

CHEM 5339.001

Bioinorganic Chemistry

Dr. Jason Smee

Contact Info

- jsmee@uttyler.edu
- 903.566.7069
- RBS 3030

Office Hours

- MF 10:30–noon
- TR 1:30–2:30 pm
- or by appointment

Inside the Syllabus

Other Useful Resources	2
Student Learning Outcomes	2
Canvas	2
Course Requirements	3
In-Class Presentation	3
Final Project	3
Homework	4
Exams	4
Grading	4
Important Dates	4
Topics Covered	5
University Policies	5-7

Course Description

Study of the role metal ions play in the structure and function of nucleic acids, proteins, and metalloenzymes. Topics include bio-coordination chemistry, modeling studies, and experimental techniques, as well as aspects of medicinal inorganic chemistry.

Bioinorganic (adjective): of, relating to, or concerned with the application of inorganic chemistry and its techniques (as nuclear magnetic resonance) to the study of biological processes and substances (as metalloproteins) in which inorganic substances are important constituents or play important roles

- [Merriam-Webster dictionary](#)

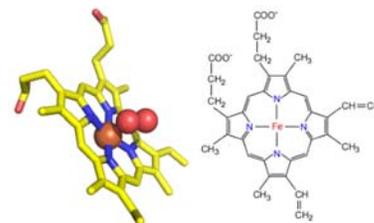
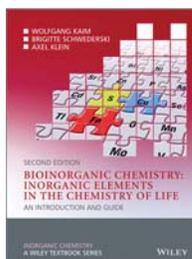


Image taken from <http://guweb2.gonzaga.edu/faculty/cronk/CHEM245pub/myoglobin.html>

Required & Recommended Materials



The **required** text is *Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide, 2/e* by Kaim, et al. (ISBN 978-1-118-13807-6/978-0-470-97523-7)

(Image from <https://www.wiley.com>.)



A scientific calculator (capable of exponents and logarithms) is **required**.

(Image from <https://www.schoolspecialty.com/casio-scientific-calculator-035399>.)

- A portable device with a webcam is **required** for participating in Zoom lectures. If circumstances dictate that we go online before Thanksgiving, we will have online lectures and we will do oral presentations using Zoom. Please install the Zoom software on your device (<https://zoom.us/download>).

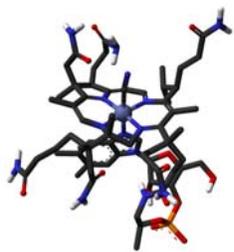
Important Covid-19 Information for Classrooms and Laboratories

Students are required to wear face masks covering their nose and mouth, and follow social distancing guidelines, at all times in public settings (including classrooms and laboratories), as specified by [Procedures for Fall 2020 Return to Normal Operations](#). The UT Tyler community of Patriots views adoption of these practices consistent with its [Honor Code](#) and a sign of good citizenship and respectful care of fellow classmates, faculty, and staff.

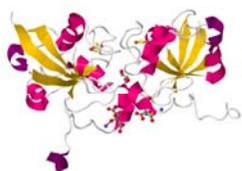
Students who are feeling ill or experiencing symptoms such as sneezing, coughing, or a higher than normal temperature will be excused from class and should stay at home and may join the class remotely. Students who have difficulty adhering to the Covid-19 safety policies for health reasons are also encouraged to join the class remotely. Students needing additional accommodations may contact the Office of Student Accessibility and Resources at University Center 3150, or call (903) 566-7079 or email saroffice@uttyler.edu.

Recording of Class Sessions

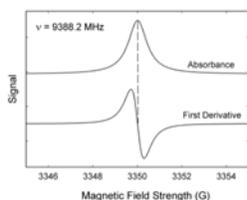
Class sessions may be recorded by the instructor for use by students enrolled in this course. Recordings that contain personally identifiable information or other information subject to FERPA shall not be shared with individuals not enrolled in this course unless appropriate consent is obtained from all relevant students. Class recordings are reserved only for the use of students enrolled in the course and only for educational purposes. Course recordings should not be shared outside of the course in any form without express permission.



Cobalamin, also known as vitamin B12 (shown here as the cyano complex), was the first known bioinorganic compound. It plays a significant role in many biological processes. (Image from Wikipedia.)



Crystal structure of human ferredoxin-I. Ferredoxins are one type of iron and sulfur-containing proteins that involved in a wide variety of electron transfer processes. (Image from Wikipedia)



Electron paramagnetic/spin resonance (EPR or ESR) is a form of spectroscopy similar to NMR, but instead of nuclei, it looks at unpaired electrons. Interestingly, EPR/ESR spectra are usually plotted as the first derivative. (Image from Wikipedia.)

