Starting in WS 2014, infos @ www.uni-ulm.de/biophysics

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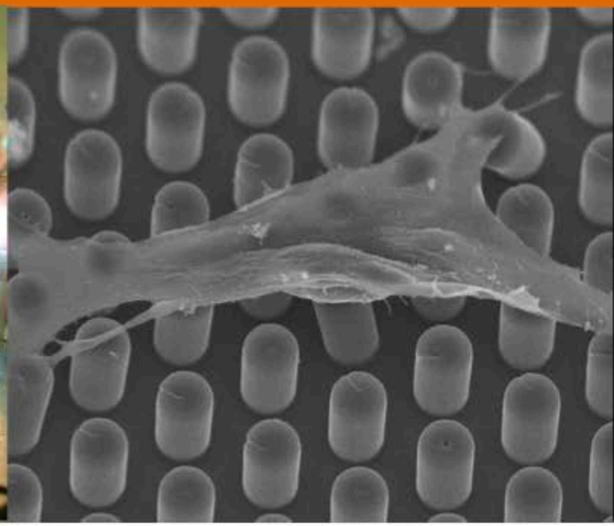
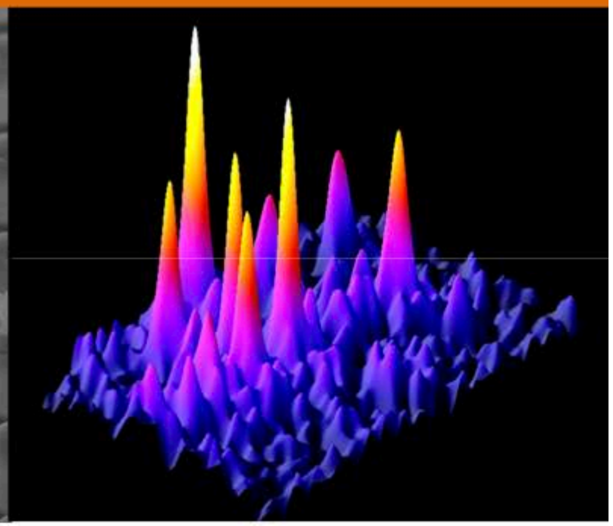


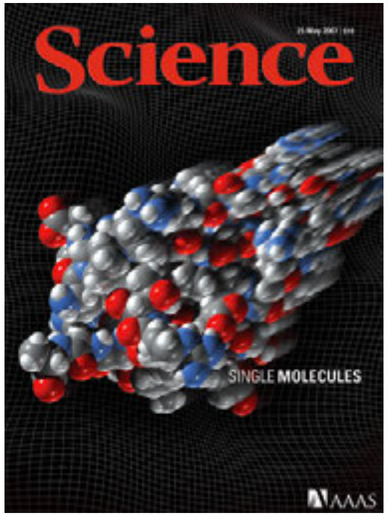


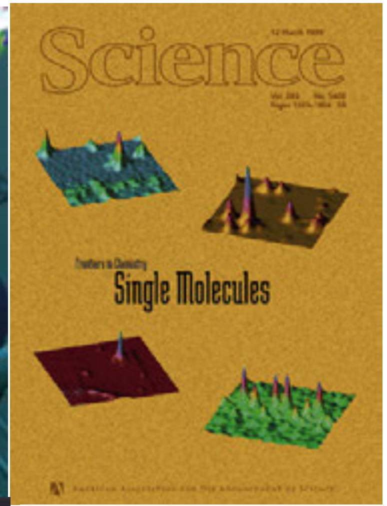
Master of Science in Biophysics

Faculty of Natural Sciences, Ulm University, Germany

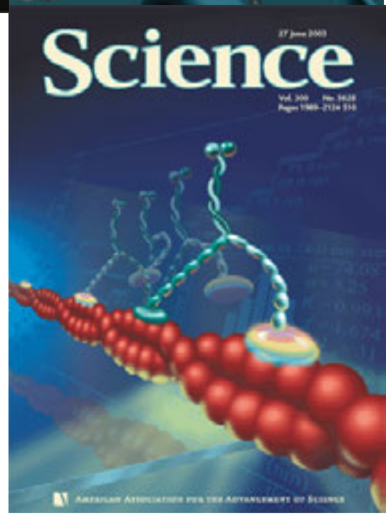
Jens Michaelis, Biophysics Institute, Ulm University

