Lesson 1 (29 August 2000)

Introduction of instructor and welcome message.

Request for names of students and faculty.

Request that participants submit examples of metalloproteins during the duration of the course. Suggested several methods, WWW search engines, Brookhaven National Laboratory Protein Databank, individual University web sites.

Available library resources: Inorganic Biochemistry: An Introduction by J. A. Cowan, Biochemistry by Voet, Voet, and Pratt, and collection of review and research articles.

Inorganic Biochemistry: Fundamentals of inorganic biochemistry, Fundamentals of inorganic solution chemistry, the elements, formal oxidation states and coordination geometries of biologically important metal ions, classification of metal ions and ligands: hard-soft acid-base (HSAB) theory, stability constants, stabilization of oxidation states, ligand field stabilization energy (Chapter 1, pp. 1-16).

Post lecture comments - one person asked questions after the class finished. Only two people would speak during class. They seem like U. S. students in that they are reserved.

Lesson 2 (1 September 2000)

Distribute syllabus to students and check for new students and attendance sheet.

Request list of metalloproteins.

Review previous lecture topics (IB Chapter 1, pp. 1-16).

Request solution to homework and go over approach to $\beta_n = K_1.K_2....K_n$.

Define terms ligand, dentate, chelate, present examples of isomers (cis and trans, fac and mer).

Discuss chelate effect and give examples to dissect thermodynamics ($\Delta G = \Delta H - T\Delta S$), (Assign review question p. 12).

Discuss absorption spectra for transition metals (colors).

Discuss spectrochemical series for ligands (weak and strong).

Discuss pairing energy relative to Δ (also denoted 10Dq, -4Dq and +6Dq), discuss effect of coordination number and high and low spin on radius (Appendix 3 p. 421) (Assign review questions p. 19, p. 20).

Discuss metal complex hydrolysis.

Inorganic Biochemistry: Fundamental of inorganic biochemistry, Fundamentals of inorganic solution chemistry, kinetics and mechanisms of reactions involving metal complexes, electron-transfer reactions (Chapter 1, pp. 16-24).

Post lecture comments - It seemed a good idea to review and repeat material from the previous lecture. The same woman asked questions during class. A few more people volunteered answers during class. One person asked me about a specific Ca(II)-binding ligand's geometry. I was able to start discussion of inner and outer sphere electron transfer reactions of metal complexes.

Lesson 3 (5 September 2000)

Attendance sheet.

Request list of metalloproteins.

Review previous lecture topics (IB Chapter 1, pp. 16-24).

Request solution to homework review question p. 12.

Request solution to homework review questions p. 19 and p. 20.

Inorganic Biochemistry: Fundamentals of inorganic biochemistry, Fundamentals of inorganic solution chemistry, electron-transfer reactions (Assign review question p. 24, problem 6 p. 62) (Chapter 1, pp. 16-24).

Inorganic Biochemistry: Fundamentals of inorganic biochemistry, Fundamentals of biochemistry, biological ligands (Assign review question p. 48) (Chapter 1, pp. 36-43).

Fundamentals of Biochemistry: Amino acids, amino acid structure, stereochemistry, nonstandard amino acids (problems 3, 5, 6, 12) (Chapter 4, pp. 77-92).

Fundamentals of Biochemistry: Proteins: primary structure, polypeptide diversity (Chapter 5, pp. 93-96).

Fundamentals of Biochemistry: Proteins: three-dimensional structure, secondary structure, tertiary structure, quaternary structure and symmetry, protein folding and stability (Chapter 6, pp. 124-160).

Post lecture comments - Discussion of the homework was limited. I had to pull teeth to get anyone to come to the board. There appears to be three people who are active in class; the rest sit there. Once I finish electron transfer reactions and begin amino acids and proteins the mood of the audience changes. Even so, they are still reluctant to contribute to the presentations. I am able to cover almost everything that was on the agenda for the class.

Lesson 4 (8 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 1, pp. 16-24; IB Chapter 1, pp. 36-43; FB Chapter 4, pp. 77-92; FB Chapter 5, pp. 93-96; FB Chapter 6, pp. 124-160).

Discuss solution to homework review question p. 24.

