Pushing and Pulling by Protein Filaments

Gayathri Pananghat
Indian Institute of Science Education and Research (IISER), Pune

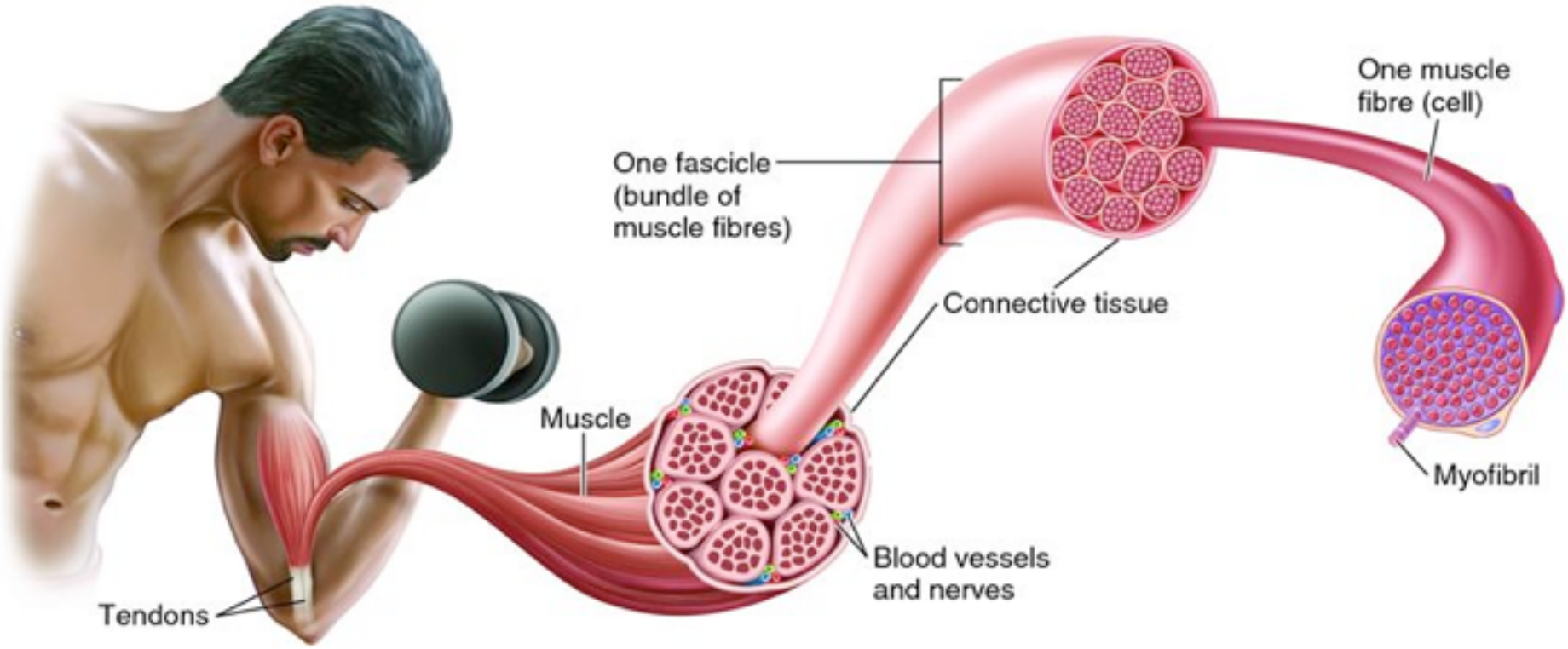
Exciting Science Group
August 2015

What is a protein?

What is a protein?

What do proteins do?

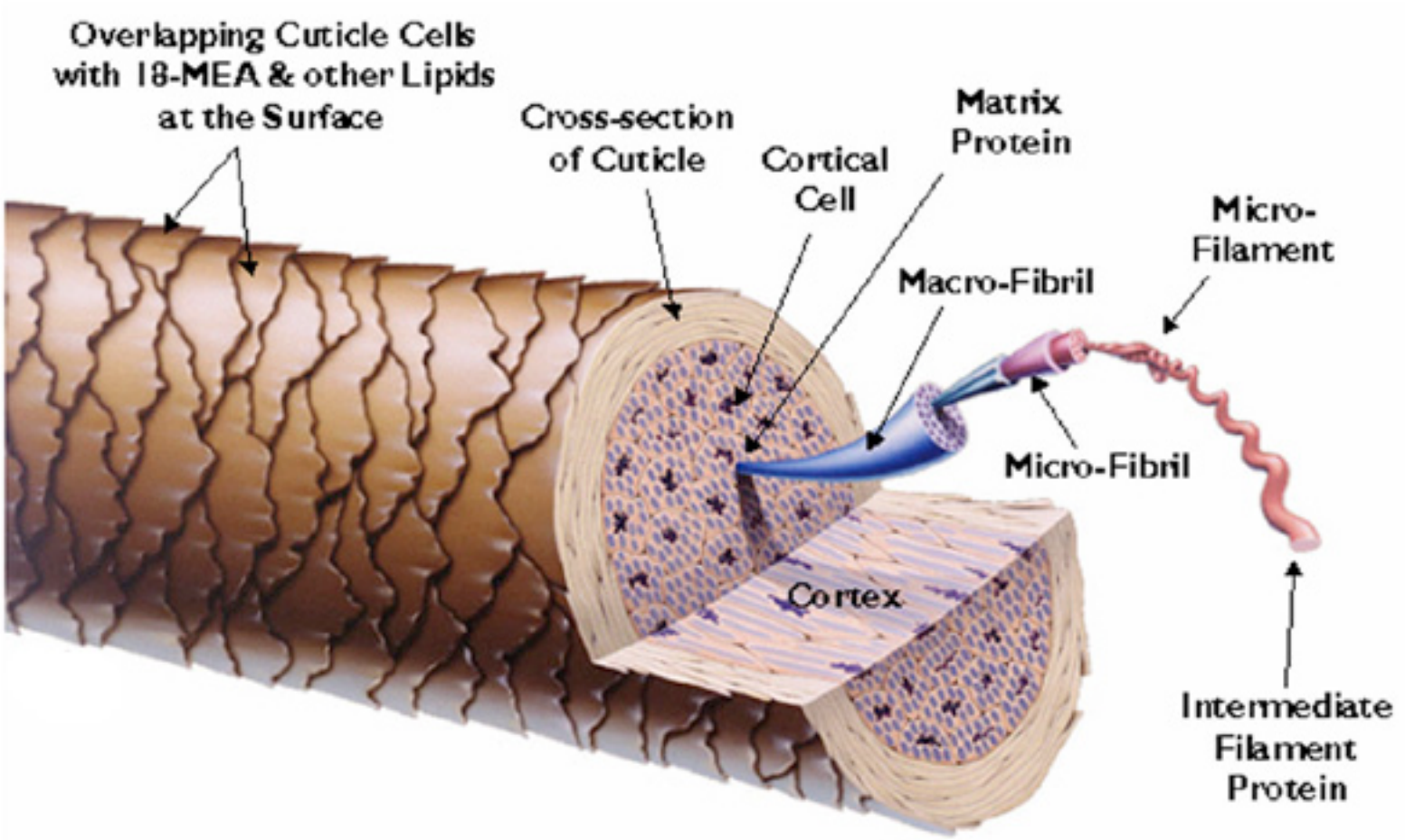
Gives structure
eg. Muscle, Hair, Silk, Spider Web



http://biology-forums.com/index.php?action=gallery;sa=view;id=1185

What do proteins do?

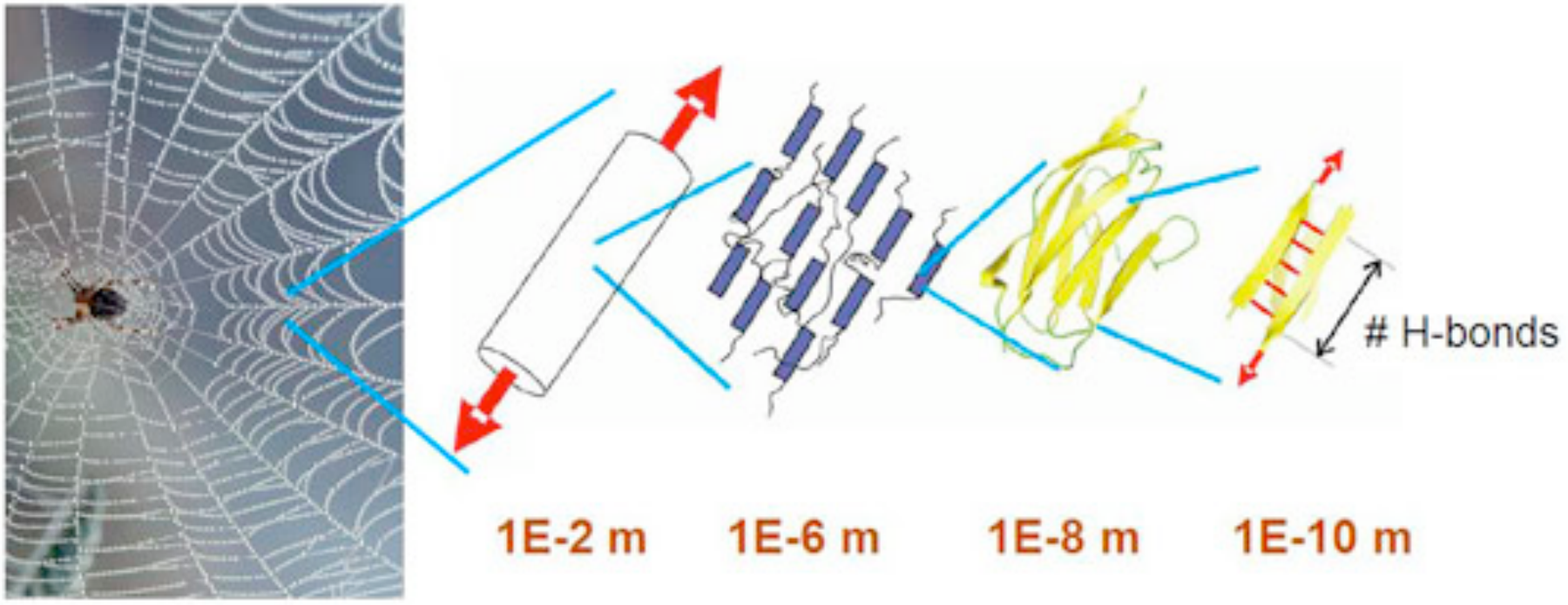
Gives structure
eg. Muscle, Hair, Silk, Spider web



What do proteins do?

Gives structure

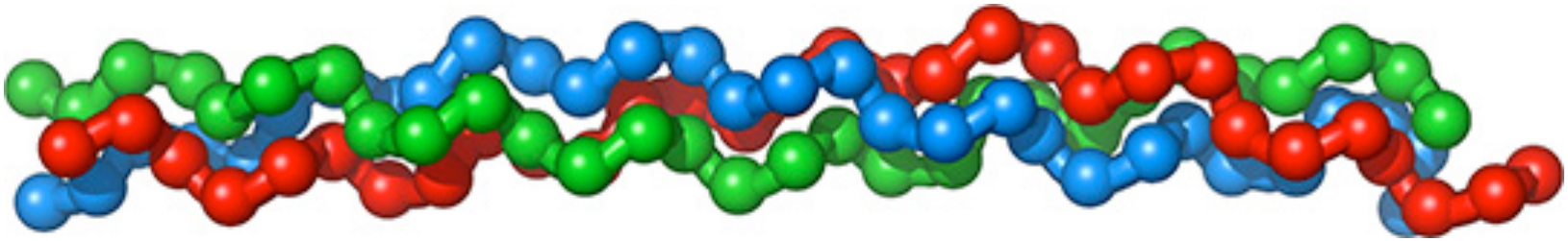
eg. Hair, Muscle, Silk, Spider web



http://www.nanowerk.com/spotlight/spotid=4523.php

What do proteins do?