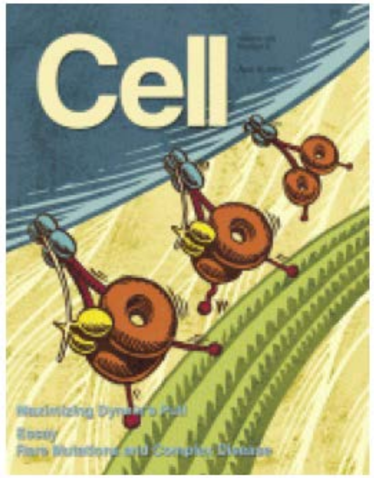
Why?





„The aim of the master's programme is to prepare students for the interdisciplinary nature of modern-day Life Sciences."





Why?.... asks the biochemist/biologist

PROLOGUE

Fifty years ago, biochemists described cells as small vessels that contain a complex mixture of chemical species undergoing reactions through diffusion and random collision. This description was satisfactory inasmuch as the intricate pathways of metabolism and, later, the basic mechanisms of gene regulation and signal transduction were still being unraveled. Gradually, and in part as a result of the parallel growth in our structural understanding of the molecular components of the cell, the limitations of this "chemical reactor" view of the cell became plain. Armed with a more precise knowledge of the structural bases of molecular interactions, the focus shifted more and more to the mechanisms by which these molecular components recognize and react with each other. Moreover, it also became clear that cells are polar structures and that the cell interior is neither isotropic nor homogeneous; that many of the essential processes of the cell, such as chromosomal segregation, translocation of organelles from one part of the cell to another, protein import into organelles, or the maintenance of a voltage across the membrane, all involve directional movement and transport of chemical species, in some cases against electrochemical gradients. Processes such as replication, transcription, and translation require directional readout of the information encoded in the sequence of linear polymers. Slowly, the old paradigm was replaced by one of a small "factory" of complex molecular structures that behave in machine-like fashion to carry out highly specialized and coordinated processes. These molecular machines are often complex assemblies of many proteins and contain parts with specialized functions, for example, as energy transducers or molecular motors, converting chemical energy (either in the form of binding energy, chemical bond hydrolysis, or electrochemical gradients) into mechanical work through conformational changes and displacements.

To understand the behavior of this molecular machinery requires a fundamental change in our conceptual and practical approaches to biochemical research. The cell, it appears, resembles more a small clockwork device than a reaction vessel of soluble components. Many of the functions of this device (which besides replication, transcription, translation, and organelle transport, include cell crawling, cell adhesion, protein folding, protein and nucleic acid unfolding, protein degradation, and protein and nucleic acid splicing) are indeed mechanical processes, and basic physical concepts such as force, torque, work, energy conversion efficiency, mechanical advantage, etc., are needed to describe them. The recent development of experimental methods that permit the direct

Carlos Bustamante

Annu. Rev. Biochem. 2004. 73:705–48

Why? ….. asks the chemist

The Nobel Prize in Chemistry

2013: Martin Karplus, Michael Levitt and Arieh Warshel
"for the development of multiscale models for complex chemical systems“

2012: Robert J. Lefkowitz and Brian K. Kobilka
"for studies of G-protein-coupled receptors“

2009: Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath
"for studies of the structure and function of the ribosome“

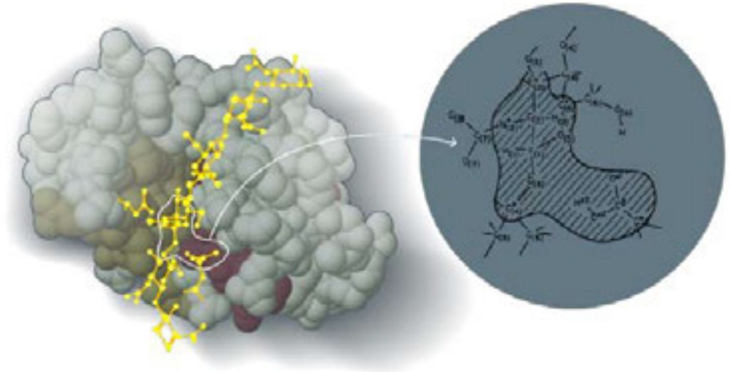
2008: Osamu Shimomura, Martin Chalfie and Roger Y. Tsien
"for the discovery and development of the green fluorescent protein, GFP“

