Academic Year	AY20/21	**Semester**	1
Course Coordinator	Alessandra Bonanni (Dr)		
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		

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	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Midterm Test 1	1, 2, 3,	Competence, Creativity	20%	Individual	
2. Midterm Test 2	4, 5, 6	Competence, Creativity	20%	Individual	

3. Final Examination	1, 2, 3, 4, 5, 6, 7, 8	Competence, Creativity, Written Communication	60%	Individual	
Total			*100%*		

Formative feedback

Formative feedback: Lecturer will be closely working with you to monitor your learning progress. She will provide you with timely feedback to improve your understanding of concepts. Furthermore, you will be given opportunities to express your ideas and discuss them with lecturer.

Summative Feedback: Summative feedback on mid-term tests will be given. You will be provided with comments on common mistakes, and areas of improvement.

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

Learning and Teaching approach

Lectures (39 hours)	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 you to watch and complete a LAMS sequence before each face-to face lecture. During the lectures, you 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, you will be encouraged to ask questions or have discussions during and after the lecture.

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

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.

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
Alessandra Bonanni (Dr)	SPMS CBC-04-19	6316 8757	a.bonanni@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	Introduction to Analytical Methods	1	Skoog West Ch 1, and Ch 8
3	Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays	2	Banica Ch 2, Ch 3, and Ch 6
4	Current Techniques for Antibody/Antigen Detection: ELISA Immunoassays	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	Current Methods for DNA Analysis: From Classical Techniques to Next Generation Sequencing (NGS)	3	Banica Ch 7
7	Introduction to Chemical Sensors and Biosensors	4	Skoog West Ch 18, Banica Ch 1
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

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.