Other Useful References

- Bioinorganic textbooks: *Inorganic Chemistry* 6/e by Shriver et al. 9781429299060; *Bioinorganic Chemistry: A Short Course*, 3/e by Roat-Malone 9781119535218; *Principles of Bioinorganic Chemistry* by Lippard and Berg 9780935702736; *Biological Inorganic Chemistry* by Bertini et al. 9781938787966
- Medicinal inorganic textbooks: *Metals in Medicine* by Dabrowiak (9780470681961); *Medicinal Inorganic Chemistry* by Sessler (978-0195686982)
- Chem LibreTexts website: of particular interest are the Bioinorganic book and the “Spectroscopy” supplementary module to (Physical and Theoretical Chemistry
- the UTT library website (library.utttyler.edu) for the following class-related activities. Need off-campus access? Go to [Connecting from Off-Campus: Welcome page](#)
 - Classic and current bioinorganic/medicinal inorganic articles for discussion and homework
 - A 15-minute oral presentation on a current article related to this course
 - A final project writing quiz/exam questions for undergraduate inorganic students using excerpts from journal articles related to this course

Student Learning Outcomes

By the end of this course, students should be able to

- 1) Interpret the results of different types of characterization techniques used in bioinorganic studies
- 2) Recognize the different roles played by metalloproteins and metalloenzymes
- 3) Extract key concepts from classic and current journal articles
- 4) Effectively present, in seminar format, a summary of the results of a journal article relating to bioinorganic or medicinal inorganic chemistry
- 5) Create quiz/exam questions for undergraduate inorganic students using excerpts of journal articles

Canvas

I will utilize Canvas to post the following items

- 1) syllabus
- 2) lecture notes
- 3) Links to Zoom recordings of lectures
- 4) grades (my Excel grade book has the official grades)

You may be asked to submit portions of homework assignments through Canvas as well. Such assignments will utilize Turnitin to minimize plagiarism.



Course Requirements

- 1) One semester of undergraduate inorganic chemistry similar to CHEM 3320 and/or CHEM 4330 and one semester of undergraduate biochemistry are strongly suggested.
- 2) We meet Wednesdays from Aug 26 to Dec 2, except during Thanksgiving week (Nov 23—27). **All classes will be online (Zoom) after Thanksgiving break (including final exams).** Attendance will be taken and class participation will be sought to nurture student communication and presentation skills.
- 3) You will be required to give a 15-minute presentation over a journal article obtained from such journals as *Inorganic Chemistry*, *Journal of Biological Inorganic Chemistry*, and *Journal of Inorganic Biochemistry*.
- 4) You will also be required to write exam questions suitable for undergraduate inorganic students using excerpts from journal articles related to bioinorganic or medicinal inorganic chemistry
- 5) The cumulative final exam (online) will be on Wednesday, December 9th from 7-9 pm and must be taken to pass the course.

In-Class Presentation

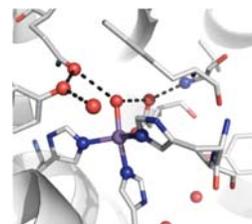
Towards the end of the semester you will be asked to give a 10-15 minute presentation summarizing the results of a recent (last 5 years) article or communication (i.e. a mini-article) relating to bioinorganic or medicinal inorganic chemistry. If you are unsure of whether a paper is suitable, please ask me. Good journals to look through are *Journal of Biological Inorganic Chemistry* (SBIC), *Journal of Inorganic Biochemistry* (Elsevier), and *Inorganic Chemistry* (ACS); although there are others .

The grade will be based primarily on organization, style, clarity, and the ability to answer questions related to this course. A rubric will be provided to help with the planning of your presentation.

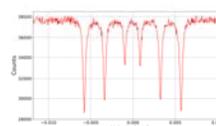
Final Project

The final project is worth 10% of the course grade. Select 5 bioinorganic or medicinal inorganic chemistry articles. Then write 3 questions for undergraduate inorganic students using an excerpted materials from each article (e.g. figure and table/graph). Topics include, but are not limited to, oxidation states, naming, orders of reactions, HSAB theory, point groups, spectroscopy, trans effect, and topics relevant to this course. More details, including my grading rubric, will be provided.

- Two multiple choice questions per article maximum.
- You must identify what inorganic topic each question covers.
- You must provide a rubric for grading any short answer/calculation problems.
- You must provide a properly formatted (ACS style) citation for each paper; providing an electronic copy is optional.



