Academic Year	AY22/23	**Semester**	1
Course Coordinator	Ling Xing Yi		
Course Code	CM4013		
Course Title	Current Topics in Analytical Chemistry		
Pre-requisites	(CM2011 and CM2062 and CM3062) or by permission		
No of AUs	3		
Contact Hours	Lectures: 39 hours		
Proposal Date	16 November 2022		

Course Aims

This course aims to develop your ability to apply a selection of bioanalytical methods:

You learn how to perform a quantitative analysis of a given sample starting from the preliminary steps of sampling and sample preparation. You will be able to choose the proper analytical method and interpret the results obtained. You will get in-depth knowledge on bioanalytical chemistry and its most important techniques, including bioanalysis, biomaterials, electroanalytical methods, with focus on point-of-care diagnosis and food quality control. You will be able to compare the results obtained by traditional analytical techniques to those obtained from more modern approaches by using chemical sensors and biosensors.

Intended Learning Outcomes (ILO)

By the end of this course the students should be able to:

1. **<u>Introduction to Analytical Methods</u>**
    a) Define analytic chemistry.
    b) List the application fields of analytic chemistry.
    c) Describe the development of analytical chemistry since the 19th century.
    d) Classify analytical methods.
    e) Identify the proper analytical method for the analysis, based on sample size and analyte level.
    f) Explain the problems involved in 'real sample analysis'
    g) Identify the right method to choose for the given sample
    h) Explain how to perform sampling and sample processing
    i) Describe how to apply different methods to eliminate the interferences
    j) Describe how to measure the property which correlates to the analyte concentration
    k) Explain how to calculate and evaluate the obtained results

2. **<u>Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays</u>**
    a) Define immunoassays
    b) List application fields of immunoassays
    c) Describe immunoassay formats and advantages

d) Describe protein structure and conformation
e) Explain enzyme working principles and their function in immunoassays
f) Describe antibody structure and functions
g) Classify antibodies according to their different properties and binding capability
h) Define ELISA Immunoassays
i) Describe the main components of ELISA Immunoassays
j) Explain the working principle of ELISA Immunoassays
k) List the most common ELISA formats
l) Explain how to represent ELISA results
m) Describe strategies for signal amplification in ELISA Immunoassays

3. <u>Current Methods for DNA Analysis: From Classical Techniques to Next Generation Sequencing (NGS)</u>

a) Describe different chromatography methods in food analysis
b) Identify the best chromatographic technique for the analysis of specific analytes in food samples
c) Define polynucleotides.
d) Classify polynucleotides according to their structure.
e) Explain DNA double helix structure.
f) Describe DNA hybridisation and denaturation.
g) Describe 'genes' and their characteristics.
h) Explain the occurrence of 'single nucleotide polymorphisms' and the effects of their presence in a DNA sequence
i) Explain how DNA can be amplified by PCR
j) Explain how human genome was sequenced during HGP by using chain-termination method
k) Identify the improvements in DNA sequencing by NGS technologies
l) Identify the future trends in this field based on third generation sequencing

4. <u>Introduction to Chemical Sensors and Biosensors</u>

a) Define 'Chemical Sensors' and 'Biosensors'
b) Describe the working principles of 'Chemical Sensors' and 'Biosensors'
c) Explain the advantages of using chemical sensor and biosensors as compared to traditional techniques
d) List the bio-recognition elements that can be used in biosensors

e) Explain the recognition event
f) Describe the different recognition mechanisms
g) Describe the detection techniques used in chemical sensors and biosensors
h) Explain how a chemical sensor is developed based on different materials, methods, and fabrication techniques
i) Illustrate chemical sensors and biosensors main features
j) List chemical sensor and biosensor application fields

5. Chemical Sensors: Applications to Real Life

a) Define Clark Oxygen Sensor
b) Describe the main components of Clark Oxygen Sensor
c) Explain the working principle of Clark Oxygen Sensor
d) Describe healthcare and environmental applications of Clark Oxygen Sensor

6. Advanced Techniques for Point-of-care Diagnosis: Enzymatic, DNA and Immunosensors

a) Describe the importance of DNA analysis and how it can be performed by using DNA sensors
b) Define 'DNA Sensors' and explain their working principles
c) Describe the different approaches for DNA probe immobilization and how to carry out DNA hybridization
d) Describe the detection techniques used in DNA sensors and their applications
e) Describe 'Aptasensors' and the advantages of replacing antibodies with aptamers
f) Define Enzymatic Sensors and describe their working principle
g) List the biorecognition elements and transducers used in Enzymatic Sensors
h) Explain how the traditional glucometer works and describe the different alternatives for glucose sensing
i) Define Immunosensors and describe their working principles
j) Describe immunosensors formats and transduction
k) Explain how the home pregnancy test works
l) Describe the different tests for early detection of colorectal cancer

7. Novel Analytical Tools for Food Analysis

a) Define Food Analysis

b) Explain why Food Analysis is carried out and who will conduct it
c) Explain what food quality and safety are
d) Explain how food quality can be assessed by traditional techniques and by electrochemical transducers
e) Explain how food samples can be analysed to detect bacteria contamination
f) Describe different chemical sensor and biosensor that can be used for Food Analysis

