

Pushing and Pulling by Protein Filaments

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

**Exciting Science Group
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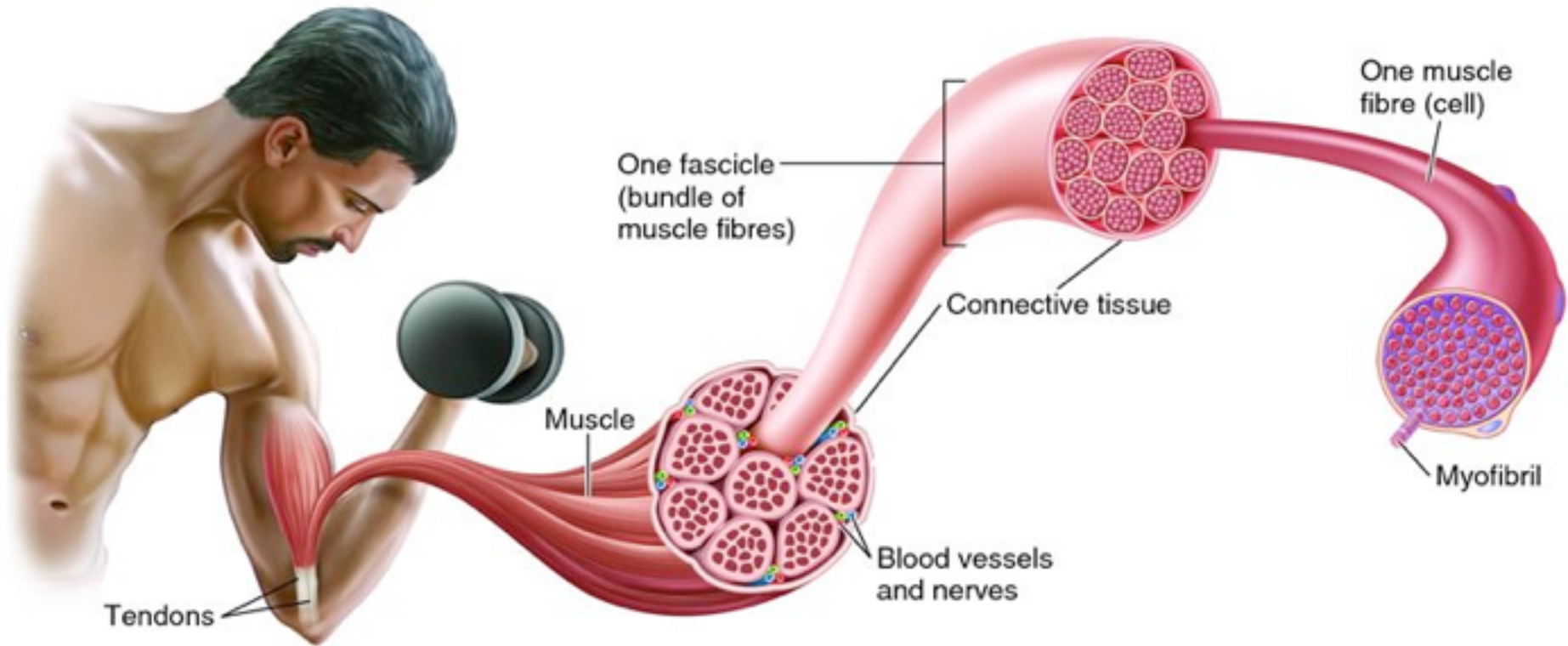
What is a protein?

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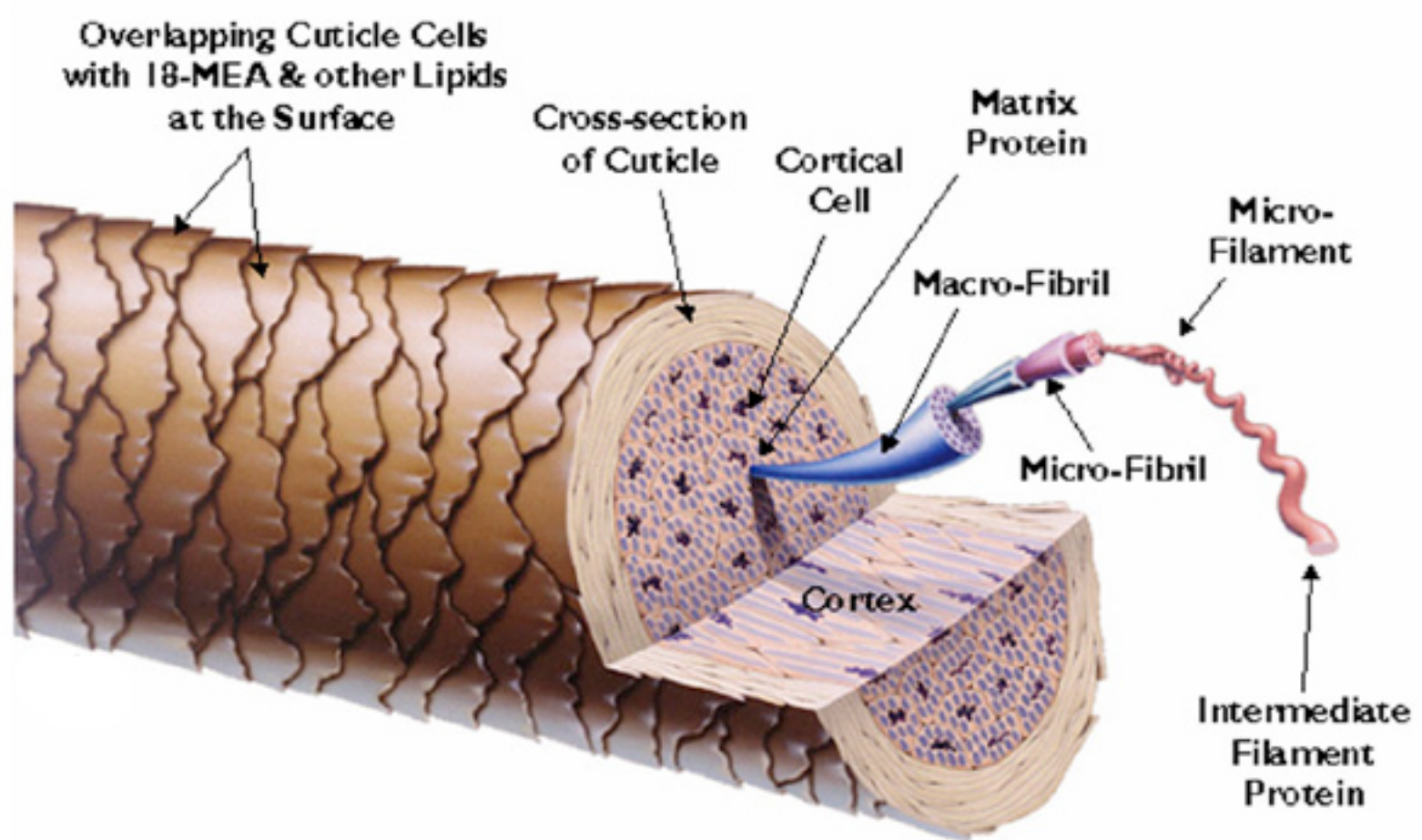
What do proteins do?

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



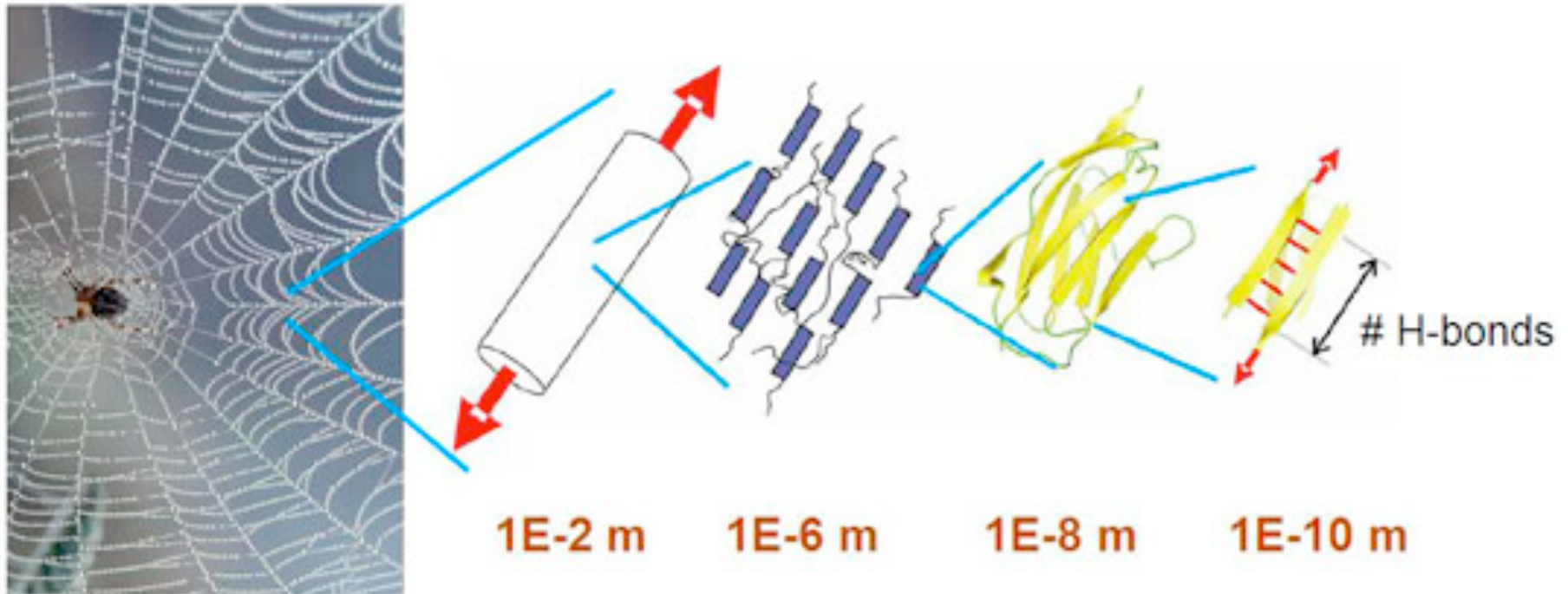
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What do proteins do?

