NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2024/2025	**Semester**	1
Course Coordinator	Prof. Duan Hongwei / Assoc Prof. Pu Kanyi		
Course Code	BG2131		
Course Title	Biomaterials (Core)		
Pre-requisites	NIL		
No of AUs	3		
Contact Hours	26 hours lecture, 12 hours tutorial		
Proposal Date	27 May 2020		

Course Aims

This course aims to support you to know and understand basic properties of biomaterials and methods so that we can manipulate them. You would also know the basic physiological consequences in relation to biomaterial implantation, and the methods for testing biomaterial compatibility. This knowledge is essential for biomedical engineers to work in biomedical fields.

Intended Learning Outcomes (ILO)

By the end of this lesson, you should be able to:

(1) Determine and predict how basic chemical properties and constituents of a biomaterial affect the bulk and surface structures of biomaterials
(2) Determine and predict how the structures of biomaterials affect their physical, mechanical, and degradation properties
(3) Identify key surface properties of biomaterials and various surface modifications methods to manipulate these properties
(4) Determine how the surface and bulk properties of biomaterials contribute to classical medical applications
(5) Determine the physiological consequences of interacting with biomaterials
(6) Identify and trace the biological events associated to biomaterials
(7) Describe and propose some basic methods for *in vitro* and *in vivo* testing.

Course Content

Biometals; Bioceramics; Biopolymers; Biodegradation of biomaterials; Surface properties and modification methods; Applications of biomaterials; Protein and cell interactions with biomaterials; innate and acquired immune response associated with biomaterials; thrombosis and infection associated with biomaterials; in vitro and in vivo assays for biomaterials.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
1) Quiz 1	LO 1-4	SLO a, b, c, d, e, g, h	20%	Individual	Appendix 1
2) Quiz 2	LO 5-7	SLO a, b, c, d, e, g, h	20%	Individual	Appendix 1

3) Final Examination (2hrs, Closed Book. Exam paper not allowed to be removed from exam hall)	LO 1-7	SLO a, b, c, d, e, g, h	60 %	Individual	Appendix 1
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)
BG2131	Core	●	●	●	●	●		◐	◐				

1) Determine and predict how basic chemical properties and constituents of a biomaterial affect the bulk and surface structures of biomaterials	a, b, c, d, e, g, h
2) Determine and predict how the structures of biomaterials affect their physical, mechanical, and degradation properties	a, b, c, d, e, g, h
3) Identify key surface properties of biomaterials and various surface modifications methods to manipulate these properties	a, b, c, d, e, g, h
4) Determine how the surface and bulk properties of biomaterials contribute to classical medical applications	a, b, c, d, e, g, h
5) Determine the physiological consequences of interacting with biomaterials	a, b, c, d, e, g, h
6) Identify and trace the biological events associated to biomaterials, and	a, b, c, d, e, g, h
7) Describe and propose some basic methods for *in vitro* and *in vivo* testing.	a, b, c, d, e, g, h

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

- CA questions are thoroughly discussed in the class;
- feedback will be provided to you on your approaches, common mistakes, and other general issues;
- Class average marks will be posted. Each student will also be informed of his/her CA marks;
- You are encouraged to drop by coordinator's office during the consultation hours to browse through their papers and discuss any issues, if needed.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working

	through a problem. Responseware questions are used to receive real-time feedback from student and enable students to participate in class.
Conceptual understanding	As this course is a core course related to biomedical application of materials, there will be a lot of emphasis on fundamental understanding of the concepts and self-directed learning. Though lecture notes are provided to students, they are encouraged to refer latest publications to test the students' critical understanding of the subject. Also, the presentation sections including the slide presentation and report will help students in achieving a comprehensive understanding of the contribution of nanotechnology to the medical field. Other approaches like responseware, and discussion sessions are in place to achieve the said learning outcomes.
Showing real-world applications	Most of the concepts in the course have real-world implications and applications. Therefore, they are used as examples while discussing the related concepts.
Use of Multimedia tools to teach abstract concepts and complex processes	Multimedia tools such as videos and animations have been selected exclusively for this course to help students better understand the contents.
Tutorial	Classroom discussion sessions on tutorial questions and related topics. Responseware questions are used to receive real-time feedback from students, followed by detailed discussion.

