Chemistry 628: Coordination and Bioinorganic Chemistry
Instructor: Dr. Barondeau, MWF 8:00 am – 8:50 am in CHEM 2121
Office Hours: Zoom office hours TR 9:00 – 10:30 am or by email appointment
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TAMU ecampus website: Go to http://ecampus.tamu.edu/, enter your netID and password to access your scores, class announcements, lecture notes, etc.

Overall description of course: an introduction to bioinorganic chemistry with an emphasis on the roles of metal ions in biological systems, physical methods for studying metalloproteins, how the protein environment tunes reactivity, and evidence presented to support catalytic mechanisms for different classes of metalloenzymes.

Required background: an undergraduate degree in chemistry or some ability to describe a reaction mechanism by "arrow pushing".

Textbook: None required. Recommend reference text: Ivano Bertini, Harry B. Gray, Edward I. Stiefel, Joan Selverstone Valentine, "Biological Inorganic Chemistry", University Science Books, 2007, ISBN 1-891389-43-2

Grading:

Exams:	100 points each (X3)
Final Exam:	200 points
Problem sets:	100 points
Total:	600 points

Problem sets will be announced.

Academic dishonesty:
Students are expected to be the sole source for any work submitted in their name. The utilization or submission of the work of others as your own is a violation of Texas A&M University scholastic dishonesty policies and is called plagiarism. If you are found guilty, you may receive a 0 on the assignment, an F in the course or worse, as determined by the Office of the Aggie Honor System. As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which belong to another. You are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research and knowledge cannot be safely communicated. The teaching assistants in lab specifically look for copied work and will give zeros to work that has been copied. If you have questions regarding plagiarism, please consult the Texas A&M University Student Rules under "Academic Misconduct." on the Aggie Honor System's website (www.tamu.edu/aggiehonor/).

Texas A&M Disability Services (845-1637 and http://disability.tamu.edu/):
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring accommodation, either temporary (e.g. broken arm) or permanent (including a learning disability), please contact me directly.

Campus Safety Measures

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, Texas A&M University has adopted policies and practices for the Fall 2020 academic term to limit virus transmission. Students must observe the following practices while participating in face-to-face courses and course-related activities (office hours, help sessions, transitioning to and between classes, study spaces, academic services, etc.):

- Self-monitoring—Students should follow CDC recommendations for self-monitoring. **Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.**
- Face Coverings—Face coverings (cloth face covering, surgical mask, etc.) must be properly worn in all non-private spaces including classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource and support offices, and outdoor spaces where 6 feet of physical distancing is difficult to reliably maintain. Description of face coverings and additional guidance are provided in the Face Covering policy and Frequently Asked Questions (FAQ) available on the Provost website.
- Physical Distancing—Physical distancing must be maintained between students, instructors, and others in course and course-related activities.
- Classroom Ingress/Egress—Students must follow marked pathways for entering and exiting classrooms and other teaching spaces. Leave classrooms promptly after course activities have concluded. Do not congregate in hallways and maintain 6-foot physical distancing when waiting to enter classrooms and other instructional spaces.
- To attend a face-to-face class, students must wear a face covering (or a face shield if they have an exemption letter). If a student refuses to wear a face covering, the instructor should ask the student to leave and join the class remotely. If the student does not leave the class, the faculty member should report that student to the Student Conduct office for sanctions. Additionally, the faculty member may choose to teach that day's class remotely for all students.

Personal Illness and Quarantine

Students required to quarantine must participate in courses and course-related activities remotely and **must not attend face-to-face course activities**. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities.

Students experiencing personal injury or Illness that is too severe for the student to attend class qualify for an excused absence (See Student Rule 7, Section 7.2.2.) To receive an excused absence, students must comply with the documentation and notification guidelines outlined in Student Rule 7. While Student Rule 7, Section 7.3.2.1, indicates a medical confirmation note from the student's medical provider is preferred, **for Fall 2020 only, students may use the Explanatory Statement for Absence from Class form in lieu of a medical confirmation. Students must submit the Explanatory Statement for Absence from Class within two business days after the last date of absence.**

For each metalloenzyme, the overall structure and active site will be shown (if known) along with the reaction catalyzed, its physiological significance, the mechanism (with supporting spectroscopic or biochemical evidence), and current challenges or areas of controversy.

Tentative schedule

Section 1: Here we will review basic coordination chemistry including crystal field theory and the effect of ligands on d-orbital splitting patterns (high spin and low spin complexes). We will also discuss factors that make transition metals excellent catalysts, survey the types of reactions catalyzed by metalloenzymes and the rules for constructing a catalytic mechanism.

Aug 19	W	Introduction and principles of inorganic and biological chemistry
Aug 21	F	Introduction and principles of inorganic and biological chemistry

Section 2: Here we will discuss the fundamental problem of metal ion bioavailability, the Irving-Williams series, and strategies cells use to obtain iron from their environment (such as siderophores and transferrin). We will also explore how metal ions are regulated, trafficked/chaperoned, stored, and detoxified. Finally, we will connect defects in metal homeostasis to human disease.

Aug 24	M	Metal ion bioavailability, transport, and regulation
Aug 26	W	Metal ion regulation and detoxification
Aug 28	F	Metal ion storage and biomineralization

Section 3: Here we will discuss fundamental theory, strengths and weaknesses, and practical aspects of physical methods used to investigate metalloprotein mechanisms. We will focus on electronic absorbance (d-d, LMCT, Soret bands, etc.), EPR, Mössbauer, and X-ray absorbance spectroscopy and briefly discuss approaches used to interrogate intermediates (such as stopped-flow and freeze quench methods).