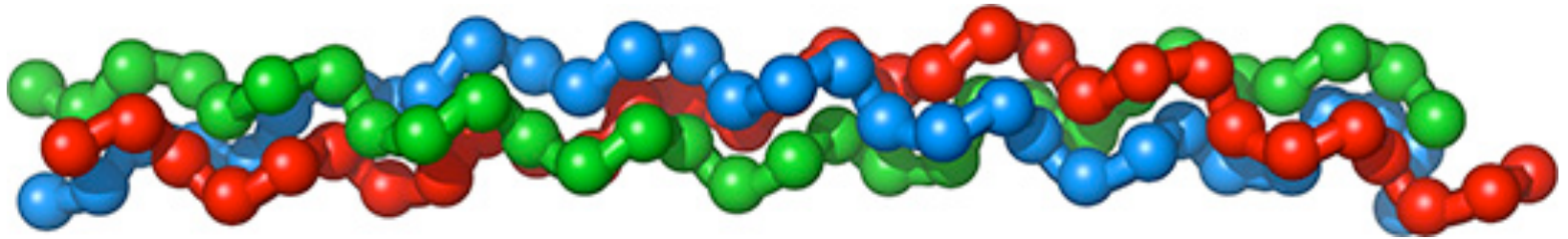
Gives structure
eg. Hair, Muscle, Silk, Spider web



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

What do proteins do?

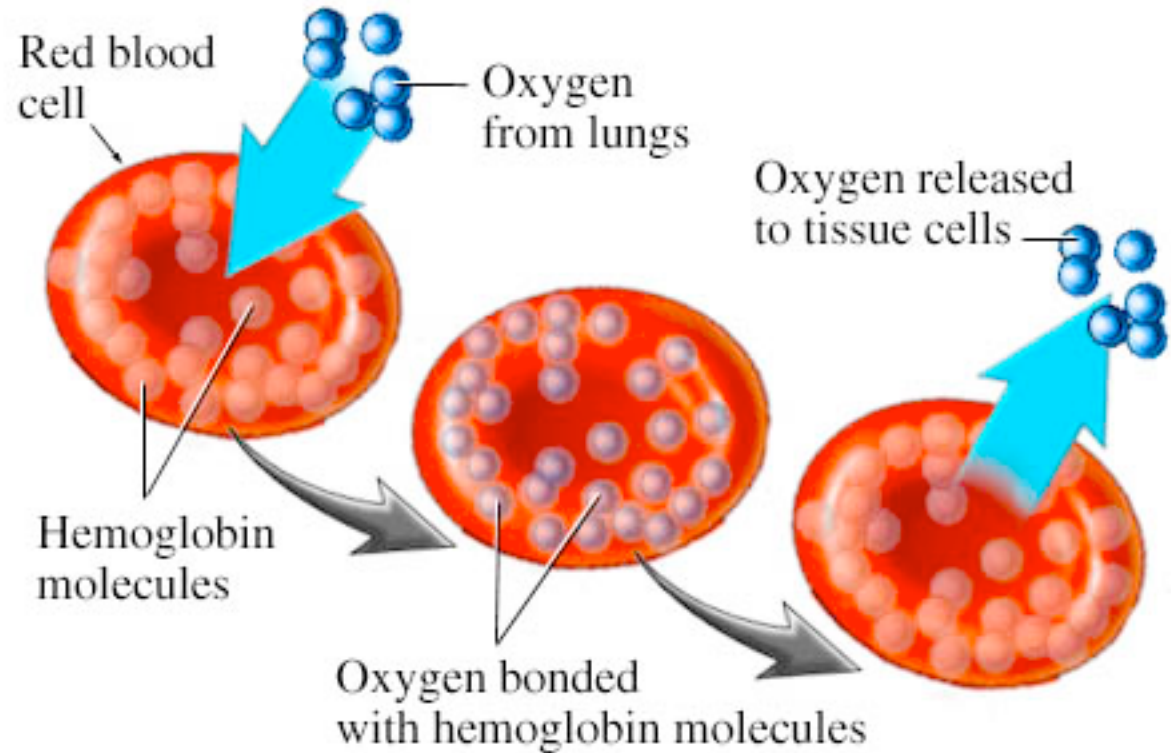
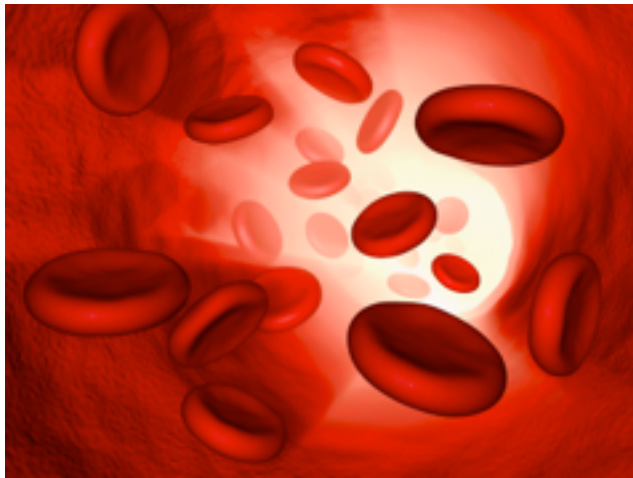
Gives structure
eg. Hair, Muscle, Silk, Spider web



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

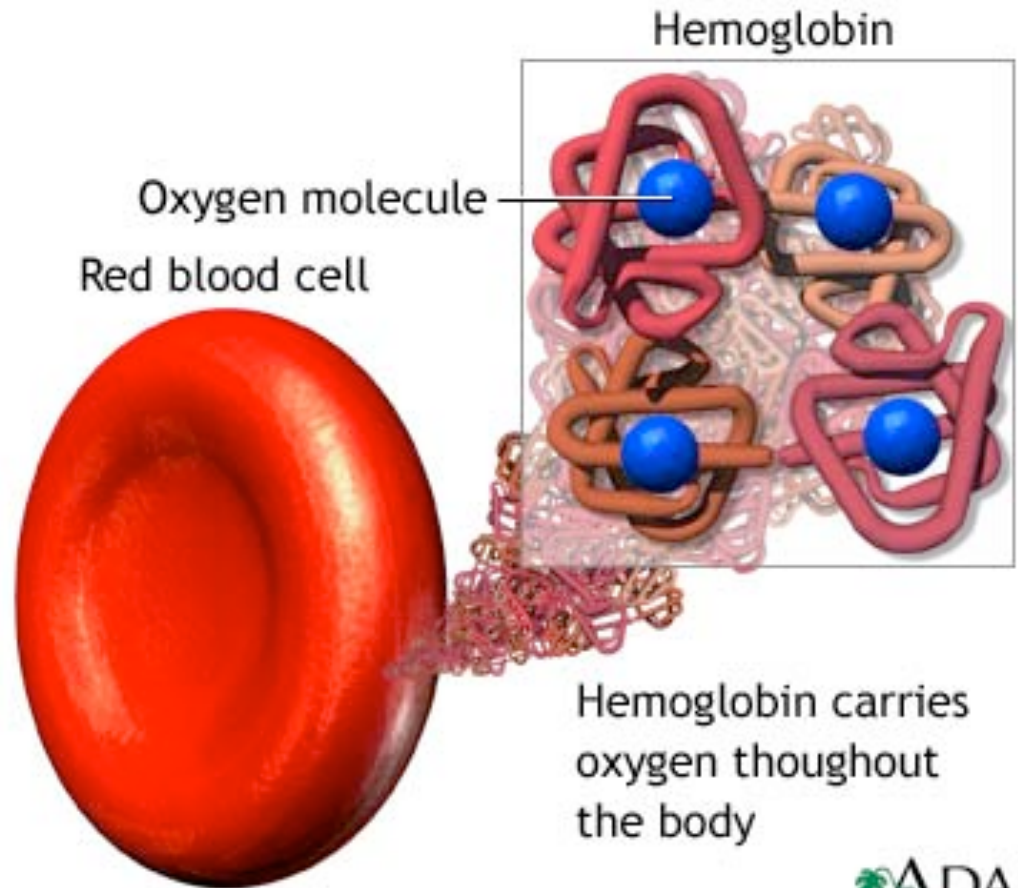
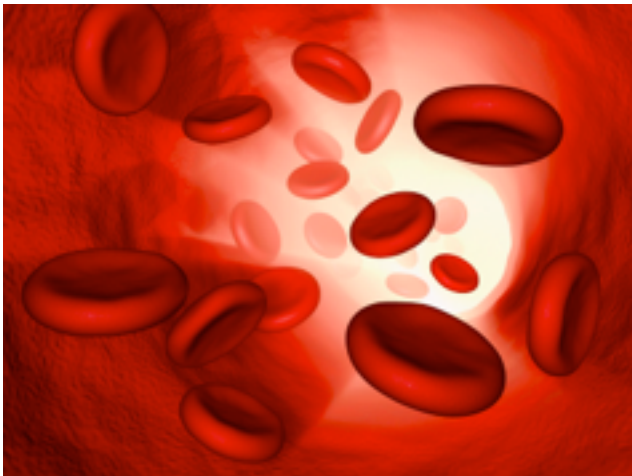
What do proteins do?

Transport



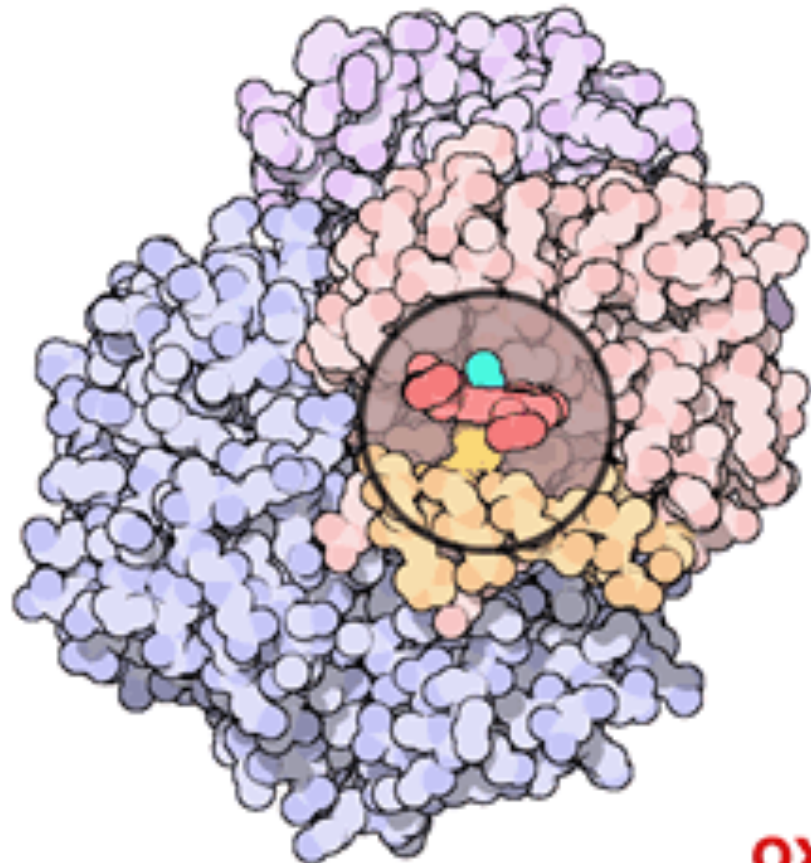
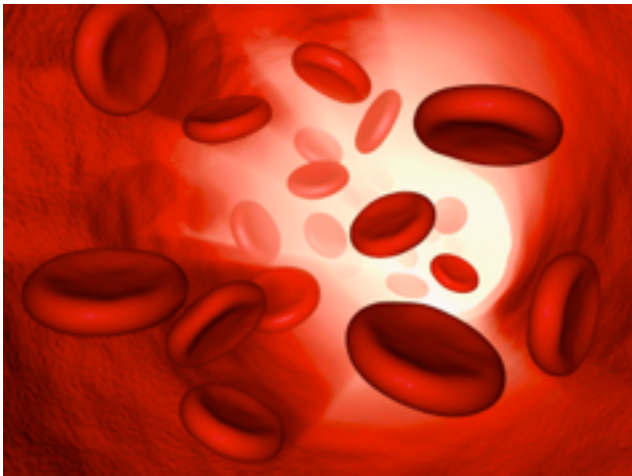
What do proteins do?

