

Course Title	<b>Advance Biological Chemistry</b>		
Course Code	<b>CM9051</b>		
Offered	Study Year 1, Sem 2   Study Year 2, Sem 2   Study Year 3, Sem 2   Study Year 4, Sem 2		
Course Coordinator	Loh Zhi Heng (Assoc Prof)	zhiheng@ntu.edu.sg	6592 1655
Pre-requisites	{CM1051, CM2031} or {CM2031, CY1101} (or by permission)		
AU	3		
Contact hours	Lectures: 39		

## Course Aims

The course aims to equip you with in-depth knowledge in biochemistry and modern biotechnology. It also aims to develop your understandings in the chemical principles behind a selection of key biological phenomena. Finally it will prepare you for Year 4 P.E. CM4051. The course would offer solid theory and knowledge supports to those of you who will seek career in biotechnology and related industrial venues.

## Intended Learning Outcomes

Upon successfully completing this course, you should be able to:

1. The structures and properties of amino acids: identify  $\alpha$ -amino and side groups of aminoacids, deduce the stereochemistry of  $\alpha$ -carbon and categorize side groups
2. The four level of protein structures: draw structure and resonance of the peptide bond, write primary structure and the sequence of proteins, describe the structural parameters of secondary structure and differentiate the major forces to fold the tertiary and quaternary structures of proteins and their biofunctions
3. Biological functions of proteins and enzymatic kinetics: a) describe the major functions of proteins in the biological systems b) distinguish six major types of enzymes.
4. Enzymatic Kinetics: a) illustrate Michaelis-Menten equation and Lineweaver-Burk equation of one step enzymatic reactions b) apply basic enzyme kinetics to study the enzyme activity and regulation by binding ligands.
5. Cofactors of enzymes: a) categorize enzymatic cofactors b) draw the structures and reaction mechanisms of redox cofactor, thiamine and biotin
6. Structure of oligonucleotides: a) distinguish the structures of nucleobases, nucleosides, nucleotides and polynucleotides b) Illustrate the helical structures of genomic DNA and the stabilizing forces.
7. Chemical and enzymatic principles of central dogma: a) Explain the unique and common properties and biofunctions of genomic DNA and four types of RNA. b) Demonstrate the procedure, protein complex and energy cost of DNA replication, RNA transcription and protein translation. c) Illustrate the polynucleotide chain reaction. d) Interpret the regulation of gene expression
8. Structures of hexose, disaccharides and polysaccharides: a) draw four stereo-chemical projections and the interconversion of linear and cyclic structures of hexose and disaccharides. b) describe the structure and glycosidic linkages of natural polysaccharides such as starch, cellulose, and chitin
9. Chemical and enzymatic principles of glucose catabolism: a) demonstrate the stepwise reactions and enzymes in the catabolism pathways, including glycolysis, citric acid cycles, electron chain transport and photosynthesis. b) calculate the interconversion ratio and stoichiometry between high energy metabolites and ATP production.

10. Structure and unique properties of lipid molecules: a) categorize lipid molecules b) demonstrate the nomenclature of unsaturated fatty acids c) Comprehend the cell membrane structures and cell permeability
11. Demonstrate the metabolism of fatty acids
12. Calculate the energy output from fatty acids oxidation
13. Compare the metabolisms of different biomolecules
14. Work as a team on the projects: a) balance the work load among team members b) maintain a friendly and constructive learning atmosphere within a team c) practise peer studying and peer mentoring with team members

## Course Content

Syllabus and the structures and properties of amino acids

Protein Structures and kinetics

Protein cofactors and DNA structures

DNA replication

Transcription and RNA processing

Protein synthesis

Carbohydrates structures

Glycolysis

Citric acid cycles

Electron transport chain and photosynthesis

Lipid, membranes

Fatty acids metabolism

Revisions on the topic discussed earlier

## Assessment

Component	Course ILOs tested	SPMS-CBC Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
<b>Continuous Assessment</b>					
<b>Mid-semester Quiz</b>					
ResponseWare	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	1. a, b, c	20	individual	See Appendix for rubric
Mid-term	1, 2, 3, 4, 5, 6, 7, 8	1. a, b, c	20	individual	See Appendix for rubric
Homework	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	1. a, b, c 2. a, b 3. a, b	20	team	See Appendix for rubric
<b>Examination (2 hours)</b>					

Final Examination	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	1. a, b, c	40	individual	See Appendix for rubric
<b>Total</b>			<b>100%</b>		

These are the relevant SPMS-CBC Graduate Attributes.