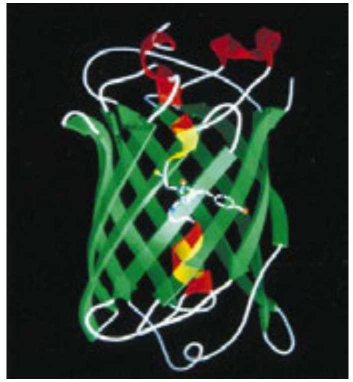
2006: Roger D. Kornberg
"for his studies of the molecular basis of eukaryotic transcription“

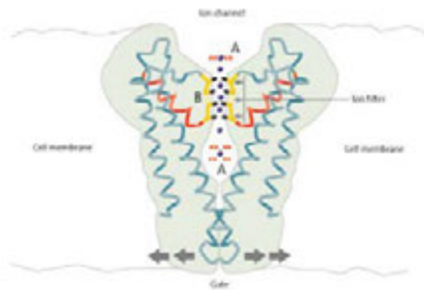
2004: Aaron Ciechanover, Avram Hershko and Irwin Rose
"for the discovery of ubiquitin-mediated protein degradation"

2003 Peter Agre, Roderick MacKinnon
„Channels in membranes“

2002: John B. Fenn, Koichi Tanaka, Kurt Wüthrich
„structure analyses of biological macromolecules“







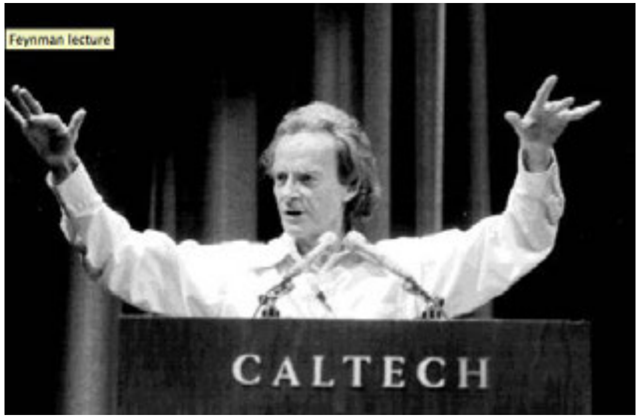
… 8 out of the 12 last Nobel prizes in chemistry related to biophysics

Why? ..... asks the physicst...

„It is very easy to answer many of these fundamental biological questions;

You just look at the thing!

You will see the order of bases in the chain; you will see the structure of the micro-cosm. Unfortunately, the present microscope sees at a scale which is just a bit too crude. Make the microscope one hundred times more powerful, and many problems of biology would be made very much easier. I exaggerate, of course, but the biologists would surely be very thankful to you---and they would prefer that to the criticism that they should use more mathematics."

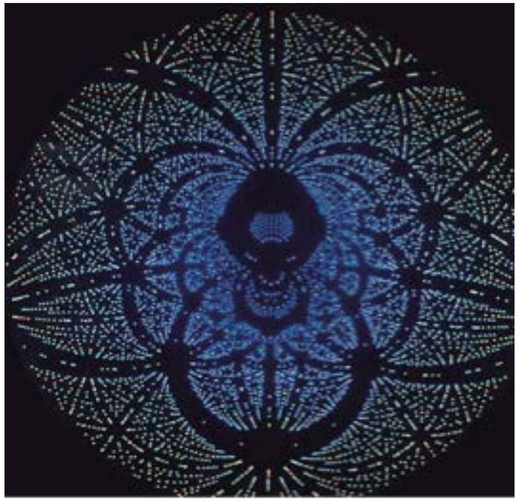


„There is plenty of room at the bottom"
Richard Feynman, APS meeting, Caltech, 1959

Why is biophysics important right now?

Society is facing physical and biological problems of global proportions.

- How will we continue to get sufficient energy?
- How can we feed the world's population?
- How do we remediate global warming?
- How do we preserve biological diversity?
- How do we secure clean and plentiful water?



These are crises that require scientific insight and innovation. Biophysics provides that insight and technologies for meeting these challenges, based on the principles of physics and the mechanisms of biology.