Transport



What do proteins do?

Transport



oxy

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

What do proteins do?

Transports cargo



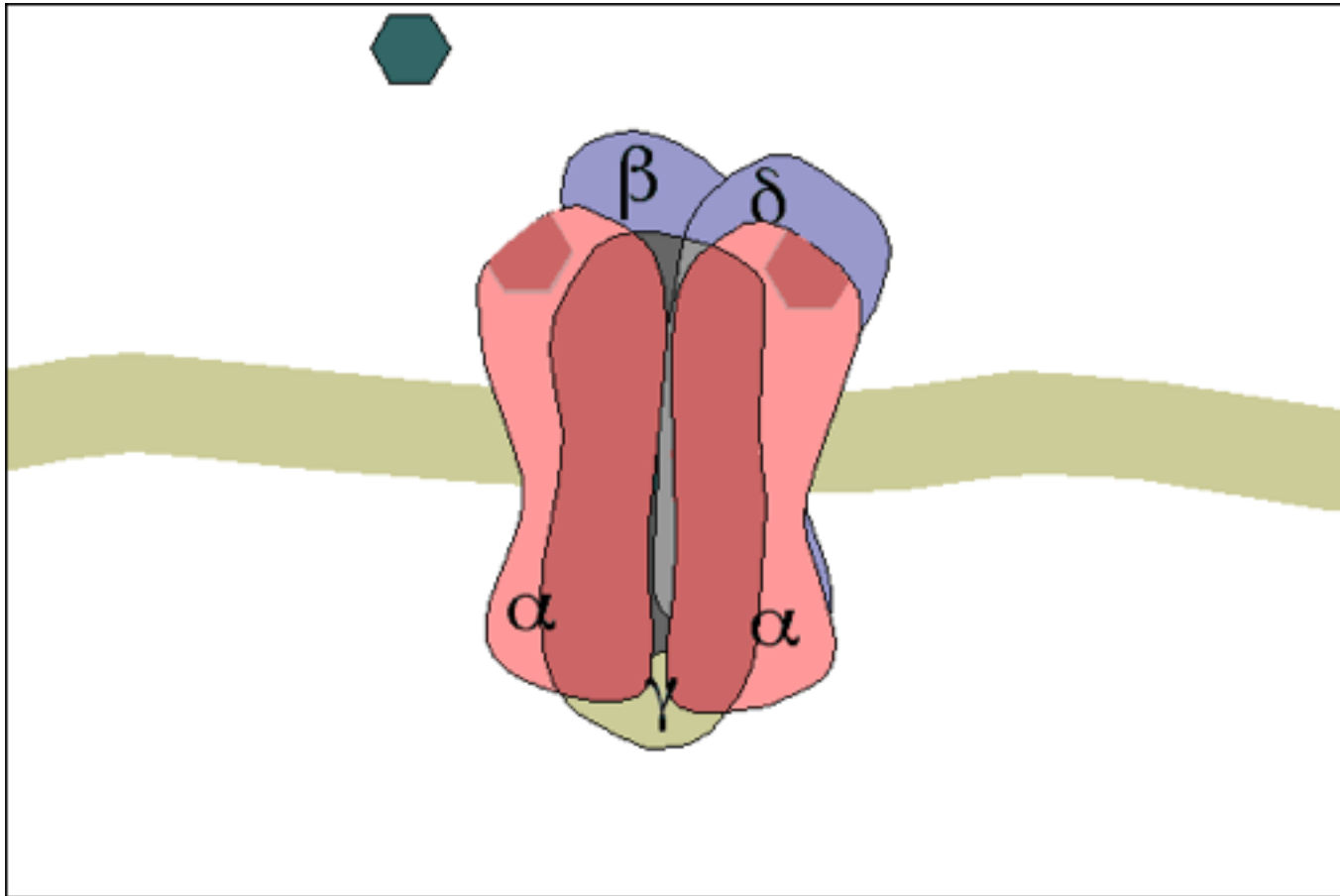
Kinesin movie links:

Ron Vale, Lab webpage (<https://valelab.ucsf.edu/external/moviepages/moviesMolecMotors.html>)

<https://coub.com/view/3ddls>

What do proteins do?

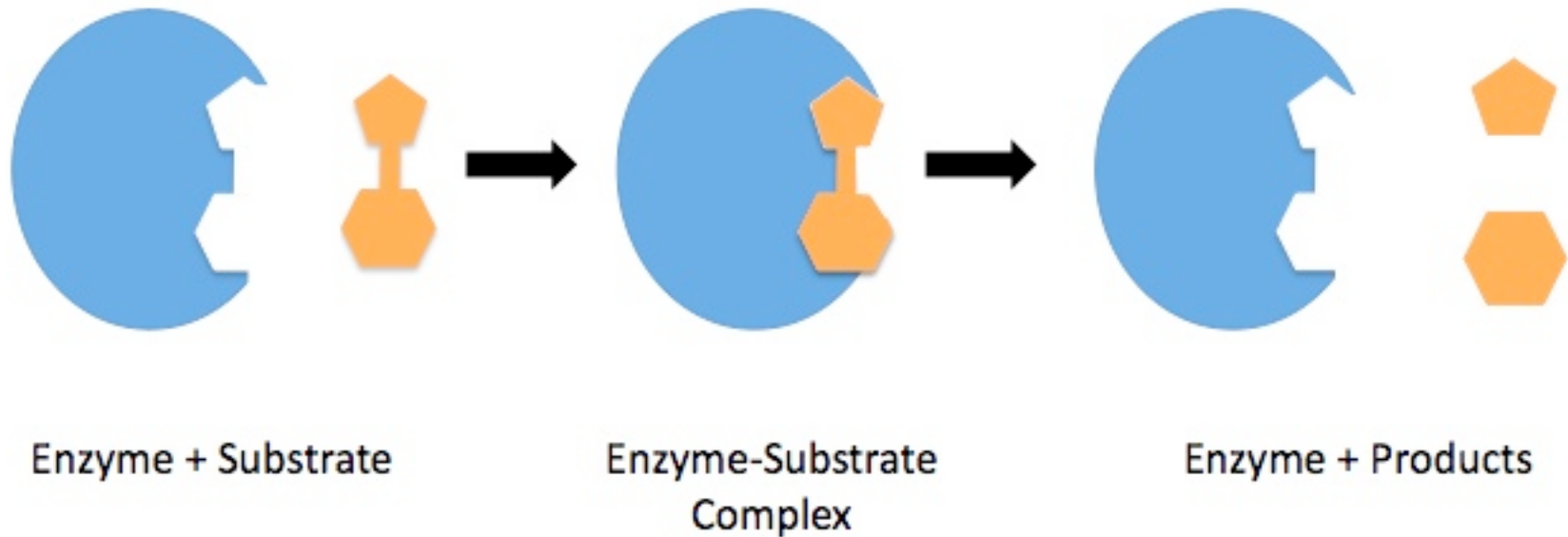
Transports cargo



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

What do proteins do?

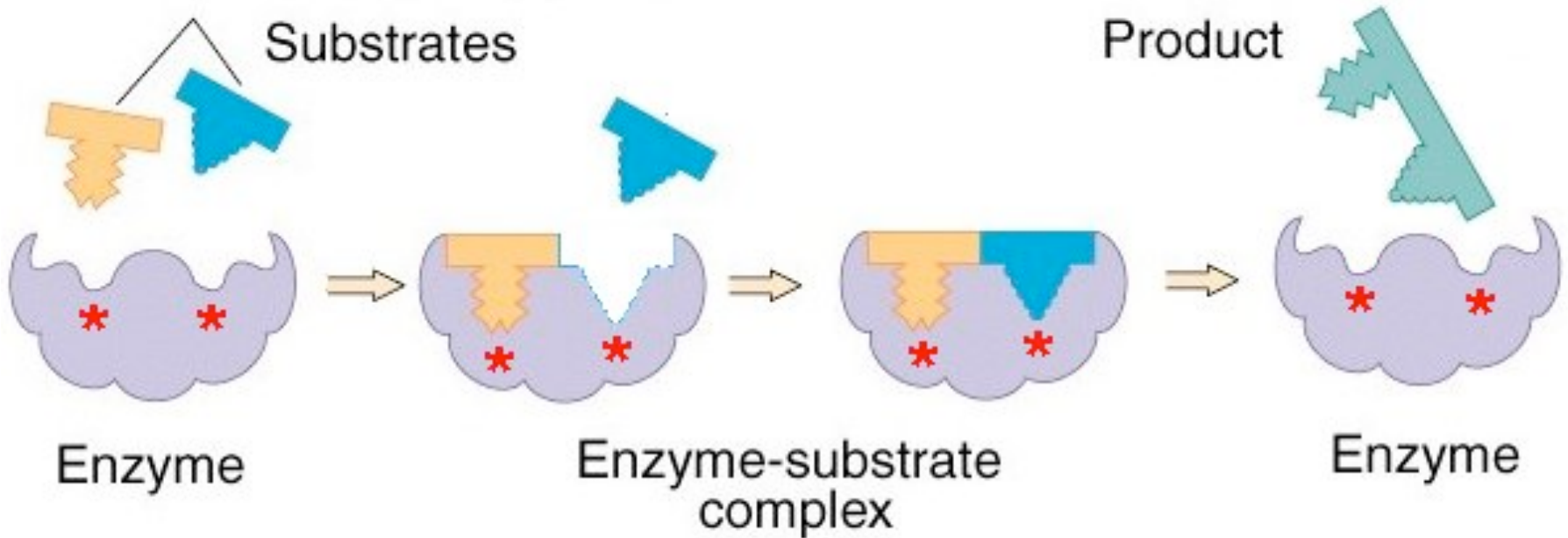
Biological catalyst



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

What do proteins do?