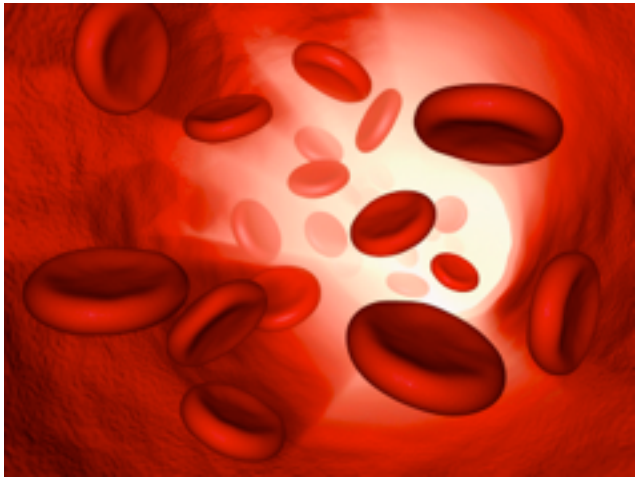
Gives structure
eg. Hair, Muscle, Silk, Spider web

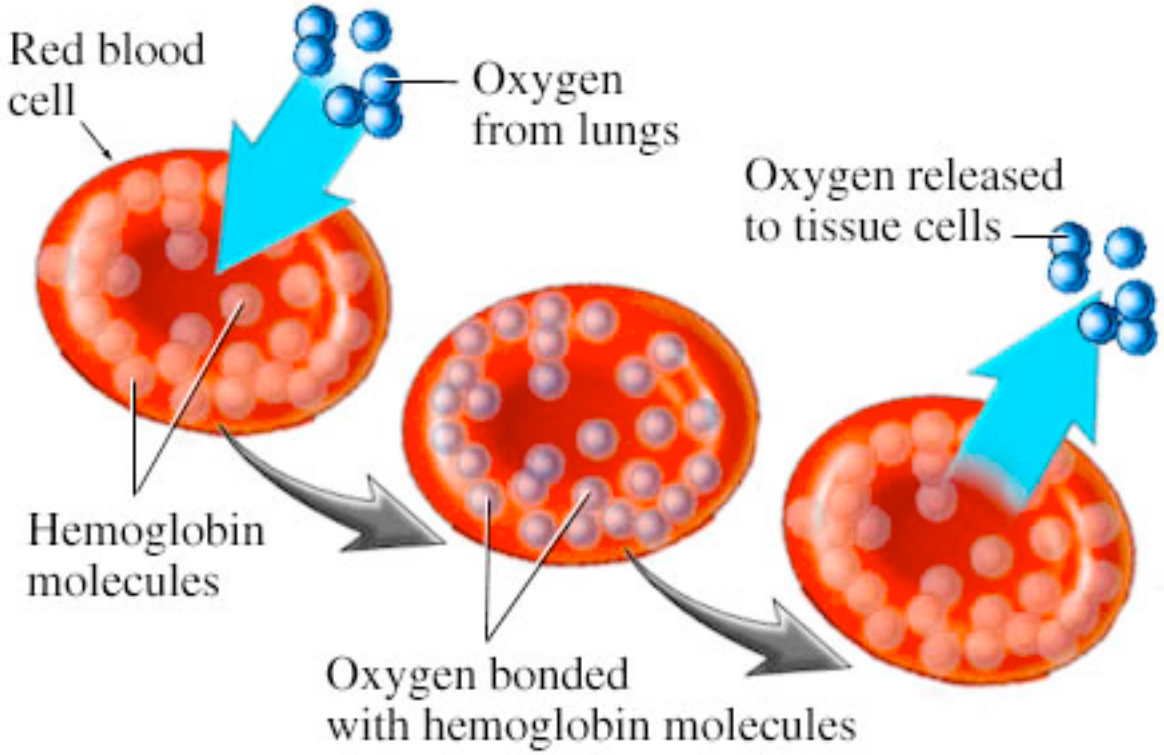


http://www.ebi.ac.uk/interpro/potm/2009_1/Protein_focus_2009_01-Collagen.html

What do proteins do?

Transport

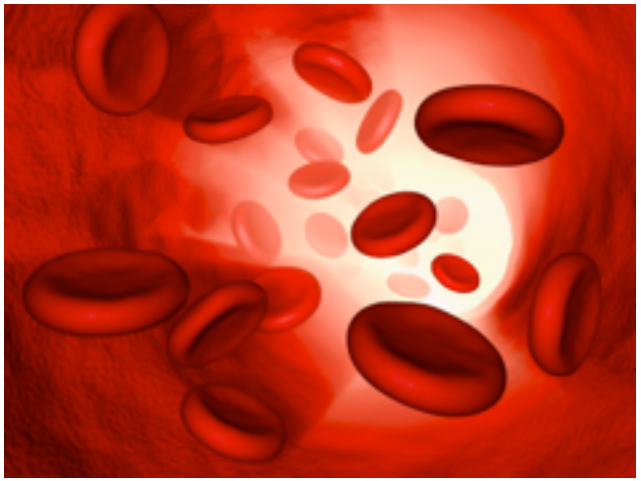


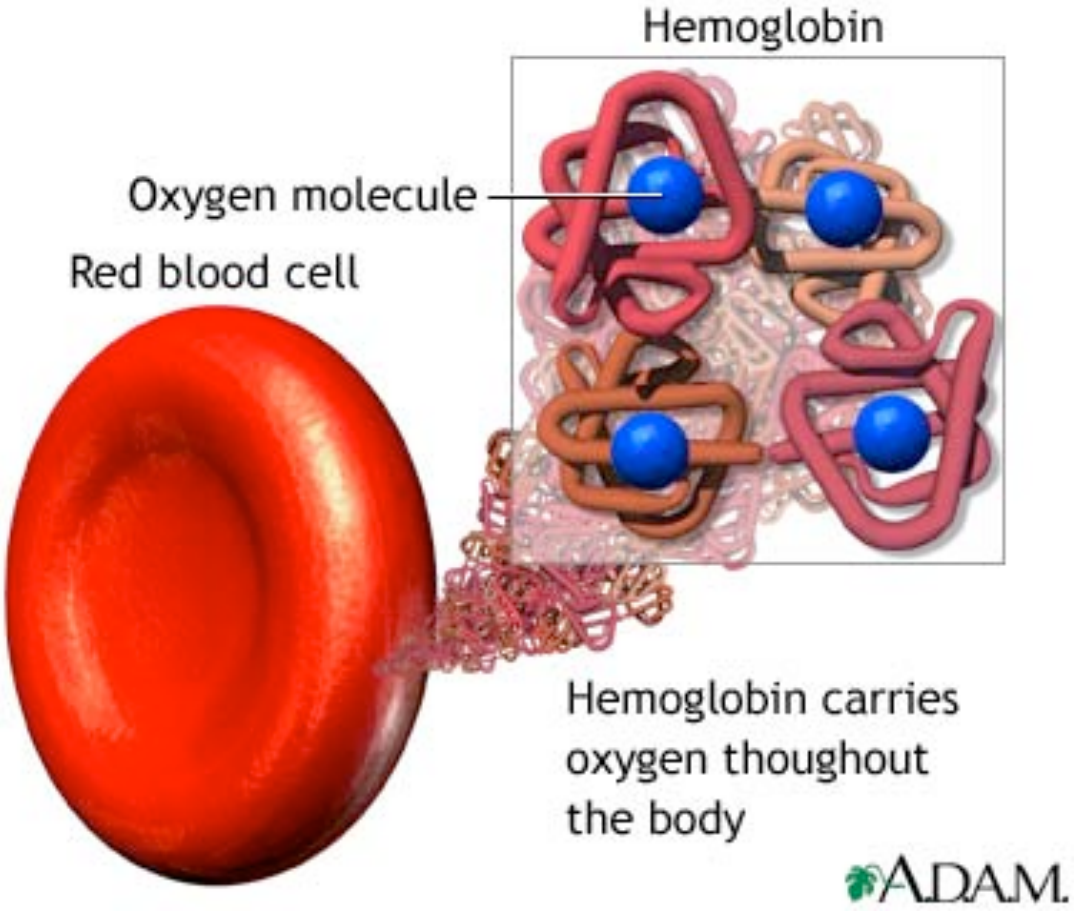


https://sjhsrc.wikispaces.com/file/view/hemo.png/386264468/hemo.png

What do proteins do?

Transport

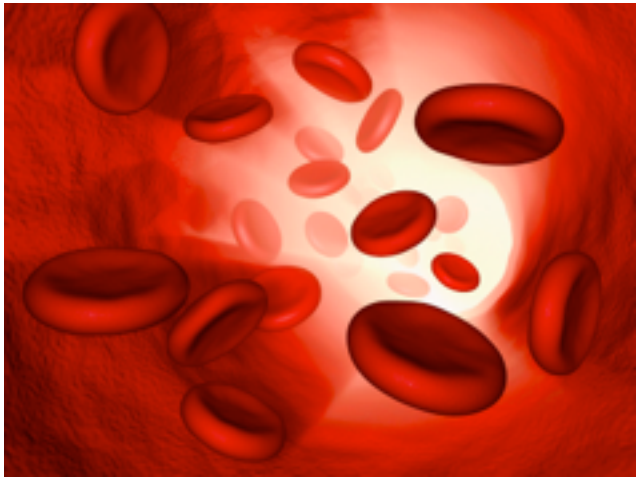


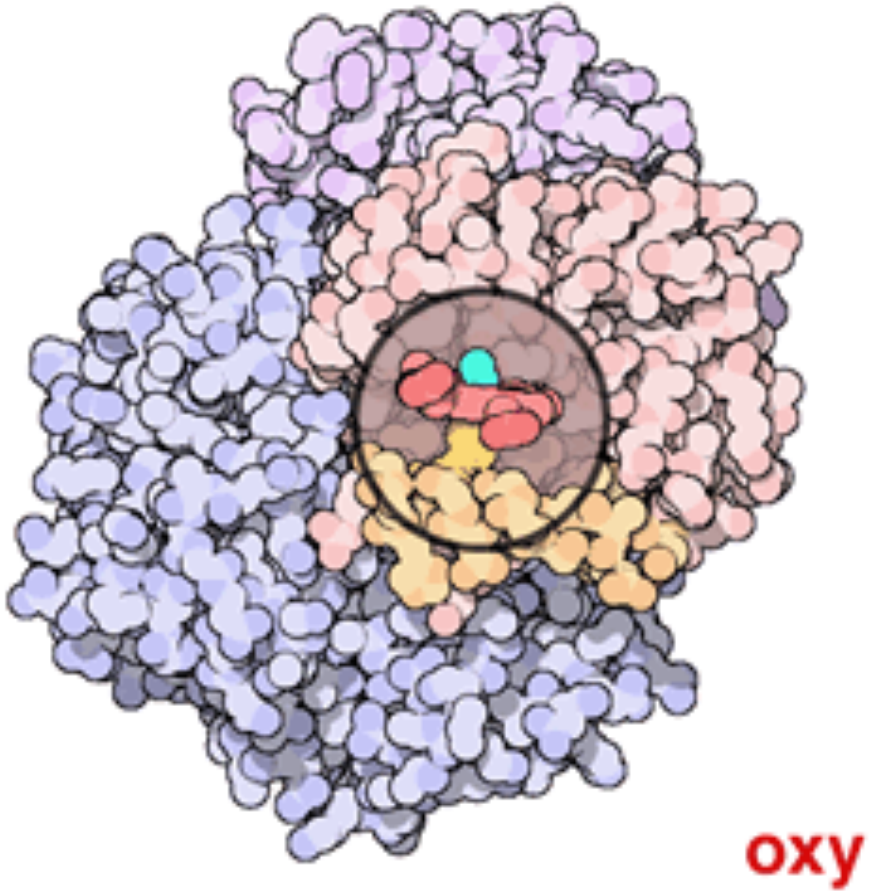


http://www.masimo.fr/hemoglobin/anemia.htm

What do proteins do?

Transport

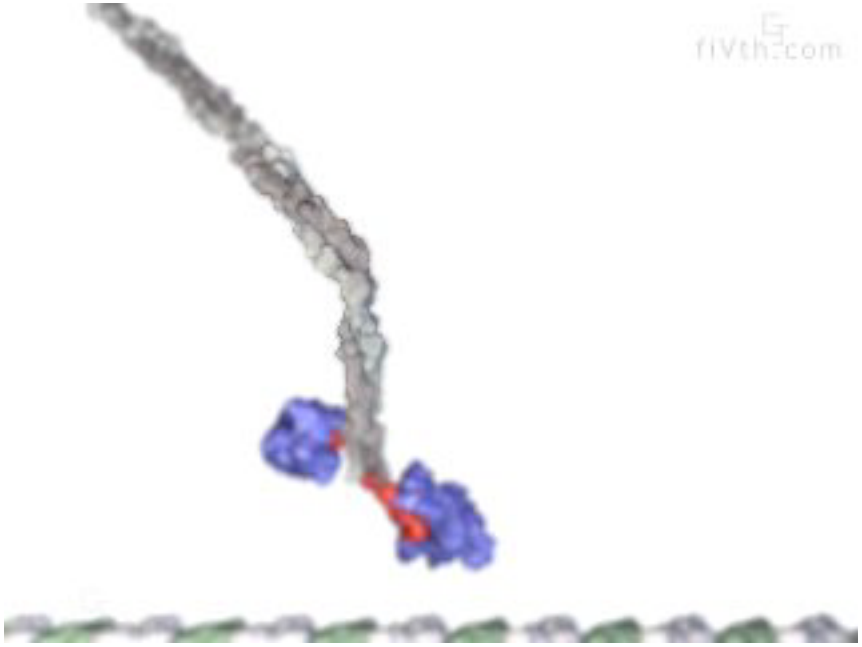




http://www.rcsb.org/pdb/101/motm.do?momID=41

What do proteins do?

