Bioinorganic Chemistry - Course Syllabus

Course Number: CBE319 / CHEMS319

Course Title: Bioinorganic Chemistry

Academic Semester:	Spring	**Academic Year:**	2015/ 2016
Semester Start Date:	Jan, 24, 2016	**Semester End Date:**	May, 19, 2016

Class Schedule: Sun. & Wed., 10:30 - 12:00

Classroom Number:

Instructor(s) Name(s): Jörg Eppinger
Email: jorg.eppinger@kaust.edu.sa

Teaching Assistant name:
Email:

Office Location: Ibn Sina bldg. 4233
Office Hours: Mon., 9:00 – 10:00

COURSE DESCRIPTION FROM PROGRAM GUIDE

The more advanced chemical and biochemical aspects and methods are all developed during the course. The course will provide students with a general overview of the many very fundamental tasks performed by inorganic elements in living organisms as well as the related methods and theories with particular emphasis on enzymatic conversions and electron transfer. This goes along with the elucidation of model systems and technical applications of both, concepts learned from nature as well as biological systems.

COMPREHENSIVE COURSE DESCRIPTION

The course “Bioinorganic Chemistry” provides students with a detailed knowledge of fundamental aspects of the subject, while it focuses on current topics, e.g. metalloenzymes in metabolism and synthesis, technical applications of hydrogenases or metal containing pharmaceuticals. Students who complete the course are expected to understand the concepts of coordination chemistry in biological environments, and to utilizes this knowledge to analyze the influence of such an environment on the reactivity of a metal centre. This expertise should serve as a tool for development of e.g. metalloenzyme applications, material synthesis and pharmaceutical development. The course is designed for PhD students in chemistry (ChemS), biology (B) and biotechnology (CBE), yet interested students on the M.Sc. level are welcome.

Approximately 2/3rd of all proteins are metalloproteins. The interplay of metal centers with biogenic ligands is the source of the diverse functions, which in their combination form life. Correspondingly, interdisciplinary research on the inorganic chemistry of life is not only fundamental to progress in biochemistry and biology, it has developed into a major source of innovation for chemists e.g. in catalyst development, material chemistry and medicine. It further is of fundamental importance to understand and investigate many diseases. The course „Biological Inorganic Chemistry“ details the numerous functions of metal ions and inorganic materials in biology. It provides a general overview of the fundamental tasks performed by inorganic elements in living organisms as well as the related methods and theories with particular emphasis on enzymatic conversions, inorganic biomaterials and medical applications. Nature's strategies are elucidated based on model systems and basic concepts are illustrated by examples relevant to technological or medical applications.

CLASS SCHEDULE:

A) Basics

Week 1 A.1: Introduction: What Bioinorganic Chemistry? General terms, how and why does nature select inorganic elements? Inorganic Elements and evolution.

Material: slides + Bertini, chapters I and II; tutorial I

Objectives: answer, why and how nature selects specific elements

Week 2 A.2: Basic biological Coordination Chemistry. Kinetic and spectroscopic characteristics of bioinorganic systems.

Material: slides + Bertini, chapters III and IV; tutorial II

Objectives: apply coordination chemistry of non-redox active metal centers to biological complexes.

Week 3 A.3: Stroll through the periodic system. Systematic overview over tasks and examples of inorganic elements in biology

Material: slides

Objectives: explain, why nature selects specific elements for specific tasks

B) Non-redox active metals

Week 4 B.1: Ion transport: membranes, energy, channels, pumps

Material: slides + Bertini, chapters V

Objectives: comprehend and discriminate the different mechanism developed to cross cellular boarders

Week 5 B.2: Biomineralization: the hard part of bioinorganic chemistry

Material: slides + Bertini, chapters VI

Objectives: know the nature and function of different bio-minerals and understand the mechanism of biomineralization based on principles derived form physical chemistry

Week 6 B.3: Nanoparticles, Inorganic structural elements in proteins, RNA & DNA

B.4: Lewis acid catalysis

Material: slides + Bertini, chapters XIV and IX

Objectives: explain applications of nanoparticels in biology, functions of non-redox active elements for protein or DNA structure and understand enzyme mechanisms of based on Lewis acid activation

C) Open shell transition metals

Week 7 C.1: Bioinorganic coordination chemistry II – transition metals

Material: slides + Bertini, tutorial 2, second part

Objectives: apply coordination chemistry of redox active metal ions to explain properties of these metal centers

