భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Introduction of Bio-nanotechnolgy
BT1110

Lecture 1 : Introduction

Himanshu Joshi 31 October 2023

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About the instructor

Himanshu Joshi

Laboratory of computational Bionanotechnology

Department of Biotechnology

Email:
hjoshi@bt.iith.ac.in

Web:
https://sites.google.com/view/molecular-simulation-lab

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About students

- Name and introduction
- Background
- Future Interest
- Contact information

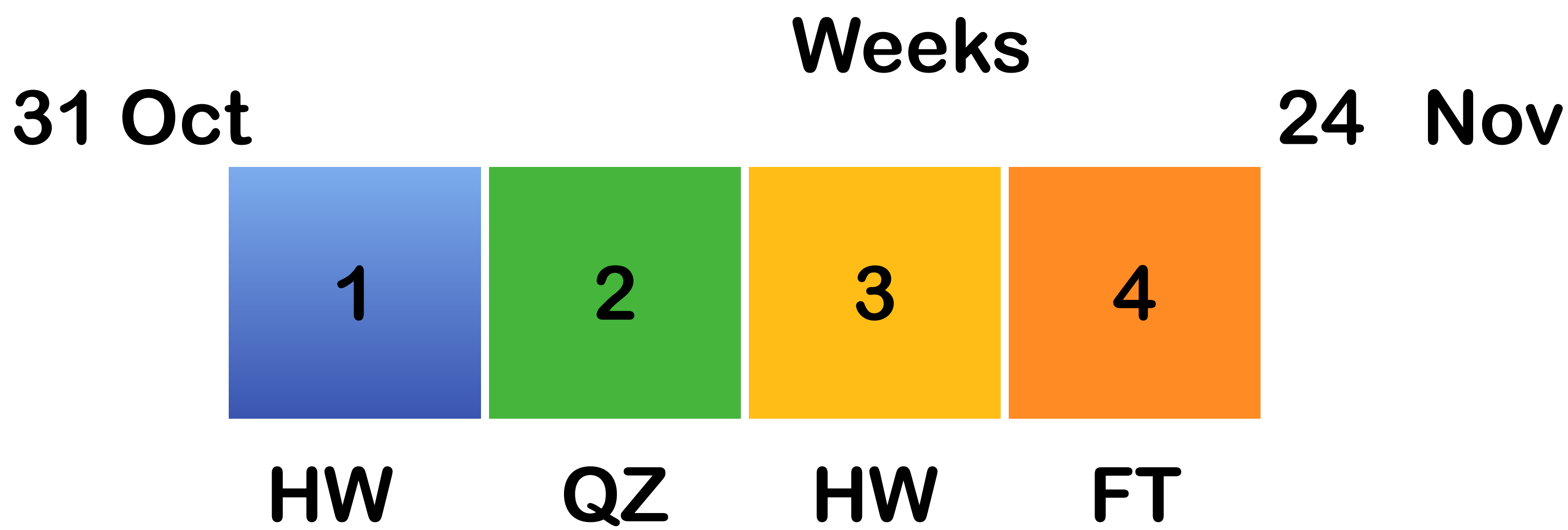
Objective of the course

- The course is designed to introduce the idea of living software revolution .
- What can we learn about the behavior of biological matter at nanoscale and engineer them for creating machines.
- From biomolecules to nanodevices for applications in electronics, agriculture, medicine etc.
- This course will help students in getting idea of the interdisciplinary nature of

Course contents

- Introduction to nanotechnology and bionanotechnology,
- Biological self-assembly
- Biologically inspired nanostructures - introduction to biomimetics
- Nucleic acid nanotechnology
- DNA origami
- Protein engineering
- Lipid nanotechnology
- Chirality in biological systems
- Interaction of nanomaterials with biological systems
- Virology: viruses and vaccines

Exam and evaluation



Homeworks/ Assignments/Reading project	20
2 quizzes one in each segment	20
1 final term exam	60
Total	**100**

Reference Books

1. ***Introduction to bionanotechnology*”.**

by

Young-Chul Lee and Ju-Young Moo

2. ***Physical Biology of the cell***

by

Rob Phillip, Jane Kondev and Julie Theriot

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Plenty of the room at the bottom

Plenty of Room at the Bottom

Richard P. Feynman
(Dated: Dec. 1959)

This is the transcript of a talk presented by Richard P. Feynman to the American Physical Society in Pasadena on December 1959, which explores the immense possibilities afforded by miniaturization.

I imagine experimental physicists must often look with envy at men like Kamerlingh Onnes, who discovered a field like low temperature, which seems to be bottomless and in which one can go down and down. Such a man is then a leader and has some temporary monopoly in a scientific adventure. Percy Bridgman, in designing a way to obtain higher pressures, opened up another new field and was able to move into it and to lead us all along. The development of ever higher vacuum was a continuing development of the same kind.

I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle. This field is not quite the same as the others in that it will not tell us much of fundamental physics (in the sense of, "What are the strange particles?") but it is more like solid-state physics in the sense that it might tell us much of great interest about the strange phenomena that occur in complex situations. Furthermore, a point that is most important is that it would have an enormous number of technical applications.

What I want to talk about is the problem of manipulating and controlling things on a small scale.

As soon as I mention this, people tell me about miniaturization, and how far it has progressed today. They tell me about electric motors that are the size of the nail on your small finger. And there is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin. But that's nothing; that's the most primitive, halting step in the direction I intend to dis-

can easily be adjusted in size as required by the photoengraving, and there is no question that there is enough room on the head of a pin to put all of the Encyclopaedia Brittanica.

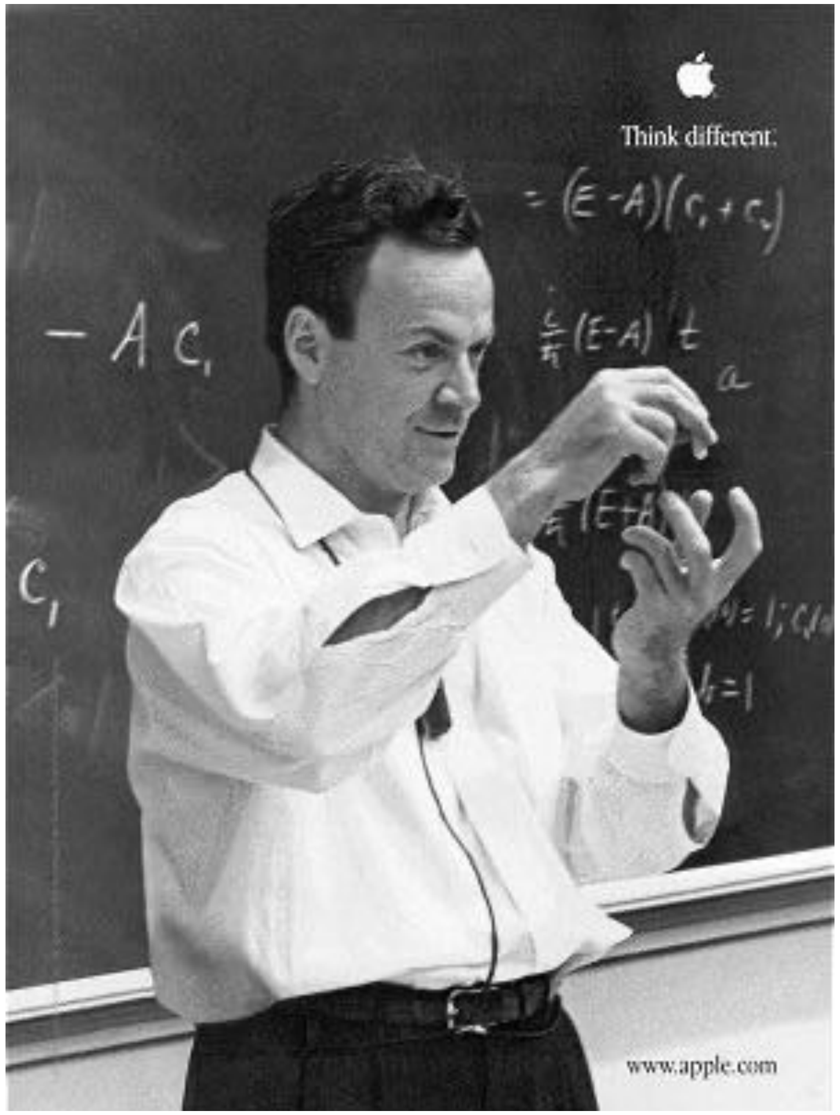
Furthermore, it can be read if it is so written. Let's imagine that it is written in raised letters of metal; that is, where the black is in the Encyclopedia, we have raised letters of metal that are actually 1/25,000 of their ordinary size. How would we read it?

