CHM198H1 - Biosensor Technology and Applications for the Non-Scientist

Course Syllabus: Winter 2023

I CONTACTS

INSTRUCTOR
Name: Michael Thompson
Email: m.thompson@utoronto.ca
Office: Lash Miller 139
Online student hours: available by appointment at m.thompson@utoronto.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 species of biological interest. The course proceeds from a description of sensor architecture, to devices types and finally to a variety of application including the detection of cancer and other diseases.

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 involved in biosensor technology
2. Compare the performance of various biosensors
3. Describe a number of biosensor applications including disease detection

PREREQUISITE COURSES:
This course assumes you have a basic understanding of chemistry principles such as taught in Grade 12 Chemistry; minor knowledge of biology is helpful.

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

- Probes

Types of probes – antibodies, nucleic acids, enzymes, receptors etc.

- Methods for probe attachment to surfaces

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

- Surface characterization

What can be learned from surface analysis

- Electrochemical sensors

Types of devices – potentiometric, amperometric, voltammetric; ion selective electrodes; history and design of the glucose electrode; nucleic acid –based electrochemical sensing

- Acoustic wave devices

The phenomenon of piezoelectricity; how this is used in acoustic biosensor technology

- Optical and electromagnetic radiation-based devices

Fiber optic-based systems for sensing; the phenomenon of surface plasmon resonance;

- Biosensor overview and applications

Detection of cancer, epilepsy, modern glucose devices

COURSE SCHEDULE & RELEVANT SESSIONAL DATES:

DATES	UNIT/WEEK	TOPICS
Jan 10th	1	Introduction to biosensor architecture
Jan 17th	2	Surface probe attachment
Jan 24th	3	Surface analysis methods
Jan 31st	4	Introduction to electrochemical sensors
Feb 7th	5	Applications of electrochemical sensors
Feb 14th	6	Introduction to piezoelectricity; acoustic wave sensors
Feb 20-24th		Reading week
Feb 27th	7	Acoustic wave biosensors
March 6th	8	Applications of acoustic wave biosensors – cancer, sepsis
March 13th	9	Introduction to optical sensors

March 20th	10	Surface plasmon resonance and applications
March 27th	11	Overview of biosensor technology and applications
April 4th	12	Course discussion and feedback

IV EVALUATION/GRADING SCHEME

MARK BREAKDOWN

Peer Assignment = 40% total grade – due before March 10th, 2023
Final Course Essay = 50% total grade – due on the last day of the semester (April 6th, 2023, at 11:59 PM).
Course Participation = 10% total grade (based on attendance and questions asked following lectures plus Zoom, email and phone discussion)

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

- Required: Each member of this course is expected to maintain a:

(i) professional and respectful attitude during all course activities, including classes, laboratories, tutorials and online activity.
(ii) personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met.
(iii) collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
(iv) familiarity with the university policy on Academic Integrity (overleaf)

- Required: 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. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, we encourage you to reach out to the staff in our Equity Offices.

- Communication with instructor (e.g., I will respond to email within 24 hrs. on weekdays).

- Privacy language and appropriate use of course materials: For additional information, see the syllabus "Copyright" section.

- Policy for late assignment submissions (e.g., x% will be deducted daily).

- Policy for reweighting due to missed pieces of academic work.

- Submission methods (e.g., use Quercus only).

- Process for requesting re-grading of course work.

- Process for signaling course absences and requesting make-up tests or exams, if applicable.

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 technical issues are possible. When working on a piece of academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc.

VII INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY

Required: (suggested text provided): Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

In laboratory reports:

1. Using someone else's ideas or words without appropriate acknowledgement.
2. Submitting your own work in more than one course without the permission of the instructor.
3. Making up sources or facts.
4. Obtaining or providing unauthorized assistance on any report. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post laboratory report material/questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour on Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.**

On quizzes and term tests:

1. Using or possessing unauthorized aids. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post quiz/term test questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour on Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.**
2. Looking at someone else's answers or collaborating/discussing answers during a quiz or term test.
3. Misrepresenting your identity.

In general academic work:

1. Falsifying institutional documents or grades.
2. Falsifying or altering any documentation required by the University.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see www.academicintegrity.utoronto.ca/).

Plagiarism Detection
Required: note for instructor: *Ouriginal (https://q.utoronto.ca/courses/46670/pages/integration-plagiarism-detection-tool) is a very highly recommended tool directly integrated into Quercus that will assist in detecting textual similarities between compared works. Students must be informed at the start of the course that the instructor will be using Ouriginal. If you plan to use this tool, the course syllabus must include the following statement (as is):*

"Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq)".

COPYRIGHT
Required: note for instructor: *sample statements for policies regarding class recordings are available here:* https://teaching.utoronto.ca/ed-tech/audio-video/sample-statements/

If a student wishes to copy or reproduce class presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited.

ACCESSIBILITY NEEDS
Required: (suggested text provided): Students with diverse learning styles and needs are welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact Accessibility Services as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES
Required: (suggested text provided): Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment, tutorial, class or laboratory session. Students must inform the instructor **before** the session/assignment date to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT
The following are some important links to help you with academic and/or technical service and support:

- General student services and resources at Student Life

- Full library service through University of Toronto Libraries
- Resources on conducting online research through University Libraries Research
- Resources on academic support from the Academic Success Centre
- Learner support at the Writing Centre
- Information for Quercus Support

ACKNOWLEDGEMENT OF TRADITIONAL LANDS

Required: (suggested text provided): We wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.