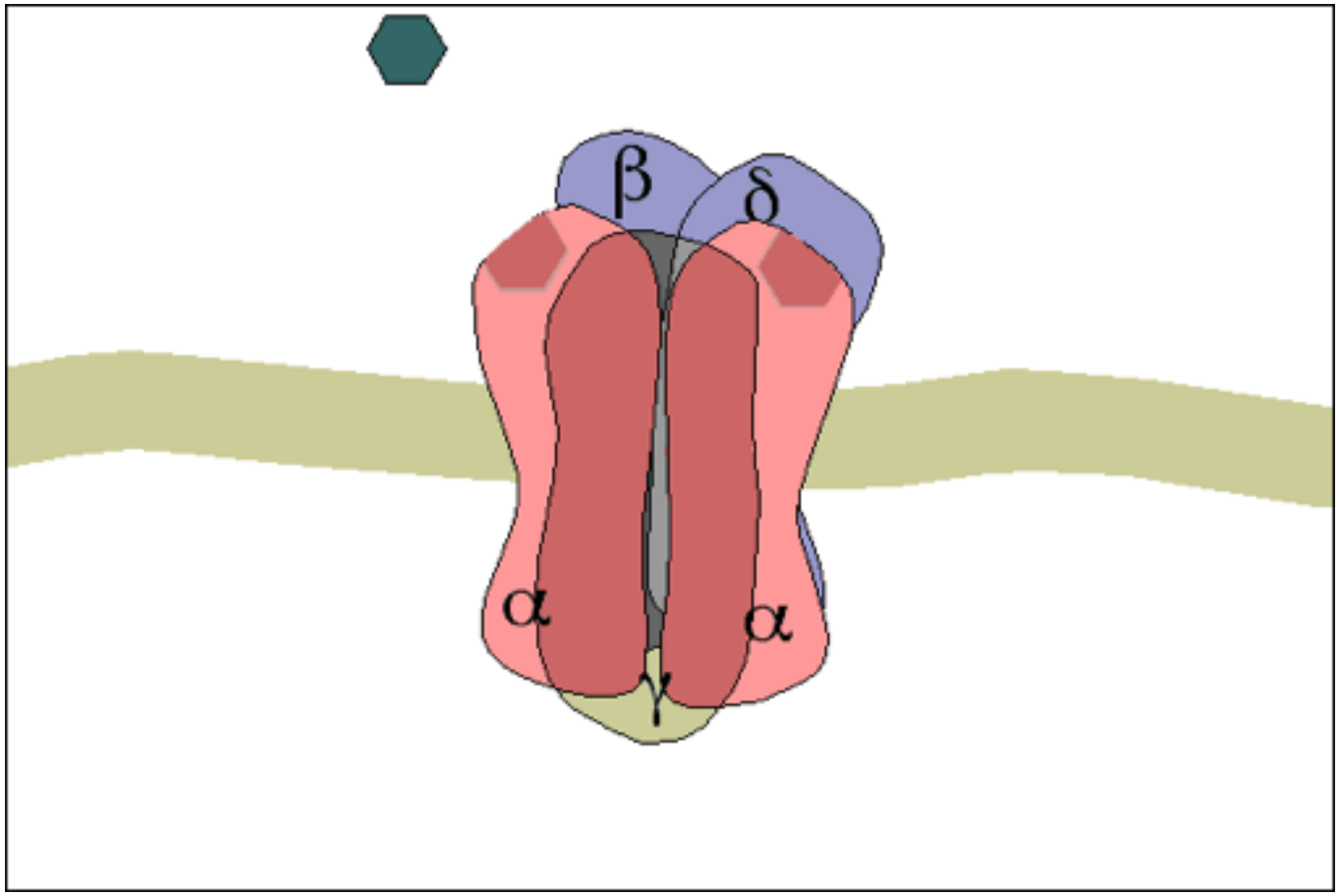
Transports cargo



Kinesin movie links:
Ron Vale, Lab webpage (https://valelab.ucsf.edu/external/moviepages/moviesMolecMotors.html)
https://coub.com/view/3ddls

What do proteins do?

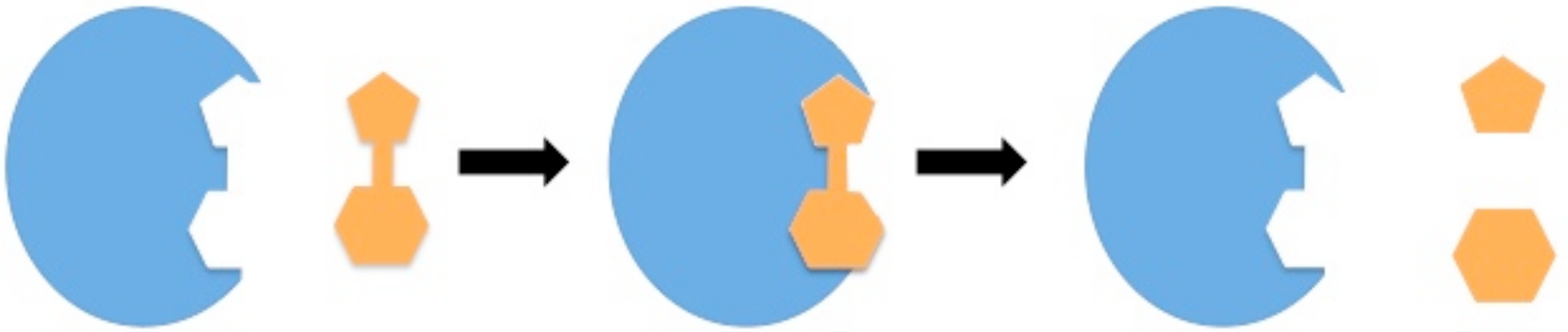
Transports cargo



http://sitemaker.umich.edu/maybaum.pharmacology.principles/files/ionchannelanim.gif

What do proteins do?

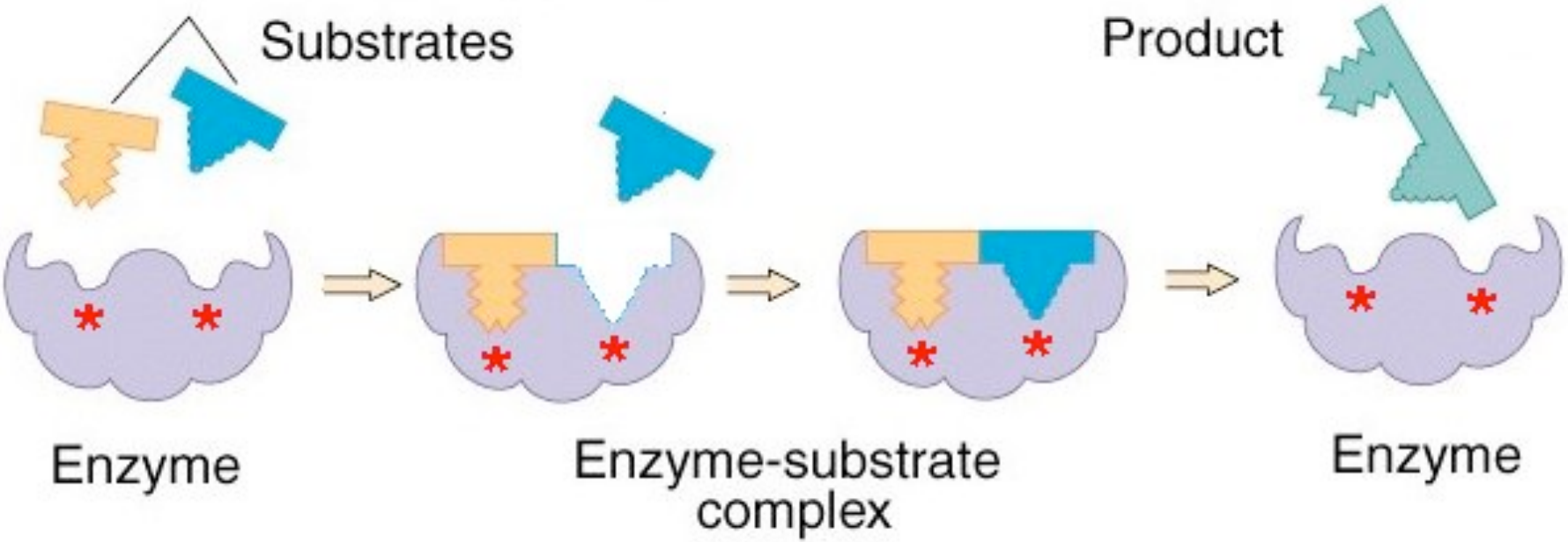
Biological catalyst



http://blogs.scientificamerican.com/lab-rat/files/2014/01/Enzyme_mechanism_1.jpg

What do proteins do?