If we had something written in such a way, we could read it using techniques in common use today. (They will undoubtedly find a better way when we do actually have it written, but to make my point conservatively I shall just take techniques we know today.) We would press the metal into a plastic material and make a mold of it, then peel the plastic off very carefully, evaporate silica into the plastic to get a very thin film, then shadow it by evaporating gold at an angle against the silica so that all the little letters will appear clearly, dissolve the plastic away from the silica film, and then look through it with an electron microscope!

There is no question that if the thing were reduced by 25,000 times in the form of raised letters on the pin, it would be easy for us to read it today. Furthermore; there is no question that we would find it easy to make copies of the master; we would just need to press the same metal plate again into plastic and we would have another copy.

How do we write small?

The next question is: How do we write it? We have



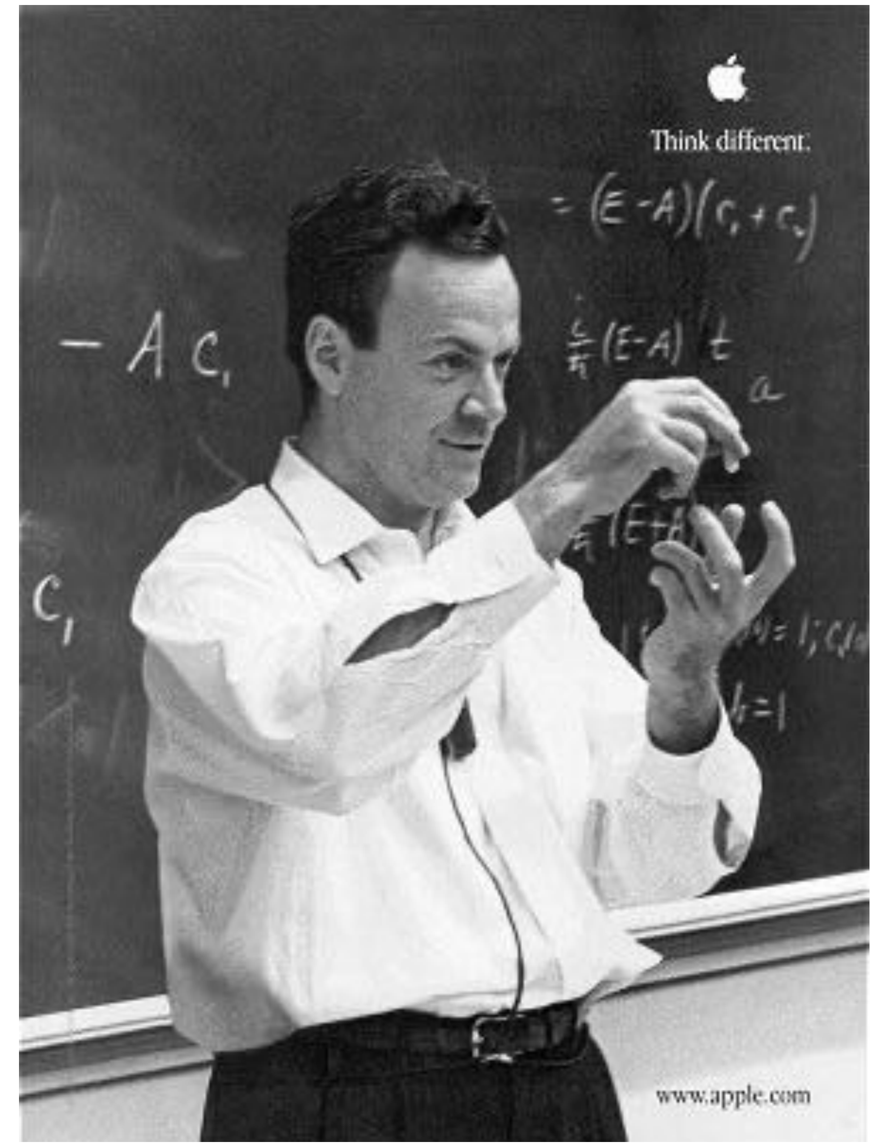
Richard Feynman

Nobel prize 1965

Motivation

There is plenty of room at the bottom.

"Everything that living things do can be understood in terms of the jigglings and wigglings of atoms".



Richard Feynman
Invented nanotechnology
"Plenty of the room at Bottom"
Caltech 1959

The idea of biomimetics

If you want to learn something built it

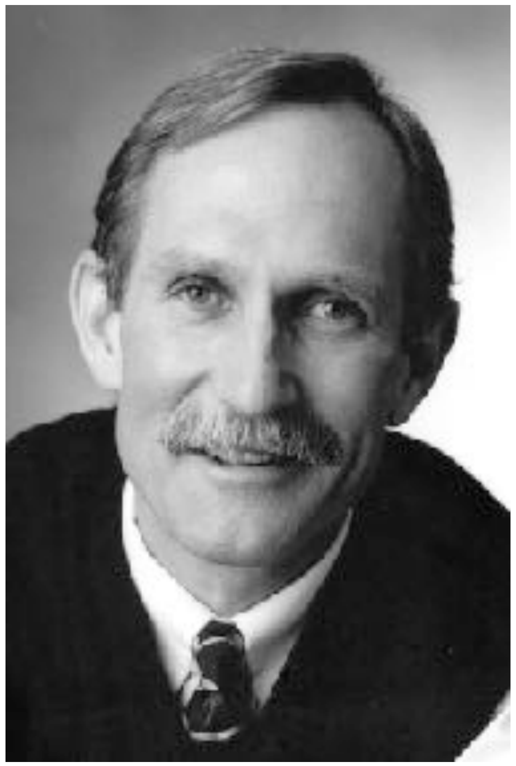
R. Feynman

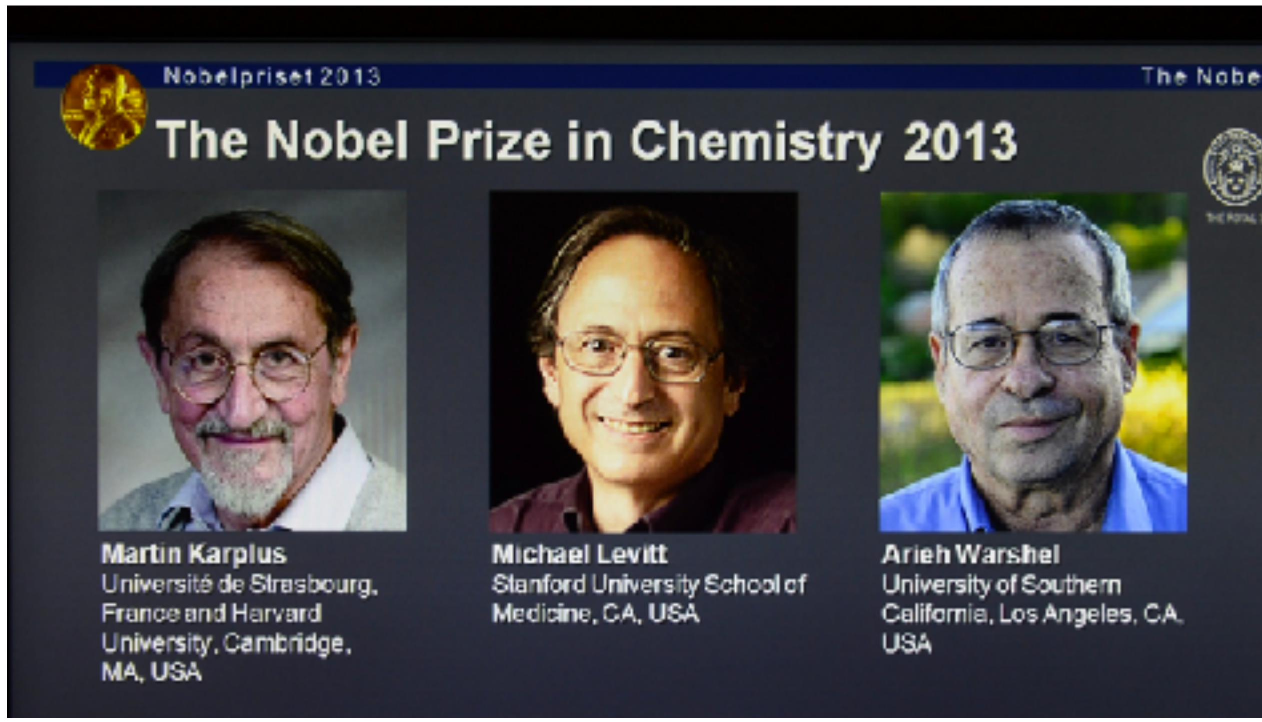
We want to learn how biology works at nanoscale and mimic for day to day technology

