NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	1
Course Coordinator	Asst Prof. Dang Thuy Tram		
Course Code	BG4231		
Course Title	Advanced Biomaterials		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	39 hours lecture, 0 hours tutorial		
Proposal Date	19/05/2020		

Course Aims

This course will discuss advanced topics related to advanced biomaterials with a focus on soft, polymeric biomaterials for biomedical applications. Basic concepts and methodology on polymer synthesis, polymer physiochemical and biological characterization will be systematically introduced. Strategies for selection of polymer design to optimize their immuno-compatibility, biodegradability and optimal implant performance will also be illustrated via real-world clinical applications in medical devices, drug delivery, tissue engineering and consumer care. Students will also be briefly introduced to key concepts in commercialization, clinical translation and regulatory issues related to biomaterial applications via examples of entrepreneurship and start-up companies in biotech industry.

Intended Learning Outcomes (ILO)

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

1. Describe and explain basic principles of polymer synthesis and characterization
2. Explain and evaluate material selection and structure-function relationships
3. Describe and differentiate methodologies for biological characterization of biomaterials including blood-material compatibility, in vitro cell/tissue-compatibility and in vivo tissue-compatibility.
4. Describe and explain technologies for material formulation and patterning for micro/nanoparticles and hydrogels
5. Explain biocompatibility and its significance in implant performance
6. Explain biodegradability concept and how it affects biomaterial design
7. Apply biomaterial concepts and principles in selecting materials for different applications in medical device, drug delivery systems and tissue engineering
8. Identify and discuss issues related to commercialization, clinical translation and regulatory issues related to biomaterial applications.
9. Evaluate biomaterials and their application using reference materials and concepts introduced in the lectures
10. Critically analyse and evaluate relevant biomaterial literature
11. Communicate clearly and accurately biomaterial-related topics to peers and the public

Course Content

The following subjects are to be covered in this course,

1. Introduction to basic concepts and methodology on polymer synthesis, polymer physiochemical and biological characterization and polymer patterning
2. Structure-function relationship and the importance of polymer selection and design considerations, particularly on biocompatibility
3. Application of biomaterial concepts and principles in selecting biomaterials for different applications in medical device, drug delivery systems and tissue engineering

4. Concepts in commercialization, clinical translation and regulatory issues related to biomaterial applications with examples of start-up companies.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
1.Group project and presentation (40%)	7,8,9,10,11	a,b,d,f,h, i, j, l	40%	Team	Annex 1
2. Final Examination (60%) (2hrs, Closed Book)	1-8	a,b,c,f,h	60%	Individual	
Total			100%		

Mapping of Course ILOs to EAB Graduate Attributes

Course Intended Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	Core	●	●	◐	◐		●		●	●	●	š	●
Understand and explain basic principles of polymer synthesis and characterization													a,b,c
Understand material selection and structure-function relationships													a,b,c
Describe and understand methodologies for biological characterization of biomaterials including blood-material compatibility, in vitro cell/tissue-compatibility and in vivo tissue-compatibility.													a,b,c
Understand and explain technologies for material formulation and patterning for micro/nanoparticles and hydrogels													a,b,c
Understand biocompatibility and its significance in implant performance													a,b,c
Explain what biodegradability is and how it affects biomaterial design													a,b,c
Apply biomaterial concepts and principles in selecting materials for different applications in medical device, drug delivery systems and tissue engineering													a,b,c,d,f,h
Identify and discuss issues related to commercialization, clinical translation and regulatory issues related to biomaterial applications.													f,h,l
Read, understand and assimilate reference materials and lectures in the evaluation of biomaterials and their applications													d,f,h
Develop analysis and critical-thinking skills for the evaluation of relevant biomaterial literature													f,h,l
Communicate understanding of biomaterial-related topics to peers and the public													J,k

Legend:
- ● Fully consistent (contributes to more than 75% of Intended Learning Outcomes)
- ◐ Partially consistent (contributes to about 50% of Intended Learning Outcomes)
- š Weakly consistent (contributes to about 25% of Intended Learning Outcomes)
- Blank Not related to Student Learning Outcomes

Formative feedback

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Present real-life case study of biomaterials and its clinical application with open-ended questions given to students early in the lecture to stimulate questions from students and solicit thoughts from their peers before instructors provide further information. This approach helps students to actively synthesize their knowledge, critically evaluate given information and recognize different viewpoints from a multidisciplinary group of peers.
Tutorial	N/A

Reading and References

1. Biomaterials Science, An Introduction to Materials in Medicine, Edited by B.D. Ratner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press.
2. Advanced Biomaterials, Edited by Bikramjit B, Dhirendra K and Ashok K, Wiley, 2009.