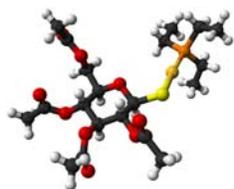
Active site of human manganese superoxide dismutase (SOD). SOD converts superoxide O_2^- into O_2 and H_2O_2 and is one of several enzymes that deal with oxidative stress. (Image from Wikipedia.)



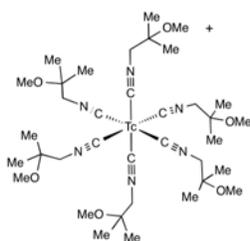
Mössbauer spectroscopy is a technique that relies upon the nearly recoil-less absorption of gamma rays and is very sensitive to the chemical environment of the sample. By far, the most commonly studied element is iron. (Image from Wikipedia.)



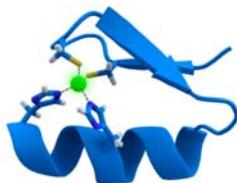
Crystal structure of octopus hemocyanin. Hemocyanin is a O_2 transport protein used by some invertebrates. The active site consists of two copper(I) ions that, upon binding O_2 , are oxidized to copper(II) resulting the blue (cyan) color. (Image from Wikipedia.)



Auranofin (Ridaura™) is a gold-phosphine thiolate complex that was a first-generation therapeutic used in the treatment of rheumatoid arthritis. (Image from Wikipedia.)



Technetium (^{99m}Tc) sestamibi (sesta = 6; MIBI = methoxyisobutylisonitrile). Known under the trade name Cardiolite™ this contrasting agent is primarily used to image heart muscle. (Image from Wikipedia.)



Cartoon image of a generic zinc finger protein in which the green zinc is coordinated to 2 Cys ligands and 2 His ligands. Such proteins enforce specific protein folding, although the coordination spheres do vary. (Image from Wikipedia.)

Homework

Homework (25% of the course grade) is comprised of 1) problem sets; and 2) questions regarding assigned reading of classic and current papers. Each assignment will be due at the beginning of the next class.

Exams

- Two mid-term exams will be given during class time and are collectively worth 30% of your overall grade. They will be a mixture of short answer/calculation questions and multiple choice. I will inform you where the material will be cut-off at least one week before the exam. The final exam is 25% of the grade.
- Missed exams due to an unexcused absence will result in a grade of zero. In the event of an excusable situation, please give me at least two days' notice (if possible) to schedule an alternate time.
- Cell phones, smart watches, and any similar electronic devices must be turned off and put away during exams. If they observed out in a visually accessible place (i.e. between legs, on the floor, etc.), it will be assumed that they are being used to cheat; your exam will taken away, you will receive a zero score (0 points) for the test, and you will be referred to the Office of Judicial Affairs.

Grading

- All grades will be shown on Canvas
- Grades will be tentatively based on a 90/80/70 scale, but may be adjusted based on my evaluation of the class's overall performance.
- The official gradebook is my Excel spreadsheet on my office desktop.

2 In-class exams	30%
Cumulative final exam	25%
Homework	25%
Presentation	10%
Final Project	10%
Total	100%

Important Dates

(Note: exam and presentation dates are tentative; the final exam date is fixed, but the time is flexible since it will be online.)

- September 4 (Friday): Census Date; last day to file for grade replacement
- October 7: Exam 1**
- November 2 (Monday): Last Day to Drop with a "W"
- November 11: Exam 2**
- November 18: Presentations (if we go online before this week, we may reschedule the presentations)**
- November 23—27: Thanksgiving, no classes
- December 9 (Monday): Final Exam, 7-9 pm**

Topics to Be Covered* (Chapter Numbers are from Kaim)