### 1. Competence

- a. Be well-versed in the foundational and advanced concepts of chemical science
- b. Evaluate chemistry-related information critically and independently
- c. Use complex reasoning to solve emergent chemical problems

### 2. Creativity

- a. Synthesize and integrate multiple ideas across the curriculum
- b. Propose innovative solutions to emergent chemistry-related problems based on their training in chemistry

### 3. Communication

- a. Demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds
- b. Effectively engage other professional chemists in collaborative endeavours

## Formative Feedback

You will be given feedback in four ways:

1. By working through ResponseWare questions 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 instructors after the grading of homework and midterm tests

## Learning and Teaching Approach

<b>Lectures</b> (39 hours)	<p>1. Response Ware: Allow instructor to challenge students during lecture and to achieve instant feedback. And the students to review the knowledge point right after the delivery and to master the knowledge in-depth. This approach is an online technology that can free students from the classroom and allows them to address the questions at their convenient and comfortable locations. The approach can also be applied to team work.</p> <p>2. Team based peer studying: Develop communication skills, team bonding, team work skills while working together as a group on homework and projects. The students also have the opportunity to conduct peer mentoring and peer studying during study.</p> <p>3. Video: Videos and animations were prepared for biological pathways, such as replication, transcription, ATP synthase, PCR, metabolism of carbohydrates and lipids. These videos will be played in class for preview and review the topics, or be placed online for students' review and exam preparation. This will facilitate the understanding of complicate biological pathways and complex structures of biomacromolecules. Besides reading references, this would offer students alternative learning materials for better comprehension.</p>
-------------------------------	---

## Reading and References

1. Principles of biochemistry, 5th ed. by D.L. Nelson & M.M. Cox ISBN-10: 1429234148
2. Bioorganic chemistry : highlights and new aspects by U. Diederichsen & T.K. Lindhorst ISBN: 3-527-29665-4
3. Oligosaccharides, their synthesis and biological roles by Helen Osborn & Tariq Khan ISBN-10: 0198502656
4. Bioorganic chemistry : peptides and proteins by Sidney M. Hecht ISBN: 9780195084689
5. Bioorganic chemistry : a chemical approach to enzyme action by Hermann Dugas. ISBN: 978-1-4612-2426-6

## Course Policies and Student Responsibilities

### Absence Due to Medical or Other Reasons

If you are sick and unable to attend your class , you have to:

1. Send an email to the instructor regarding the absence and the requests for a replacement class if necessary.
2. Submit the original Medical Certificate\* to administrator.
3. Attend the assigned replacement class (subject to availability).

\* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

## 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
Loh Zhi Heng (Assoc Prof)	SPMS-CBC-01-19A	6592 1655	zhiheng@ntu.edu.sg

## Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Syllabus and the structures and properties of amino acids	1, 2	
2	Protein Structures and kinetics	2, 3, 14	
3	Protein cofactors and DNA structures	3, 4, 5	
4	DNA replication	6	
5	Transcription and RNA processing	7	
6	Protein synthesis	8	
7	Carbohydrates structures	9	

8	Glycolysis	10	midterm
9	Citric acid cycles	10	
10	Electron transport chain and photosynthesis	10	
11	Lipid, membranes	11	
12	Fatty acids metabolism	13	
13	Revisions on the topic discussed earlier	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	