Course Policies and Student Responsibilities

General: Students are expected to complete all online activities and take all scheduled assignments and tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all discussions and activities.

Continuous assessments: Students are required to attend all continuous assessments.
Absenteeism: Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

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
Dang Thuy Tram	N1.3-B3-09	6790-4257	ttdang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction to polymeric biomaterials	1,2,6	Lecture note 1
2	Characterization of polymeric biomaterials	3,5	Lecture note 2
3	Formulation and patterning of polymeric biomaterials	4	Lecture note 3
4	Application of Biomaterials in Medical Devices	5,7	Lecture note 4
5	Application of Biomaterials in Drug Delivery	7	Lecture note 5
6	Application of Biomaterials in Tissue Engineering	7	Lecture note 6
7	Commercialization, Clinical Translation and Regulatory Issues	8	Lecture note 7
8	Special topic	7,8,9,10,11	Student group presentation
9	Special topic	7,8,9,10,11	Student group presentation
10	Special topic	7,8,9,10,11	Student group presentation
11	Special topic	7,8,9,10,11	Student group presentation
12	Industry lecture	1,2,4,7	Lecture note from invited industry speaker

Appendix 1: Assessment Criteria for Project

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge Describe the basics of polymer design and synthesis	Poor familiarity of polymer design and synthesis	Below average familiarity of the basic polymer design and synthesis	Average familiarity of the basic polymer design and synthesis	Good familiarity of the basic polymer design and synthesis	Very good familiarity of polymer design and synthesis
Comprehension Discuss how material design relates to their bio/physico-chemical characteristics and influence their clinical performance	Poor understanding of how material design relates to their bio/physico-chemical characteristics and influence their clinical performance	Below average understanding of how material design relates to their bio/physico-chemical characteristics and influence their clinical performance	Average familiarity of the basic optics principles Average understanding of how material design relates to their bio/physico-chemical characteristics and influence their clinical performance	Good familiarity of the basic optics principles Good understanding of how material design relates to their bio/physico-chemical characteristics and influence their clinical performance	Very good familiarity of the basic optics Very good understanding of how material design relates to their bio/physico-chemical characteristics and influence their clinical performance
Application Evaluate the pros and cons of material section for specific medical application	Poor evaluation of the pros and cons of material section for specific medical application	Below average evaluation of the pros and cons of material section for specific medical application	Average evaluation of the pros and cons of material section for specific medical application	Good evaluation of the pros and cons of material section for specific medical application	Very good evaluation of the pros and cons of material section for specific medical application
Team work Demonstrate ability to contribute to group project	Made no effort to contribute during teamwork.	Did not contribute much effort during teamwork	Made some contributions but greater effort could have been exhibited during teamwork.	Exhibited appropriate effort in contributions during teamwork.	Demonstrate outstanding contributions and efforts during teamwork.

Assessment Form for Peer Evaluation (10%)
Please indicate your perceptions of other team member's contribution during the project development. Use the scale below for assessing each team member.

10-9	8-7	6-4	3-1	0
Demonstrate outstanding contributions and efforts during teamwork.	Exhibited appropriate effort in contributions during teamwork.	Made some contributions but greater effort could have been exhibited during teamwork.	Did not contribute much effort during teamwork.	Made no effort to contribute during teamwork.

Team member:											
Preparation for work accomplishment: completed readings.	10	9	8	7	6	5	4	3	2	1	0
Task-related collaborative behavior: task-focused, respectful of others, and cooperative.	10	9	8	7	6	5	4	3	2	1	0
Team adjustment behaviors: intra-team coaching, problem solving	10	9	8	7	6	5	4	3	2	1	0
Work behaviors: involved and participatory	10	9	8	7	6	5	4	3	2	1	0
Communication: information shared and exchanged, engaged in process, and made verbal contributions.	10	9	8	7	6	5	4	3	2	1	0
Provide constructive feedback for this team member. (Consisting of two to three sentences):											

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change