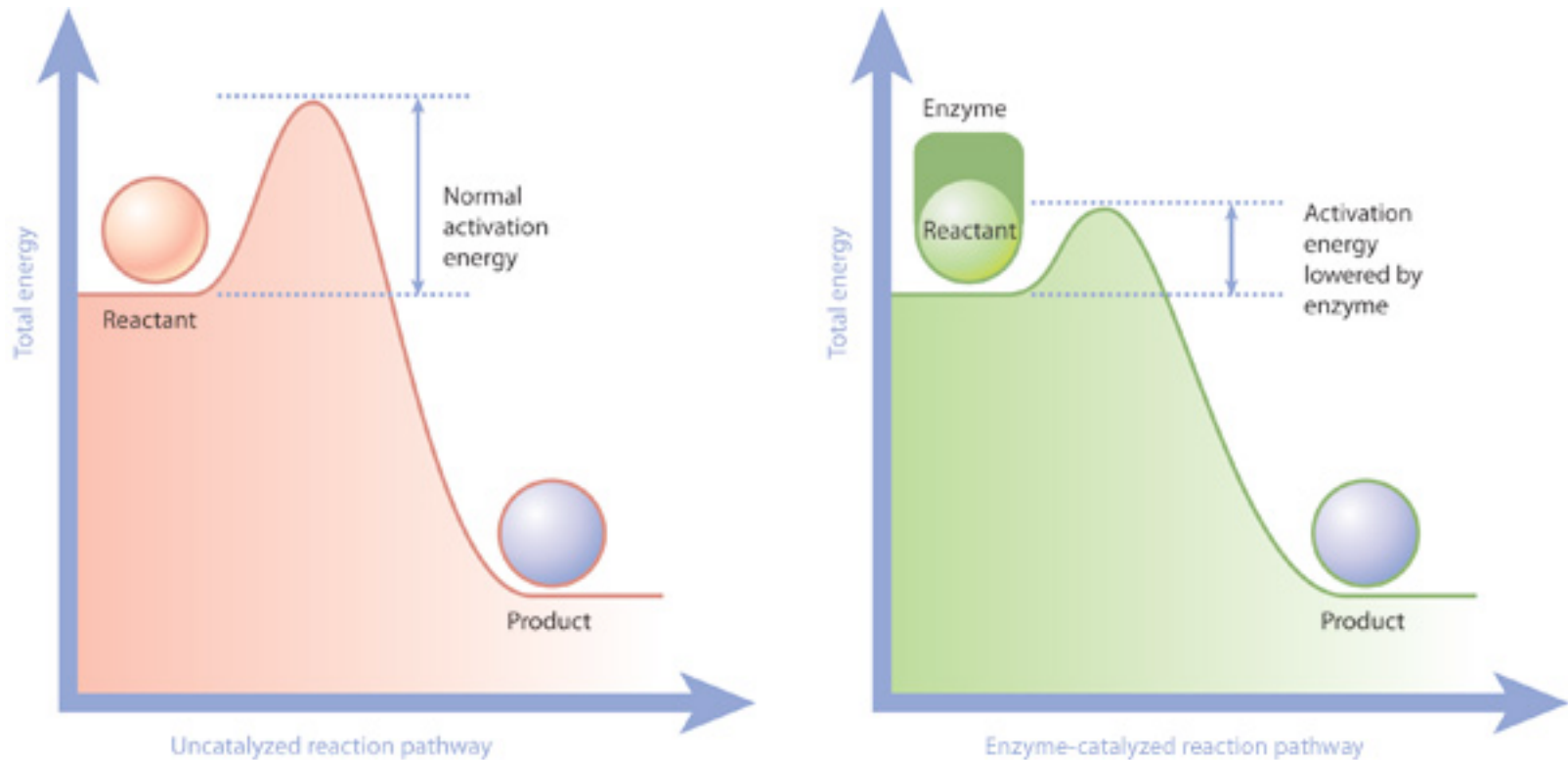
Biological catalyst



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

What do proteins do?

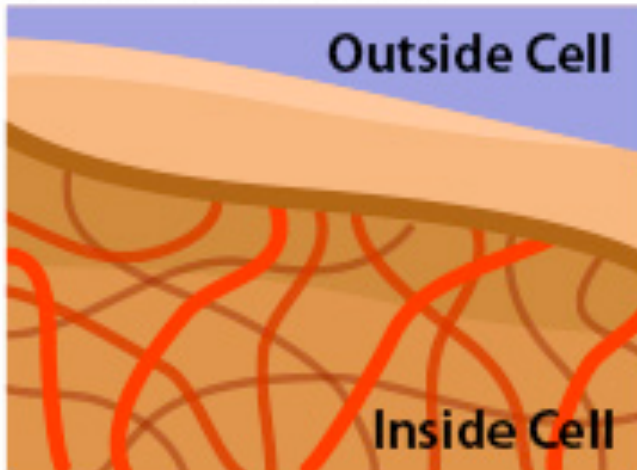
Biological catalyst



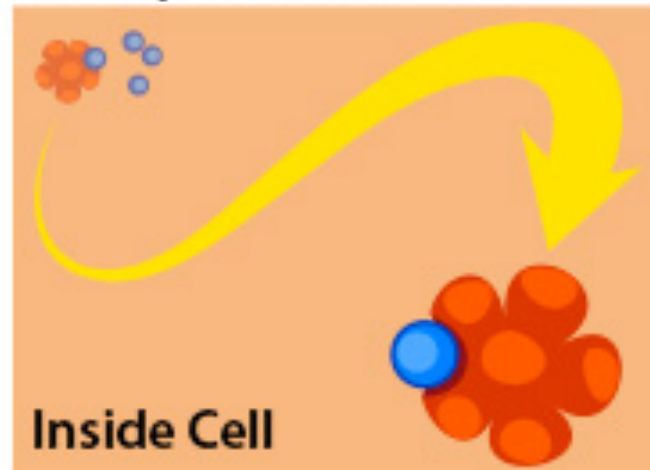
<http://www.nature.com/scitable/topicpage/protein-function-14123348>

What do proteins do?

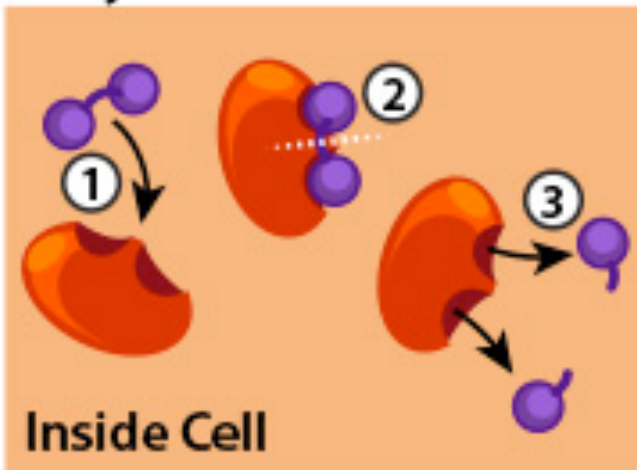
Structure Protein



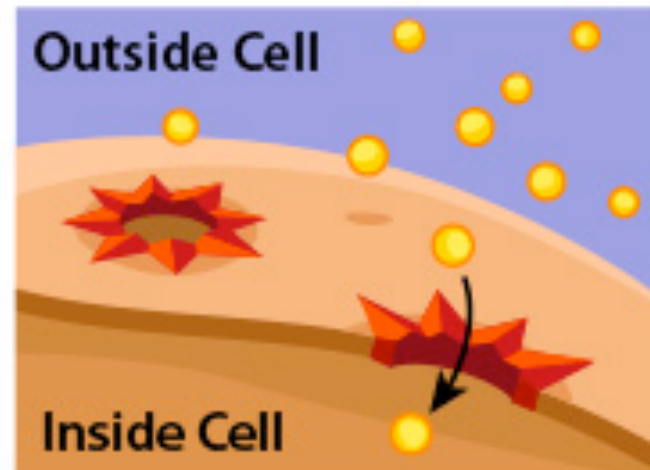
Transport Protein



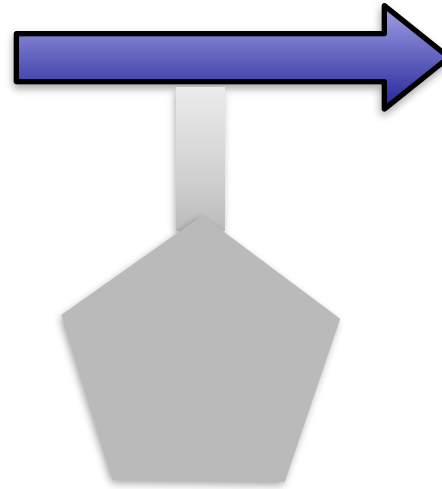
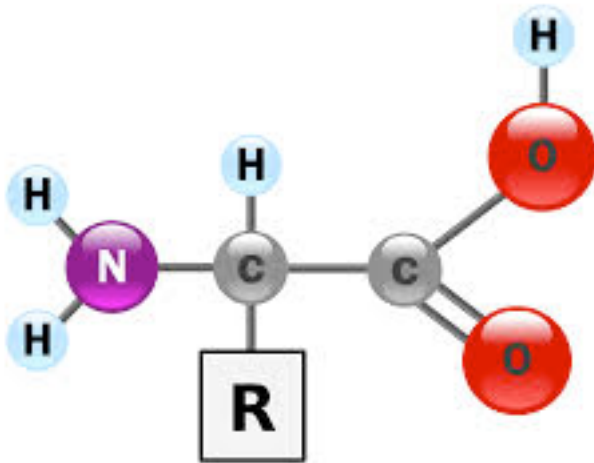
Enzymes



