CHM 1102 H: Biosensors and Chemical Sensors

Course Syllabus: Fall 2021

I CONTACTS

INSTRUCTOR

Name: Michael Thompson
Email: m.thompson@utoronto.ca
Office: Lash Miller 139
Online student hours: available by appointment at m.thompson@uotonto.ca

Instructor Bio: Professor Michael Thompson obtained his undergraduate degree from the University of Wales, UK and his PhD in analytical chemistry from McMaster University. Following a period as Science Research Council PDF at Swansea University he was appointed Lecturer in Instrumental Analysis at Loughborough University. He then moved to the University of Toronto where he is now Professor of Bioanalytical Chemistry. He has held a number of distinguished research posts including the Leverhulme Fellowship at the University of Durham and the Science Foundation Ireland E.T.S Walton Research Fellowship at the Tyndall National Institute, Cork City. He is recognized internationally for his pioneering work over many years in the area of research into new biosensor technologies and the surface chemistry of biochemical and biological entities. He has made major contributions to the label-free detection of biological macromolecule interactions and surface behavior of cells using ultra high frequency acoustic wave physics. He has also pioneered the development of anti-fouling surface modification, in particular antithrombogenic and anti-microbial adhesion materials. Thompson has served on the Editorial Boards of a number of major international journals including Analytical Chemistry, The Analyst, Talanta, Analytica Chimica Acta and Biosensors and Bioelectronics. He is currently Editor-in-Chief of the monograph series "Detection Science" for the Royal Society of Chemistry, UK. He has been awarded many prestigious international prizes for his research including The Robert Boyle Gold Medal of the Royal Society of Chemistry, E.W.R. Steacie Award of the Chemical Society of Canada, the Theophilus Redwood Award of the Royal Society of Chemistry, the E.T.S. Walton Award of the Science Foundation of Ireland and the Fisher Scientific Award in Analytical Chemistry of the Chemical Society of Canada. He was made a Fellow of the Royal Society of Canada in 1999.

II COURSE OVERVIEW

COURSE DESCRIPTION:
The notion of a sensor device is common knowledge to all. The range of these structures in modern times is immense, ranging from simple physical measurements such as temperature to complex devices that incorporate human cells in their design. The number of applications is also numerous including industrial processing, pharmaceutical analysis, automotive operation, military technology and environmental signaling to name just a few areas of use. In this course, we introduce the basics of a special branch of sensor technology that deals with the detection of chemicals and biological species. The course proceeds from a description of sensor architecture, to devices types and finally to a variety of applications. The course is especially interdisciplinary in nature, allowing the student to gain a good understanding of the merging of chemistry with biology and engineering.

STUDENT LEARNING OUTCOMES:
Student will understand how sensor devices are fabricated and used in terms of applications with regard to practical problems. In particular, students will be able to:
1. Appreciate the chemistry of sensor transduction processes.
2. Compare the performance of various biosensors
3. Consider biosensor applications

READINGS:
Many readings are handed out as the course progresses. There is no specific course text book.

III HOW THE COURSE IS ORGANIZED

- Introduction to biosensor architecture

Types of sensors; components and design; ideal requirements

- Probe attachment

Types of probe – antibodies, nucleic acids, enzymes, receptors; criteria for device surface attachment, introduction to the non-specific adsorption problem

- Methods for probe attachment to surfaces

Adsorption; chemisorption v physisorption; polymer trapping; covalent attachment; film deposition techniques; molecular imprinted polymers and biomimicry.

- Surface characterization

Probe information required; general characteristics of surface analysis, X-ray photoelectron spectroscopy; secondary ion mass spectrometry; Auger spectroscopy; probe techniques such atomic force microscopy

- Electrochemical sensors

Types of device – potentiometric, amperometric, voltammetric; ion selective electrodes; physics of field effect transistor technology - ISFETS, IMMUNOFETS; history and design of the glucose electrode; nucleic acid –based electrochemical sensing

- Acoustic wave devices

The phenomenon of piezoelectricity; operation of devices in air; bulk acoustic wave devices as chemical sensors; the Sauerbrey response equation; propagation of acoustic waves in fluids; other devices – surface acoustic wave, shear horizontal wave, surface transverse wave

- Optical and electromagnetic radiation-based devices

Sources of radiation for sensors; laser technology; optical components; fiber optic-based systems for sensing; intrinsic versus extrinsic sensing mechanisms; evanescent wave technology; the phenomenon of surface plasmon resonance; design of the SPR experiment for bio-sensing; other types such interferometry

IV EVALUATION/GRADING SCHEME

MARK BREAKDOWN

Peer Assignment =50% total grade
Final Course Essay = 50% total grade – due on the last day of the semester
Note: if an unexpected technical issue occurs with a university system (e.g., Quercus services, network outage) that affects availability or functionality, it may be necessary to revise the timing or weighting of the assessments.

V COURSE POLICIES

- The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each

other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.

- Privacy language and appropriate use of course materials: https://teaching.utoronto.ca/ed-tech/audio-video/sample-statements/

- Deadlines for assignment submissions and late policy (e.g. 5% will be deducted daily).

- Submission methods – by email attachment to instructor
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- Process for requesting re-grading of course work, if applicable - regraded on request

Extensions or penalties for late work allowed in the case of illness or emergency.

VI TECHNOLOGY REQUIREMENTS

Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here: https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/

Advice for students more broadly regarding online learning is available here: https://onlinelearning.utoronto.ca/getting-ready-for-online/

This course requires the use of computers, and of course sometimes things can go wrong when using them. You are responsible for ensuring that you maintain regular backup copies of your files, use antivirus software (if using your own computer), and schedule enough time when completing an assignment to allow for delays due to technical difficulties. Computer viruses, crashed hard drives, broken printers, lost or corrupted files, incompatible file formats, and similar mishaps are common issues when using technology, and are not acceptable grounds for a deadline extension.