Discuss solution to homework problem 6 p. 62.

Discuss solution to homework review question p. 48.

Discuss solution to homework problems 3, 5, 6, and 12 p. 92.

Fundamentals of Biochemistry: Proteins: three-dimensional structure, disulfide bonds, membrane spanning regions, channels, secondary structure, tertiary structure, quaternary structure and symmetry, protein folding and stability (Chapter 6, pp. 124-160).

Inorganic Biochemistry: Experimental methods, Physicochemical methods, introduction to spectroscopy, optical spectroscopy, magnetic resonance and related properties, solution methods dependent on X-radiation and γ-radiation, electrochemical methods (Chapter 2, pp. 65-74).

Post lecture comments - .I went over the homework and there is better participation from two of the faculty taking the course, but there are no students in the class from what I have been told. I will go slowly through the physical methods.

Lesson 5 (12 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 2, pp. 65-74).

Inorganic Biochemistry: Experimental methods, Physicochemical methods, optical spectroscopy, magnetic resonance and related properties (Chapter 2, pp. 74-88).

Post lecture comments - There were 8 people in the class tonight and that soon dwindled to six after the first break. The same two people are contributing to discussions. I have little problem filling the time with relevant information.

Lesson 6 (15 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 2, pp. 74-88).

Discuss Fig 2.12C as an example of exchange in NMR.

Discuss Fig 2.15 and relation 2.12 as an example of distance determination.

Discuss examples of EPR of transition metal ions, use Co^{2+} LS I = 7/2 (8 lines) and Mn^{2+} HS I = 5/2 (6 lines).

Inorganic Biochemistry: Experimental methods, Physicochemical methods, magnetic resonance and related properties, solution methods dependent on X-radiation and γ-radiation (Chapter 2, pp. 88-95).

Post lecture comments - There were more people in class tonight and it appeared to run smoother, although the same people contributed to discussions and asked questions during the breaks. Using slides seems to be effective in keeping their attention, but it is unclear to me if it helps their learning. I am going slowly and running behind schedule but that's fine for now.

Lesson 7 (19 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 2, pp. 88-95).

Discuss using isotopes to confirm EPR signals, ^{61}Ni is a good example, also consider more complicated situation of delocalized electron over ligands.

Discuss using intensity of EPR signal to follow reactions and to determine the number of spins (electrons) associated with the metal center.

Discuss the equivalence of N,O and S,Cl in EXAFS.

Discuss the position of the absorption edge in XANES as a marker for oxidation state.

Inorganic Biochemistry: Experimental methods, Physicochemical methods, solution methods dependent on X-radiation and γ-radiation, electrochemical methods (Chapter 2, pp. 95-107).

Post lecture comments - Class went fine, slow but steady. The class seems to want to discuss proteins already, but they do not have the foundation to understand what will be important. This seems just like the students from SIU. I would place the discussion of dioxygen carriers either in this lecture or the previous lecture to keep to audience's attention and to keep Mb, Hb, Hr, and Hc separate from the enzymes. There were 8 people before the break and 4 people remained through the entire lecture.

Lesson 8 (22 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 2, pp. 95-107).

Discuss Fig 2.35 and the role of ionizable groups near redox centers.

Discuss the following question, "Why is it possible for electrons to flow from a redox center with a more positive E˚ to one with a more negative E˚ within an electron-transfer complex?" (FB p. 528)

Fundamentals of Biochemistry: Enzymatic catalysis, general properties of enzymes, activation energy and the reaction coordinate, catalytic mechanisms (Chapter 11, pp. 281-293.

Post lecture comments - There were 7 people in class tonight and 2 left after the break for a meeting. During discussion of standard redox potentials it was apparent that one faculty member has difficulty with the concept of coupled reactions. I tried to be patient and work through his difficulty and decided that he did not learn the science the first time he encountered it during his studies. He is one of the biology faculty and that is consistent with what I have experienced at SIUC. I think that the other participants have little difficulty understanding the material. I am convinced that this will be a good course for me to teach upon my return and that I should cover what I know is important and use selected protein examples as appropriate.

Lesson 9 (26 September 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (FB Chapter 11, pp. 281-293).

