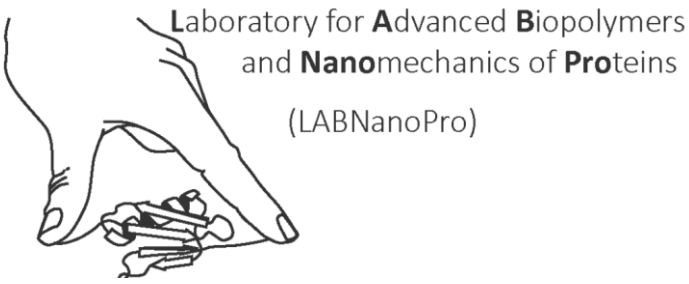
TECHNION Israel Institute of Technology | BME Faculty of Biomedical Engineering

Yuval Garini | Mail: Yuval.garini@technion.ac.il | Web: www.garini-lab.com | Tel: +972-77-887-1280

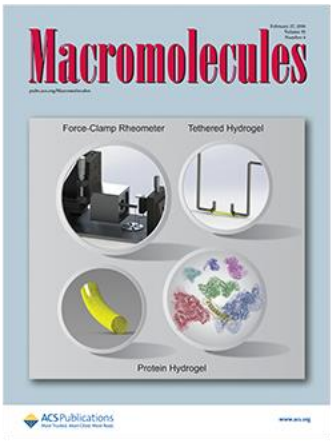
Mechanical response of proteins



Course type:	Lectures + homework + short quiz
Hours:	3h lectures X 4 meetings (total 13)
Academic points:	1.0
Website:	Moodle
Lecturer:	Prof. Ionel Popa, popa@uwm.edu Dept. of Physics, Univ. of Wisconsin-Milwaukee, WI, USA https://popalab.uwm.edu/

1 Course purpose:

Proteins are the busy workers keeping our cells alive and performing most of their function. Biochemical assay has been used to study proteins since men invented fire and boiled the first egg. However, there is a secret life that proteins have in vivo, of which we know very little, and which involves localized mechanical interactions, denaturation of the folded structure of a protein under a transient pulling vector from a neighboring molecule, and large assemblies and disassemblies of many proteins acting in a tag-of-war. These mechanical interactions have eluded scientists for so long, as they cannot be studied with typical biochemical assays. In this short course, I invite you to join me on a journey where we will look at proteins from a new perspective, that of mechanical interactions. During this class, I also plan to use hands-on experiments, to try to emphasize on various specific aspects of the unique mechanical response of proteins. As I plan to also explain the classical biochemical view alongside in most of the topics that we will touch, this class is also appropriate for students who did not take any biophysics or biology courses, but are curious to learn how the engines of our cells work inside our bodies.



2 Course subjects:

1. Introduction to biophysics
2. Short overview of cellular organization
3. The main structural levels of proteins from a mechanical perspective
4. The main stages of protein folding
5. What is an energy landscape?
6. Protein folding and unfolding under force and the multidimensionality of the protein energy landscape
7. How mechanical unfolding and refolding regulates stress
8. Single molecule force spectroscopy methods
9. In vivo and biomaterials approaches to study protein unfolding
10. Key characteristics related to mechanical unfolding and refolding of proteins in vivo
11. Muscular contraction and protein refolding-induced function
12. Cellular mechano-transduction – mechanical unfolding maintains the force balance and regulates the dynamics of the cellular cytoskeleton
13. How cells in our ears transform pressure waves into perceived sound
14. Force-regulated attachment of bacterial adhesion
15. How degradation of proteins requires mechanical unfolding of the tertiary structure

3 Course obligations and grade structure:

Required prior background: Mathematics courses, Basic physics courses.

Grade structure: Homework (40%), Attendance (30%), Short quiz (30%).

4 Bibliography

1. "Molecular Biology of the Cell", 7th Ed., by Bruce Alberts, 2022, ISBN 978-0393884821
2. "Giant Molecules: Here, There, and Everywhere", 2nd Ed., by Alexander Grosberg and Alexei R. Khoklov, 2010, ISBN 978-9812839220
3. "Integrated Molecular and Cellular Biophysics," by Valerica Raicu and Aurel Popescu, 2008, ISBN 978-1-4020-8267-2.
4. "Single-molecule Studies of Proteins," by Andres F. Oberhauser, 2013 ISBN 978-1-4614-4920-1
5. "The Physics of Proteins - An Introduction to Biological Physics and Molecular Biophysics," 2010, by Shirley S. Chan and Winnie S. Chan, ISBN 978-1-4419-1043-1.
6. "Single Molecule Spectroscopy in Chemistry, Physics and Biology," by Rudolf Rigler, Jerker Widengren, 2009, ISBN 978-3-642-02597-6.
7. "Multiscale Mechanics of Biological Materials," by Markus J. Buehler and Roberto Ballarini, 2013, ISBN 978-3-7091-1573-2.
8. "Molecular Force Sensors", by Rachel Bender and Khalid Salaita, 2021, ISBN 9780841299177
9. Journal papers

5 Possible seminar subjects

	Subject
1	Introduction and Cellular organization
2	Protein folding and structure, from a mechanical perspective
3	Energy landscapes as the protein's blueprint
4	The mechanical response of proteins
5	Methods to study mechanical unfolding of proteins
6	How cells and tissues use mechanical unfolding and refolding as a gain-of-function
7	Class recap & quiz