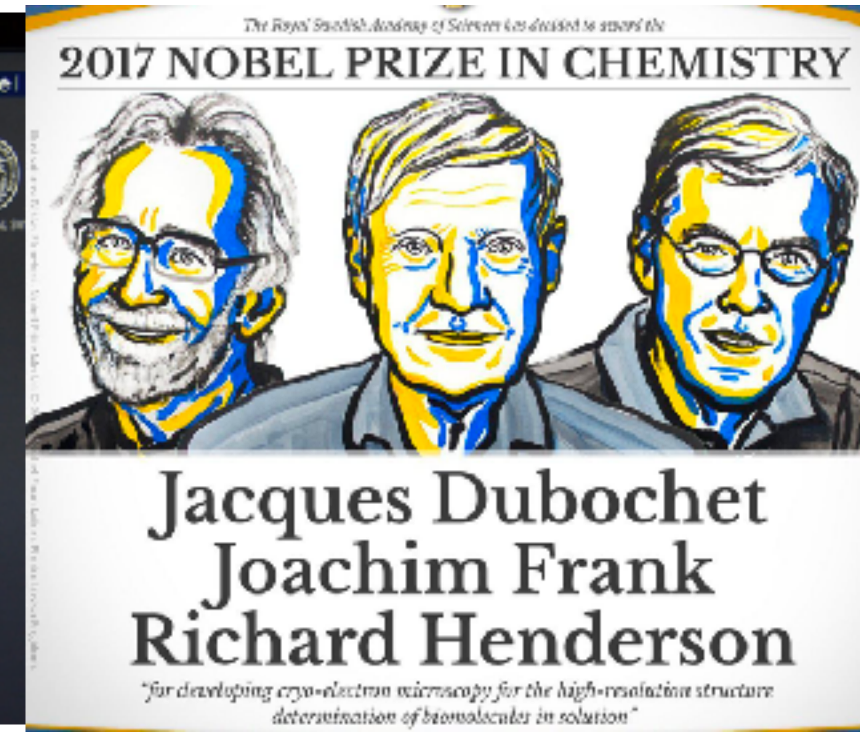
Link to a ted talk

https://www.youtube.com/watch?v=sjV7NNwm1GU&ab_channel=TEDxTalks

Recent recognitions







for the discovery of water channels

2003 Nobel prize

or the development of multiscale models for complex chemical systems

2013 Nobel prize

"for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution"

2017 Nobel prize

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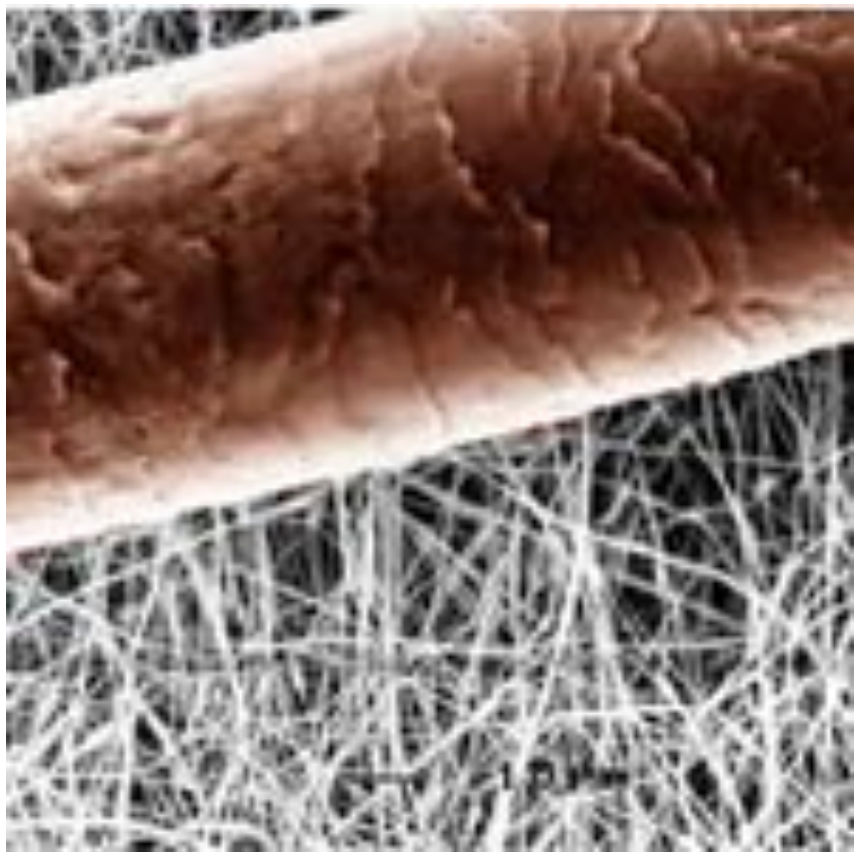
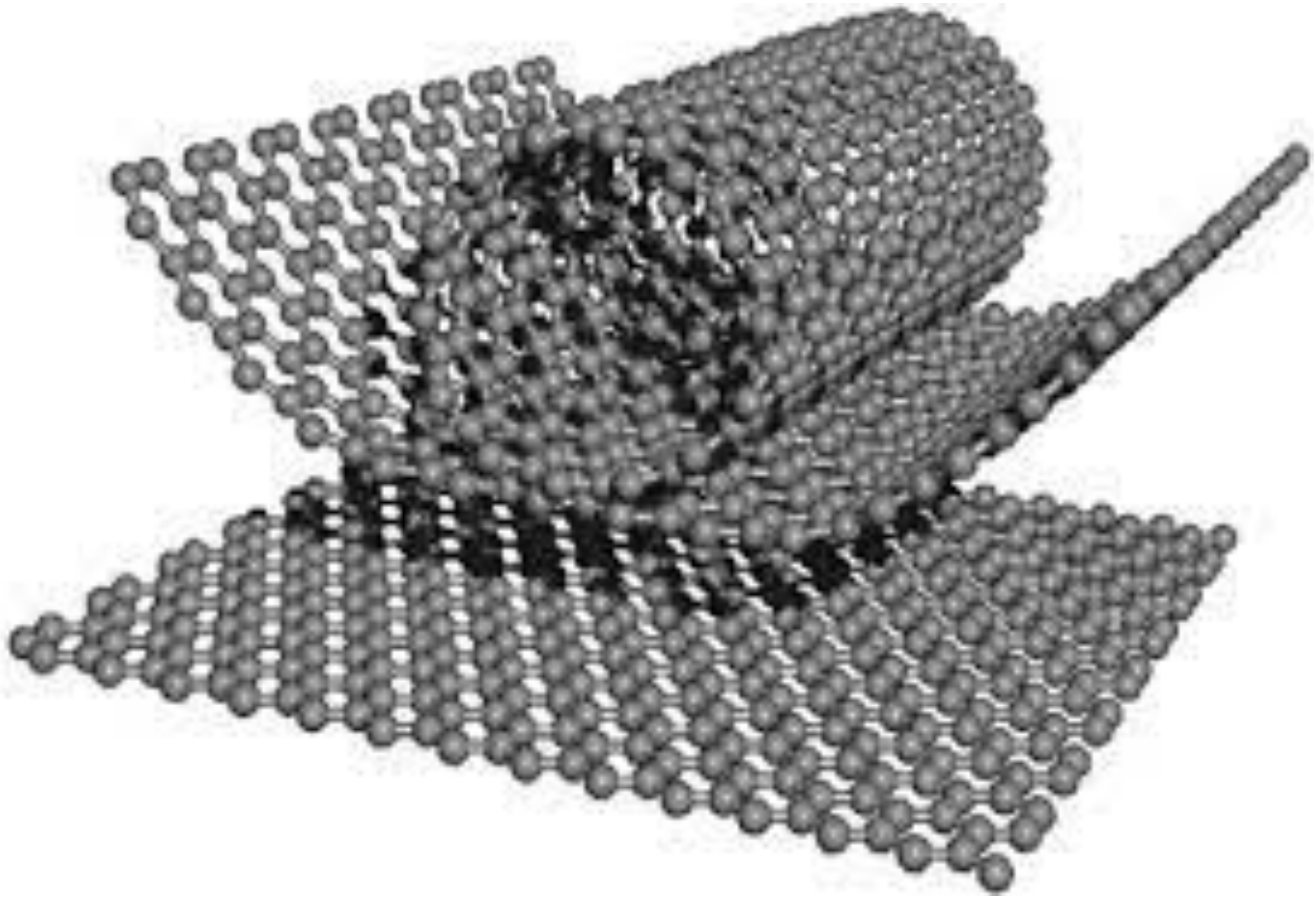
Nanotechnology