Discuss Problem 5 (IB pp. 125-126).

Discuss Problem 3 (FB p. 321).

Fundamentals of Biochemistry: Enzymatic catalysis, catalytic mechanisms (Chapter 11, pp. 293-296).

Discuss Lewis acidity - $Ca^{2+} < Mg^{2+} < Mn^{2+} < Fe^{2+} < Co^{2+} < Ni^{2+} < Cu^{2+} > Zn^{2+}$

Discuss Zn^{2+} for C=O groups, Mg^{2+} for phosphate esters, Zn^{2+}-H_2O pK~8 and Mg^{2+}-H_2O pK~11.

Discuss carbonic anhydrase (FB p. 295) during metal ion catalysis.

Discuss Problem 2 (IB pp. 384-385)

Demonstrate Protein Explorer, Chime, and Protein Comparator within Netscape browser, use carbonic anhydrase, urease, arginase structures as examples.

URL for RasMol, Chime, Protein Explorer: http://www.umass.edu/microbio/rasmol

URL for Protein databases: http://cmm.info.nih.gov/modeling/databases.html

Post lecture comments - Class went fairly well with the use of the white board, problems, and multimedia. Attendance was up, around 12 to 14 people stayed for the entire session and one person was standing at the door watching the computer presentation. The demonstration of Protein Explorer and Protein Comparator was well received but then again it is the medium that they like, whether there is any learning taking place is unknown. This is pure entertainment as far as I am concerned.

Lesson 10 (29 September 2000)

We cancel class for tonight because of the Festival Primavera and the trip to "El Brujo."

Lesson 11 (3 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (FB Chapter 11, pp. 293-296).

Discuss Problems 2 and 4 (FB p. 321).

Fundamentals of Biochemistry: Enzymatic catalysis, catalytic mechanisms (Chapter 11, pp. 296-299).

Discuss isocitrate dehydrogenase (FB p. 477) during metal ion catalysis.

Discuss arginase (2 Mn^{2+}) catalytic mechanism (X-ray structure paper).

Discuss urease (2 Ni^{2+}) catalytic mechanism (X-ray structure papers).

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (I) Oxygen carriers and hydrolases, hydrolase enzymes (Chapter 4, pp. 179-190)

Discuss carboxypeptidase A (Zn^{2+}) catalytic mechanism.

Discuss alkaline phosphatase (2 Zn^{2+}, Mg^{2+}) catalytic mechanism.

Discuss purple acid phosphatase (2 Fe^{2+}) catalytic mechanism.

Post lecture comments - Class was fine with good attendance of 12 to 14 people. I covered everything up to aconitase mechanism, which will be discussed next lecture. I think it is still good idea to write mechanisms on the board or draw them on overheads during class and not to prepare them ahead of time. I am getting some good questions during class from the physician but some participants don't seem to know some of this material.

Lesson 12 (6 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (FB Chapter 11, pp. 296-299; IB Chapter 4, pp. 179-190).

Review arginase and urease protein and active site structures.

Discuss alkaline phosphatase (2 Zn^{2+}, Mg^{2+}) catalytic mechanism and crystal structure with Zn^{2+}-O-Ser bond of 2.1 Å.

Discuss purple acid phosphatase (2 Fe^{2+}) catalytic mechanism and crystal structure with Fe^{3+}-O-Tyr bond of 1.96 Å.

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (I) Oxygen carriers and hydrolases, hydro-lyase enzymes-aconitase (Chapter 4, pp. 190-196)

Discuss hydro-lyase enzymes - aconitase [Fe_4S_4] catalytic mechanism (X-ray structure paper).

Post lecture comments - The class was well attended, more than 12 participants, and well received. The faculty enjoy the combination of discussion and visual aids especially when investigating enzyme mechanisms. I think that this would work well with students only if they were actively studying and learning the material. Otherwise, it is only entertainment that will distract them from the learning process.

Lesson 13 (10 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 4, pp. 190-194).

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (I) Oxygen carriers and hydrolases, hydro-lyase enzymes-aconitase (Chapter 4, pp. 194-196)

Discuss hydro-lyase enzymes - aconitase [Fe_4S_4] catalytic mechanism (X-ray structure paper) and EPR/ENDOR results.

