School of Physical and Chemical Sciences

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

General Course Information

BCHM 339/CHEM 339
Bioinorganic and Bioorganic Chemistry

0.125 EFTS 15 Points
Semester 2 2022

Description
Bioinorganic chemistry is the study of the ways that nature uses the properties of metal ions to control and catalyse biological processes. Processes to be studied will include transport of electrons, small molecules, and essential trace elements, as well as chemical transformations that involve redox reactions, activation of water molecules in hydrolysis reactions, and the role of metal ions in biosynthetic reactions.
The bioorganic chemistry portion of the course will focus on the role that small molecular weight organic compounds can play in dissecting, probing and manipulating biological systems. We will use examples from human and animal health (i.e. cancer, infection) to illustrate this interdisciplinary process.

Timetable
Lectures: Three hours of lectures per week. Tutorial problems and related discussions will be distributed through lectures. Details on lecture times to be confirmed on 'My Timetable' and the Web.

Students should note that in the Science Faculty the average student is responsible for approximately 4.5 hours of additional study for each hour of lecture at the 300-level.

Course Co-ordinator
Professor Richard Hartshorn,
email: richard.hartshorn@canterbury.ac.nz
Email me if you have any queries about the course.

Lecturers
Dr Tim Allison,
email: timothy.allison@canterbury.ac.nz

Dr Jodie Johnston
email: jodie.johnston@canterbury.ac.nz

Assessment

Assignment 1 (RMH Block 1):	10%
Test (RMH Block 1):	15%
Test (TA)	25%
Exam (JJ/RMH Block 2):	50%

Examination and Formal Tests
Test 1: **Week 5 RMH Block 1** One 60 min test to be advised in MyTimetable
Test 2: **Week 7 TA** One 90 min test to be advised in MyTimetable
Exam: to be advised

Textbooks
Biological inorganic chemistry: a new introduction to molecular structure and function / Robert R. Crichton (https://www-sciencedirect-com.ezproxy.canterbury.ac.nz/science/book/9780128117415).

Introduction to Bioorganic Chemistry and Chemical Biology / D. Van Vranken and G. A. Weiss (QD 415 .V36 2013, EPS Library).

Prerequisites
P: BCHM212 or CHEM212

Web-based resources
Various learning resources (lecture material, reference links, quizzes, discussion forums etc.) for this course are available via the University of Canterbury's *Learn* web site -- http://learn.canterbury.ac.nz/. This site will also be used regularly as a means of communication and information distribution for all of your Canterbury courses. You should familiarise yourself with *Learn* as soon as possible.

Learning Outcomes
A specialised third year course to build on prior study in biochemistry and chemistry
Develop critical analysis skills in biochemistry and chemistry
Develop advanced problem-solving skills
Develop an understanding of:

- the roles of metal ions vital biological processes;
- the relationships between small organic molecules and large molecules in biological systems;
- the roles of metal ions in biological redox chemistry.

Summary of the Course Content

The topics coved by this course are:

Metals in Biology, Medicine and Biological Redox Processes Block 1 (9 lectures)

Prof. Richard Hartshorn
Specific examples of biological molecules containing transition metal ions will be examined and their activity related to the properties of those metal ions, including the following topics: key zinc enzymes/proteins (carbonic anhydrase, carboxypeptidase, and zinc finger proteins); oxygen utilisation and disposal (cytochrome C oxidase, superoxide dismutase); oxygen transport and storage (hemoglobin and myoglobin); iron transport (siderophores); nerve function, energy transduction, and biological electron transfer reactions (e.g. in respiration).

Detailed Learning Objectives
By the end of this course you will be able to:

- Compare and contrast the roles of different metal ions in biological processes
- Discuss the factors that are important in the selective binding of metal ions
- Provide and explain examples of selective binding of metal ions in biological and medicinal applications
- Describe and discuss the structure and mechanism of action of Hemoglobin
- Outline and discuss, using specific examples, the role of zinc in biological systems
- Discuss the use of model systems to investigate the nature and action of metal containing enzymes

Chemical Aspects of Biosynthesis (9 lectures)

Dr Tim Allison
Anabolism is the synthesis of complex molecules in living organisms from simpler ones. These processes are used for the storage of energy, but also the creation of molecules that are crucial to life, called primary metabolites. The same pathways that produce the primary metabolites are also used to produce a fascinating and diverse array of more complex molecules known as secondary metabolites, or natural products. In this part of the course, we will explore these aspects of metabolism. We will focus on the biosynthesis of two classes of lipids: fatty acids and terpenes, highlighting two distinct approaches nature uses to catalyse the formation of carbon-carbon bonds in these polymers, which are both synthesised from the same metabolic precursor.