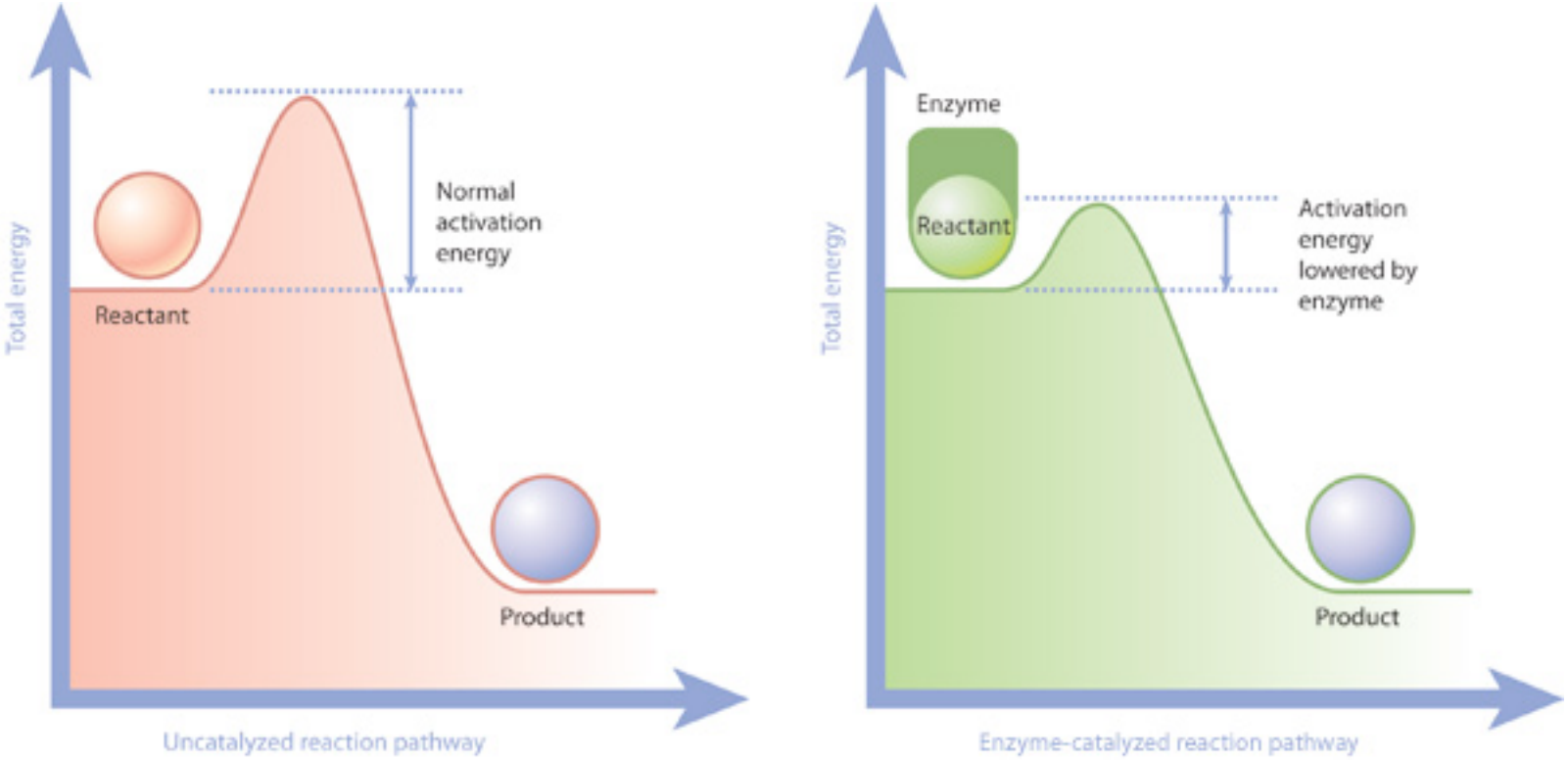
Biological catalyst



http://www.mun.ca/biology/scarr/Induced-Fit_Model.html

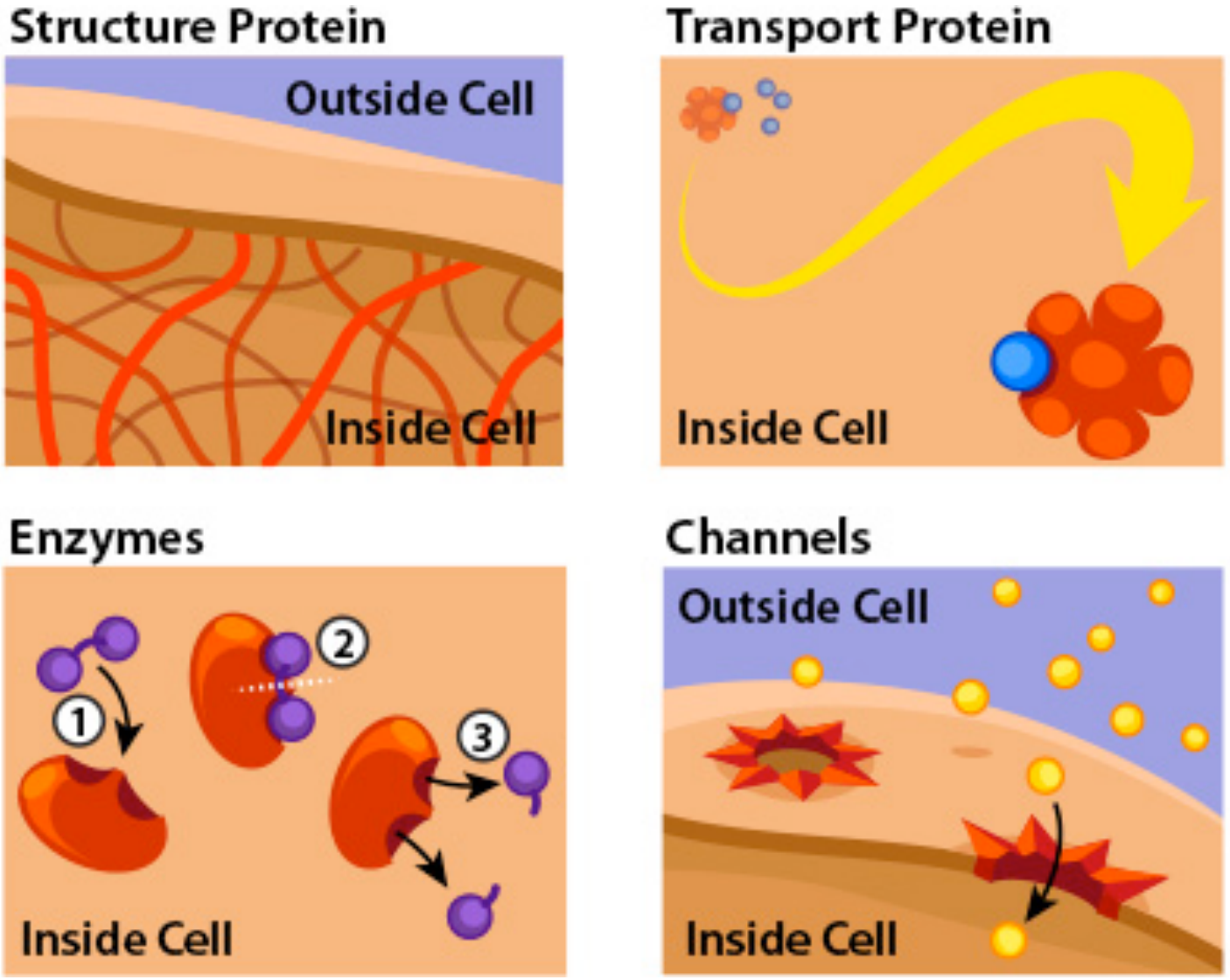
What do proteins do?

Biological catalyst



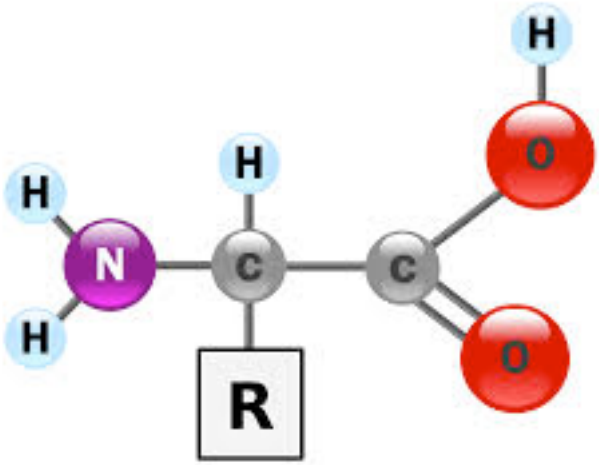
http://www.nature.com/scitable/topicpage/protein-function-14123348

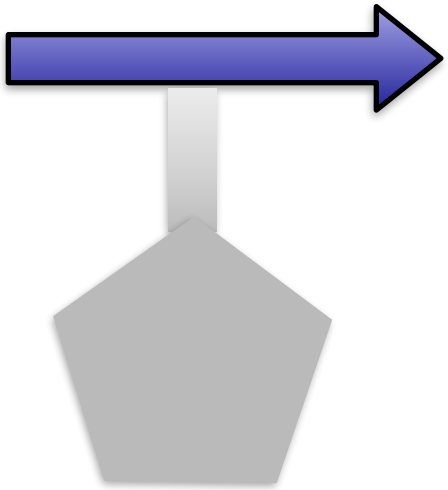
What do proteins do?



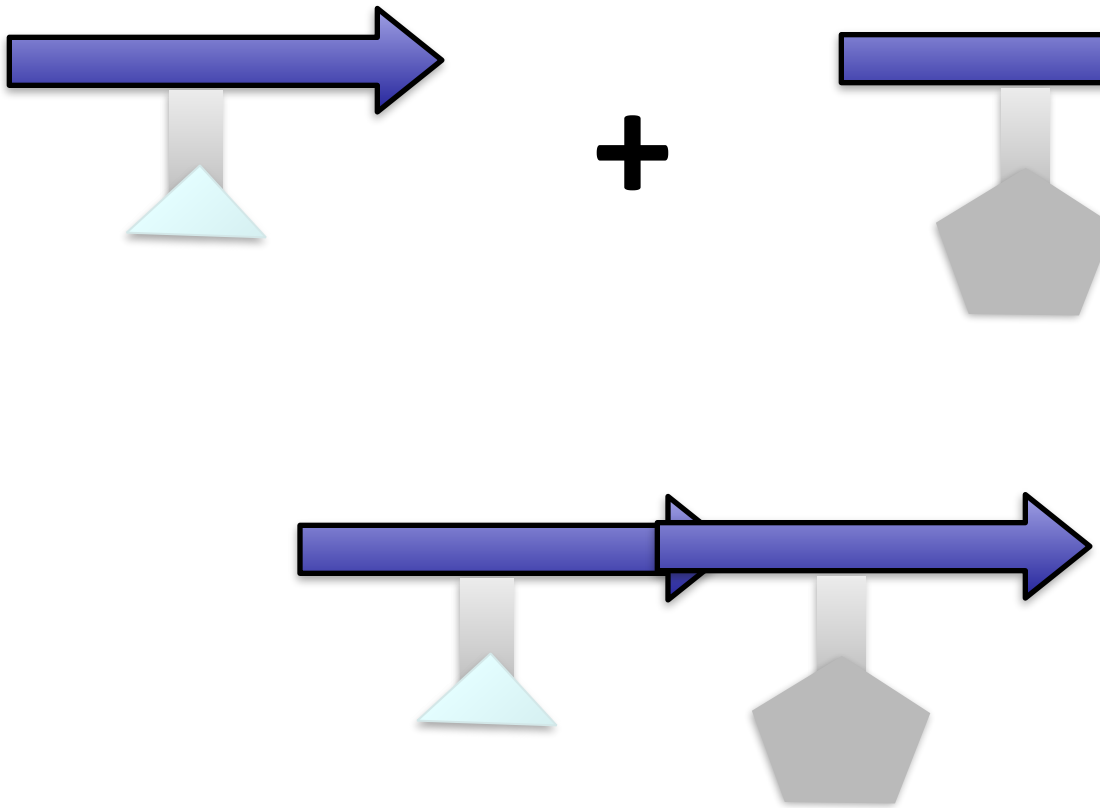
http://askabiologist.asu.edu/venom/what-are-proteins