- **Chapter 1:** Historical Background, Current Relevance, and Perspectives
- **Chapter 2:** Some General Principles (reviewing coordination chemistry: nomenclature, geometric and stereo isomers, Lewis acid-base theory, hard-soft acid-base theory, and crystal/ligand field theory, etc.)
- **Characterization Methods** (IR/Raman, NMR, EPR, Mössbauer, X-Ray techniques, circular dichroism, and electrochemistry)
- **Chapter 8:** Uptake, Transport and Storage of Iron (siderophores, transport, and storage)
- **Chapter 5:** The Dioxygen Molecule, O₂ (properties of O₂, hemoglobin and myoglobin, hemerythrin and hemocyanin)
- **Chapter 6:** Catalysis through Hemoproteins (cytochrome P450, peroxidases, oxygenases)
- **Chapter 7:** Iron-Sulfur and Other Non-heme Iron Proteins (rubredoxin, ferredoxin, , ribonucleotide reductase, monooxygenase, phosphatases)
- **Chapter 10:** Copper-containing proteins ("blue" copper proteins, cytochrome *c* oxidase)
- **Chapter 11:** Biological Functions of the "Early" Transition Metals (elements: V, Mo, W, and Cr; oxotransferases, nitrogenases, haloperoxidases)
- **Chapter 3:** Cobalamins, Including Vitamin and Coenzyme B12 (bioorganometallics, general reactions, enzymatic functions, and model systems)
- **Chapter 9:** Nickel-containing enzymes (urease, hydrogenase, acetyl CoA Synthase, SOD)
- **Chapter 12:** Zinc (carbonic anhydrase, hydrolases, ADH, "zinc finger" proteins)
- **Chapter 18:** Biochemical Behavior of Radionuclides and Medical Imaging
- **Chapter 19:** Chemotherapy Involving Nonessential Elements (cisplatin, gold arthritis drugs, lithium-based drugs, ulcer treatments, etc.)

* Due to time constraints, not all Chapters (or all sections of each Chapter) will be covered.



ASQUID (superconducting quantum interference device) is a very sensitive magnetometer used to measure very small amounts of magnetic material such as in metalloproteins. This image is taken from https://superconductivity.biu.ac.il/files/superconductivity/imgs/gallery/lab_060311_02.jpg. (Accessed 08/16/20).

University Policies

UT Tyler Honor Code

Every member of the UT Tyler community joins together to embrace: Honor and integrity that will not allow me to lie, cheat, or steal, nor to accept the actions of those who do.

Students Rights and Responsibilities

To know and understand the policies that affect your rights and responsibilities as a student at UT Tyler, please follow this link: <http://www.uttyler.edu/wellness/rightsresponsibilities.php>

Campus Carry

We respect the right and privacy of students 21 and over who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at <http://www.uttyler.edu/about/campus-carry/index.php>

UT Tyler a Tobacco-Free University

All forms of tobacco will not be permitted on the UT Tyler main campus, branch campuses, and any property owned by UT Tyler. This applies to all members of the University community, including students, faculty, staff, University affiliates, contractors, and visitors. Forms of tobacco not permitted include cigarettes, cigars, pipes, water pipes (hookah), bidis, kreteks, electronic cigarettes, smokeless tobacco, snuff, chewing tobacco, and all other tobacco products. There are several cessation programs available to students looking to quit smoking, including counseling, quitlines, and group support. For more information on cessation programs please visit www.uttyler.edu/tobacco-free.

University Policies (cont.)

Grade Replacement/Forgiveness and Census Date Policies

Students repeating a course for grade forgiveness (grade replacement) must file a Grade Replacement Contract with the Enrollment Services Center (ADM 230) on or before the Census Date of the semester in which the course will be repeated. Grade Replacement Contracts are available in the Enrollment Services Center or at <http://www.uttyler.edu/registrar>. Each semester's Census Date can be found on the Contract itself, on the Academic Calendar, or in the information pamphlets published each semester by the Office of the Registrar. Failure to file a Grade Replacement Contract will result in both the original and repeated grade being used to calculate your overall grade point average. Undergraduates are eligible to exercise grade replacement for only three course repeats during their career at UT Tyler; graduates are eligible for two grade replacements. Full policy details are printed on each Grade Replacement Contract.

The Census Date is the deadline for many forms and enrollment actions of which students need to be aware. These include:

- Submitting Grade Replacement Contracts, Transient Forms, requests to withhold directory information, approvals for taking courses as Audit, Pass/Fail or Credit/No Credit.
- Receiving 100% refunds for partial withdrawals. (There is no refund for these after the Census Date)
- Schedule adjustments (section changes, adding a new class, dropping without a "W" grade)
- Being reinstated or re-enrolled in classes after being dropped for non-payment
- Completing the process for tuition exemptions or waivers through Financial Aid

State-Mandated Course Drop Policy

Texas law prohibits a student who began college for the first time in Fall 2007 or thereafter from dropping more than six courses during their entire undergraduate career. This includes courses dropped at another 2-year or 4-year Texas public college or university. For purposes of this rule, a dropped course is any course that is dropped after the census date (See Academic Calendar for the specific date). Exceptions to the 6-drop rule may be found in the catalog. Petitions for exemptions must be submitted to the Enrollment Services Center and must be accompanied by documentation of the extenuating circumstance. Please contact the Enrollment Services Center if you have any questions.