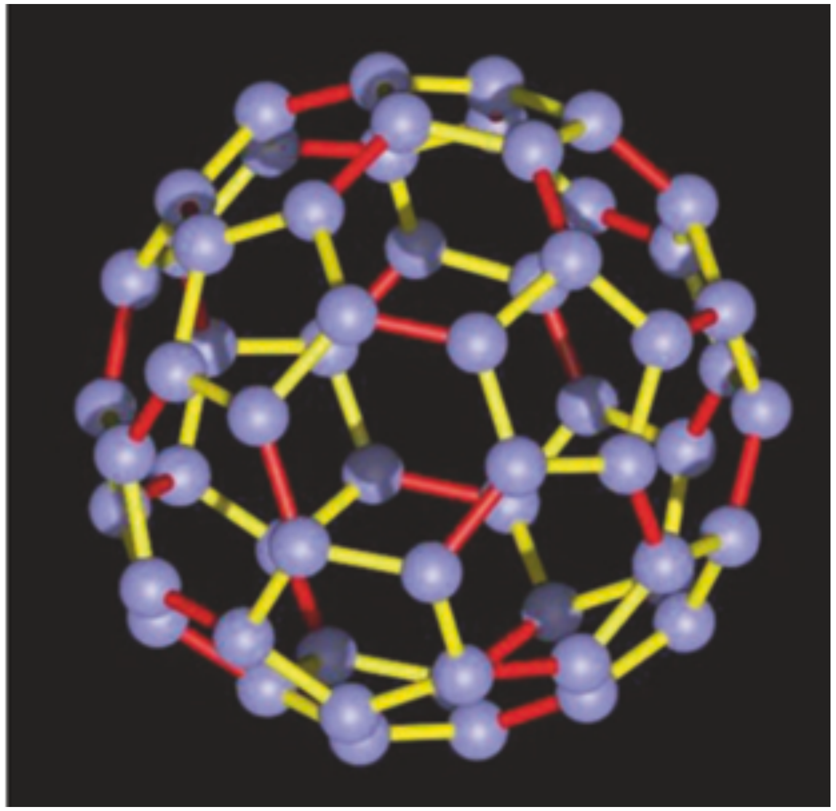
The thickness of human hair is 8000 nm

Materials who have dimensions in the 1 to 100 nm range in one directions.