8. <u>Advanced Materials used in Analytical Chemistry</u>

a) Define 'nanotechnology' and describe different kinds of nanomaterials
b) Explain the characteristics of nanomaterials and how they can be synthesised
c) List nanotechnology general applications
d) Describe the use of gold nanoparticles and semiconductor quantum dots as labels in chemical sensors
e) Describe the use of carbon nanomaterials as platforms and support for labels in chemical sensors
f) Explain how nanomaterials can contribute to signal enhancement in chemical sensors

Course Content

1. Introduction to Analytical Methods
2. Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays
3. Current Methods for DNA Analysis: From Classical Techniques to Next Generation Sequencing (NGS)
4. Introduction to Chemical Sensors and Biosensors
5. Chemical Sensors: Applications to Real Life
6. Advanced Techniques for Point-of-care Diagnosis: Enzymatic, DNA and Immunosensors
7. Novel Analytical Tools for Food Analysis
8. Advanced Materials used in Analytical Chemistry

Assessment (includes both continuous and summative assessment)

Component	ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment Rubrics
1. Midterm Test	1 – 3	Communication & Competence.	30%	Individual	Point-based marking (not rubrics based)
2. Final Examination	4 – 8	Communication & Competence.	30%	Individual	Point-based marking (not rubrics based)
3. Literature Review	1 – 8	Communication, Competence, Creativity	15%	Individual	See Appendix 1
4. Oral Presentation	1 – 8	Communication, Competence, Creativity	20%	Team	See Appendix 2
5. Peer Evaluation	1-8	Competence, Communication Critical thinking	5%	Individual	See Appendix 3
Total			100%		

Description of Assessment Components:

Assessment Component	Description
Literature review	Student will choose a published article related to advanaced analytical technique, and critically read and identify the purpose of individual article, and research on the relevant background and related information online. They will then summarize in an essay.
Oral presentation	It will be done in a group of 2-4 students, whereby the group members will discuss and select a project on the latest development of analytical chemistry. The presentation ends with questions and answer session, it will be a peer-questioning session where other non-presenting students will ask questions.
Peer Evaluation	Students will review group members' contribution and performance in the group oral presentation. This will allow students to critique and provide feedback to each other on their work.

Formative feedback

Formative feedback: Lecturer(s) will be closely working with students to monitor their learning progress. They will provide students with timely feedback to improve their understanding of concepts. Furthermore, students will be given opportunities to express their ideas and discuss them with lecturer (s).

Summative Feedback: Summative feedback on mid-term tests, literature review and oral presentation will be given. Students will be provided with comments on common mistakes, and areas of improvement.

This will help students to achieve the intended learning outcomes 1 to 8 above.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lectures	A "blended" learning approach will be adopted, involving both online and face-to-face lectures. Online knowledge clips containing basic background on analytical and bioanalytical techniques will be uploaded every week, for students to watch and complete a LAMS sequence before each face-to face lecture. During the lectures, students will learn detailed principles and protocols for analytical and bioanalytical chemistry. The concepts will be illustrated with worked examples and with real world applications to show the relevance and importance of learning these topics and their links to our daily life. In addition, students will be encouraged to ask questions or have discussions during and after the lecture.
Oral presentation	It is done in a group of 2-4 students, whereby the group members will discuss and select a project on how to make use nanoscience and nanotechnology to resolve the issues that are related to the Singapore government future research and innovation roadmap. The presentation ends with questions and answer session, where I have invited a panel of 5 members to evaluate their performance and ask related questions to probe students' understanding on their topic. The Q&A session is also open to all participants, where all students will be given the opportunity to interact with each other. The learning outcomes of the oral presentation is multiple-pronged. Firstly, the students must learn to work in a group, mimicking their future work place and scenario. Students will need to discuss and come to an agreed topic for discussion. Also, an oral presentation is one of the way to conveys information. This will be important for students as a future worker to present, inform or persuade a new idea/ product.
Literature review	The aim of literature review is to encourage the students to have more critical thinking - in terms of reading and writing. In

	particular, students are to critically read and identify the purpose of individual article, and research on the relevant background and related information online. For the critical writing part, only when fully understand the context of the article, students are able to evaluate and critique in the quality of the article.
Peer Evaluation	Students will review group members' contribution and performance in the group oral presentation. This will allow students to critique and provide feedback to each other on their work.

Reading and References

Recommended textbook: Fundamentals of Analytical Chemistry, by Skoog, West, Holler and Crouch, 8th edition, Thomson, 2004. Brooks/Cole Cengage Learning. ISBN: 0534417973

Recommended textbook: Chemical Sensors and Biosensors, Fundamentals and Applications, by F.G. Banica, Wiley 2012. ISBN: 978-0-470-71066-1

Course Policies and Student Responsibilities

(1) General
You are expected to read the lecture/tutorial/laboratory materials prior to the respective lectures. This will help you to learn much more efficiently as you will already have an impression on the topics to be covered. You are also advised to read through the recommended textbooks as outlined in the Weekly Schedule.

