SYLLABUS

Chemical Elements in Living Systems (CHMD69H3)

Winter 2023

Instructor Information

Instructor	Email	Office	Office hours:
Alen Hadzovic	alen.hadzovic@utoronto.ca	EV568	The office hours will be by appointment – when you need assistance, please e-mail me and we'll set up the time!
Sarah Guay (librarian)	sarah.guay@utoronto.ca	EV368	

General Overview

Chemical Elements in Living Systems course (CHMD69H3) focuses on the world of inorganic chemistry in living systems. We shall concentrate on structure and reactivity of metalloproteins: proteins whose structure and/or function depend on the presence of one or more metallic centers; emphasizing their structure, reactivity and role in the living systems. Applications of analytical methods to the problems in biological inorganic chemistry will also be briefly discussed using specific examples. To follow the course material some background in following topics is very important and will be assumed through the course:

- Inorganic chemistry: periodic table, electronic configurations, chemical reactivity, oxidation states/numbers, molecular geometry
- Basic concepts from biochemistry (proteins, DNA and RNA)
- Basic principles of structural methods in inorganic chemistry
- Cell structure

Most of the background comes from the courses that are prerequisite for CHMD69H3: Introduction to inorganic chemistry (CHMB31H3) and biochemistry courses (CHMB62H3 and/or BIOC12H3/C13H3).

Topics Covered

Some of the topics covered in the course are as follows (not necessarily in order)

1. The chemical elements in the living systems
   - Journey through the periodic table from the point of view of a living system
   - Availability of elements (abundance) and biogeochemical cycles
   - Homeostasis
2. Inorganic chemistry and origin of life
3. Biocoordination chemistry
   - Basic coordination chemistry: coordination numbers and geometries
   - Biological and inorganic ligands (overview)

- Metal-protein interactions
- Instrumental techniques (not covered in other courses)

4. Metal ion transport and storage
   - Control of metal ion concentration
   - Recognition of metal ions
   - Transport and storage of selected ions: Na^{+}, K^{+}, $Fe^{2+/3+}$
5. Dioxygen transport
6. Metal ion receptors and signaling
   - Metalloregulatory proteins
   - Role of Zn^{2+} binding domains
   - Role of Ca^{2+} in cells of higher organisms
7. Non-redox metalloenzymes
   - Overview
   - Metal dependent lyase and hydrolase
   - Aconitase
   - Carboxypeptidase
   - Carbonic anhydrase
8. Redox metalloproteins.
   - Overview: electron carriers vs. oxo-reductases
   - Electron sources and electron chains in living systems
   - Iron-sulfur proteins
   - Cytochromes
   - Copper proteins
   - Respiration and photosynthesis
9. Further on oxygen metabolism.
   - Superoxide dismutase
   - Peroxidases
10. Hydrogen metabolism - hydrogenases
11. Nitrogen metabolism – nitrogenases

Course Evaluation

Assignments	20%
Quercus quizzes	5%
Sort paper	15%
Lecture based on paper	20%
Final exam	40%

There will be **four short assignments** through semester focusing on the lecture material. Typically, you would be assigned a paper used during lectures and would be required to answer several questions related to the

paper and course material as well as provide a short summary of the relevant points from the paper. The dates will be communicated during the semester. You will typically have a week to compete your assignment. The assignments will be due in-class.

Quercus quizzes are designed four you to quickly check your knowledge. We'll have a quiz every two weeks focusing on basic concepts from the lectures and material from previous courses required to understand CHMD69. For example, questions such as "What is primary protein structure?", "Are group 1 cations strong or weak Leiws acids?" represent material from prerequisite courses that can be on the quiz. Typically, you will have 2-3 days to complete the quiz.

You are required to write a short paper (1000 to 1500 words in length) on an assigned metalloenzyme or process related to the course material. The list of enzymes/processes and basic literature references will be provided separately on Quercus. You can also suggest a topic that is not on the list, but you have to discuss. More details on the paper requirements as well as the due date will be provided on Quercus prior to the beginning of the classes.

Your presentation will be on the topic of your short paper. However, the presentation will be a team effort. We will combine two or more papers under one umbrella with a common presentation. Each individual team member is responsible for presenting their part but the team will prepare an overview of the topic for the class. Each of you will receive a separate grade for the presentation. The presentations will take place during the last week of classes (or depending on the class size, two last weeks).