A protein is made up of amino acids

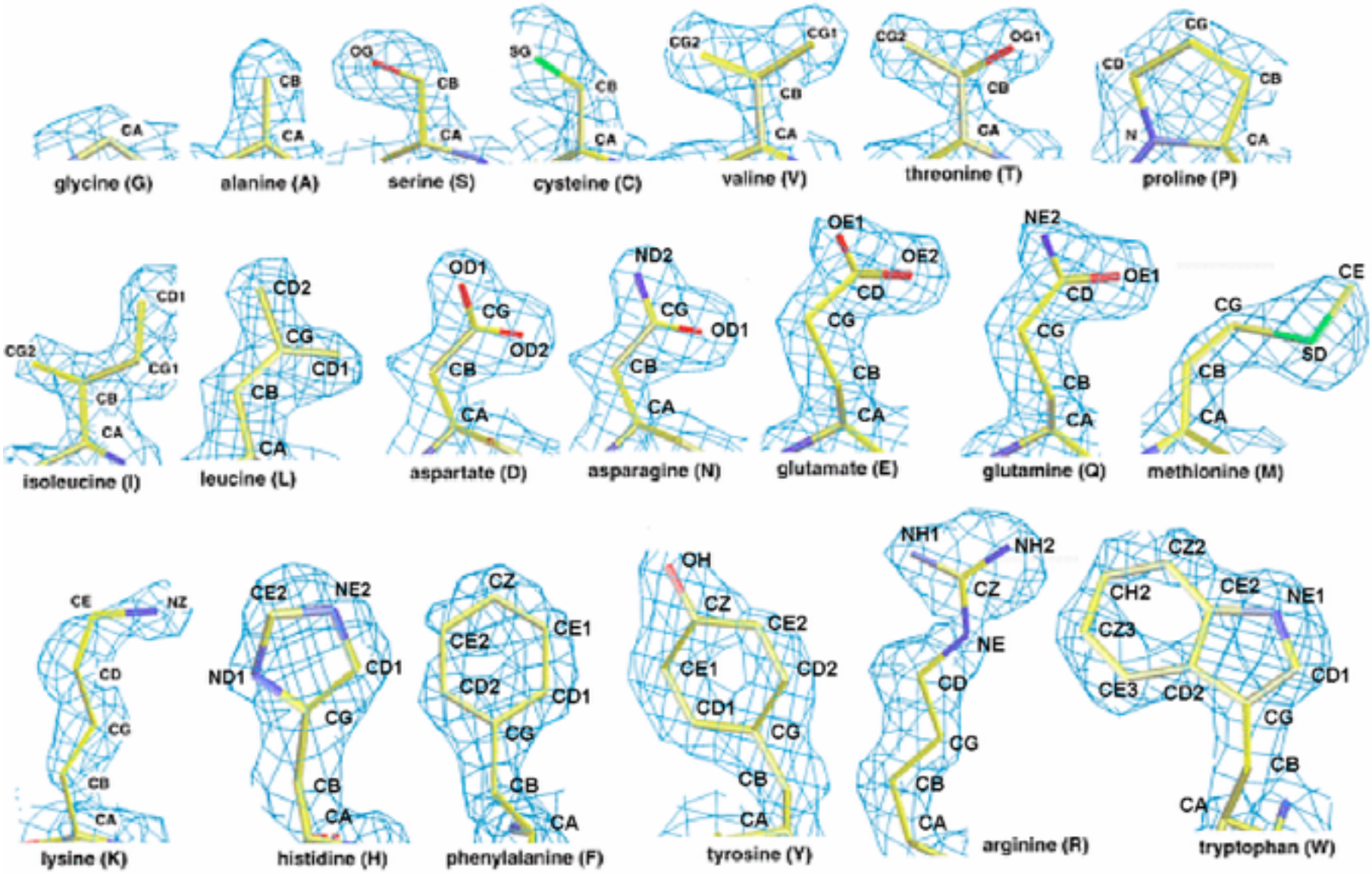




A protein is made up of amino acids

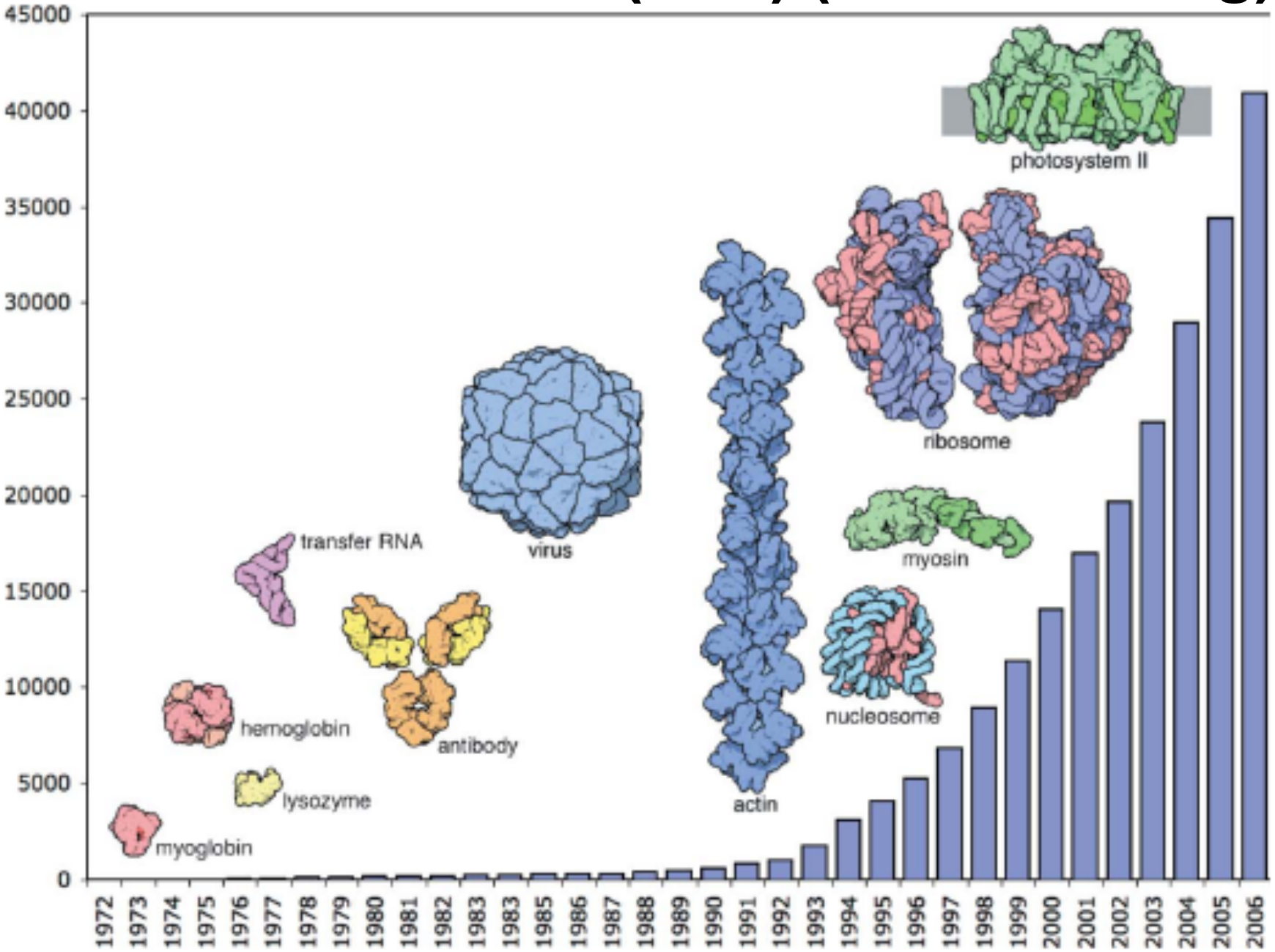


A protein is made up of amino acids



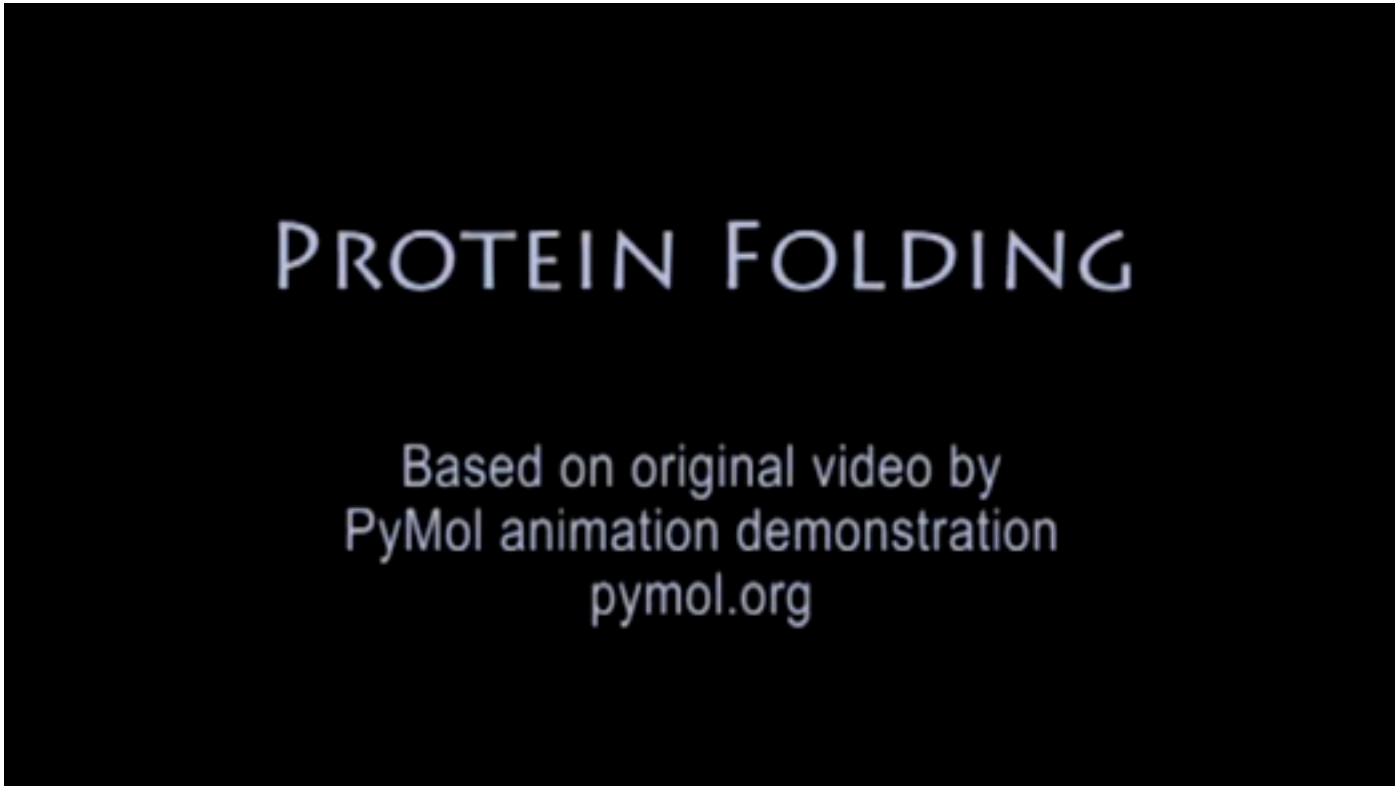
http://people.mbi.ucla.edu/sawaya/m230d/Modelbuilding/modelbuilding.html

Protein data bank (PDB) (www.rcsb.org)

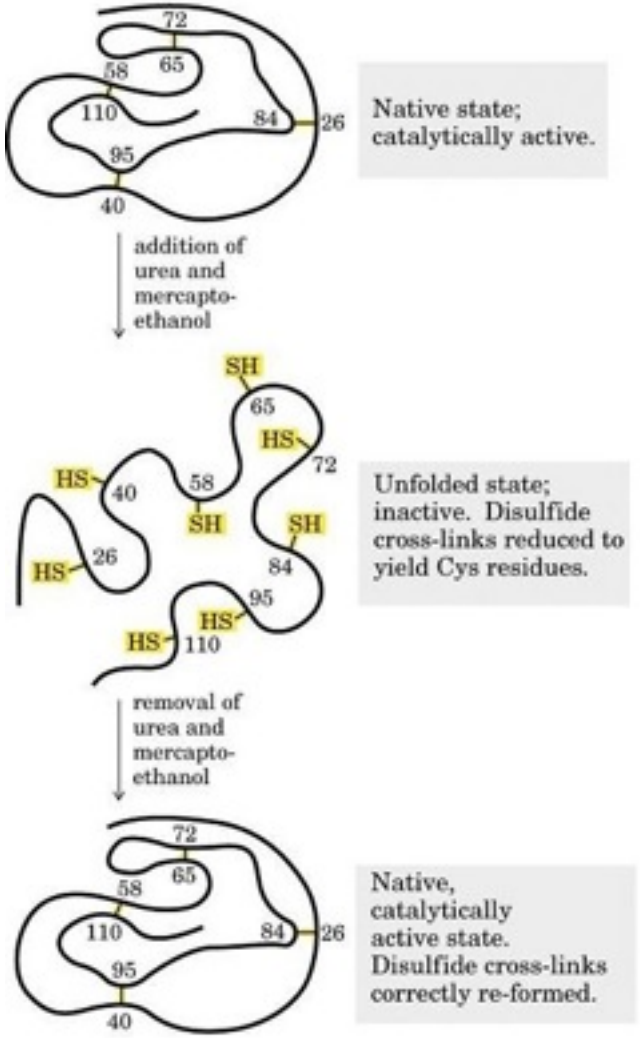


Protein folding

The process by which the protein takes up its native conformation



Anfinsen's experiment (1969)



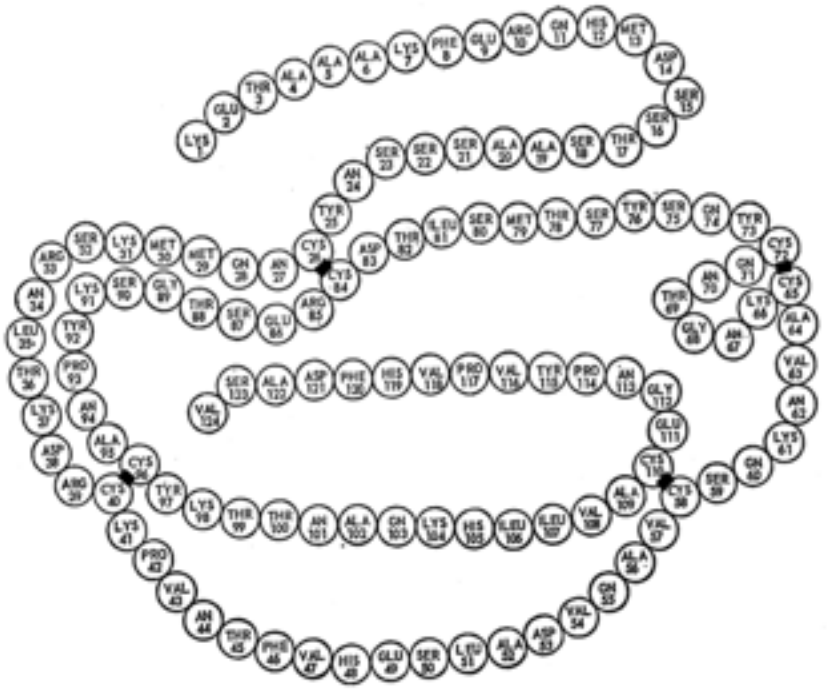


Fig. 1. The amino acid sequence of bovine pancreatic ribonuclease (*50*).