(2) Absenteeism
If you miss a lecture, you are expected to make up for the lost learning activities. If you are sick and unable to attend your class, you have to:

1. send an email to the instructor regarding the absence
2. submit the Medical Certificate* to the school administrator. **(*** the medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.)

There will be make-up test for those who miss the mid-term test with approval.

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
Ling Xing Yi	CCEB-04-07	6513 2740	xyling@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Introduction to Analytical Methods	1	Skoog West Ch 1, and Ch 8
2	Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays	1	Banica Ch 2, Ch 3, and Ch 6
3	Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays	2	Banica Ch 2, Ch 3, and Ch 6
4	Current Methods for DNA Analysis: From Classical Techniques to Next Generation Sequencing (NGS)	2	Banica Ch 2, Ch 3, and Ch 6
5	Current Methods for DNA Analysis: From Classical Techniques to Next Generation Sequencing (NGS)	3	Banica Ch 7
6	Oral Presentation	1 – 8	Assessment
7	Midterm Test	1 – 3	Assessment
8	Introduction to Chemical Sensors and Biosensors	4	Skoog West Ch 18, Banica Ch 1
9	Chemical Sensors: Applications to Real Life	5	Skoog West Ch 23
10	Advanced Techniques for Point-of-care Diagnosis: Enzymatic, DNA and Immunosensors	6	Banica Ch 7
11	Advanced Techniques for Point-of-care Diagnosis: Enzymatic, DNA and Immunosensors	6	Banica Ch 7
12	Novel Analytical Tools for Food Analysis	7	Skoog West Ch 18, Banica Ch 1

13	Advanced Materials used in Analytical Chemistry	8	Banica Ch 8, and Ch 20

The above schedule is for illustrative purposes and is subject to the exigencies of the calendar

Appendix 1: Assessment Criteria for Literature Review

Rubric for Literature Review (15%)

Excellent (13 – 15 marks)	Demonstrates complete achievement of the learning outcomes 1 – 8. Able to critically summarize and appraise a scientific literature. Able to highlight the major research finding and breakthrough of the literature and demonstrate excellent understanding of the research in a related field. Identify and ask critical questions on potential research gaps and inconsistencies in the work.
Good (10– 12 marks)	Demonstrates complete achievement of the learning outcomes 1 – 8. Able to summarize a scientific literature. Demonstrate good understanding of the research in a related field. Identify and ask questions related to potential research gaps and inconsistencies in the work.
Satisfactory (7 – 9 marks)	Demonstrates partial achievement of the learning outcomes 1 – 8. Able to summarize a scientific literature, but may not be precise enough. Demonstrate some level of understanding of the research in a related field. Able to partially identify and ask questions related to potential research gaps and inconsistencies in the work
Unsatisfactory (4 – 6 marks)	Demonstrates minimal achievement of the learning outcomes 1 – 8. Not able to summarize a scientific literature. Demonstrate minimal understanding of the research in a related field. Not able to identify and ask questions related to potential research gaps and inconsistencies in the work.
Poor (<3 marks)	Does not possess sufficient understanding on the learning outcomes 1 – 8. Not able to summarize a scientific literature. Not able to understand related research. Not able to identify and ask questions related to potential research gaps and inconsistencies in the work.

Appendix 2: Assessment Criteria for Oral Presentation

Rubric for Oral Presentation (20%)

Performance Level	**Criteria**
Excellent (20 – 17 marks)	Demonstrates complete achievement of the learning outcomes 1 – 8. Able to organize the team to present the assigned topic and answer the comments/questions after the oral presentation. Show good communication ability to lead the team and peer tutor the team members.
Good (16 – 13 marks)	Demonstrates complete achievement of the learning outcomes 1 – 8. Able to present the scientific topic and have good communication with the team members.
Satisfactory (12 – 9 marks)	Demonstrates partial achievement of the learning outcomes 1 – 8. Able to present the scientific topic but may not be precise or concise enough.
Unsatisfactory (8 – 5 marks)	Demonstrates minimal achievement of the learning outcomes 1 – 8. Not able to present the scientific topic well or have difficulty to maintain good communication with the team member.
Poor (<5 marks)	Do not possess sufficient understanding on the learning outcomes 1 – 8. Not able to complete presentation and not able to answer questions.

Appendix 3: Assessment Criteria for Peer Evaluation

Rubric for Peer Evaluation (5%)

5-4	**4-3**	**3-2**	**2-1**	**1-0**
Contribution to the team's presentation was exceptional, i.e. student put in fair share of work, supported other team members and contributed significantly to prepare and improve the overall presentation.	Contribution to the team's presentation was significant, i.e. student put in fair share of work and supported other team members.	Contribution to the team's presentation was at least adequate, i.e. student put in fair share of work.	Insufficient contribution to the team's presentation, i.e. student did not do fair share of work.	No contribution to the team's presentation.