Curriculum

<table>
<tr><th>Semester</th><th colspan="4">Curriculum</th></tr>
<tr><td>1</td><td rowspan="2">Biophysics (Compulsories) 30 CP</td><td rowspan="2">Subject I (Electives) 6-12 CP</td><td rowspan="2">Subject II (Electives) 6-12 CP</td><td>Adaption Modules 9 CP</td></tr>
<tr><td>2</td><td>ASQ 3 CP</td></tr>
<tr><td>3</td><td>Biophysics Research Project 15 CP</td><td colspan="3">Selected Research Project 15 CP</td></tr>
<tr><td>4</td><td colspan="4">Master's Thesis 30 CP</td></tr>
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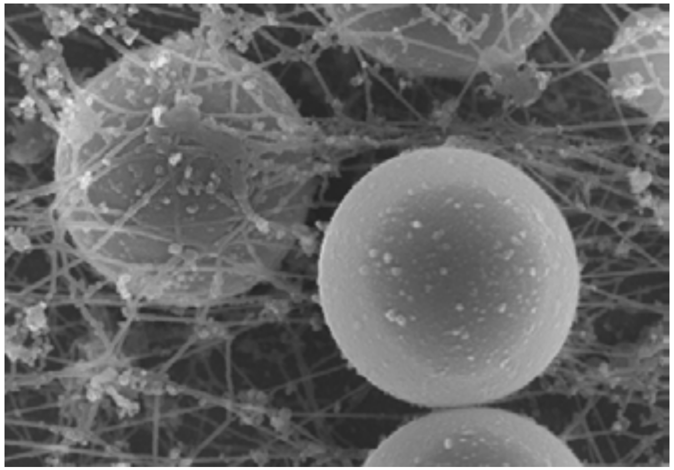
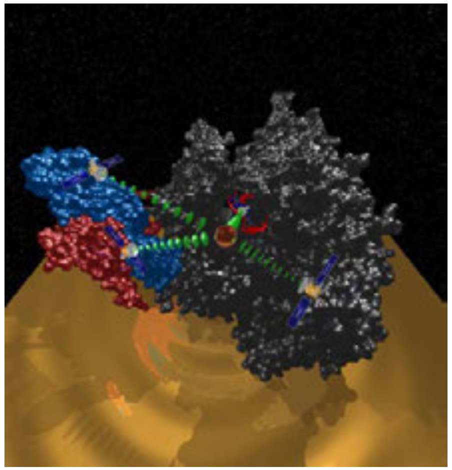
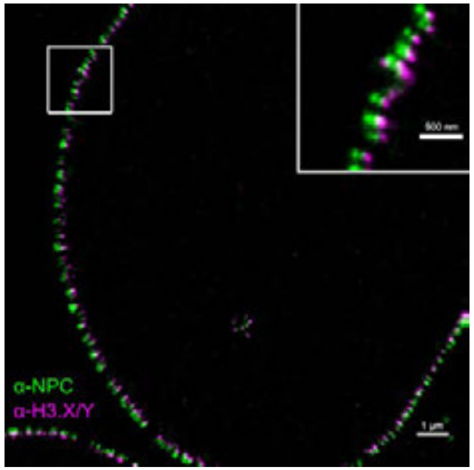
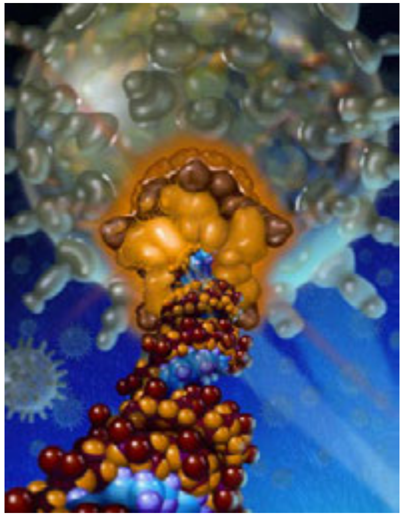