1 m = 10^9 nm



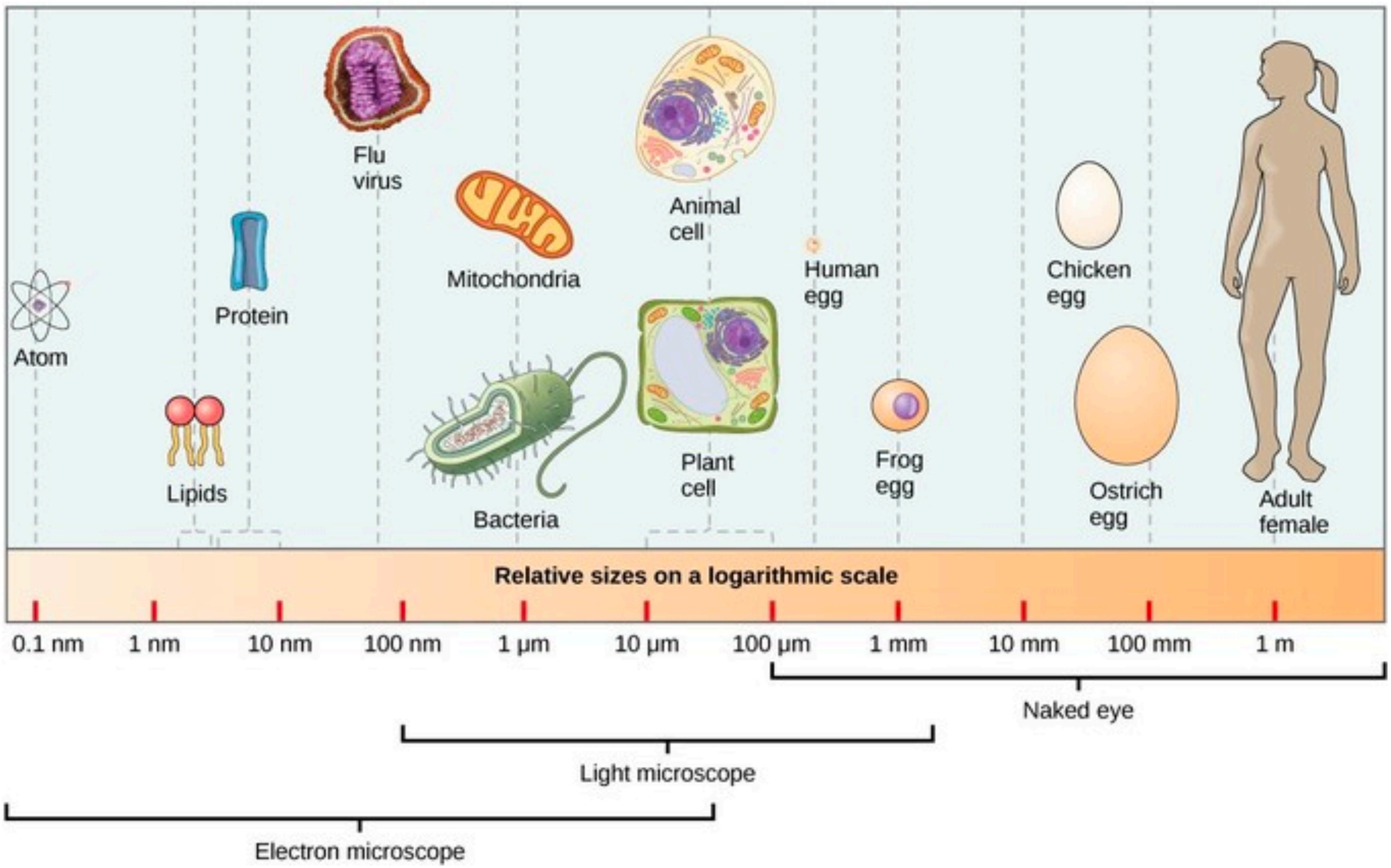
Graphene and Carbon nanotubes



Buckminsterfullerene

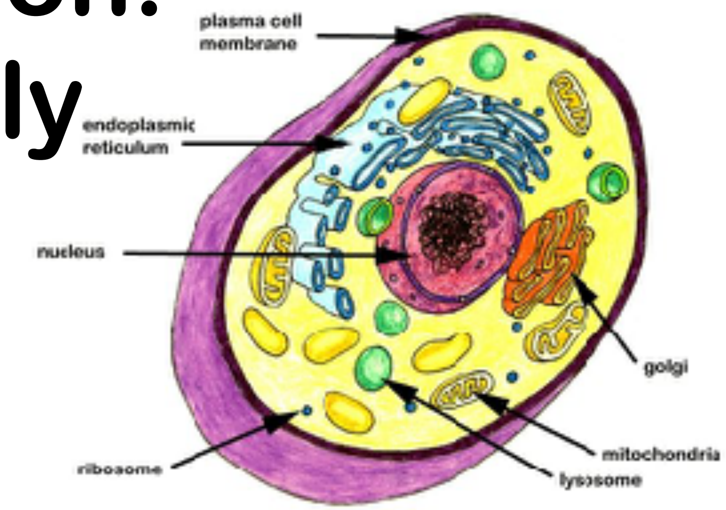
Relative Size of Atoms to Humans

Log scale



Ref : https://bio.libretexts.org/

A living software revolution: Bottom up self-assembly



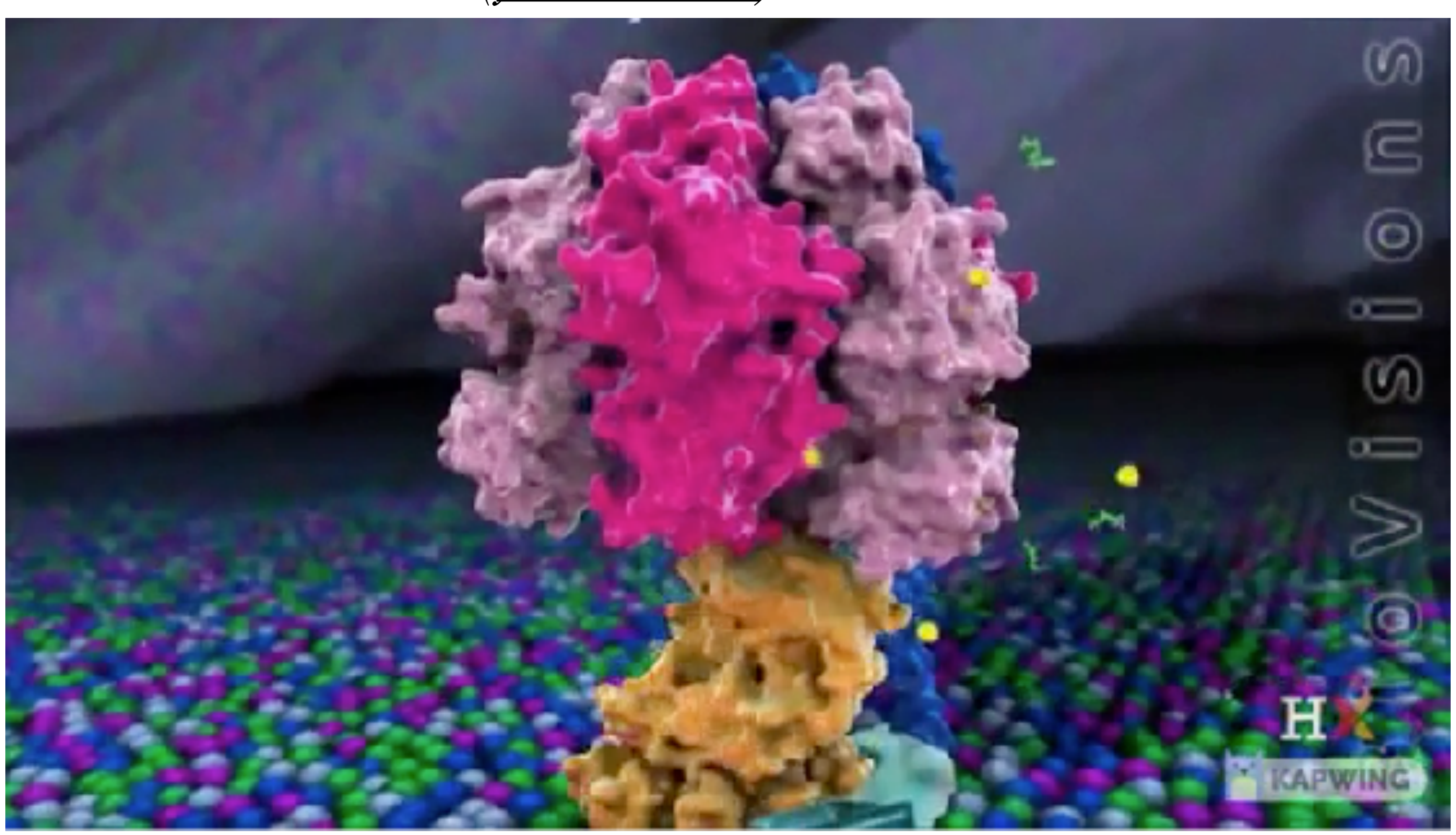
source:Alberto Cereser

- The basic unit of life, a biological cell, is most amazing machine ever built.
- The precise organization in nature is desired for the accurate functioning of various cellular organelles.
- Inspired by the cellular machinery, can we make the synthetic system using biological matter.

Question:

Can we create synthetic analog of these bio machines?

source:HarvardX ([youtube.com]())



Soft-matter
Disorder to more ordered structures.
Interactions : vdW, electrostatic,
π-π interaction, hydrogen bonding