Detailed learning objectives
By the end of this course, you will be able to:

- Recognise the structural affinities of major classes of natural products
- Appreciate the biological and chemical origins of these compounds
- Offer rational mechanistic explanations for many of the transformations
- Compare and contrast different mechanisms of carbon-carbon bond formation
- Outline and discuss the roles of common enzyme cofactors
- Explain how complex secondary metabolites find their origin in the biosynthetic pathways of primary metabolism

Enzyme Chemistry and it's Biocatalytic Applications (9 lectures)

Dr Jodie Johnston
Enzymes are natures catalysts responsible for carrying out the chemical transformations of life. Due to their remarkable catalytic abilities, they have also been used as biocatalytic tools in a range of applications including the food and pharmaceuticals industries. This block will first focus on some fundamental enzyme chemistry concepts; including catalytic mechanisms, cofactors, selectivity, specificity, diversity of fold and function, promiscuity and mechanisms for regulation. We will then explore how these concepts are applied in example enzyme systems from the ThDP-dependent enzyme superfamilies including a section how these fundamental enzyme chemistry concepts apply in the use of enzymes as biocatalysts. We will discuss several industrially relevant examples of enzyme biocatalysts and explore the limitations and advantages of using enzymes in this manner. We will also cover how engineering of enzymes can be used to optimise their utility in biocatalytic applications.

Detailed Learning Objectives
By the end of this course, you will be able to:

- Describe, with examples, fundamental concepts of enzyme chemistry including catalytic mechanisms, the catalytic cycle, the role of cofactors, selectivity, specificity, diversity of fold and function, promiscuity, the role of dynamics in catalysis and mechanisms for regulation
- Explain, with examples, the similarities and differences in catalytic mechanism of ThDP-dependent Decarboxylase superfamily enzymes
- Discuss, with examples, the conserved and non-conserved structural features of the ThDP-dependent Decarboxylase superfamily that enable them to adapt their catalytic scaffold for different chemistries
- Explain, with examples, how you can convert the natural chemistry of an enzyme for use in a biocatalytic application and be able to discuss the role enzyme promiscuity play in this process
- Discuss the advantages and challenges of using enzymes in biocatalytic applications and explain, with examples, approaches you might take to make a better biocatalyst
- Describe the basic approaches to enzyme engineering and explain, with examples, why modifying an enzymes natural properties might be desirable

Metals in Biology, Medicine and Biological Redox Processes Block 2 (9 lectures)

Prof. Richard Hartshorn
Specific examples of biological molecules containing transition metal ions will be examined and their activity related to the properties of those metal ions, including the following topics: nerve function, energy transduction, and biological electron transfer reactions (e.g. in respiration).

Cytochrome P450 is a key enzyme for oxidising organic molecules in drug metabolism and biosynthetic reactions. We will examine the detailed mechanisms of the reactions that it catalyses, including a discussion of the methods used to elucidate the mechanism (radical clocks, isotope effects).

Detailed Learning Objectives
By the end of this course you will be able to:

- Compare and contrast the roles of different metal ions in biological processes

- Use a detailed understanding of electron transfer mechanism to provide insights into the structural properties of electron transfer proteins
- Discuss the use of model systems to investigate the nature and action of metal containing enzymes
- Describe and discuss the mechanism of Cytochome P450
- Outline and explain methods used to elucidate the mechanism
- Critically interpret experimental results to draw conclusions about mechanisms, kinetics, and thermodynamics in bioinorganic reactions

GENERAL INFORMATION 2022

Policy on 'Dishonest Practice'
The University has strict guidelines regarding 'dishonest practice' and 'breach of instructions' in relation to the completion and submission of examinable material. In cases where dishonest practice is involved in tests or other work submitted for credit a department may choose to not mark such work ('Academic Integrity and Breach of Instruction Regulations').

The School of Physical and Chemical Sciences upholds this policy. It considers plagiarism, collusion, copying, and ghost writing to be unacceptable and dishonest practices:

- ***Plagiarism*** is the presentation of any material (text, data or figures, on any medium including computer files) from any other source without clear and adequate acknowledgement of the source.
- ***Collusion*** is the presentation of work performed in whole, or in part, in conjunction with another person or persons, but submitted as if it has been completed by the named author alone. This interpretation is not intended to discourage students from having discussions about how to approach an assigned task and incorporating general ideas that come from those discussions into their own individual submissions, but acknowledgement is necessary.
- ***Copying*** is the use of material (in any medium, including computer files) produced by another person or persons with or without their knowledge and approval. **This includes copying of the lab reports (raw data may be shared within the group if permitted or required by the experiment) - data analysis and interpretation of obtained results MUST be performed individually.**
- ***Ghost writing*** is the use of other person(s) (with, or without payment) to prepare all or part of an item of work submitted for assessment.