Disability/Accessibility Services

In accordance with Section 504 of the Rehabilitation Act, Americans with Disabilities Act (ADA) and the ADA Amendments Act (ADAAA) the University of Texas at Tyler offers accommodations to students with learning, physical and/or psychological disabilities. If you have a disability, including a non-visible diagnosis such as a learning disorder, chronic illness, TBI, PTSD, ADHD, or you have a history of modifications or accommodations in a previous educational environment, you are encouraged to visit <https://hood.accessiblelearning.com/UTTyler> and fill out the New Student application. The Student Accessibility and Resources (SAR) office will contact you when your application has been submitted and an appointment with Cynthia Lowery, Assistant Director of Student Services/ADA Coordinator. For more information, including filling out an application for services, please visit the SAR webpage at <http://www.uttyler.edu/disabilityservices>, the SAR office located in the University Center, # 3150 or call 903.566.7079.

Student Absence due to Religious Observance

Students who anticipate being absent from class due to a religious observance are requested to inform the instructor of such absences by the second class meeting of the semester.

Student Absence for University-Sponsored Events and Activities

If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify the instructor at least two weeks prior to the date of the planned absence. At that time the instructor will set a date and time when make-up assignments will be completed.

Social Security and FERPA Statement

It is the policy of The University of Texas at Tyler to protect the confidential nature of social security numbers. The University has changed its computer programming so that all students have an identification number. The electronic transmission of grades (e.g., via e-mail) risks violation of the Family Educational Rights and Privacy Act; grades will not be transmitted electronically.

University Policies (cont.)

Emergency Exits and Evacuation

Everyone is required to exit the building when a fire alarm goes off. Follow your instructor's directions regarding the appropriate exit. If you require assistance during an evacuation, inform your instructor in the first week of class. Do not re-enter the building unless given permission by University Police, Fire department, or Fire Prevention Services.

Student Standards of Academic Conduct

Disciplinary proceedings may be initiated against any student who engages in scholastic dishonesty, including, but not limited to, cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.

i. "Cheating" includes, but is not limited to:

- copying from another student's test paper;
- using, during a test, materials not authorized by the person giving the test;
- failure to comply with instructions given by the person administering the test;
- possession during a test of materials which are not authorized by the person giving the test, such as class notes or specifically designed "crib notes". The presence of textbooks constitutes a violation if they have been specifically prohibited by the person administering the test;
- using, buying, stealing, transporting, or soliciting in whole or part the contents of an unadministered test, test key, homework solution, or computer program;
- collaborating with or seeking aid from another student during a test or other assignment without authority;
- discussing the contents of an examination with another student who will take the examination;
- divulging the contents of an examination, for the purpose of preserving questions for use by another, when the instructor has designated that the examination is not to be removed from the examination room or not to be returned or to be kept by the student;
- substituting for another person, or permitting another person to substitute for oneself to take a course, a test, or any course-related assignment;
- paying or offering money or other valuable thing to, or coercing another person to obtain an unadministered test, test key, homework solution, or computer program or information about an unadministered test, test key, home solution or computer program;
- falsifying research data, laboratory reports, and/or other academic work offered for credit;
- taking, keeping, misplacing, or damaging the property of The University of Texas at Tyler, or of another, if the student knows or reasonably should know that an unfair academic advantage would be gained by such conduct; and
- misrepresenting facts, including providing false grades or resumes, for the purpose of obtaining an academic or financial benefit or injuring another student academically or financially.

ii. "Plagiarism" includes, but is not limited to, the appropriation, buying, receiving as a gift, or obtaining by any means another's work and the submission of it as one's own academic work offered for credit.

iii. "Collusion" includes, but is not limited to, the unauthorized collaboration with another person in preparing academic assignments offered for credit or collaboration with another person to commit a violation of any section of the rules on scholastic dishonesty.

iv. All written work that is submitted will be subject to review by plagiarism software.

UT Tyler Resources for Students

- UT Tyler Writing Center (903.565.5995), writingcenter@uttyler.edu
- UT Tyler Tutoring Center (903.565.5964), tutoring@uttyler.edu
- The Mathematics Learning Center, RBN 4021, this is the open access computer lab for math students, with tutors on duty to assist students who are enrolled in early-career courses.
- UT Tyler Counseling Center (903.566.7254)

There's a lot of Fe in bioinorganic; I find that very iron-ic.