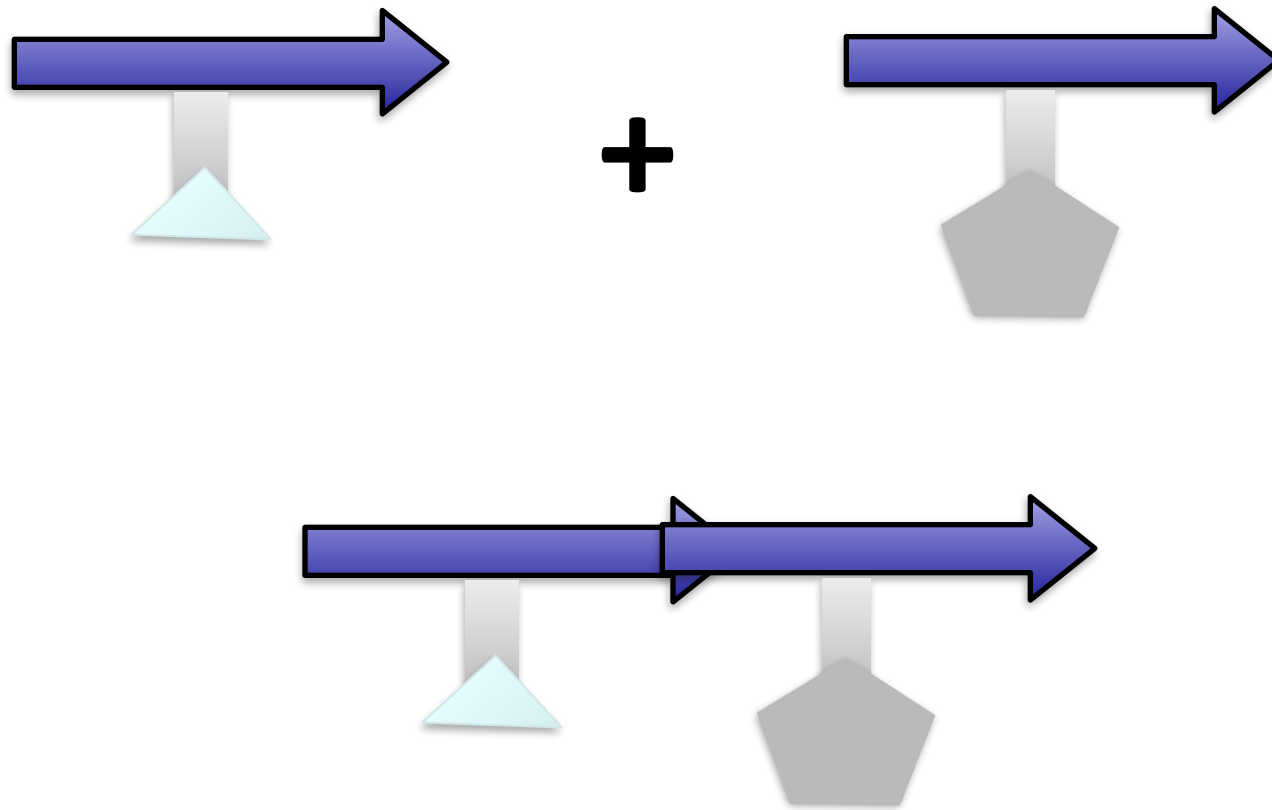
Channels



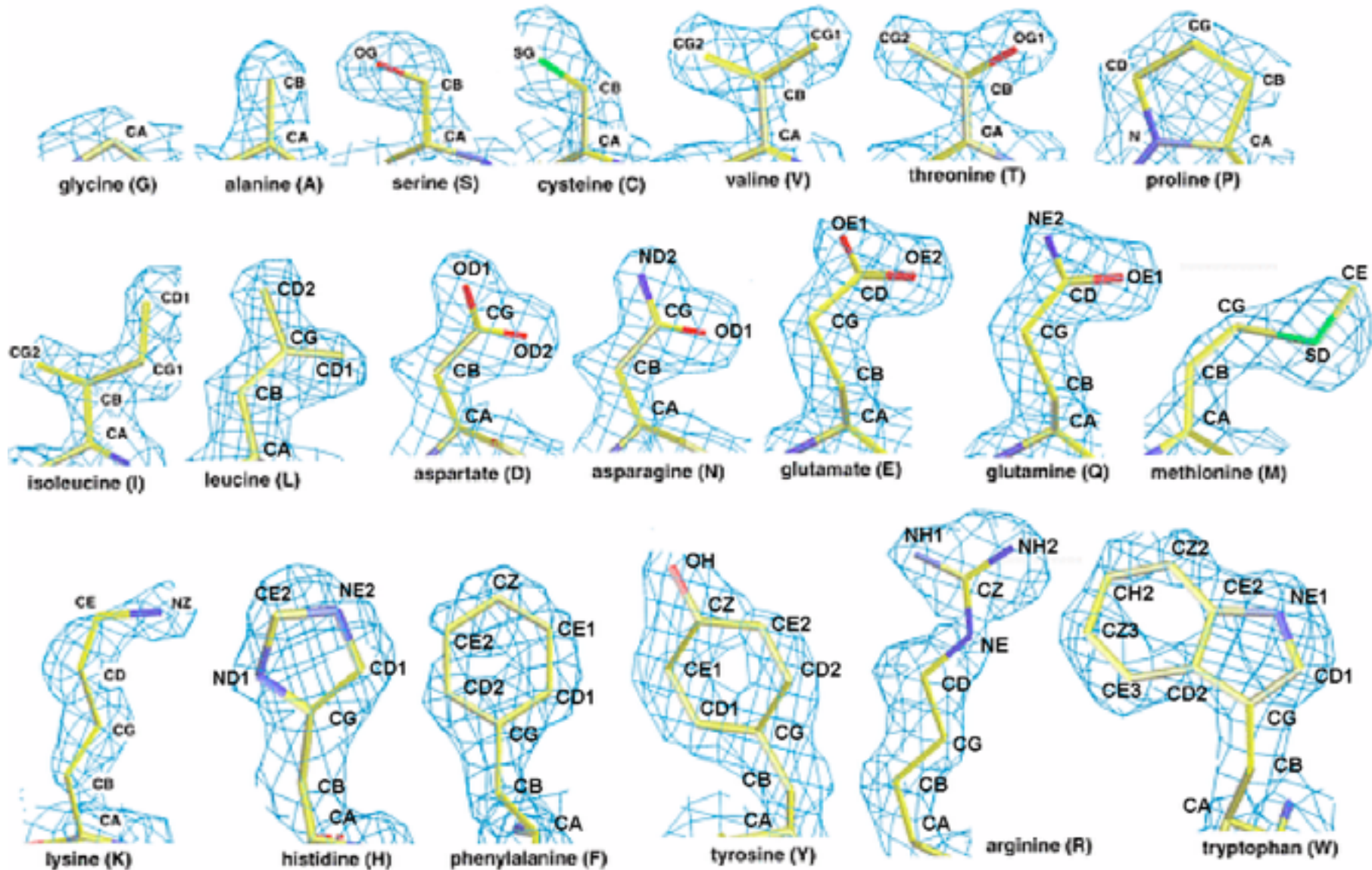
A protein is made up of amino acids



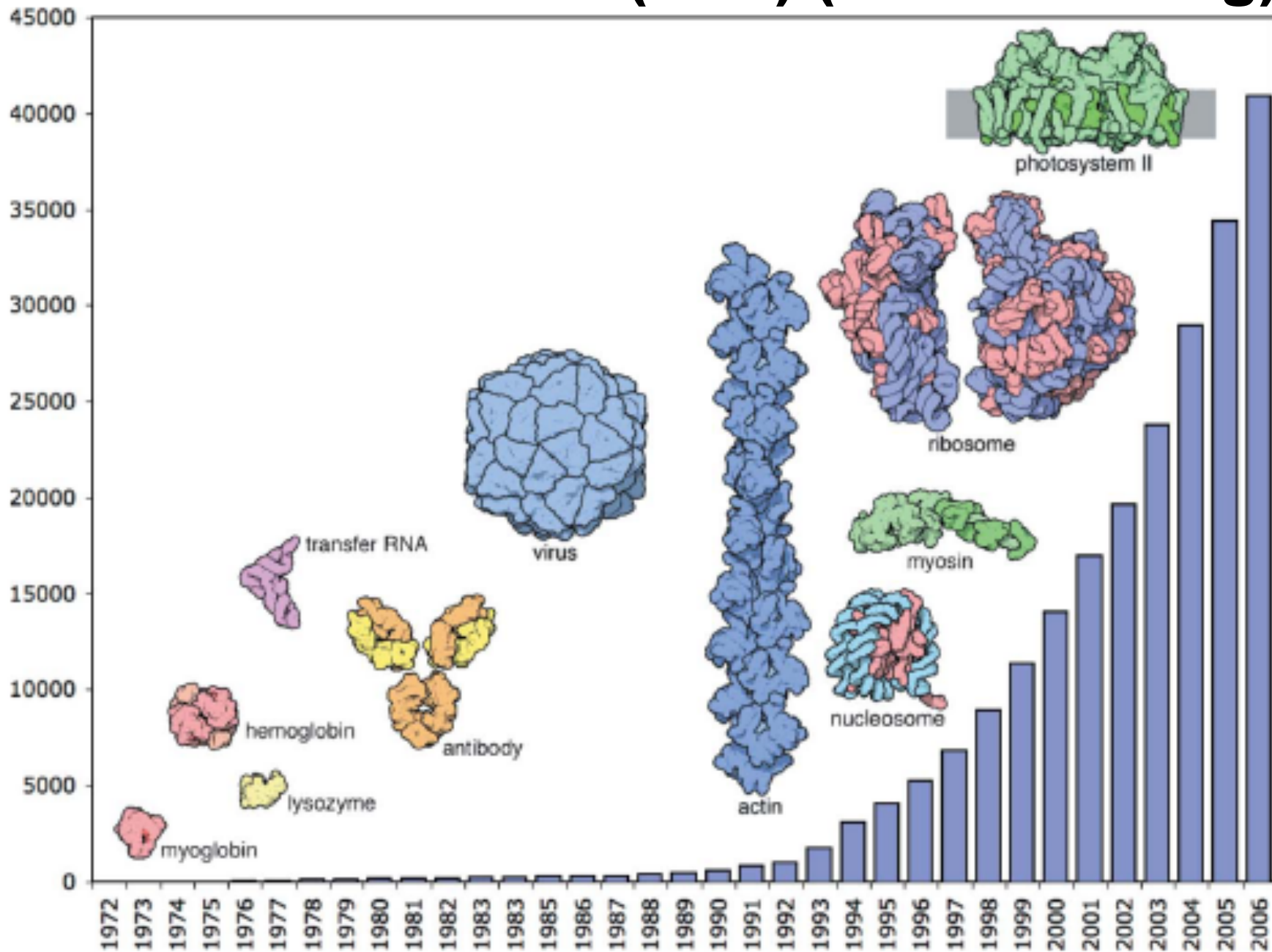
A protein is made up of amino acids



A protein is made up of amino acids



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



Protein folding

The process by which the protein takes up its native conformation

PROTEIN FOLDING

Based on original video by
PyMol animation demonstration
pymol.org

Anfinsen's experiment (1969)