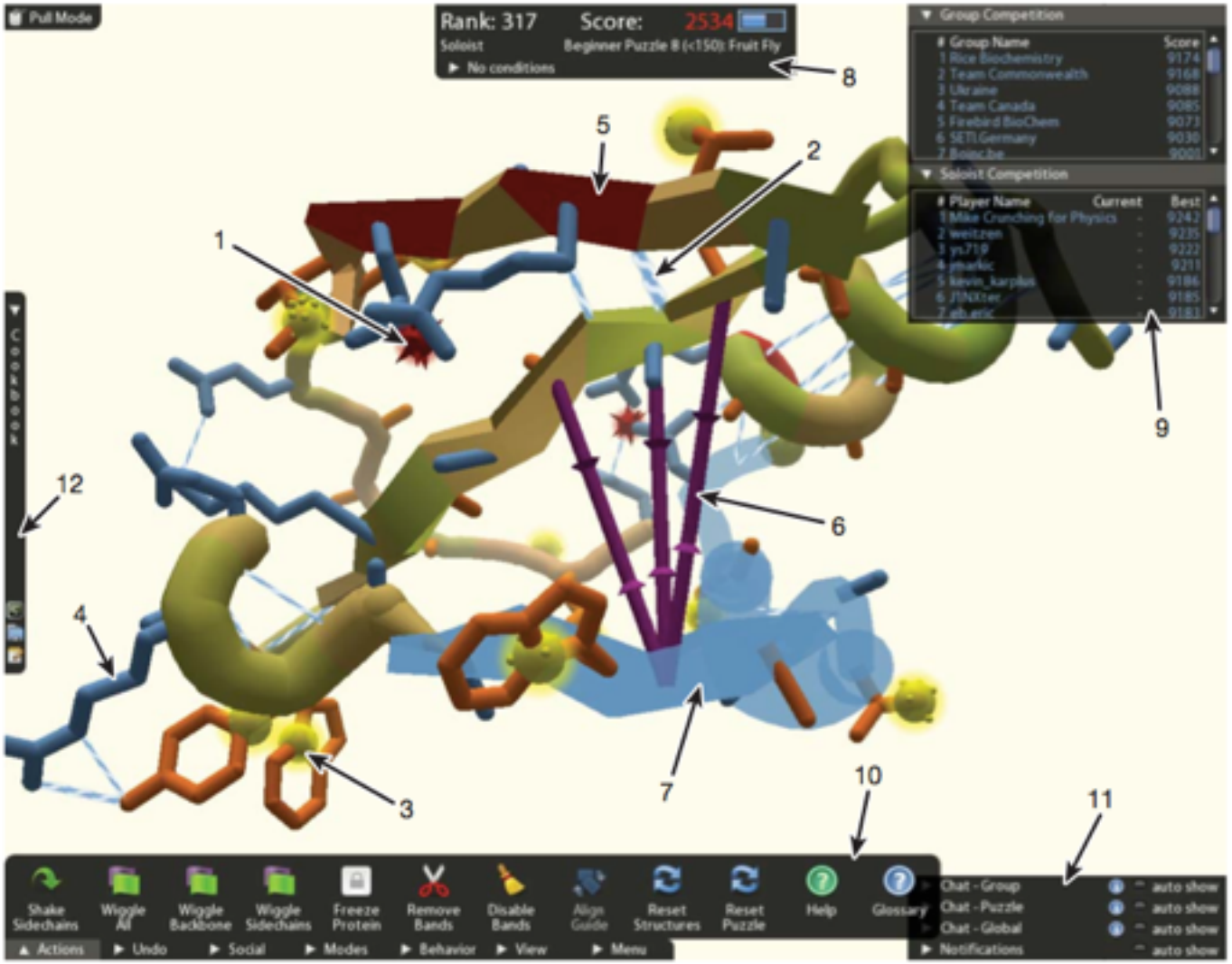
The information about the three-dimensional structure is contained in the sequence of the protein itself.

Principles that govern protein structure, Anfinsen, Science, 1973 (Nobel Lecture)

Protein structure prediction attempts

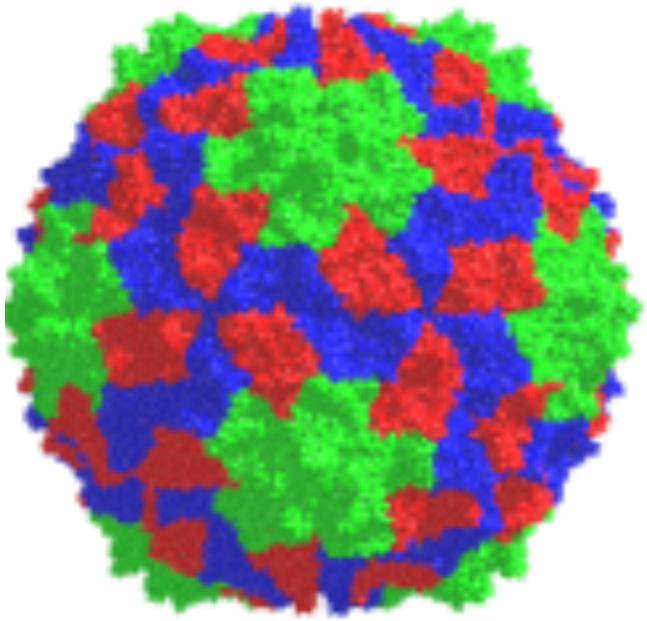
Understanding the principles that govern protein folding should allow us to predict the structure given the sequence information

A game where the score is thermodynamics!



https://en.wikipedia.org/wiki/Foldit

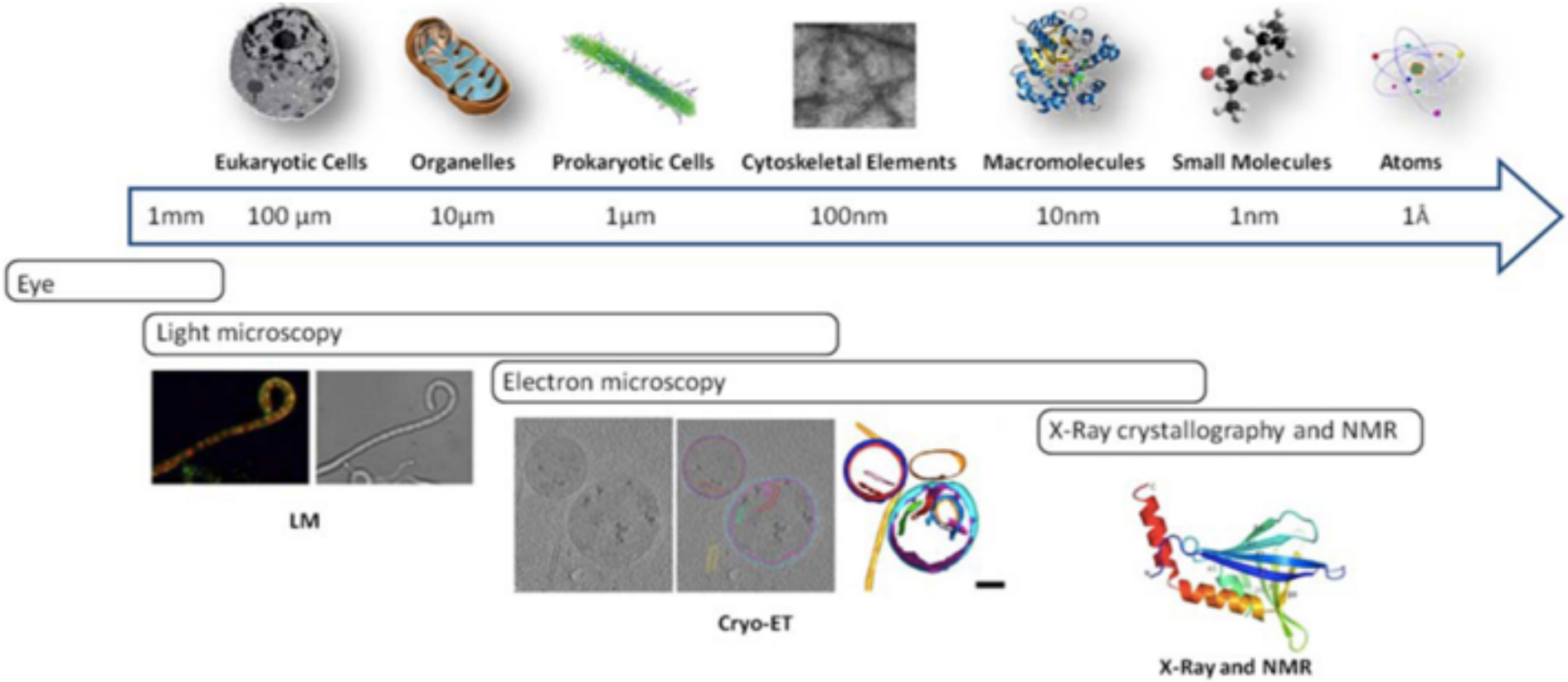
Proteins assemble to form bigger structures



28 nm

http://www.pnas.org/content/suppl/2007/12/05/0709489104.DC1/09489Movie1.mov

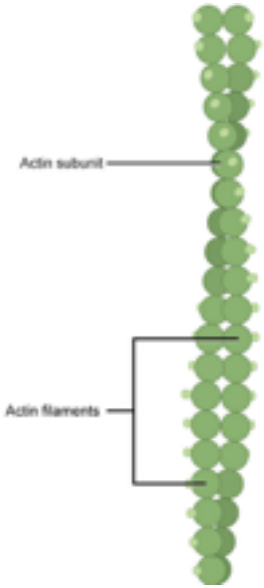
Visualising Macromolecular Complexes



Amino acids	< 3 Å
Secondary structure - **α**- helix & **β**- strands	4 - 7 Å
Individual protein subunits (~ 30 kDa)	30 - 40 Å

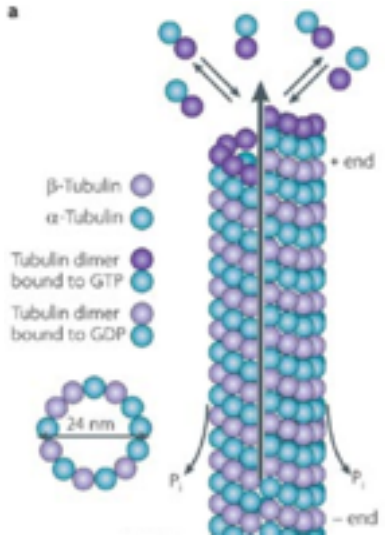
What is cytoskeleton?

Microfilaments (~ 7 nm)

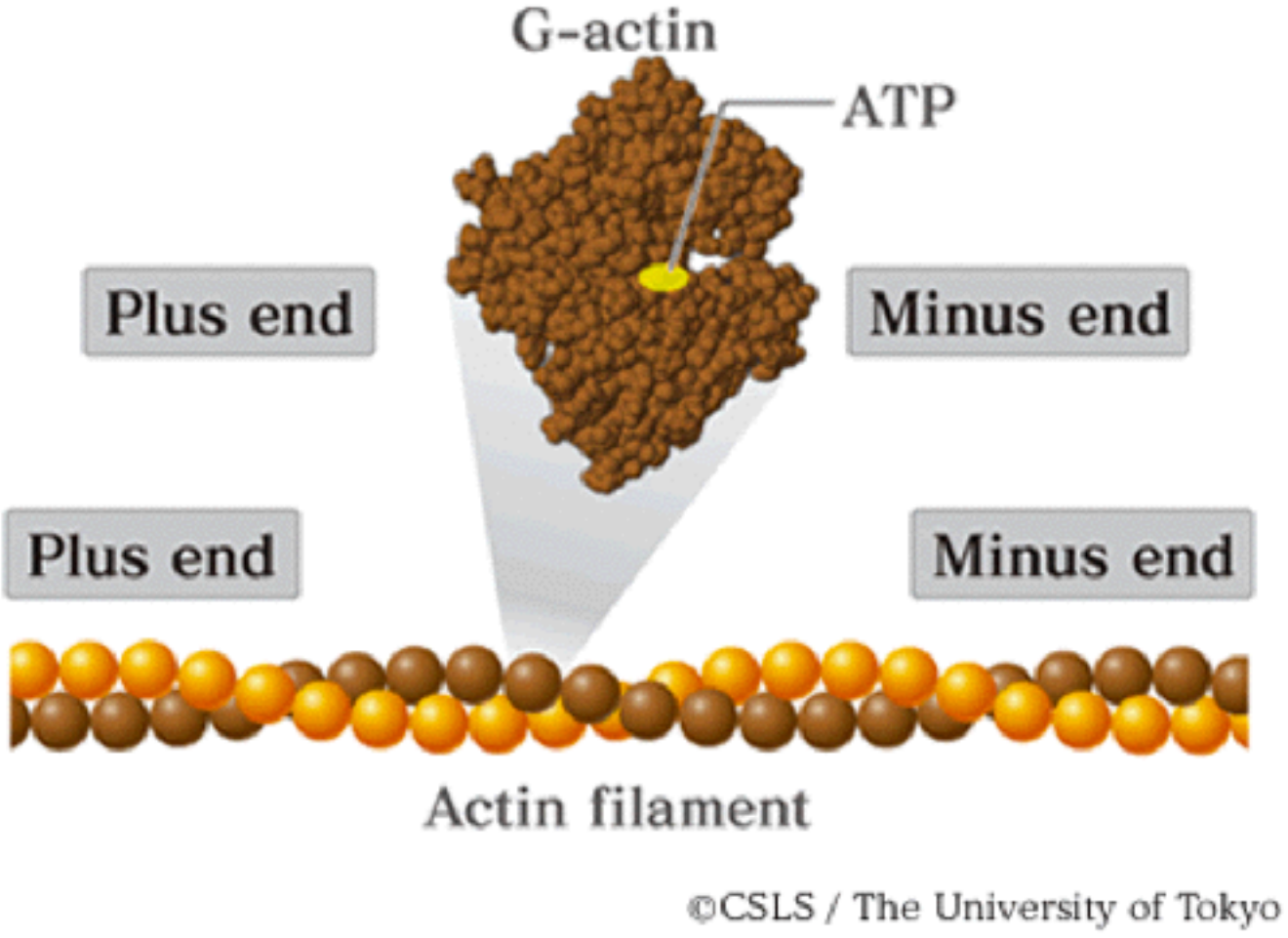


Intermediate filaments (~ 8-10 nm)