## Appendix 1: Assessment Rubrics

### Rubric for Mid-semester Quiz: ResponseWare (20%)

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer Responseware questions correctly in and out of class. Complete homework punctually and correctly, working very effectively as a team to maintain a highly supportive and constructive learning atmosphere with well-balanced workload among team members (Learning Outcome 14). Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 13 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in Responseware questions in and out of class. Complete homework punctually and be correct on majority of the questions, working effectively as a team to maintain a supportive and constructive learning atmosphere with balanced workload among team members (LO 14). Able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in Responseware questions in and out of class. Complete homework with average marks, working somewhat effectively as a team to maintain a somewhat supportive and constructive learning atmosphere with a somewhat balanced workload among team members (LO 14). Partially able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in Responseware questions in and out of class. Not able to complete homework on time or achieve average marks, working somewhat ineffectively as a team to maintain a supportive and constructive learning atmosphere with a somewhat unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in Responseware questions in and out of class. Not able to complete homework, and work ineffectively as a team to maintain a supportive and constructive learning atmosphere with unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.

### Rubric for Mid-semester Quiz: Mid-term (20%)

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer Responseware questions correctly in and out of class. Complete homework punctually and correctly, working very effectively as a team to maintain a highly supportive and constructive learning atmosphere with well-balanced workload among team members (Learning Outcome 14). Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 13 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in Responseware questions in and out of class. Complete homework punctually and be correct on majority of the questions, working effectively as a team to maintain a supportive and constructive learning atmosphere with balanced workload among team members (LO 14). Able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.

B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in Responseware questions in and out of class. Complete homework with average marks, working somewhat effectively as a team to maintain a somewhat supportive and constructive learning atmosphere with a somewhat balanced workload among team members (LO 14). Partially able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in Responseware questions in and out of class. Not able to complete homework on time or achieve average marks, working somewhat ineffectively as a team to maintain a supportive and constructive learning atmosphere with a somewhat unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in Responseware questions in and out of class. Not able to complete homework, and work ineffectively as a team to maintain a supportive and constructive learning atmosphere with unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.

### Rubric for Mid-semester Quiz: Homework (20%)

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer Responseware questions correctly in and out of class. Complete homework punctually and correctly, working very effectively as a team to maintain a highly supportive and constructive learning atmosphere with well-balanced workload among team members (Learning Outcome 14). Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 13 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in Responseware questions in and out of class. Complete homework punctually and be correct on majority of the questions, working effectively as a team to maintain a supportive and constructive learning atmosphere with balanced workload among team members (LO 14). Able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in Responseware questions in and out of class. Complete homework with average marks, working somewhat effectively as a team to maintain a somewhat supportive and constructive learning atmosphere with a somewhat balanced workload among team members (LO 14). Partially able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in Responseware questions in and out of class. Not able to complete homework on time or achieve average marks, working somewhat ineffectively as a team to maintain a supportive and constructive learning atmosphere with a somewhat unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in Responseware questions in and out of class. Not able to complete homework, and work ineffectively as a team to maintain a supportive and constructive learning atmosphere with unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.

### Rubric for Examination: Final Examination (40%)

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer Responseware questions correctly in and out of class. Complete homework punctually and correctly, working very effectively as a team to maintain a highly supportive and constructive learning atmosphere with well-balanced workload among team members (Learning Outcome 14). Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 13 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in Responseware questions in and out of class. Complete homework punctually and be correct on majority of the questions, working effectively as a team to maintain a supportive and constructive learning atmosphere with balanced workload among

	team members (LO 14). Able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in Responseware questions in and out of class. Complete homework with average marks, working somewhat effectively as a team to maintain a somewhat supportive and constructive learning atmosphere with a somewhat balanced workload among team members (LO 14). Partially able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in Responseware questions in and out of class. Not able to complete homework on time or achieve average marks, working somewhat ineffectively as a team to maintain a supportive and constructive learning atmosphere with a somewhat unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in Responseware questions in and out of class. Not able to complete homework, and work ineffectively as a team to maintain a supportive and constructive learning atmosphere with unbalanced workload among team members (LO 14). Not able to apply the knowledge learned with referenced to the LO 1 to 13 to answer most of the questions in written exams.