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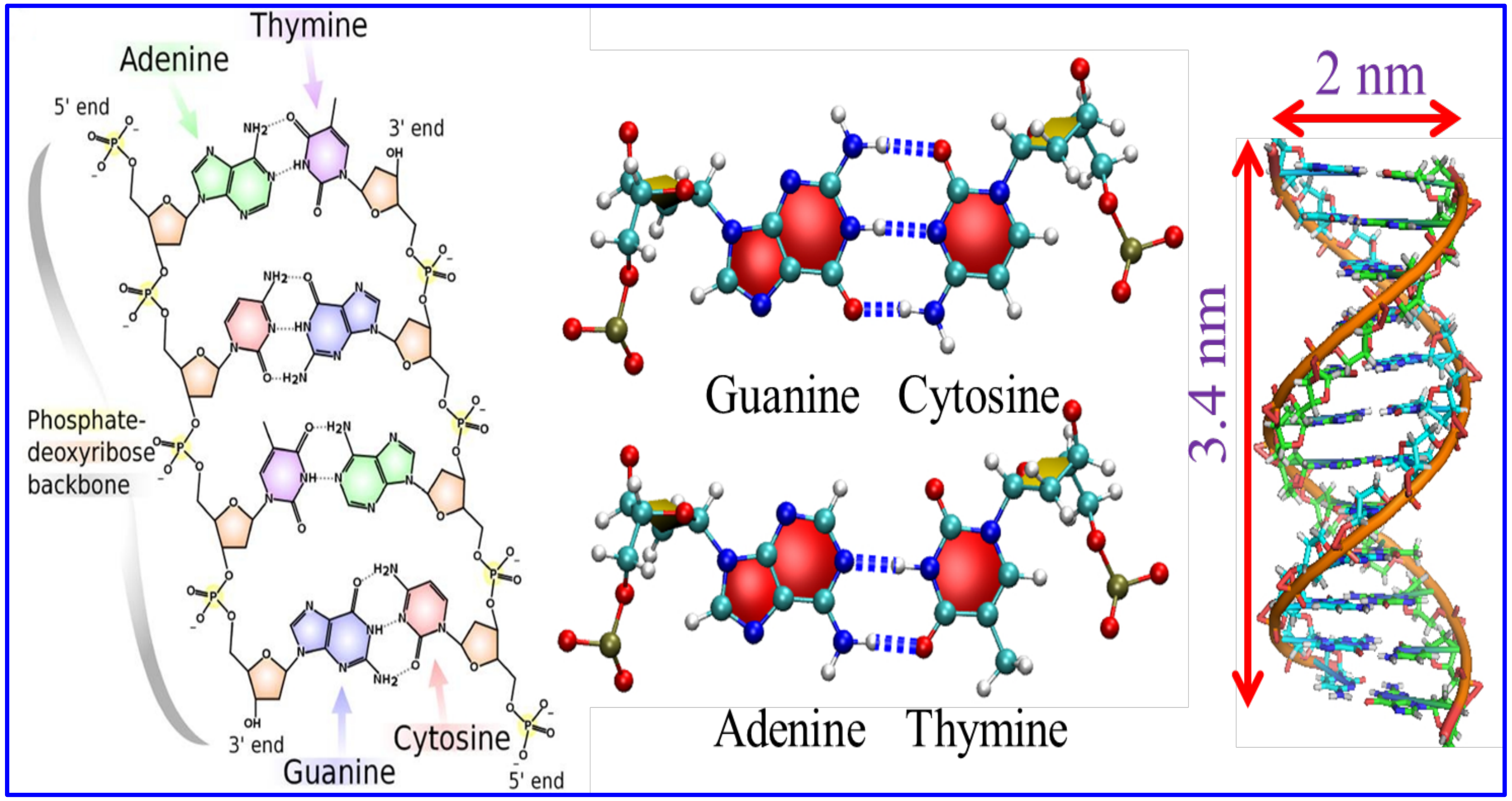
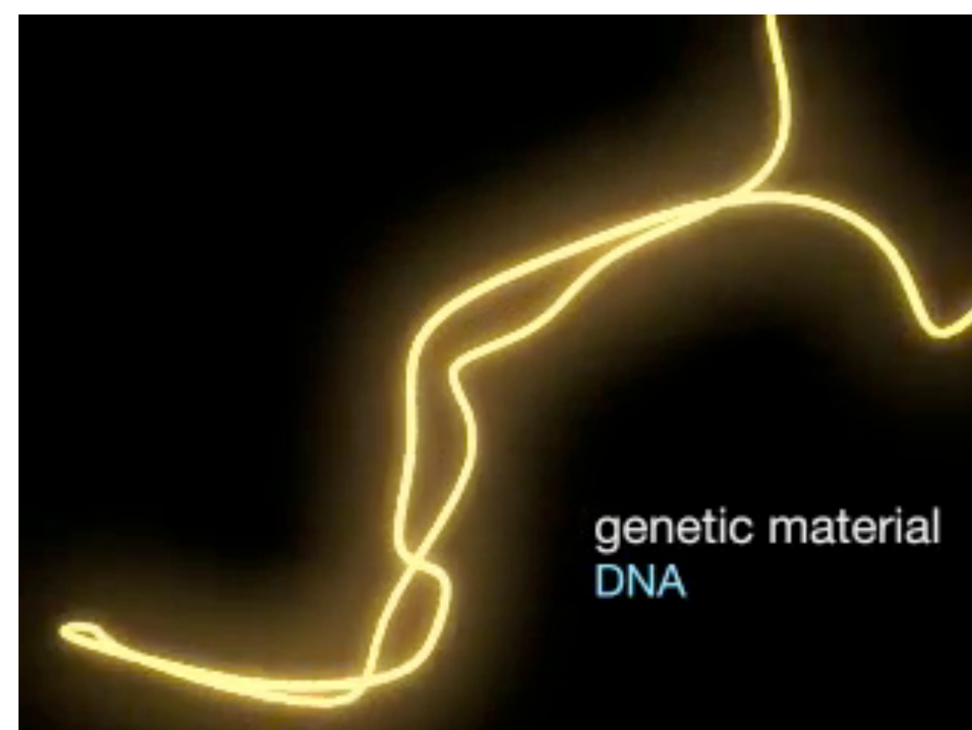
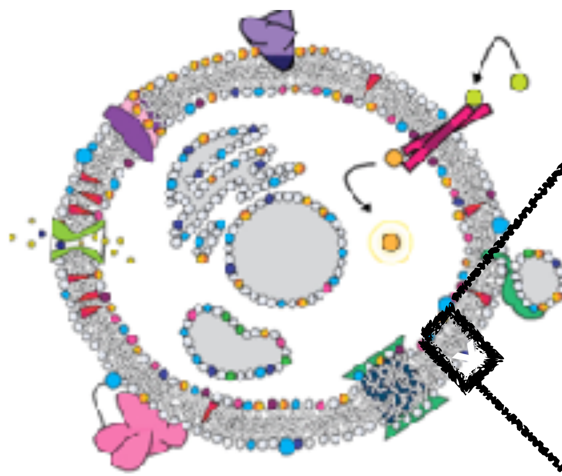
DNA: A truly nanoscale object



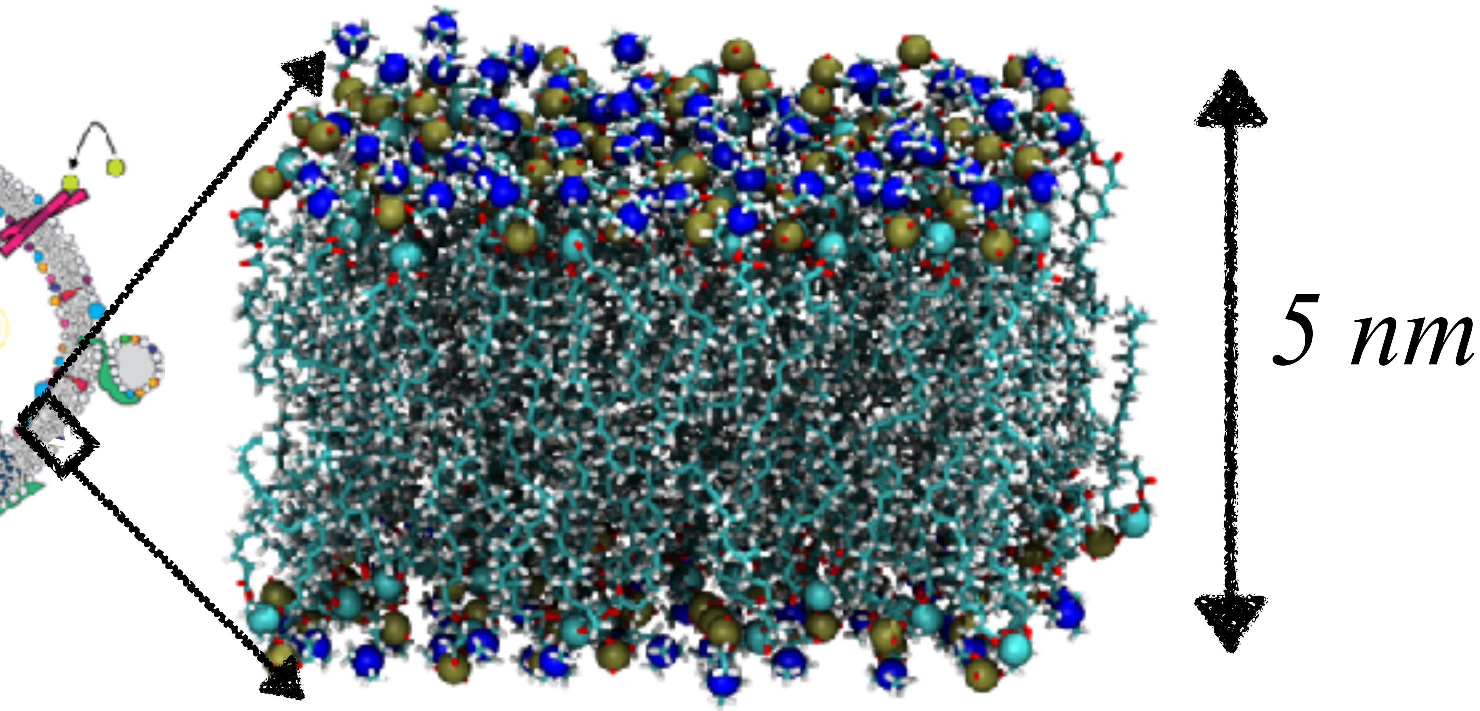
1. Molecular recognition property
2. Chemically easy to modify the backbone
3. Well studied molecule.