Reading and References

1. Biomaterials, J.S. Temenoff and A. G. Mikos (Editors); Pearson International Edition, 2008. ISBN 0-13-235044-0

2. Biological Performance of Materials, J.Black, Marcel Dekker, 3rd Edition, 1999. ISBN 0-82477106-0

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 tutorial 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
Duan Hongwei	N1.3-B3-12	83538461	hduan@ntu.edu.sg
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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction	1, 2	Lectures, responseware
2	Bio- Polymers	1, 2, 4	Lectures, responseware
3	Bio-Metals and Bio-Ceramics	1, 2, 4	Lectures, responseware
4	Metal corrosion and surface properties	1, 2, 3, 4	Lectures, responseware
5	Applications of biodegradable polymers	1, 2, 3, 4	Lectures, responseware
6	Applications of bio-metals and bio-ceramics	1, 2, 3, 4	Lectures, responseware
7	Quiz 1	1, 2, 3, 4	
8	Protein interactions with biomaterials and related assays	5, 6, 7	Lectures, responseware
9	Cell interactions with biomaterials and related assays	5, 6, 7	Lectures, responseware
10	Innate and acquired immune response associated with biomaterials and related assays	5, 6, 7	Lectures, res Lectures, responseware ponseware
11	Thrombosis and infection associated with biomaterials and related assays	5, 6, 7	Lectures, responseware
12	Quiz 2	5, 6, 7	
13	Summary	1, 2, 3, 4, 5, 6, 7	Lectures, responseware

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Essential knowledge Understand the principles of biomaterials	Fail to understand the definition and basic category of biomaterials	Able to understand the definition of biomaterials able to identify different biomaterials	Understand the definition of biomaterials able to identify different biomaterials, and understand their basis properties	Understand the definition of biomaterials able to differentiate different biomaterials, and know their individual properties	Understand the definition of biomaterials able to differentiate different biomaterials, know their individual properties and able to predict the potential properties of combinational biomaterials
Analysis Characterize biomaterials and quantify their properties	Fail to know the common methods to characterize biomaterials and quantify their basis properties	Know the common methods to characterize biomaterials and their procedures but do not understand which methods should be used to quantify the specific properties of biomaterials	Know the common methods to characterize biomaterials and understand which methods should be used to quantify the specific properties of biomaterials	Know the common methods to characterize biomaterial, understand which methods should be used to quantify the specific properties of biomaterials and know which methods are needed for particular materials but not familiar with the data analysis from the methods	Know the common methods to characterize biomaterial, understand which methods should be used to quantify the specific properties of biomaterials and know which methods are needed for particular materials and able to analyse the data to rank the properties of biomaterials
Application Apply biomaterials to solve medical problems	Fail to understand the importance of biomaterials in solving medical problems	Understand the importance of biomaterials in solving medical problems but can not categorize biomaterials into biomedical applications	Fully understand the importance of biomaterials in solving medical problems; and able to categorize some biomaterials into biomedical applications	Fully understand the importance of biomaterials in solving medical problems; able to categorize all the biomaterials into different biomedical applications; but unable to identify the necessary biomaterials that are needed to solve particular biomedical problem	Fully understand the importance of biomaterials in solving medical problems; able to categorize biomaterials into biomedical applications; and identify the necessary biomaterials that are needed to solve particular biomedical problem

Systematic understanding Relation of the structures, properties, and biocompatibility of biomaterials	Fail to understand the relationship between structures, properties, and biocompatibility of biomaterials	Know the general structures, properties, and biocompatibility of biomaterials but fail to correlate them with different biomaterials	Know the general structures, properties, and biocompatibility of biomaterials and able to correlate some of them with different biomaterials	Know the general structures, properties, and biocompatibility of biomaterials and able to clearly correlate all of them with different biomaterials	Know the general structures, properties, and biocompatibility of biomaterials, able to clearly correlate all of them with different biomaterials and know the potential new properties when combining some of the biomaterials.

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