Fundamentals of Biochemistry: Enzyme kinetics, inhibition, and regulation, reaction kinetics (Chapter 12, pp. 322-332).

Post lecture comments - Class was poorly attended at first but soon there were approximately 10 people, most show up late probably due to work. I covered less than anticipated and there may be some need to extend the course or combine the material with the next course. I want to cover some of the topics in detail and an extra couple of weeks would be welcomed. I get some very good questions from the faculty.

Lesson 14 (13 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 4, pp. 194-196; FB Chapter 12, pp. 322-332).

Discuss how diffusion limit can be exceeded by enzyme complex that channels substrates.

Discuss Problems 2, 3, 5, and 6 (FB p. 348)

Discuss Question 2 (IB p. 121).

Fundamentals of Biochemistry: Enzyme kinetics, inhibition, and regulation, reaction kinetics, enzyme inhibition (Chapter 12, pp. 332-342).

Post lecture comments - Lecture tonight started with 4 people, one was a visitor, so we decided initially to have a one-hour lecture. Soon there were more people and the class was held for the normal length of time. The material was presented will little difficulty as far as I could determine and there were some good questions from a few people.

Lesson 15 (17 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (FB Chapter 12, pp. 332-342).

Discuss Problems 8 and 9 (FB p. 349)

Inorganic Biochemistry: Biochemical methods, enzyme kinetics (Chapter 2, pp. 108-114).

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (I) Oxygen carriers and hydrolases, oxygen carriers (Chapter 4, pp. 167-179).

Discuss structures of myoglobin, hemoglobin, hemerythrin, and hemocyanin (type III Cu).

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (II) Redox chemistry, introduction, prothetic centers, cofactors, and coenzymes in metalloredox proteins and enzymes (Chapter 5, pp. 203-206).

Post lecture comments - The lecture was well attended even though we started late, everyone arrived at about the same time. We used multimedia presentation after covering fast kinetic techniques. Even though the faculty know some things about the systems that are disussed, there is much that they do not know with respect to fundamental chemistry that lays the foundation of the science. This is especially evident when discussing formal oxidation states and transfer of electron density during coordinate bond formation. I find that there is some conversation during my discussions that has to do with them not accepting the new concepts that are presented. One example tonight was the introduction of proton-pumping as the role of cytochrome *c* oxidase. There was much debate when I suggested that this was the actual role of the enzyme, not formation of water from dioxygen.

Lesson 16 (20 October 2000)

Attendance sheet.

Request list of metalloproteins or URLs of course related sites.

Review previous lecture topics (IB Chapter 2, pp. 108-114).

Review previous lecture topics (IB Chapter 4, pp. 167-179).

Review previous lecture topics (IB Chapter 5, pp. 203-206).

Inorganic Biochemistry: Metalloproteins and metalloenzymes: (II) Redox chemistry, prothetic centers, cofactors, and coenzymes in metalloredox proteins and enzymes, electron-transfer pathways in respiratory metabolism, electron-transfer pathways in nonrespiratory metabolism (Chapter 5, pp. 206-218, 233-235, 236-238).

Discuss FeS clusters using rubredoxin, Reiske Fe protein, ferredoxin I, and ferredoxin II as examples.

Discuss heme centers using cytochrome *c* peroxide-cytchrome *c* complex as example.

Discuss type I, II, and III Cu centers using plastocyanin, hemocyanin, and ascorbate oxidase are examples.

Discuss Mo center (pterin) using Co dehydrogenase as example.

Discuss Co centers using glutamate mutase as example.

Discuss Ni centers using FeNi hydrogenase as example.

Discuss reduced porphyrins using sulfite reductase as example.

Discuss nitrogenase enzyme.

Thank the class for their attendance and participation.

Post lecture comments - The class was well attended and appeared to go well. Combining computer modeling and lecture notes seems to work well. The class appeared to follow the concepts and more people asked questions, particularly when I discussed nitrogenase system. They were very interested in ATP hydrolysis and conformational changes, more so that it applied to myosin and muscle contraction, which they were familiar with. I was thanked by two University administrators and several members of the class were very appreciative of the presentations. They are looking forward to the next course.