

Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2023-2024
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Liang Zhao-Xun
Course Author Email	zxliang@ntu.edu.sg
Course Title	Natural Products in Medicinal Chemistry
Course Code	BS3028
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	BS1003 Organic Chemistry & BS1005 Biochemistry I & BS1006 Principles of Genetics OR BS1013 Foundations of Chemistry II & BS1005 Biochemistry I & BS1006 Principles of Genetics OR CM2031 Organic and Bioorganic Chemistry
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

The module will expose the students to fundamental concepts and frontiers in modern biochemistry and natural product biosynthesis, with the objective of equipping the students with essential analytical skills for dissecting the structure-function relationship in natural products enzymes and analyzing and annotating biosynthetic pathways. Textbooks and reading materials were chosen accordingly to foster the students' interest in the research areas of drug discovery and natural product biosynthesis.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Apply genomics and recombinant DNA technologies to studying natural product biosynthesis and facilitate discovery of new natural products
ILO 2	Manipulate protein or cell-based biological systems to create new chemistry.
ILO 3	Analyze and assess primary literature in the field of enzymology and natural product biosynthesis.
ILO 4	Recognize, draw and analyze chemical structures of major classes of secondary metabolites
ILO 5	Compare and contrast how biomolecules are synthesized by living cells and by chemists.
ILO 6	Propose reasonable biosynthetic mechanism
ILO 7	Propose biosynthetic mechanism for major classes of natural products

Course Content

Major classes of biosynthetic enzymes.
Classification of major classes of secondary metabolites.
Mechanism of action of natural product-based drugs
The role of organic cofactor in enzyme catalysis
Biosynthesis of polyketide
Biosynthetic mechanism of terpenoids
Biosynthetic mechanism of ribosome-derived peptide natural products
Biosynthetic mechanism of non-ribosome-derived peptide natural products
Biosynthetic gene cluster and its regulation
Engineering of biosynthetic pathways

Reading and References (if applicable)

Although no textbooks are formally required, some of the material in the lecture notes can be found in the book Natural Product Biosynthesis (Ref 1). Research articles will be provided to you throughout the semester as additional reading materials to broaden and deepen your understanding of the topics. You are NOT required to know or remember all the details of the research articles. Instead, apply the critical reading skill to grasp the important and relevant concepts. Below are several recommended reference books that you may find useful. The books can be found on the reservation shelf in the library. Many fundamental Biochemistry textbooks that contain relevant information are also available in the library.

- 1) Natural Product Biosynthesis by Christopher Walsh and Yi Tang, royal Society of Chemistry, 2017
- 2) Antibiotics: actions, origins, resistance, by Christopher Walsh. 2003.
- 3) The Organic Chemistry of Enzyme-catalyzed Reactions by Richard B. Silverman, Academic Press, 2002
- 4) Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht
- 5) Principles of Bioinorganic Chemistry by Stephen J. Lippard and Jeremy M. Berg

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Natural products as drugs	1, 2, 4, 7		In-person	
2	Biosynthesis of natural product	1, 5, 6		In-person	
3	Enzymes in natural product biosynthesis	1, 2, 3, 4		In-person	
4	Bio-synthetic enzymes with organic cofactor	2, 3, 5, 6		In-person	
5	Metalloenzymes	1, 3, 5, 6, 7		In-person	
6	Terpene biosynthesis	1, 3, 5, 6, 7		In-person	
7	Polyketide biosynthesis	1, 3, 5, 6, 7		In-person	
8	Biosynthesis of peptide-based natural products	2, 3, 5, 6, 7		In-person	
9	Alkaloid biosynthesis	1, 2, 3, 4, 5, 6, 7		In-person	
10	Biosynthetic pathway	1, 3, 5, 6, 7		In-person	
11	Engineering of biosynthetic pathways	4, 5, 6, 7		In-person	
12	Student presentation	3, 4, 6, 7			

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
13	Review, consultation & discussion	1, 2, 3, 4, 5, 6, 7			

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	The lectures are designed to bridge chemistry and biology and to highlight the use of biological tools in discovering new chemistry. You will have the opportunities to draw structures and biosynthetic mechanisms on the white board and inspect protein structures using computational software during class. These approaches are the means for achieving objectives 1-7.
tutorials	The tutorial questions are designed to reinforce the fundamental concepts in chemical biology and natural product biosynthesis. Through the interactive tutorial sessions within a small class, objectives 1-7 can be achieved.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Presentation(Presentation)	1, 3, 4, 5, 6, 7	1.b 2. e, f 3. a, b, c 5. a, c 7.a, c	20		Individual and Team	Holistic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(Mid-semester Quiz: Essay)	1, 2, 3, 4, 5, 6, 7	1.b 2. a 3. c, e 5. a, c 7.a, c	20		Individual	Holistic	Multistructural
3	Summative Assessment (EXAM): Final exam(Examination: Essay)	1, 2, 3, 4, 5, 6, 7	1.b 2. e, f 3. c 5. a 7.a	20		Individual	Holistic	Multistructural
4	Summative Assessment (EXAM): Final exam(Examination: Short Answer Questions)	1, 2, 3, 4, 5, 6, 7	1.b 2. e 3. c, e 5. a 7.a	40		Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

Formative Feedback

Because it's a small class, there is plenty of time and opportunities for you to discuss the lecture material and tutorial questions/answers with me after the lecture or tutorials. The discussions will have significantly positive impact on all the intended learning outcomes.

Besides the post-lecture/tutorial discussion, feedback will be provided in the form of Examiner's report at the end of

the semester.

Feedback on your mid-term essay report and student presentation will also be provided.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
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Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings and activities, attend all lectures and tutorials punctually and take all scheduled assignments by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for lectures you have missed. You are expected to participate in discussions and activities in class.

Policy (Absenteeism)

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for tutorial activities.

Policy (Others, if applicable)

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Last Updated By: Siti Nur Amirah Binte Suhari