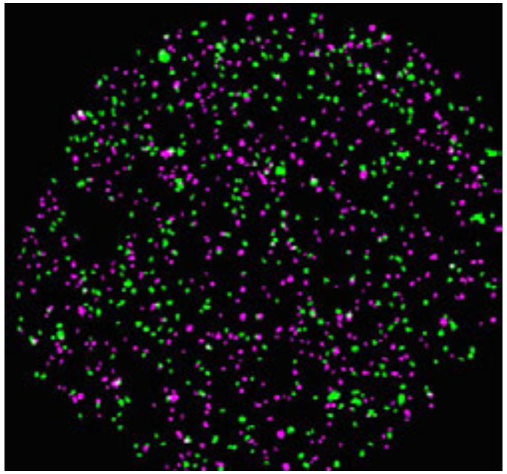


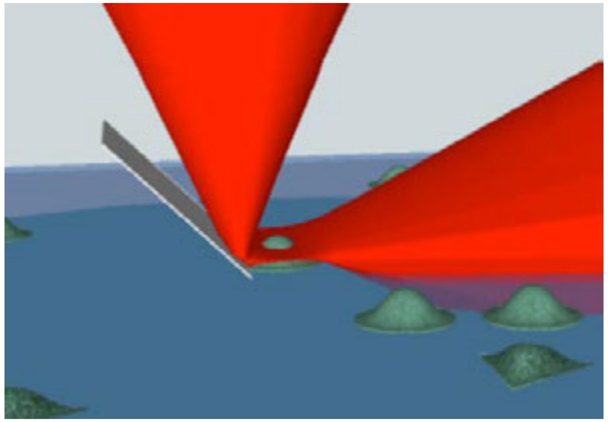


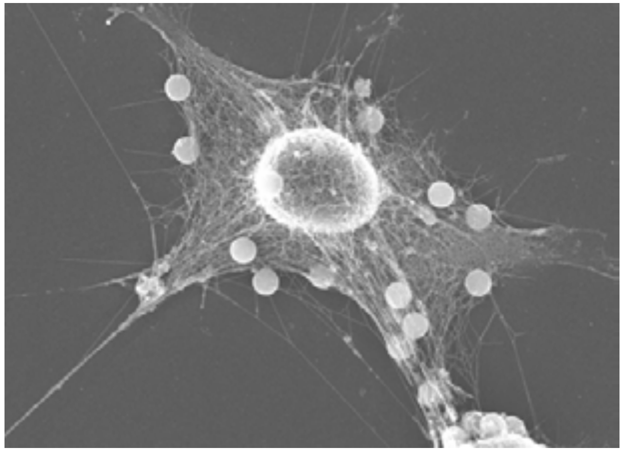
Curriculum: Compulsories

Biophysics (Compulsories) (30 CP):
- Biophysics Lab (8 CP)
- Biophysics Seminar (4 CP)
- Biophysics: Fundamentals (9 CP)
- Biophysics: Advanced Methods (9 CP)