Additional Information
Special consideration of assessment*:** If you feel that illness, injury, bereavement or any other critical extenuating circumstance beyond your control has prevented you from completing an item of assessment or affected your performance in that assessment, you may apply for special consideration. Special consideration is not available for items worth less than 10% of the course. Applications for special consideration should be made **within five days** of the due date for the work or examination. In the case of illness or injury, medical consultation should normally have taken place shortly before, or within 24 hours after, the due date for the required work or the date of the test or examination. For details on special consideration, or to make an application, refer to the Examinations Office website http://www.canterbury.ac.nz/exams/. ***You have the right to appeal any decision.

Extensions of deadlines: Where an extension may be granted for an assessment item, this will be decided by application to the course co-ordinator.

Late withdrawal from the course: If you are prevented by extenuating circumstances from completing the course after the final date for withdrawing from the course, you may apply for special consideration for late discontinuation. For details on special consideration, or to make an application, refer to the Examinations Office website http://www.canterbury.ac.nz/exams/. Applications must be submitted ***within five days*** of the end of the main examination period for the semester.

***Missing of tests*:** In rare cases a student will not be able to sit a test. In such cases, the student should consult with the course co-ordinator to arrange alternative procedures. **This must be done well in advance of the set date for the test.**

Past tests and exams: these can be found on our website using the link below:

www.chem.canterbury.ac.nz/for/undergraduate.shtml

***Submission of reports and assignments*: Reports (including lab reports) and assignments should be handed in on time.** Extensions will be granted only in exceptional circumstances (such as illness or bereavement). If an extension is required, as early as possible you should request it from the lecturer concerned.
Note: If you do not submit an assignment for assessment, you will be allotted zero marks, which will affect your final result. You should ensure that you pick up marked assignments and keep them until the end of the course as evidence that the work was completed and marked in the case that either is disputed. To guard against accidental loss, it would be prudent to keep photocopies or electronic copies of anything submitted.

Late Work: Acceptance of late work will be at the discretion of the course coordinator. Please contact the coordinator if your assessment is likely to be late.

Marks and Grades: The following numbers should be considered as a guide to the expected grades under normal circumstances. The School reserves the right to adjust mark/grade conversions, if necessary.

Please note that for all invigilated assessments (tests and exams) worth 33% and above, failure to obtain a mark of at least 40% will result in a final grade no higher than an R at 100 and 200 level, and a C- at 300 level.

Grade:	**A+**	**A**	**A−**	**B+**	**B**	**B−**	**C+**	**C**	**C-**	**D**	**E**
Minimum mark %:	**90**	**85**	**80**	**75**	**70**	**65**	**60**	**55**	**50**	**40**	**0**

Reconsideration of Grades: Students should, in the first instance, speak to the course co-ordinator about their marks. If they cannot reach an agreeable solution, or have questions about their grade in a course, students should then speak to the Director of Undergraduate Studies, Assoc Prof Greg Russell (phone 3694228). Students can appeal any decision made on their final grade. You can apply at the Registry for reconsideration of the final grade within four weeks of the date of publication of final results. Be aware that there are time limits for each step of the appeals process.

Students with Disabilities: Students with disabilities should speak with someone at Equity and Disability Service, phone: 369 3334 (or ext. 93334), email: eds@canterbury.ac.nz).

***Academic Advice*:** Assoc Prof Greg Russell is the coordinator of undergraduate chemistry courses. His interest is in the academic performance and well-being of all such students. Anyone experiencing problems with their chemistry courses or requiring guidance about their B.Sc. in Chemistry should get in contact with Greg.

***Staff-Class Rep Liaison*:** Assoc Prof Greg Russell is in charge of liaison with students in chemistry courses. Your class will appoint a student representative to the liaison committee at the start of the semester. Please feel free to talk to the Academic Liaison or the student rep about any problems or concerns that you might have.

Greg Russell (greg.russell@canterbury.ac.nz, tel. 369 5129)
Director of Undergraduate Studies
School of Physical and Chemical Sciences
2022