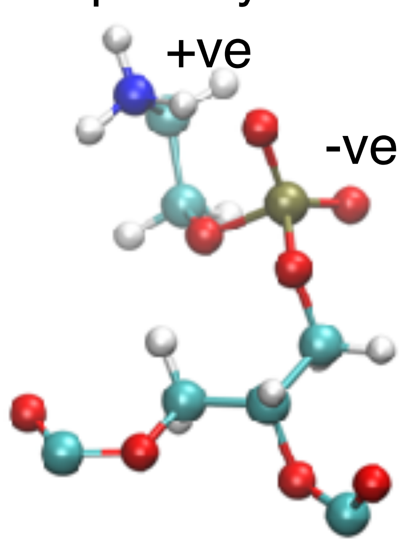
Structure of phospholipid bilayer membranes



source: Wikipedia

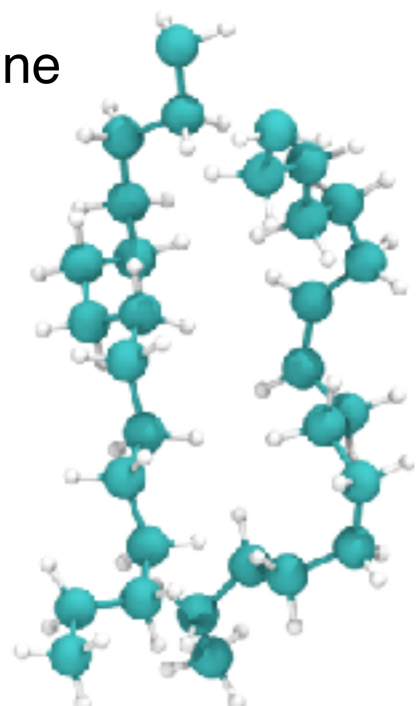


Phosphatidyl**e**thanolamine

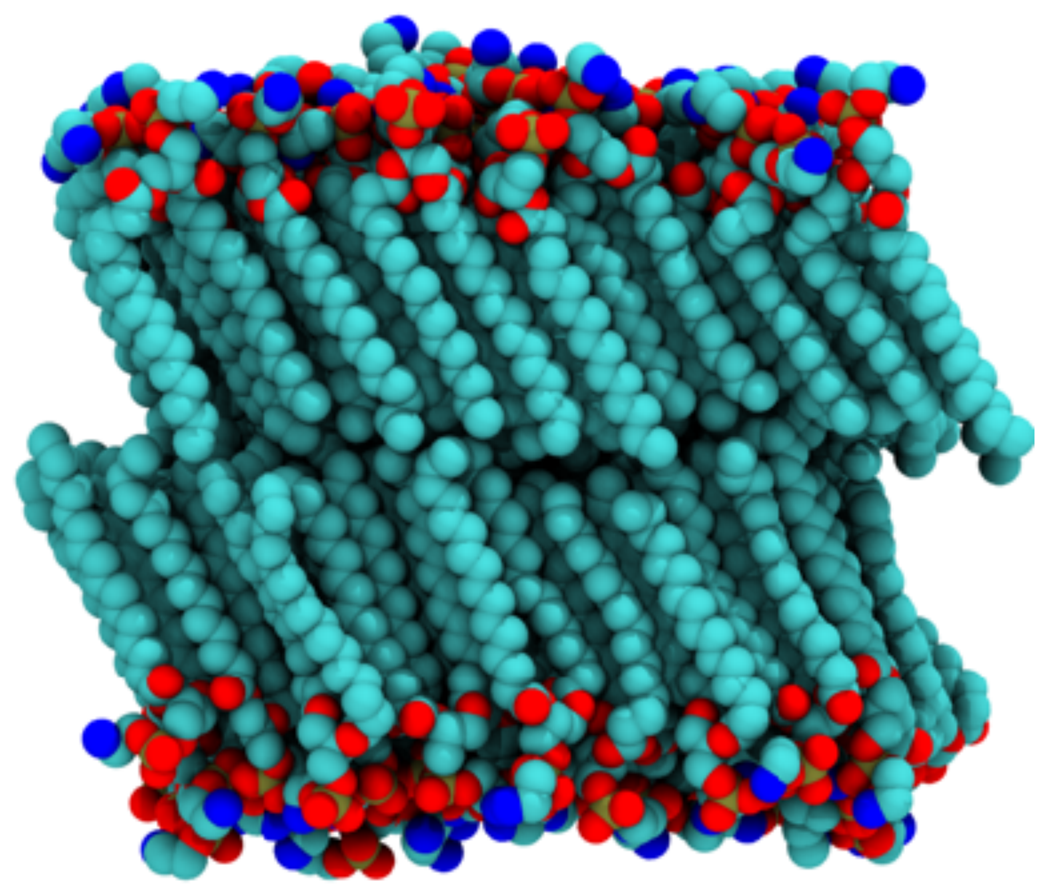


PE

1-**P**almitoyl-2-**o**leoyl

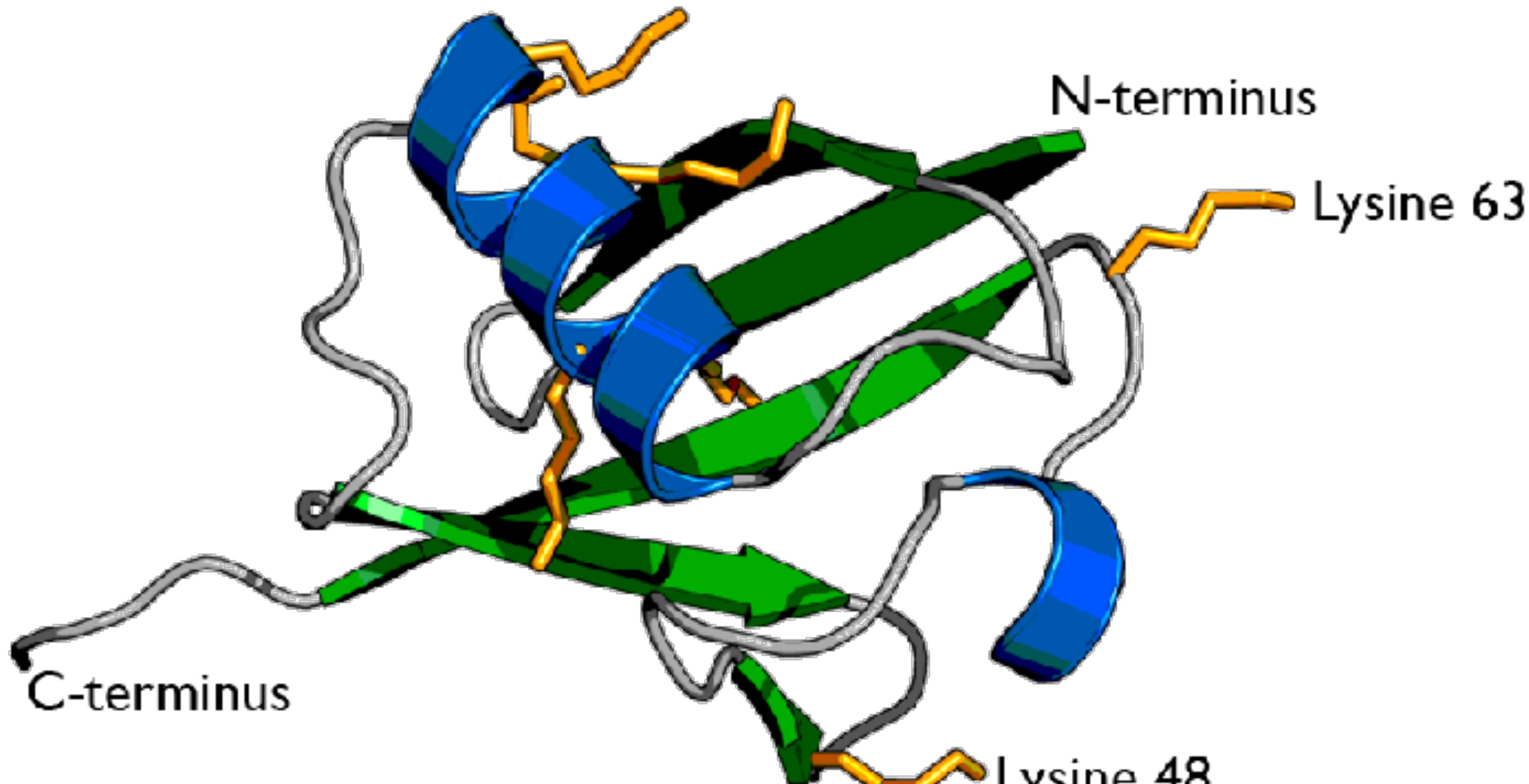


PO



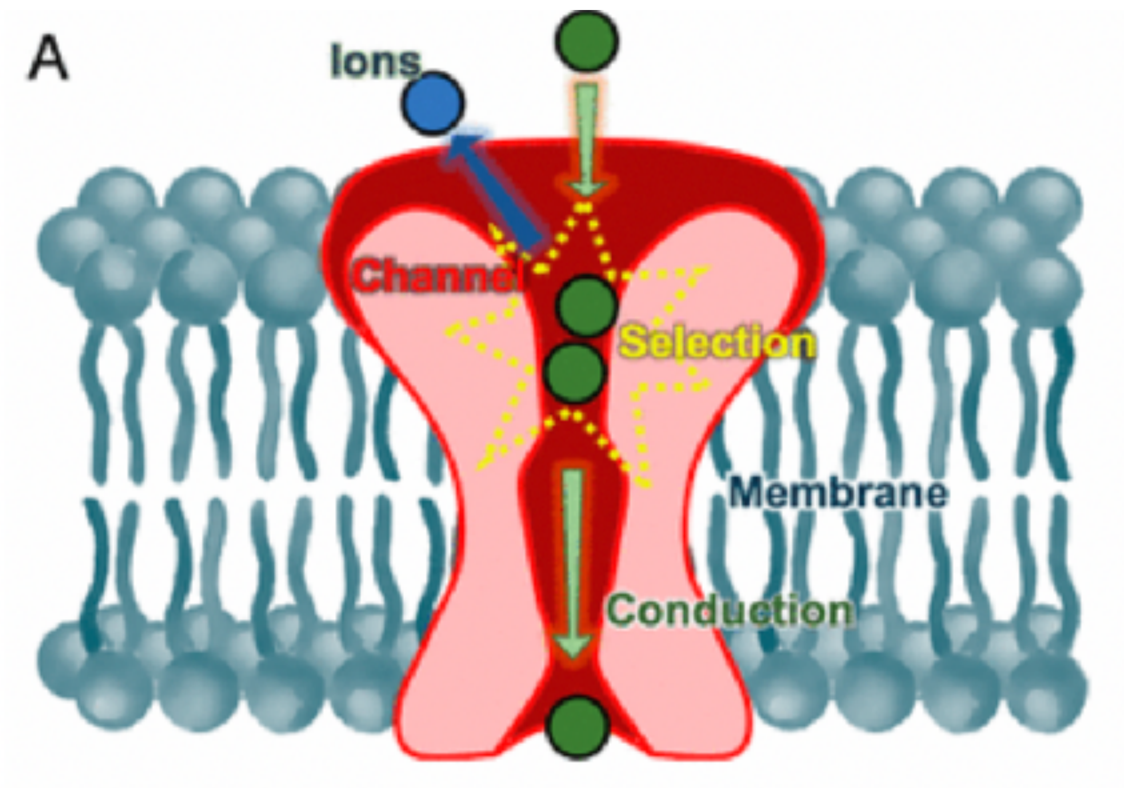
Proteins

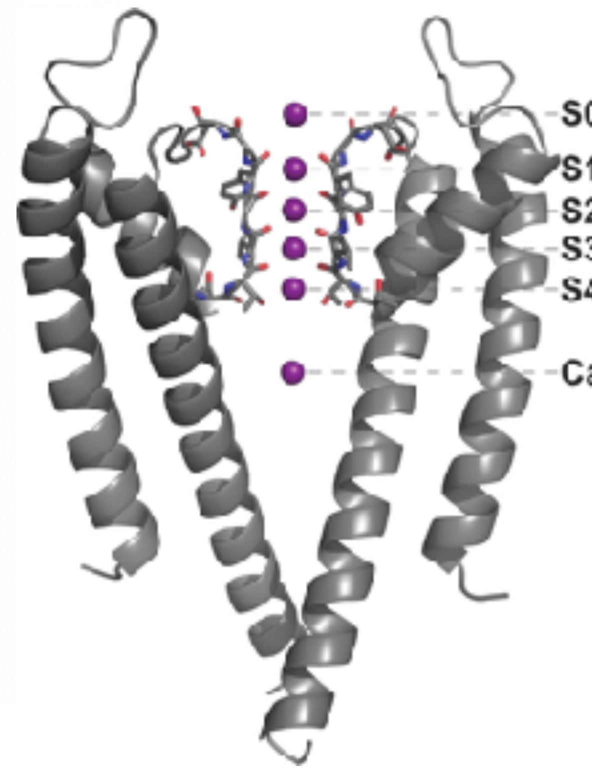
76 amino acids