Aug 31	M	Electronic absorbance and vibrational spectroscopy
Sept 2	W	Rapid kinetics, Protein crystallography and XAS spectroscopy
Sept 4	F	XAS spectroscopy
Sept 7	M	EPR spectroscopy
Sept 9	W	EPR and Mossbauer spectroscopy
Sept 11	F	Mossbauer spectroscopy
Sept 14	M	Mossbauer spectroscopy
TBA	**TBA**	**Exam 1: lectures through Sep 14th (outside of class)**

Section 4: Heme is an extremely versatile cofactor. Here we will focus on specific examples where changes in axial ligation or second shell residues tune the reactivity of heme-containing proteins from reversible small molecule binding and sensing to the generation of reactive intermediates capable of C-H bond activation or even degradation of the heme cofactor itself.

Sept 16	W	Tuning of redox potential and introduction to hemes
Sept 18	F	Heme ligand discrimination (CO/NO/O_2 sensors/transporters)
Sept 21	M	Heme-based reactivity (P450 and cytochrome oxidase)
Sept 23	W	Heme-based reactivity (heme oxygenase and NOS)

Section 5: Fe-S clusters are ubiquitous cofactors that exist in different forms (rubredoxin, [2Fe-2S], [3Fe-4S], [4Fe-4S], etc.) and are essential for many critical cellular processes. Here, we will focus on the redox and spin coupling properties of Fe-S clusters, details of how these clusters are synthesized in the cell, and how they are used as electron transfer agents, small molecule sensors and catalysts.

Sept 25	F	Fe-S clusters properties and biosynthesis
Sept 28	M	Fe-S cluster biosynthesis and sensing
Sept 30	W	Catalysis by Fe-S enzymes (aconitase, biotin/lipoyl synthase)
Oct 2	F	Catalysis by Fe-S proteins (radical SAM enzymes, DNA repair)

Section 6: Here we will discuss reactions catalyzed by enzymes containing other tetrapyrrole cofactors including the 6-electron reduction by sulfite reductase (siroheme), photooxidation chemistry by chlorophyll, and the reactivity of cobalamins.

Oct 5	M	Sulfite reductase and chlorophyll
Oct 7	W	B_{12}-based reactivity (RnR, Met synthase, reductive halogenation)
Oct 9	F	B_{12}-based reactivity (Genk and reductive halogenation)
TBA	**TBA**	**Exam 2: lectures through Oct 9th (outside of class)**

Section 7: Here we will compare the reactivity and provide step-by-step mechanisms for different classes of mononuclear non-heme Fe enzymes including intradiol/extradiol dioxygenases, pterin-dependent systems that hydroxylate amino acids, Rieske dioxygenases, and α-keto dependent enzymes.

Oct 12	M	Mononuclear Fe (Rieske dioxygenase, pterin hydroxylase)
Oct 14	W	Mononuclear Fe (O_2-activating and α-keto dependent)
Oct 16	F	Mononuclear Fe (α-keto dependent)

Section 8: Here we will discuss the di-iron systems with special attention to intermediates in methane monooxygenase. We will also compare the different reactivities of the Fe-O-Fe cofactor in ribonucleotide reductase, hemerythrin, and rubrerythrin. Finally, we will discuss and compare how Cu, Fe, Mn, and Ni enzymes remove superoxide.

Oct 19	M	Fe-O-Fe proteins (RnR)
Oct 21	W	Fe-O-Fe proteins (methane monoxygenase)
Oct 23	F	Removing ROS (hemerythrin, rubrerythrin, SOR)
Oct 26	M	Removing ROS (SOR and CuZnSOD/CCS)
Oct 28	W	Removing ROS (FeSOD, MnSOD, NiSOD)

Section 9: Here we will discuss the synthesis of the cofactors and current thoughts regarding the catalytic mechanism of nitrogenase. We will also discuss the mechanisms for Mo-pterin containing enzymes.

Oct 30	F	Mo/W enzymes (CO dehydrogenase)
Nov 2	M	Mo/W enzymes (DMSO reductase and Nitrogenase)
Nov 4	W	Mo/W enzymes (Nitrogenase)
TBA	**TBA**	**Exam 3: lectures through Nov 4th (outside of class)**

Section 10: Here we explore the reactivity of Cu-containing proteins and highlight the idea of an entatic state for blue copper centers. We will also examine how Cu centers interact and activate oxygen and how Cu-containing enzymes facilitate post-translational modifications in their active sites to generate modified amino acids that are critical for activity.

Nov 6	F	Cu enzymes (hemocyanin and plactocyanin)
Nov 9	M	Cu enzymes (galactose oxidase and amine oxidase)
Nov 11	W	Cu enzymes (amine oxidase)

Section 11: Here we discuss the organometallic cofactors and/or reaction mechanisms for the Ni-pincher complexes, F430 methyl reductase, CODH/ACS, and hydrogenase. We will also briefly discuss the application of protein film electrochemistry for the study of hydrogenases, compare the different classes of hydrogenase, and explore how the cyanide and carbon monoxide ligands are synthesized.

Nov 13	F	Ni enzymes (Urease and CODH/ACS)
Nov 16	M	Ni enzymes (methyl reductase and Ni pincher complexes)
Nov 18	W	Ni enzymes (NiFe hydrogenase)
Nov 20	F	Ni enzymes (FeFe hydrogenase and Hmd)

Section 12: Here we will briefly discuss the role/mechanism of other metal ions such as Mn, Zn, and Ca in bioinorganic chemistry.

Nov 23	M	Mn enzymes (arginase, catalase, OEC), Zn and Ca proteins
Dec 1	**T**	**Comprehensive FINAL EXAM – 200 points 8:00 – 10:30 am**