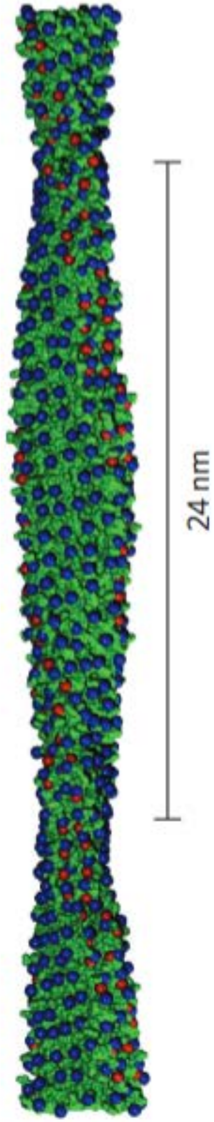


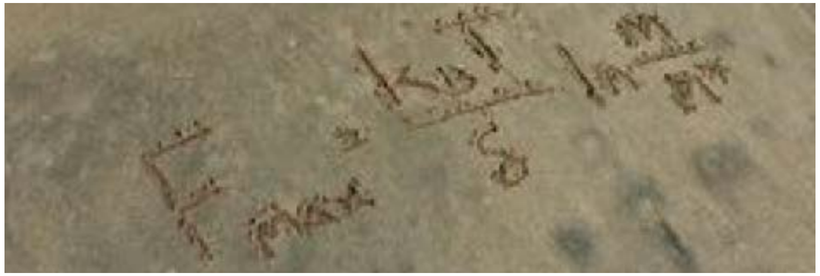


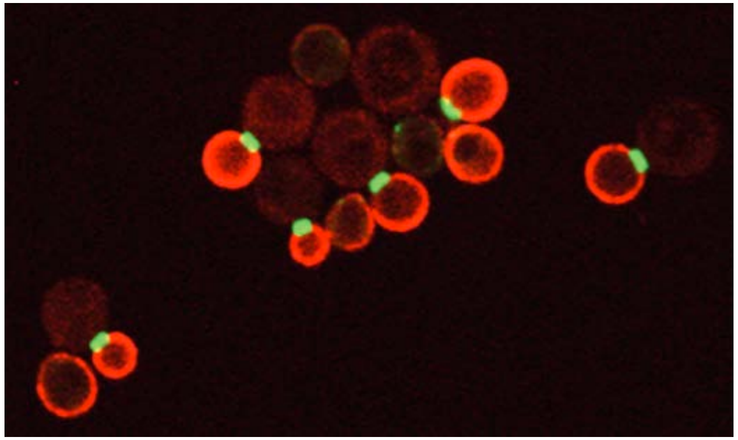


Curriculum: Electives

- Biochemistry
- Cell Biology and Genetics
- Inorganic Chemistry
- Molecular Medicine
- Neurobiology
- Organic Chemistry
- Physics and Biophysics
- Stochastics and Bioinformatics



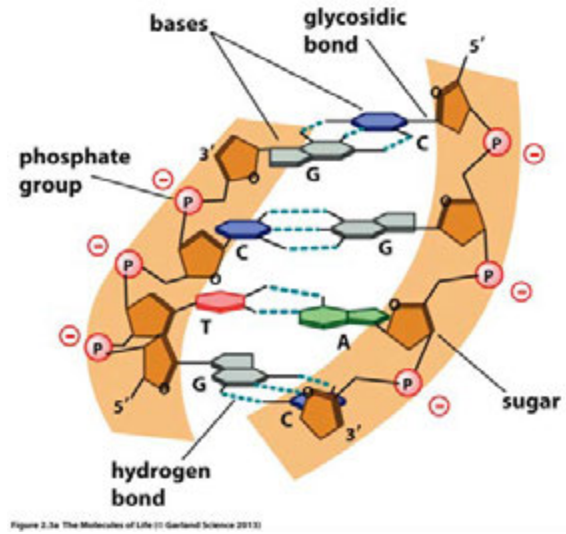




Curriculum: Adaptation

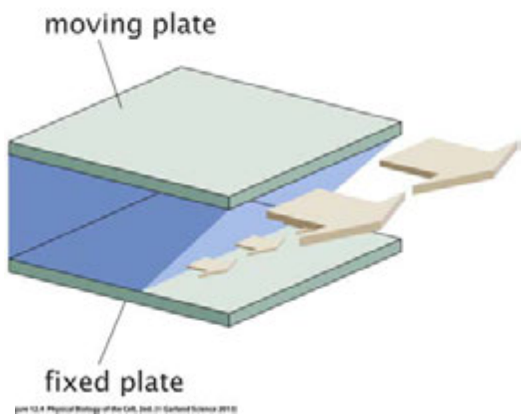
For People with **Bachelor in Physics** or related fields:

- Introduction to Chemistry 3 CP
- Introduction to Biology and Biochemistry 4 CP
- Introductory Biochemistry Lab 2 CP

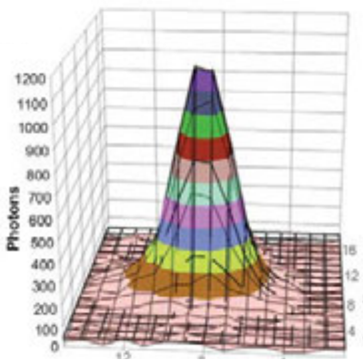


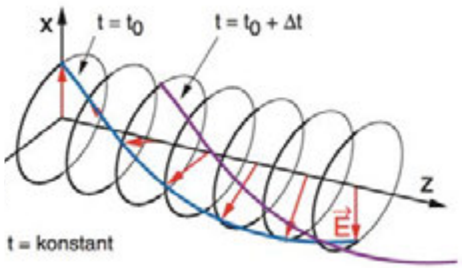
For People with **Bachelor in Biochemistry, Chemistry, Molecular Medicine, Biology**, etc.

- Mathematical Physics (Lecture and Excercises) 5 CP
- Introductory Physics Lab 4 CP



$$\left\langle (\Delta x)^2 \right\rangle = \frac{s^2 + a^2/12}{N} + \frac{8\pi s^4 b^2}{a^2 N^2}$$





Curriculum: Research