Academic Year	AY20/21	**Semester**	1
Course Coordinator	Motoki Yamane		
Course Code	CM4031		
Course Title	Asymmetric Synthesis		
Pre-requisites	CM3031 or by permission		
No of AUs	3		
Contact Hours	Lectures: 39 hours (3 hours per week)		
Proposal Date	10 December 2019		

Course Aims

This course aims to introduce the principles of asymmetric synthesis. You will learn about various methodologies for controlling the absolute stereochemistry of the desired product in organic synthesis, including natural product synthesis. The course will also introduce advanced topics such as asymmetric catalysis and the application of chiral synthons in total synthesis.

Intended Learning Outcomes (ILO)

Upon successful completion of this course, you should be able to:

1. Describe the basic principles of asymmetric synthesis, including the classification, representation, and significance of chirality
2. Describe the various approaches to asymmetric synthesis, including the use of a chiral pool of reagents, diastereoselective synthesis, and enatioselective synthesis
3. Identify thermodynamic- and kinetic factors that dictate the outcomes of asymmetric synthetic reactions
4. Describe various asymmetric synthesis methods for making C–H, C–C, and C–O bonds, explain their underlying mechanisms, and apply them to the synthesis of various target molecules, including natural products

Course Content

Review of the basic principles of chirality and stereochemistry, and the historical development of these topics

Asymmetric reactions involving C–H bond formation via reduction of ketones and hydrogenation of alkenes

Asymmetric reactions involving C–C bond formation via α-alkylation of carbonyl compounds, aldol reactions, and Diels-Alder reactions

Asymmetric reactions involving C–O bond formation via epoxidation and dihydroxylation

Application to the synthesis of natural products

Assessment (includes both continuous and summative assessment)

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. Midterm Test 1	1, 2	Competence, Creativity	20%	Individual	Point-based marking (not rubrics based)
2. Midterm Test 2	3, 4	Competence, Creativity	20%	Individual	Point-based marking (not rubrics based)
3. Examination	1, 2, 3, 4	Competence, Creativity	60%	Individual	Point-based marking (not rubrics based)
Total			100%		

Formative feedback

You will be given feedback in three ways:

1. By working through examples provided during lectures
2. By response to postings on the course discussion board
3. By attending consultation hours
4. By studying the comments provided by the instructor after the grading of the midterms

Learning and Teaching approach

Lectures	Face-to-face lectures will be employed to enable you to interact directly with the instructor.

Reading and References

Recommended textbook: Principles of Asymmetric Synthesis, 2nd Ed. (2012), by Robert Gawley and Jeffrey Aube, Elsevier; ISBN-13: 9780080448602 (paperback) or 9780080914138 (e-book)

Course Policies and Student Responsibilities

(1) General

You are expected to read the lecture materials prior to the lecture session in question. This will help you to learn much more efficiently as you will already have an impression on the topics to be covered. You should also read the textbook and to attempt the exercises provided in the problem sets.

(2) Absenteeism

If you miss a lecture, you are expected to make up for the lost learning activities. If you miss the mid-term test with approval, you will either be offered a make-up test or grading based upon the final exam score.

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. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Motoki Yamane	SPMS-CBC-03-03	6513 7367	yamane@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Classification of chirality, representation of chirality, identification of stereoisomers, number of stereoisomers	1	Lecture, problem set
2	History of tartaric acid, biological significance of stereoisomers, separation of stereoisomers	1	Lecture, problem set
3	Approaches to symmetric synthesis via chiral pool, diastereoselective, and enantioselective methods	2, 3	Lecture
4	Thermodynamic and kinetic control in asymmetric synthesis, methods to determine enantiomeric excess	3	Lecture
5	Asymmetric C–H bond formation via reduction of ketones, metal hydrides, β-hydrides, transition metal-catalyzed hydrogenations, BINAL-H, kinetic resolution	4	Lecture, assessment
6	Asymmetric C–H bond formation via hydrogenation of alkenes, Wilkinson's catalyst, reactivities of alkenes, enantioselective hydrogenation, hydrometalation, hydroformylation	4	Lecture

7	Asymmetric C–C bond formation via α-alkylation of carbonyl compounds, regioselective enolate formation, diastereoselective α-alkylation, chiral auxiliary method	4	Lecture
8	Asymmetric C–C bond formation via the aldol reaction, cross-aldol reaction, regioselective enolate formation, diastereoselective aldol reaction, asymmetric aldol reaction	4	Lecture
9	Asymmetric C–C bond formation via the Diels-Alder reaction, stereochemical requirements, regioselectivity, diastereoselective and enantioselective Diels-Alder reactions	4	Lecture
10	Asymmetric C–O bond formation via epoxidation, metal-catalyzed, Sharpless epoxidation	4	Lecture, assessment
11	Asymmetric C–O bond formation via dihydroxylation, asymmetric dihydroxylation,	4	Lecture
12	Natural product synthesis: corossoline and prostaglandins	4	Lecture
13	Review	1, 2, 3, 4	Lecture

CBC Programme Learning Outcome

The Division of Chemistry and Biological Chemistry (CBC) offers an undergraduate degree major in Chemistry that satisfies the American Chemical Society (ACS) curricular guidelines and equips students with knowledge relevant to the industry. Graduates of the Division of Chemistry and Biological Chemistry should have the following key attributes:

1. Competence

Graduates should be well-versed in the foundational and advanced concepts of chemical science, be able to evaluate chemistry-related information critically and independently, and be able to use complex reasoning to solve emergent chemical problems.

2. Creativity

Graduates should be able to synthesize and integrate multiple ideas across the curriculum, and propose innovative solutions to emergent chemistry-related problems based on their training in chemistry.

3. Communication

Graduates should be able to demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds. They should also be able to effectively engage other professional chemists in collaborative endeavours.

4. Character

Graduates should be able to act in responsible ways and uphold the high ethical standards that the society expects of professional chemists.

5. Civic-mindedness

Graduates should be aware of the impact of chemistry on society, and how chemistry can be applied to benefit mankind. They should also be aware of and uphold the best chemical safety practices.