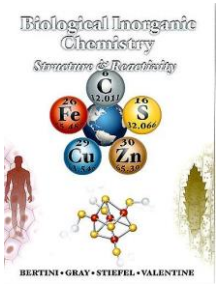
The exact date for the final exam will be announced during the semester. The exam is cumulative and will be based on all course material. It is a 24 hours asynchronous online exam and submissions will be in electronic format through Quercus. The exam will have short answer questions but you will also be asked to make a summary of a paper relevant to the course material.

Office hours and contact info

My office is in EV (Environmental Science and Chemistry) building, 5th floor, room EV568. If you need any assistance during the semester, please e-mail me and we'll set up the time for an online meeting (via Zoom or MS Teams – your preference). Based on my experiences from last semester, some flexibility in office hours/meeting times is needed (rather than fixed times of the week).

I can be reached via e-mail: alen.hadzovic@utoronto.ca.

Course readings



The course textbook is:
Bertini, I., Gray, H. B., Stiefel, E. I., and Valentine, J. S. (Eds.). *Biological inorganic chemistry: Structure and reactivity*. Mill Valley, CA: University Science Books, 2007.

This textbook is available as an ebook through the UofT library system, so you do not need to buy it.

Another important on-line source is *The Guided Tour of Metalloproteins*.

Also useful is your inorganic chemistry textbook:

Weller, Overton, Rourke, and Armstrong. **Shriver and Atkins' Inorganic chemistry**. 7th edition. Oxford University Press, 2018 (older editions are also acceptable)

Some other useful books are (can be found in the library):

Housecroft, C.E. and Alan G. Sharpe. Inorganic Chemistry. 4th ed. Harlow: Pearson – Prentice Hall, 2008.

Kaim, W., and Schwederski, B. Bioinorganic chemistry: Inorganic elements in the chemistry of life – An introduction and guide. Chichester: John Wiley & Sons, 1994.

Ochai, E. Bioinorganic chemistry: A survey. Amsterdam: Elsevier – Academic Press, 2008.

Frausto da Silva, J.J.R., and Williams, R. J. P. The biological chemistry of the elements: The inorganic chemistry of life. 2nd ed. Oxford: Oxford University Press, 2001.

Cowan, J. A. Inorganic biochemistry: An introduction. 2nd ed. New York: VCH, 1993.

Kraatz, B., and Metzler Nolte, N. Concepts and models of bioinorganic chemistry. New York: Wiley, 2006.

Crichton, R. Biological inorganic chemistry: An introduction. Amsterdam: Elsevier: 2008.

Important references from current literature will be provided throughout the course on the lecture slides.

Academic Integrity

Academic integrity is one of the cornerstones of the University of Toronto. It is critically important both to maintain our community which honors the values of honesty, trust, respect, fairness and responsibility. It also protects you, the student within our community as well as the value of the degree towards which you are all working so diligently. Detailed information about how to act with academic integrity, the Code of Behavior on Academic Matters, and the processes by which allegations of academic misconduct are resolved can be found online Student Academic Integrity | Faculty of Arts & Science (utoronto.ca) and FAQ | Vice Principal Academic & Dean (utoronto.ca)

Section B of the University of Toronto's Code of Behaviour on Academic Matters (http://www.governingcouncil.utoronto.ca/policies/behaveac.htm) lists actions that are considered academic offences. Some of the most common offences are:

- To use someone else's ideas or words in their own work without acknowledging that those ideas/words are not their own with a citation and quotation marks, i.e. to commit **plagiarism**.
- To include **false**, **misleading** or **concocted** citations in their work.
- To obtain **unauthorized** assistance on any assignment.
- To provide **unauthorized** assistance to another student. *This includes showing another student completed work*.

- To submit their own work for credit in **more than one course** without the permission of the instructor.
- To **falsify** or **alter** any documentation required by the University. This includes, but is not limited to, doctor's notes.
- To use or possess an unauthorized aid in any test or exam.

There are other offences covered under the Code, but these are by far the most common. Please respect these rules and the values which they protect. Offences against academic integrity will be dealt with according to the procedures outlined in the Code of Behavior on Academic Matters.

Accessibility

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office (ability@utsc.utoronto.ca) as soon as possible. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. More details are available at: http://www.utsc.utoronto.ca/ability/.