Polymer Networks

Subject area: Biology/Biomedical Engineering

University: Technion
Level: BA4, MA all years, PhD
Teaching mode: hybrid: some students participate online, other students attend real-life
Instructor(s): Assistant Professor Joshua M. Grolman

Short description

The focus will be on relating structure with functionality, whether it be chemical or physical in nature, and how this affects biological phenotypes. Beginning with polymer composition, architecture, and mechanics, with a clear focus on macromolecular organization. We will then move from the small scale of how polymers behave in macromolecularly in networks up to the composites like the Extracellular Matrix, and eventually making our way to tissue

Full description

The aim of the course will be to develop student understanding of the many classifications of polymer network architectures, both natural and man-made. The focus will be on relating structure with functionality, whether it be chemical or physical in nature, and how this affects biological phenotypes. We will start with an overview of polymer composition, architecture, and mechanics, with a clear focus on macromolecular organization like networks. We will then move from the small scale of how polymers behave in macromolecularly in networks up to the composites like the Extracellular Matrix (ECM), and eventually making our way to tissue and organ-level structures. Mechanical properties of networks will be explained in the context of maximizing entropy, and we will briefly cover an introduction to Statistical Thermodynamics through this application. We will then cover how three different cell types interact on all levels with the architecture, primarily through the viewpoint of mechanics, though no prior knowledge of biology is expected. This course is targeted at students in Materials and Biology and Materials and Chemistry concentrations in our department but is expected to also draw students from Biomedical Engineering as well, in the final two or three semesters of their career.

1. Brief introduction/refresher on polymers and some examples of polymers both synthetic and biological. We will cover condensation reactions, free radical, as just some basic examples of how polymers are synthesized.
2. Polymer architecture including linear, block, star, comb, brush, dendrimer. We will also briefly cover strategies for making these polymers, including Ring Opening Metathesis Polymerization (ROMP), controlled radical polymerization, ionic interactions, etc. Further elaboration on how each of these systems are made will come on weeks 4 and 5.
3. Comparing how polymer architecture can drive different mechanical properties. Also, we will cover how mechanical properties are measured, the advantages and disadvantages of each.

4. Biological polymer network hydrogels architecture, synthesis, and mechanical properties. The differences between synthetic and biological systems will be discussed and highlighted.
5. Synthetic polymer network hydrogels architecture, synthesis, and mechanical properties. We will go through the last three decades of biomaterial research as a historical overview.
6. The structure-function relationships of the Extracellular Matrix and their components
7. The structure-function relationships of tissues and their components.
8. The cell lipid bilayer as a polymeric network. How 'non-traditional' macromolecular constructs can function as networks
9. The stem cell microenvironment. What effects does a network's architecture have on differentiation?
10. The cancer/tumor microenvironment. Why does a tumor stiffen and pre-stress the surrounding tissue? What changes does the ECM undergo?
11. Immunomechanics Part 1: Innate immunity and interactions with the ECM and Cell-Cell.
12. Immunomechanics Part 2: Adaptive immunity and interactions with the ECM.
13. Student final project presentation of a paper of their choice that includes polymeric architecture, where they will briefly present a paper explaining the main points of the paper. This project can be started after week 4.

Learning outcomes

After taking this class, students will become familiar with the many types of polymer networks, both those involved in biomaterials that are man-made as well as those found in living organisms. They will also gain an appreciation for the structure-function relationship between materials and their mechanical, chemical and biological outcomes.

General information

Contact hours per week:	3
Total workload:	60~ (in student hours for the whole course)
ECTS credits:	2.2
Language:	English
Course start date:	01 January 2023
Course end date:	01 July 2023
Add. info about start date:	
Weekly teaching day/time:	
Time zone:	CET +1 (Estonia, Israel)
Further information:	Please note that Technion does not work with ECTS. The amount of ECTS which you see in the description is meant to give an indication of the intensity of the course. However, the transcript of records will not be listing ECTS

Prerequisites:	Prerequisites (one of the following or an equivalent course): introduction to polymer science (314312), fundamentals of biomaterials (338401), fundamentals of biomechanics (334222) (315053) Biomedical Polymers
Activities and methods:	Lectures, Self-study, Exercises
Presence on campus:	Not required, but highly encouraged for active dialogue.

Final examination

Form:	Oral + Project
Date:	
Location/format:	online
Re-sit possibility:	yes
Transcript available:	on request
Add. info/requirements:	

Registration

To register for this course, follow the registration requirements of your **home university** as specified here: www.euroteq.eu/courses-registration.

Administration

Number of places:	5
Minimum participants:	
Internal course code:	
Contact:	Bat-el Almogy, academic@int.technion.ac.il

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