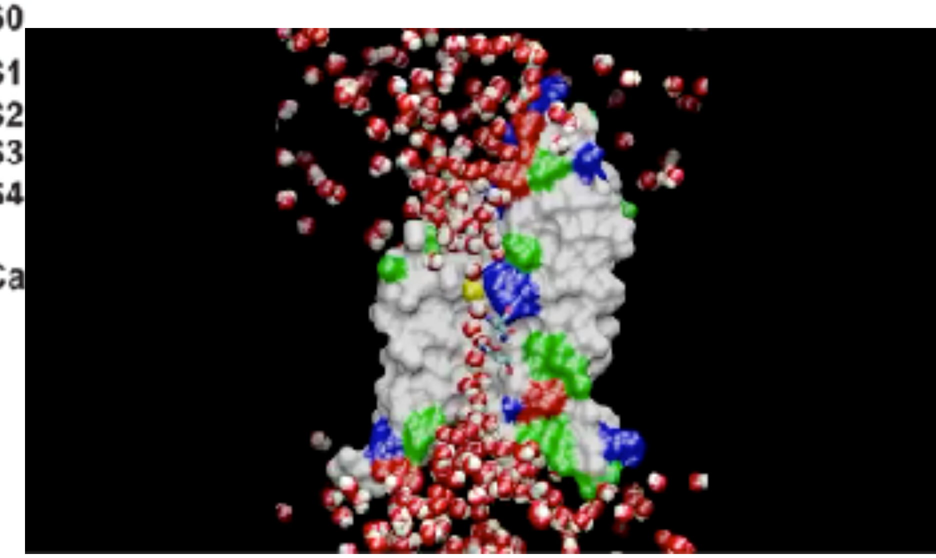


- Regulating the survival and death of cancer cells
- Its relationship to stress
- Tts role at mitochondria and its disease implications

Protein channels in membrane and biomimetics







Chem. Rev. 2019, 119, 13, 7737–7832

Protein channels regulates some key functions at cellular level like

- Propagation of nerve impulses
- Enabling vital functions like heartbeat
- Brain activity
- Muscle contraction etc