Microtubules (~ 25 nm)

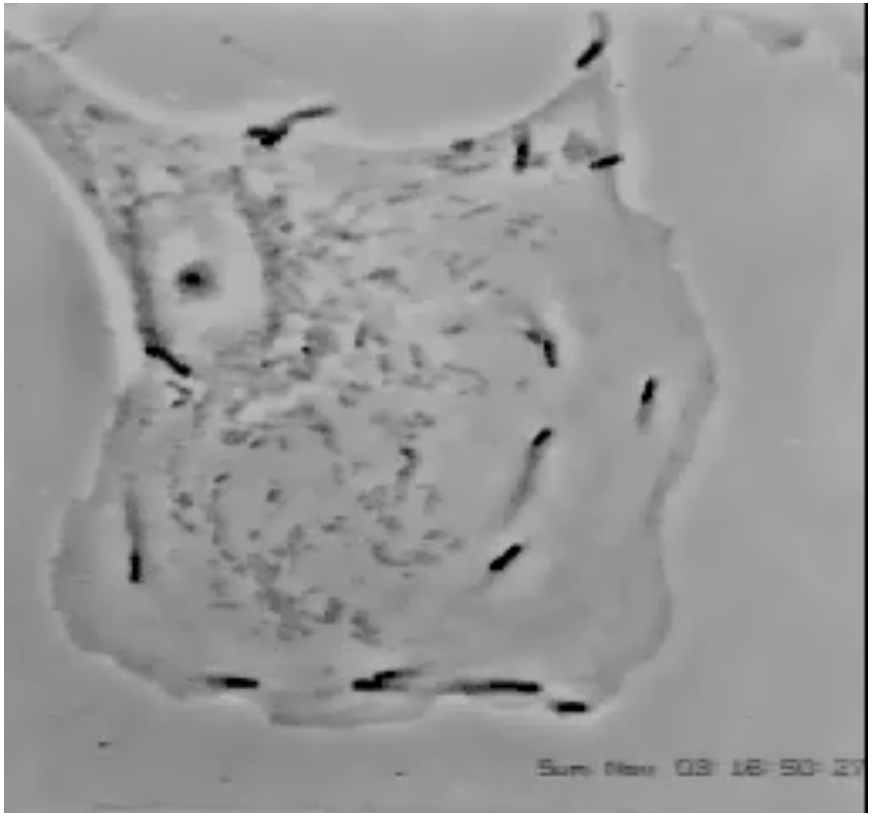


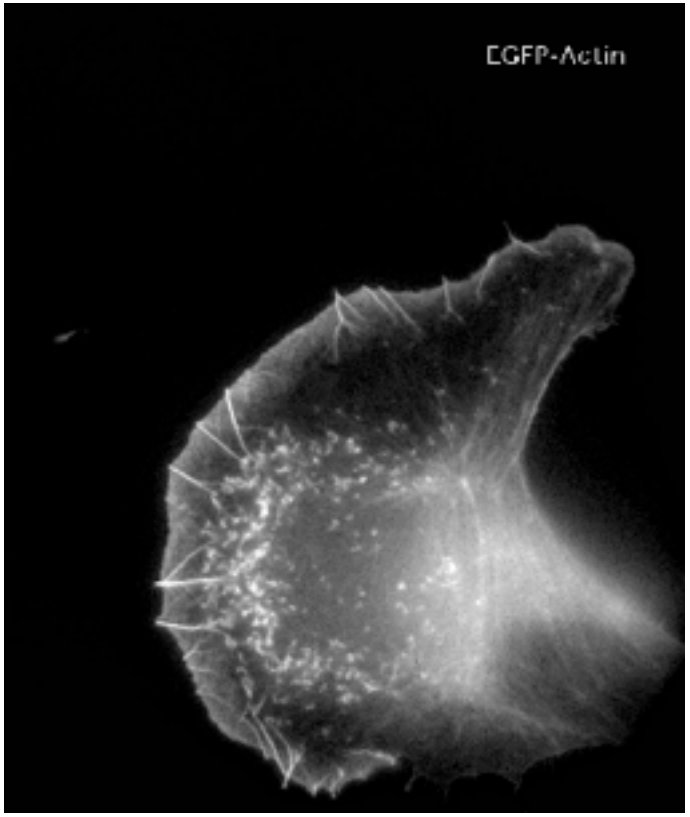
Microfilaments



http://www.mechanobio.info/modules/go-0030041
http://csls-text.c.u-tokyo.ac.jp/flash/0611_1.html

Pushing by Actin filaments

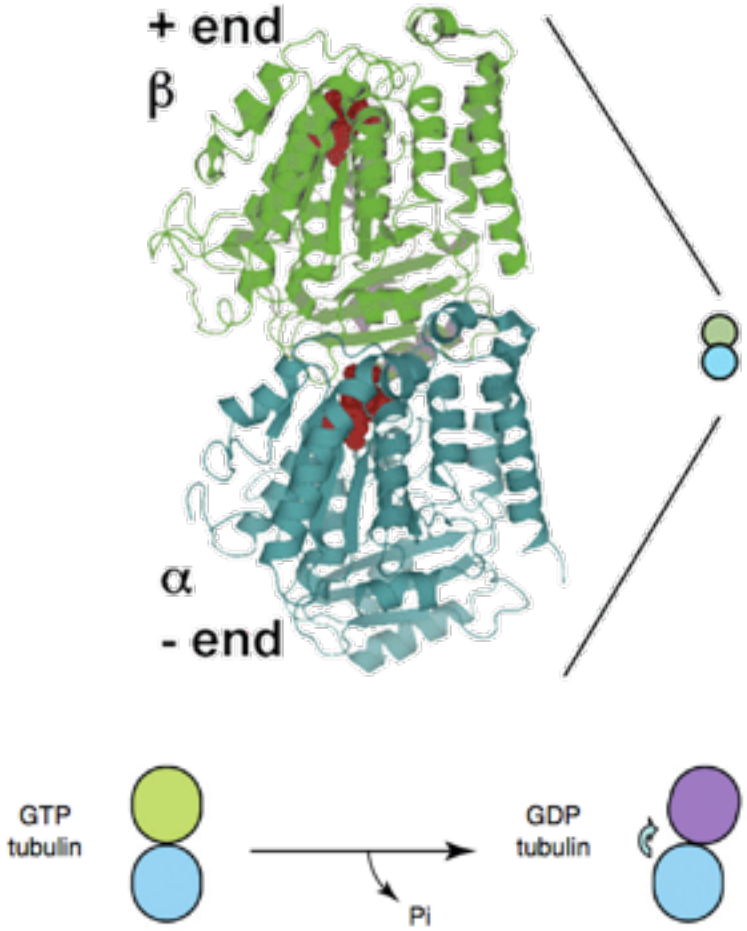


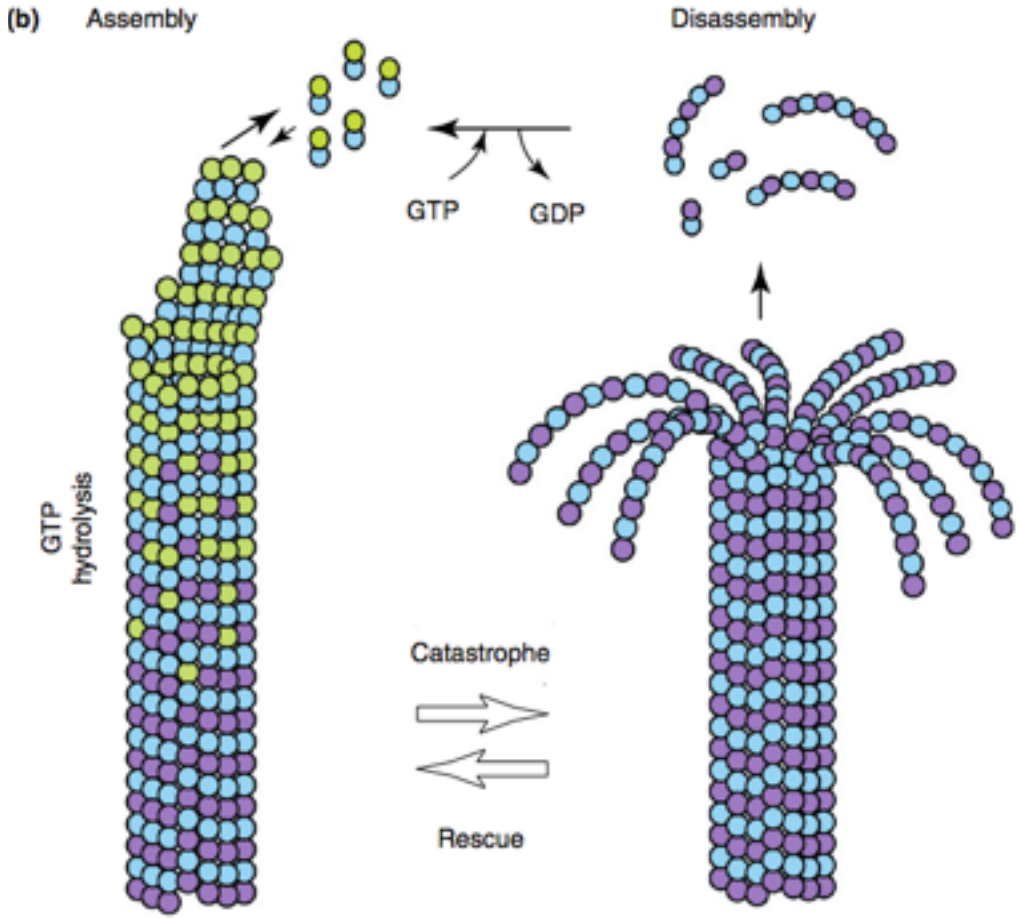


Lab webpage: Julie Theriot (http://cmgm.stanford.edu/theriot/movies.html)