Week 8 C.2: Electron transport in biology – iron sulfur clusters, enzymes for respiration, photosynthesis and related pathways

Material: slides + Bertini chapter X

Objectives: apply the Marcus theory to explain electron transport in biology

Week 9: C.3: Oxygen transport – metal-oxygen coordination in proteins

Material: slides + Bertini chapter XI.1. and XI.4

Objectives: explain oxygen-transport using ligand field theory

Week 10: C.4: Oxygen activation and processing by cytochromes

Material: slides + Bertini chapter XI.3, XI.6, XI.8

Objectives: comprehend and discriminate the different mechanism of enzymatic dioxygen activation using cytochromes

Week 11: C.5: Small molecule activation and conversion by metalloenzymes – photosynthetic water splitting

Material: slides + Bertini chapter X.4 and XI.2, XI.5

Objectives: comprehend and discriminate the different mechanism of enzymatic dioxygen activation without cytochromes

Week 12: C.6: Radicals and Bioorganometallic Chemistry – from RNA to DNA and from Vitamin B12 to methanogens and methanotrophs

Material: slides + Bertini chapter XIII

Objectives: explain, how nature creates and utilizes radical intermediates in enzyme mechanism

Week 13: C.7: Biological conversion and formation of hydrogen and nitrogen– hydrogenases and nitrogenases

Material: slides + Bertini chapter XII

Objectives: understand based on coordination chemistry principles, how nature tailors metal centers to activate hydrogen and nitrogen

D) Medical implications

Week 14: D.1: Metal pharmacology: uptake storage toxicity

Material: slides + Bertini chapter VIII

Objectives: explain the principles and mechanism of, how homeostasis is retained in a cell

Week 15: D.2: Metals in medicine: anti cancer agents, diabetes, arthritis, radionuclides and related applications

Material: slides + Bertini chapter VII

Objectives: know and understand medical applications of metal ions and complexes

GOALS AND OBJECTIVES

By the end of the course students will be able to:

- understand how metal ions interact with biological environments and how these interaction influences the properties of metal centers

- apply principles of coordination chemistry to explain how nature tailors properties of metal centers for specific applications

- answer critical questions (asked by fellow students or the instructor) and engage in scientific discussion on bioinorganic chemistry related topics

- demonstrate in a written homework the ability comprehend current problems in bioinorganic chemistry and answer specific scientific questions using the knowledge provided during the course

- understand current publications in the area of bioinorganic chemistry in high impact journal (IF > 5) at the level, which is required to present a self-selected topic to an audience in a conference-style seminar.

Specific weekly objectives are listed in the course description

REQUIRED KNOWLEDGE

Basic knowledge of (i) biological and biochemical principles and (ii) General and Inorganic Chemistry as it is provided by in an undergraduate chemistry, biochemistry, biotechnology or chemical engineering program. The course will use concepts of Coordina

REFERENCE TEXTS

Ivano Bertini, Harry B. Gray, Edward I. Stiefel, Joan Selverstone Valentine, „Biological Inorganic Chemistry – Structure & Reactivity“

METHOD OF EVALUATION

Percentages %	Graded content
4 points each = 40 points = 40 % 20 points = 20 % 40 points = 40 %	**10 quizzes Homework <u>Final presentation</u>: The final presentation's grading will depend on: content (40 %), presentation quality (15 %), presentation within time limit**

COURSE REQUIREMENTS

Assignments

current literature will be distributed in class assessed by quizzes.
Homework will be distributed after week 5 and collected in the beginning of week 7.
The final presentation should be based on a self-selected original article not older than 2 years and published in a journal with impact factor > 5.000.

Course Policies

There will be no make-up quizzes, deadline extensions or additional opportunities to give the final presentation. If there is an emergency that will keep you from taking an exam, you must contact me via email as soon as you are aware that you will miss a test or deadline.
In accordance with the University policy and professional standards, the highest levels of academic integrity are expected in this class. The code of student conduct is strictly enforced. Academic dishonesty, e.g. plagiarism in homework will result in reductions in grades and/or expulsions from this class and/or the University.

Additional Information

All slides will be made available via a class-specific drop-box folder at least one week before the lecture. Reading assignments based on current articles will be distributed in class. The key to doing well and learning the material in this class is to read through all slides before coming to class so that the lecture is the second time that you are thinking about the material. However, several important and particularly difficult topics will be developed in class at the whiteboard only.

NOTE

The instructor reserves the right to make changes to this syllabus as necessary.