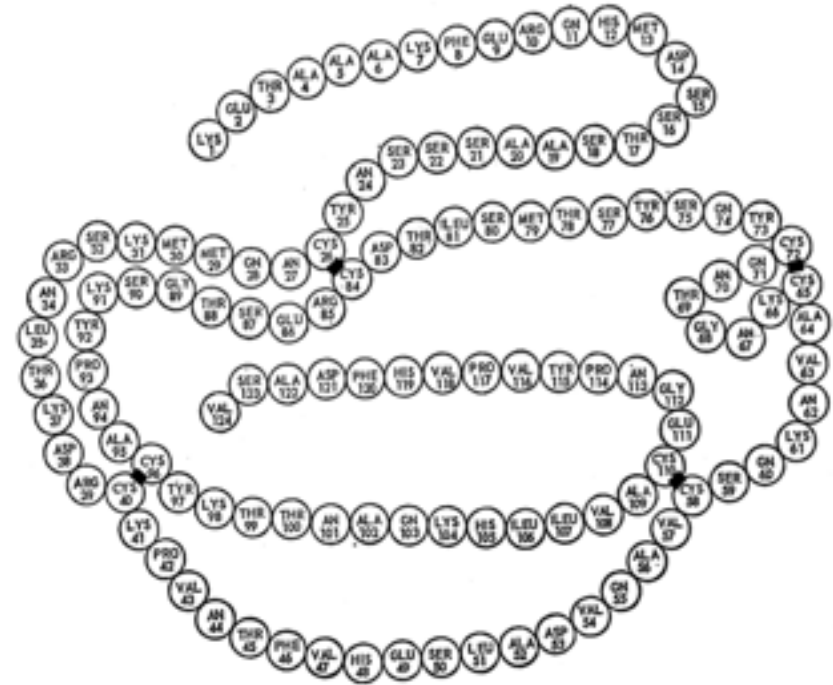
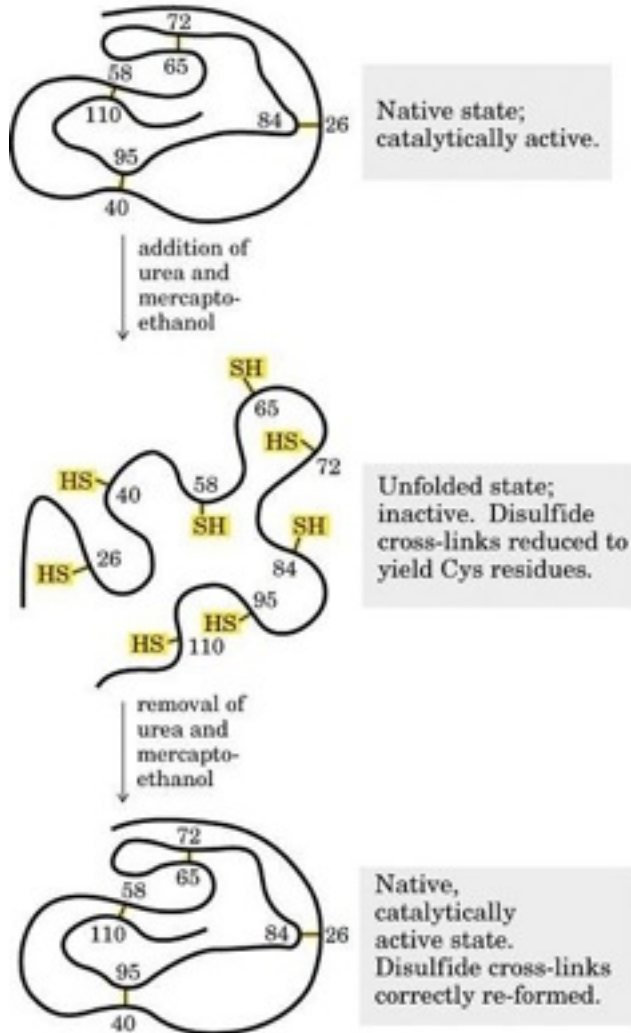


Fig. 1. The amino acid sequence of bovine pancreatic ribonuclease (50).

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

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!

The screenshot displays the Foldit game interface. At the top, it shows the player's Rank (317) and Score (2534) for the puzzle 'Beginner Puzzle 8 (-150): Fruit Fly'. The puzzle is in 'Soloist' mode with 'No conditions'. A 'Group Competition' table is visible on the right, and a 'Soloist Competition' table is also present. The main area shows a 3D protein structure with various colored segments and arrows pointing to specific features. A control panel at the bottom contains various actions like 'Shake Sidechains', 'Wiggle All', 'Wiggle Backbone', 'Wiggle Sidechains', 'Freeze Protein', 'Remove Bands', 'Disable Bands', 'Align Guide', 'Reset Structures', 'Reset Puzzle', 'Help', and 'Glossary'. There are also chat and notification options.

Rank: 317 Score: 2534
Soloist Beginner Puzzle 8 (-150): Fruit Fly
No conditions

Group Competition

#	Group Name	Score
1	Rice Biochemistry	9174
2	Team Commonwealth	9168
3	Ukraine	9088
4	Team Canada	9085
5	Firebird BioChem	9073
6	SETI/Germany	9030
7	Bosc.be	9000

Soloist Competition

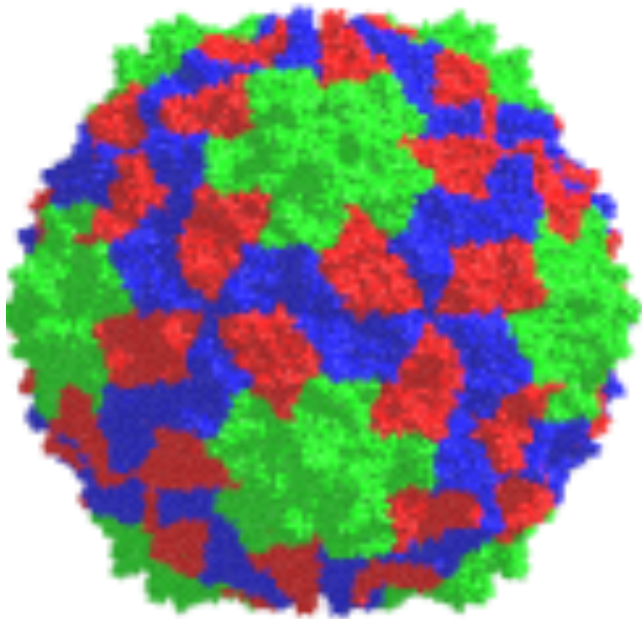
#	Player Name	Current	Best
1	Mike Crumling for Physics	-	9242
2	weitzel	-	9235
3	ys719	-	9222
4	pharkic	-	9211
5	kevin_karplus	-	9186
6	JINXter	-	9185
7	ab.eric	-	9181

Shake Sidechains Wiggle All Wiggle Backbone Wiggle Sidechains Freeze Protein Remove Bands Disable Bands Align Guide Reset Structures Reset Puzzle Help Glossary

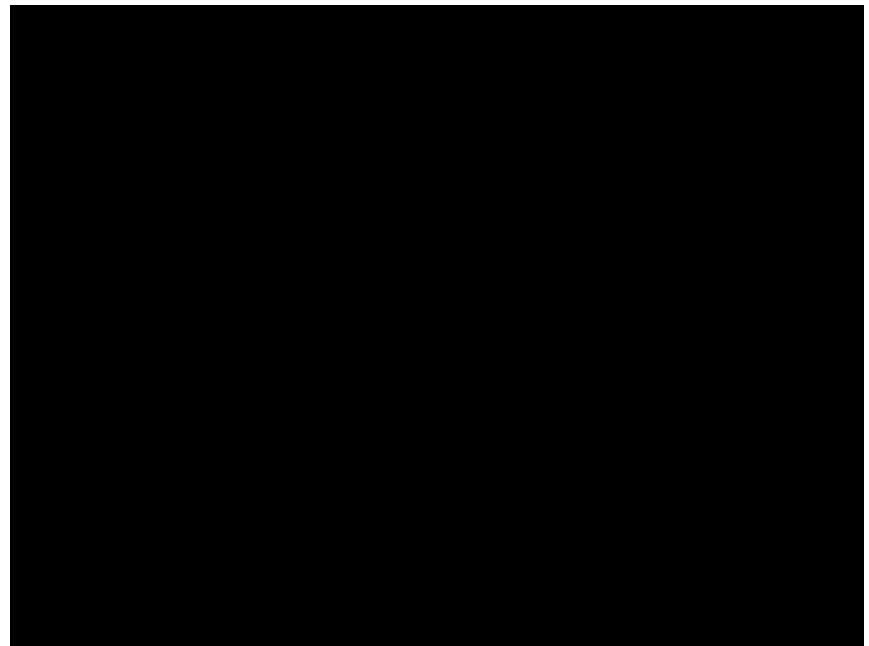
Chat - Group Chat - Puzzle Chat - Global Notifications

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

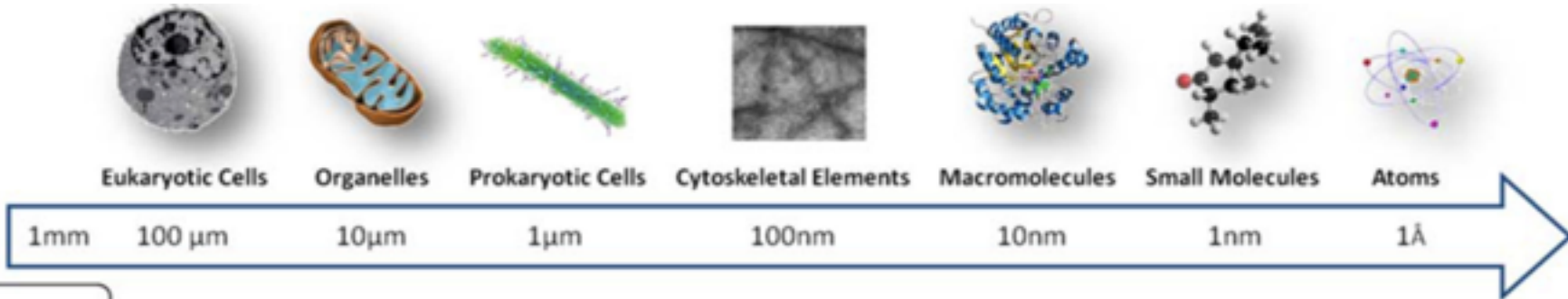
Proteins assemble to form bigger structures



28 nm

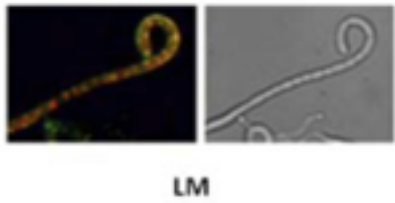


Visualising Macromolecular Complexes

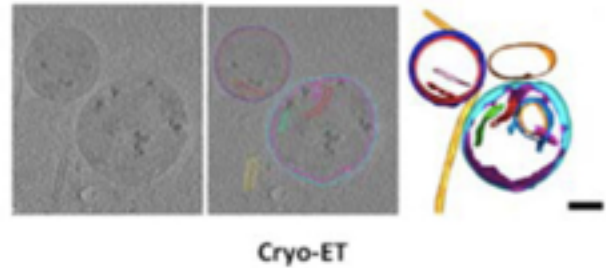


Eye

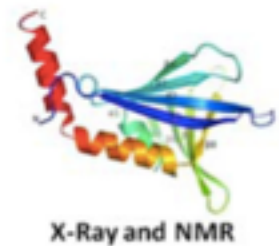
Light microscopy



Electron microscopy



X-Ray crystallography and NMR



Amino acids

< 3 Å

Secondary structure - α - helix & β - strands

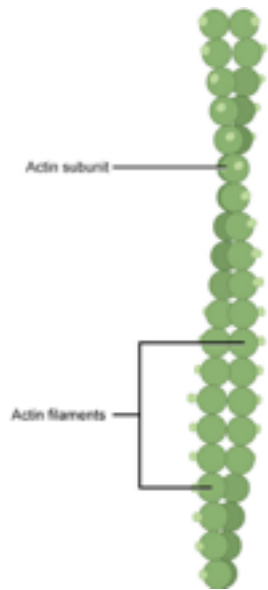
4 - 7 Å

Individual protein subunits (~ 30 kDa)

30 - 40 Å

What is cytoskeleton?

