful learning experience. Once you have spent some time reading the articles, visiting the web page, looking at some of the linked publications on the web, and have done some initial literature searches, I encourage you to come and discuss with me any aspects of the assignment and possible directions you might want to take.