SYLLABUS

Chemical Elements in Living Systems

(CHMD69H3) Winter 2024

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) looks at inorganic chemistry of life. 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. Some background in following topics is very important to follow the course material; prior knowledge of prerequisite material will be assumed. Most important examples are:

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

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

Course Evaluation

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

There will be **four short assignments.** For each assignment you will be given a paper to read and then answer questions connecting the paper with course material. The due dates will be communicated during the

semester. You will typically have a week to complete your assignment and submit your work online (Quercus upload).

Quercus quizzes are designed to help you relate knowledge from previous (prerequisite) courses and CHMD69H3. We'll have a total of five quizzes. 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 suggested enzymes/processes will be provided 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. The presentations will take place close to the end of the semester, the exact date(s) depend on the class size, and will be communicated to you sometime after the reading week.

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. The format is short answer questions, and the duration is two hours (2 h).

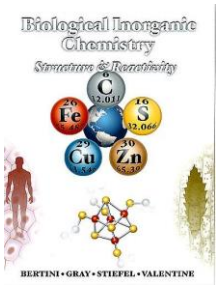
All late assignments (short assignments, quizzes, and paper) will be subject to 1% penalty per day. If an assignment is more than a week late, it will not be accepted, unless proper arrangements have been made with the instructor prior to assignment due date.

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/.