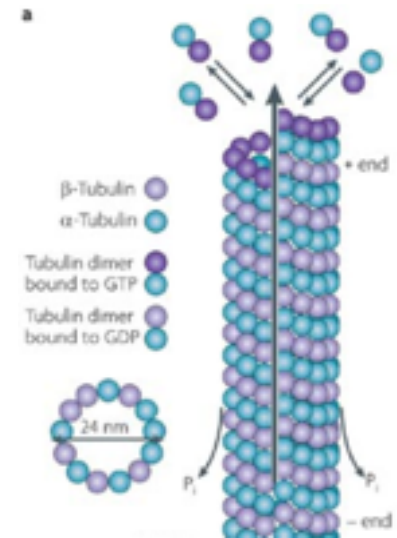
Microfilaments
(~ 7 nm)



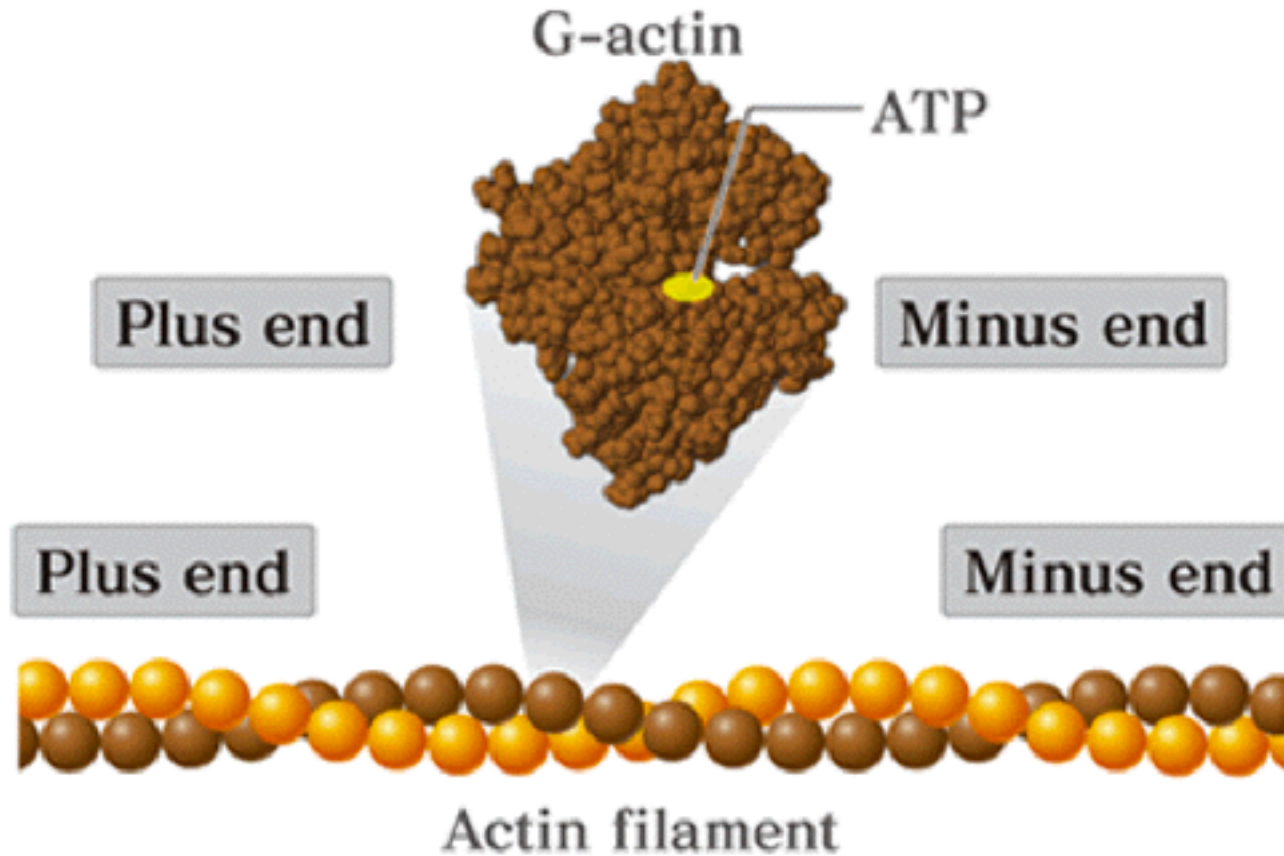
Intermediate filaments
(~ 8-10 nm)



Microtubules
(~ 25 nm)



Microfilaments

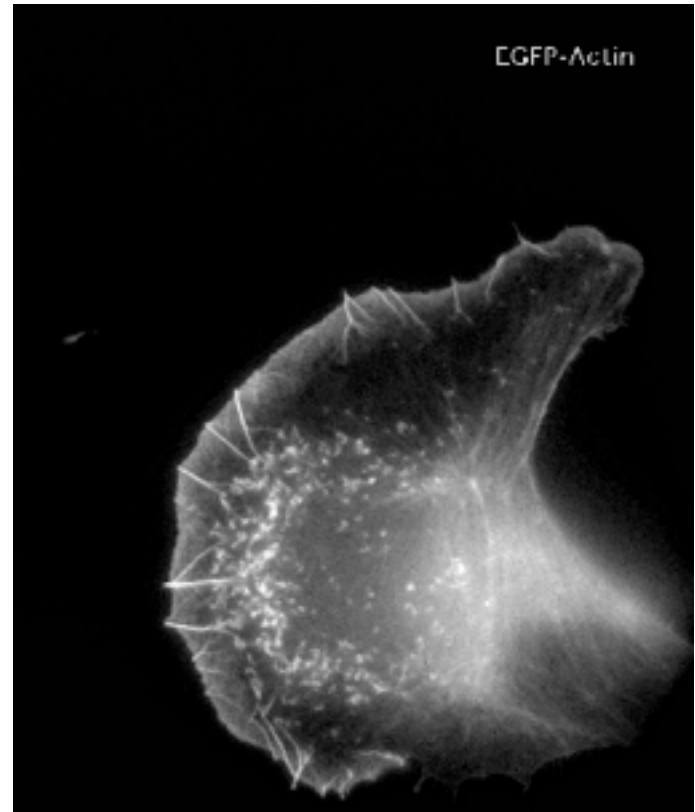
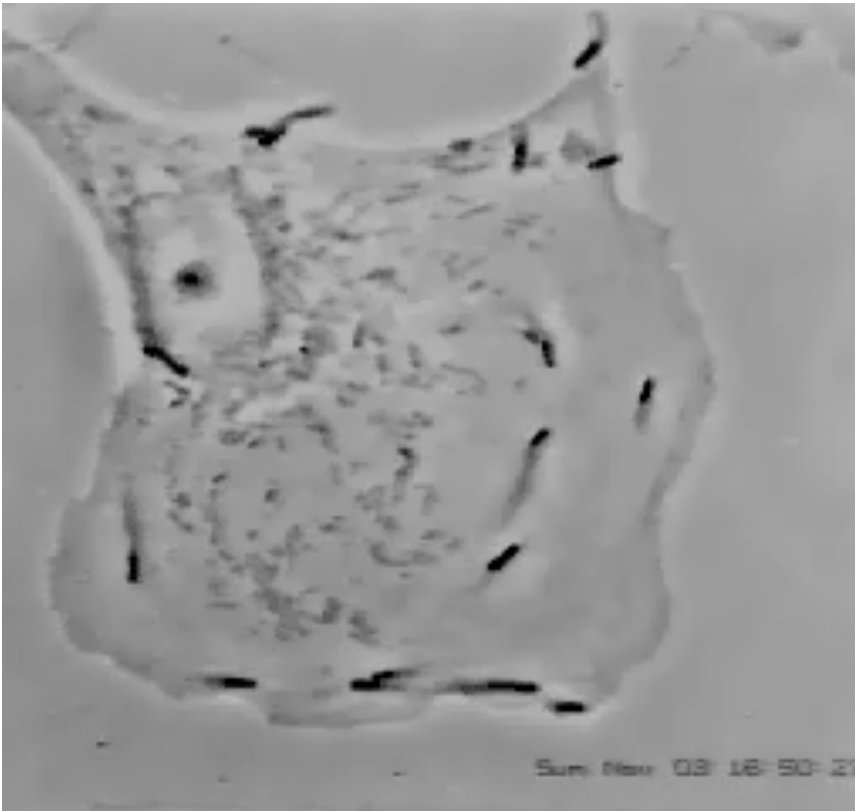