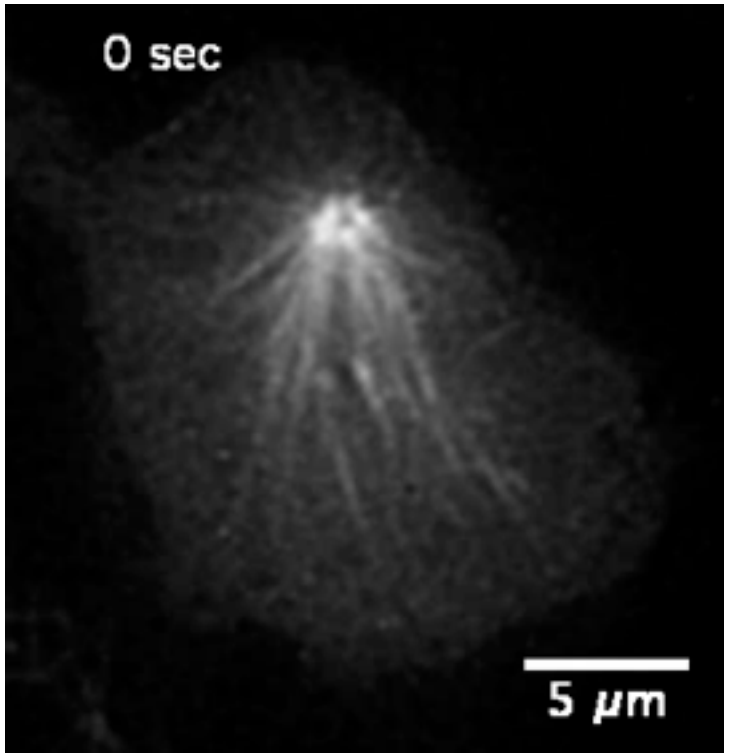
Microfilaments

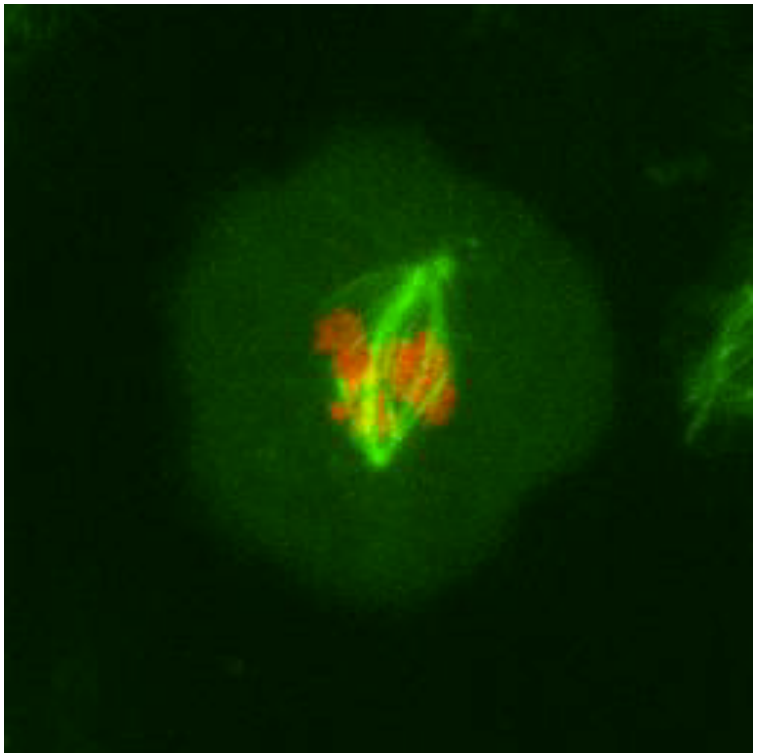
Monomers: Tubulin dimers





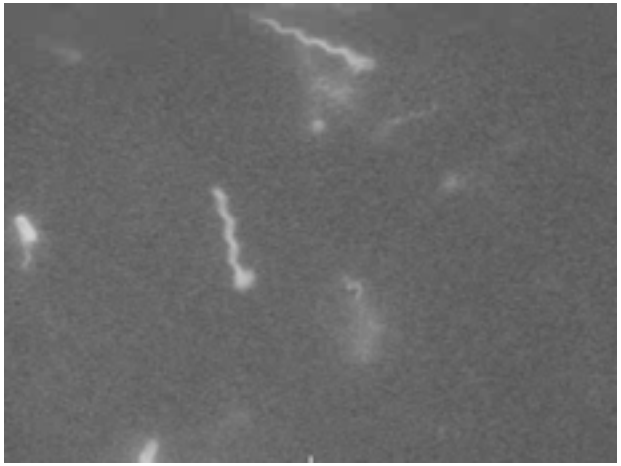
Pushing of chromosomes by Microtubules

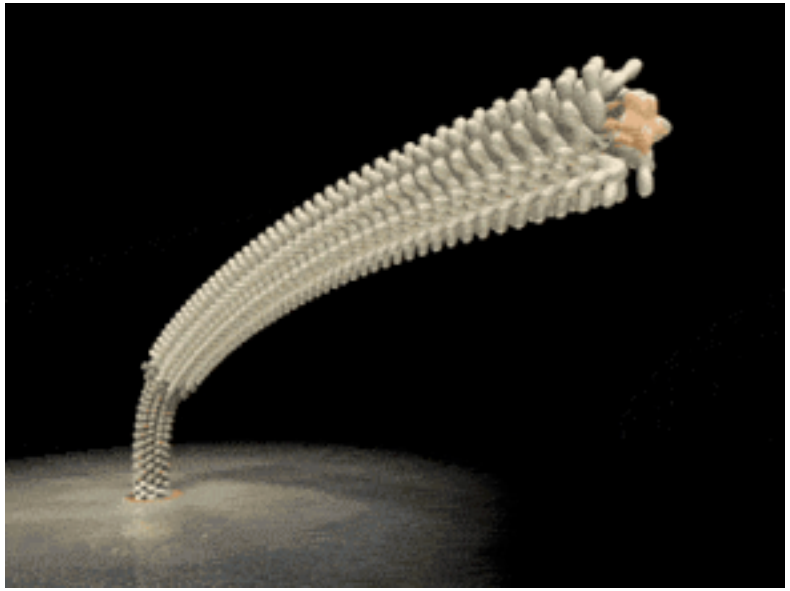




Lab webpages: Salmon and Ron Vale

Bacterial Flagella

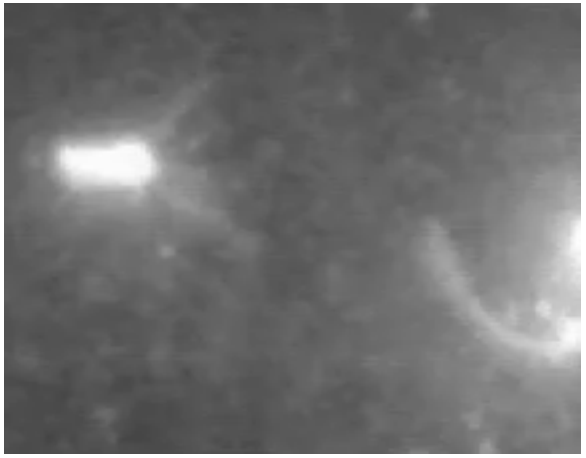




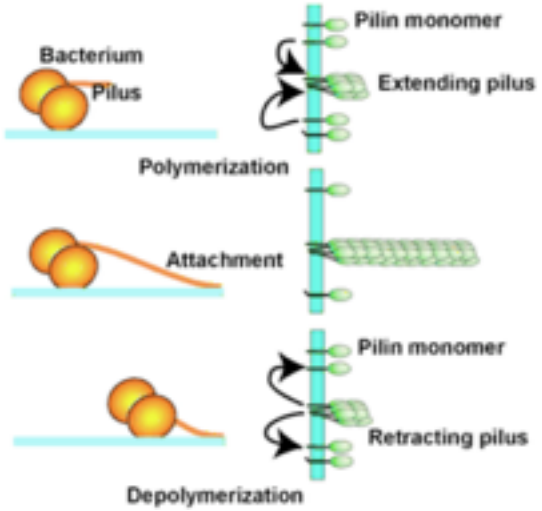
Lab webpages: Howard Berg & Keiichi Namba

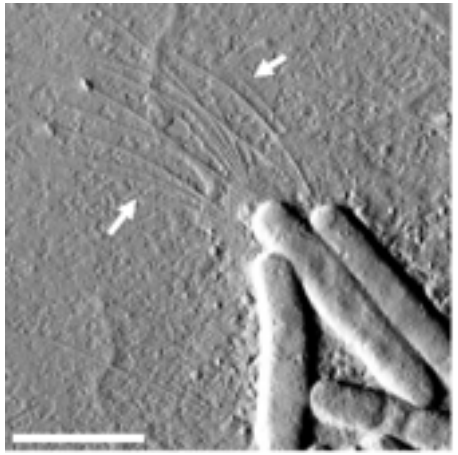
Proton driven motor movie
http://www.fbs.osaka-u.ac.jp/labs/namba/npn/

Bacterial Type IV Pili



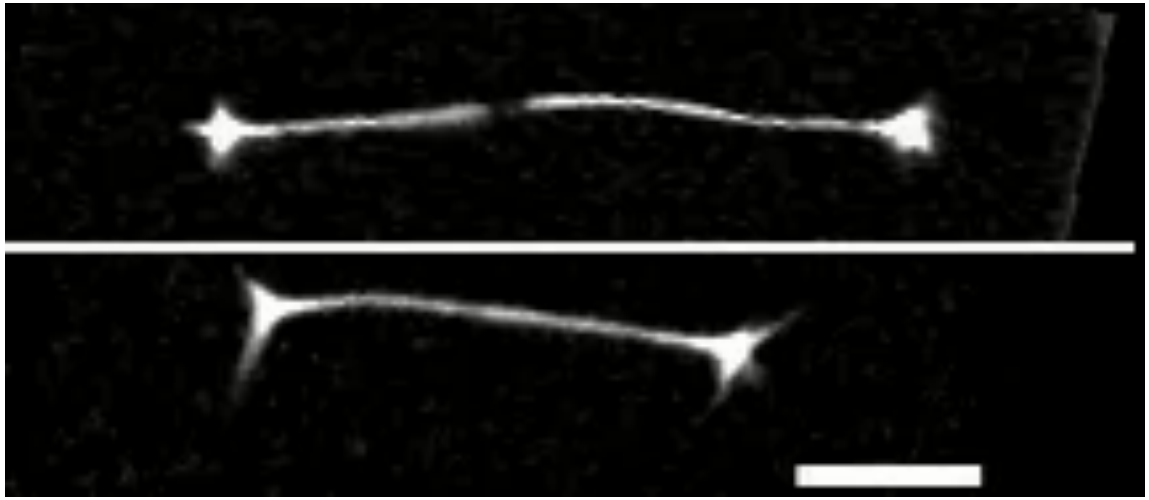
Lab webpage: Howard Berg





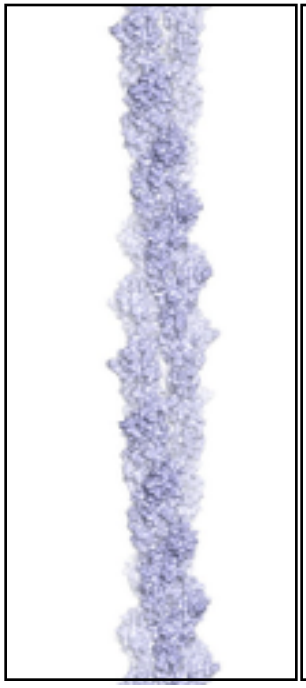
Lab webpages: Shi; Holtz & Kurre

A simple DNA segragating machine



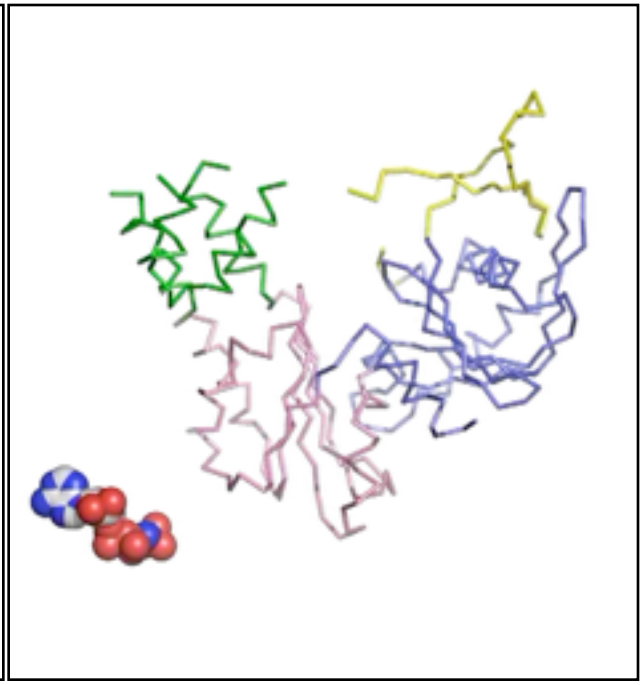
Garner, et al, Science, 2007

Cryoelectron microscopy



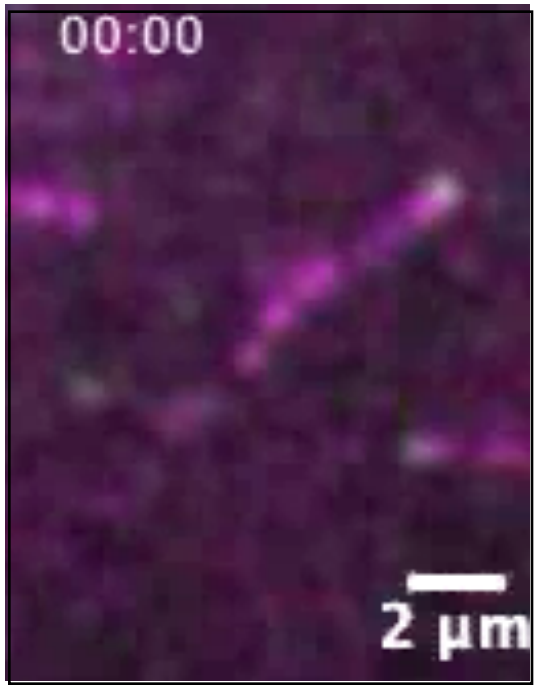
Macromolecular assembly

X-ray crystallography



Snapshots of conformational states of components

TIRF microscopy



Dynamics of assembly/ in vitro reconstitution

Molecular mechanism behind fundamental biological processes