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<http://www.mechanobio.info/modules/go-0030041>

http://csls-text.c.u-tokyo.ac.jp/flash/0611_1.html

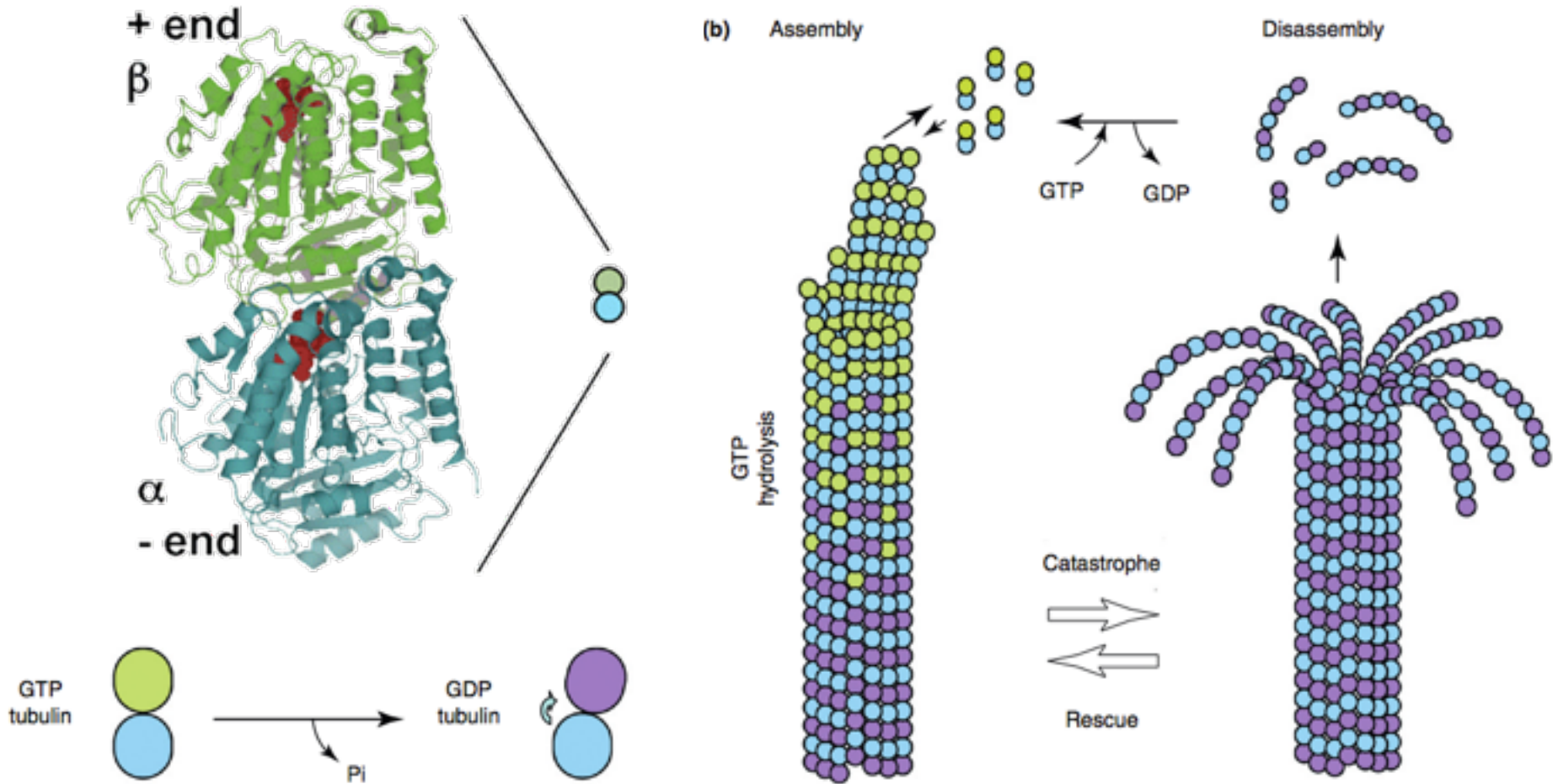
Pushing by Actin filaments



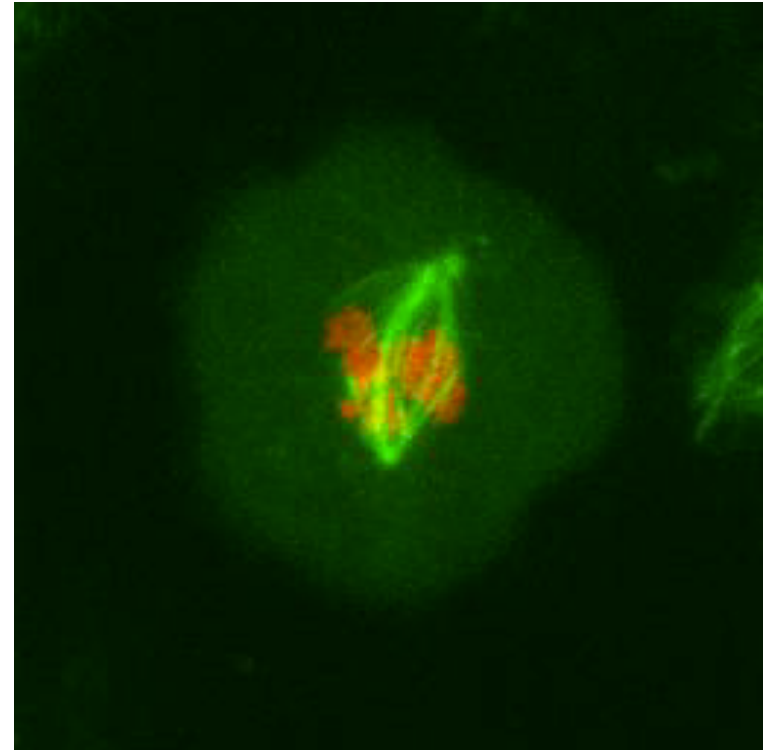
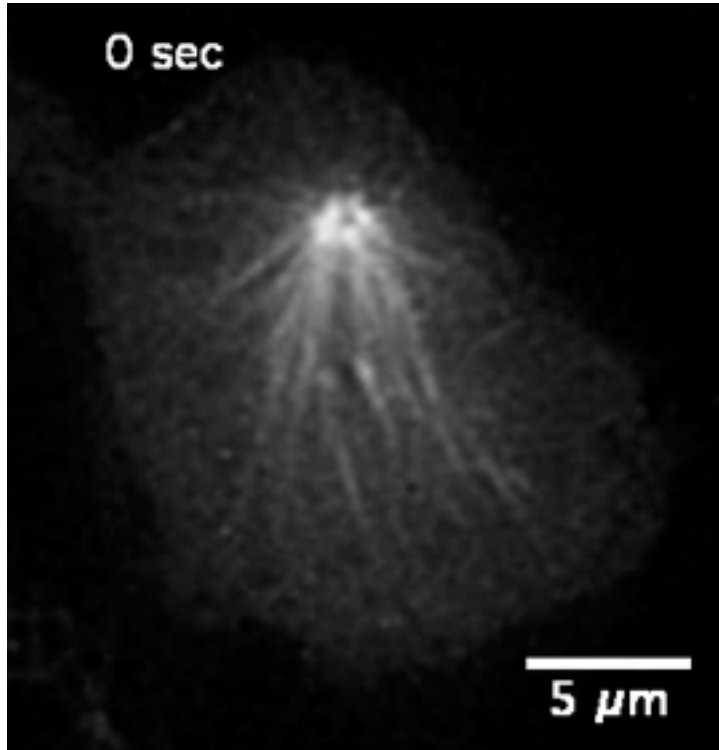
Lab webpage: Julie Theriot (<http://cmgm.stanford.edu/theriot/movies.html>)

Microfilaments

Monomers: Tubulin dimers

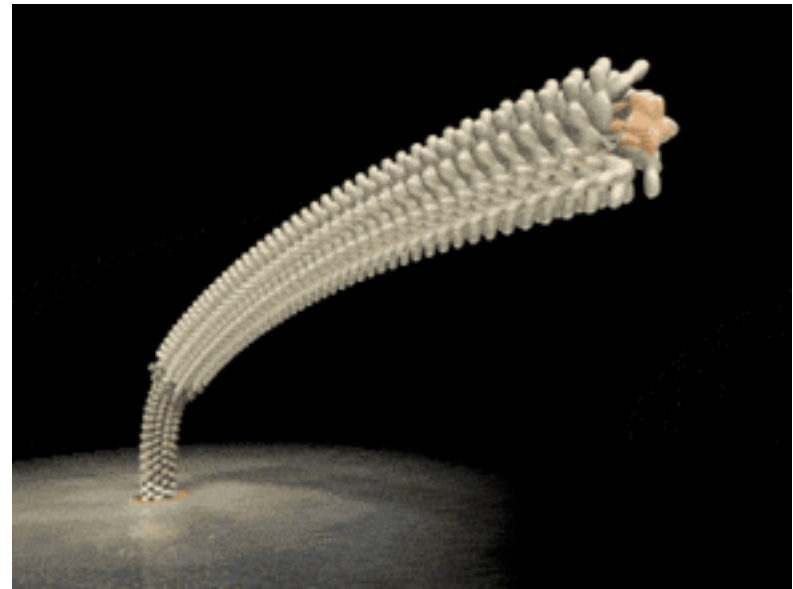
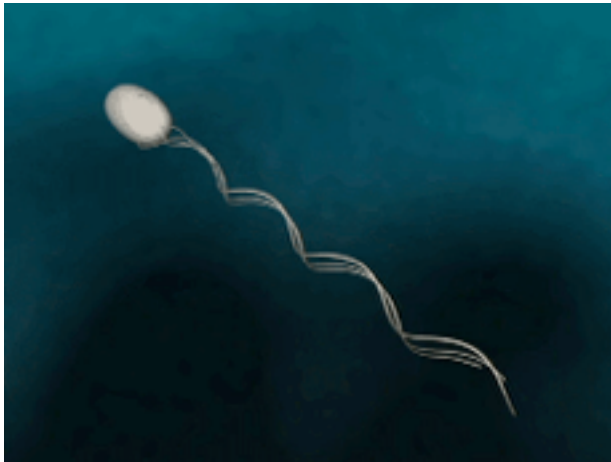
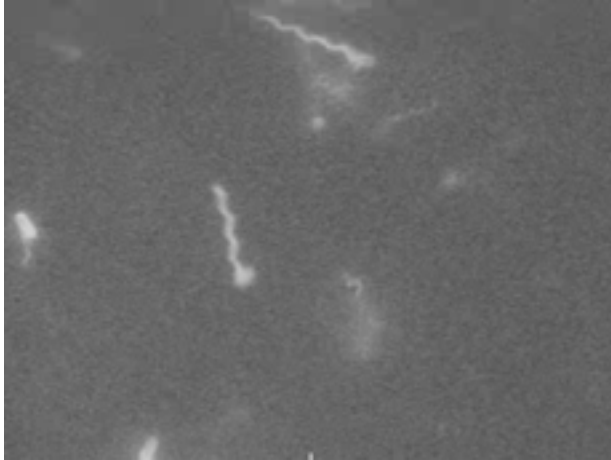


Pushing of chromosomes by Microtubules



Lab webpages: [Salmon](#) and [Ron Vale](#)

Bacterial Flagella

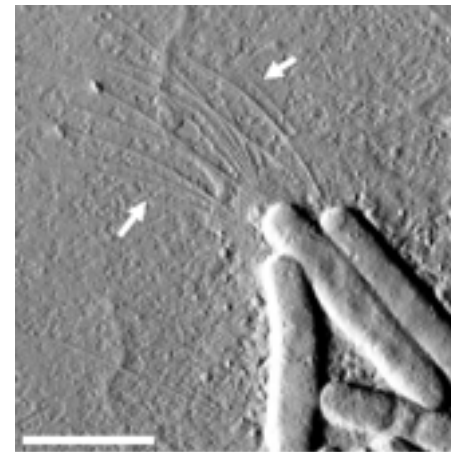
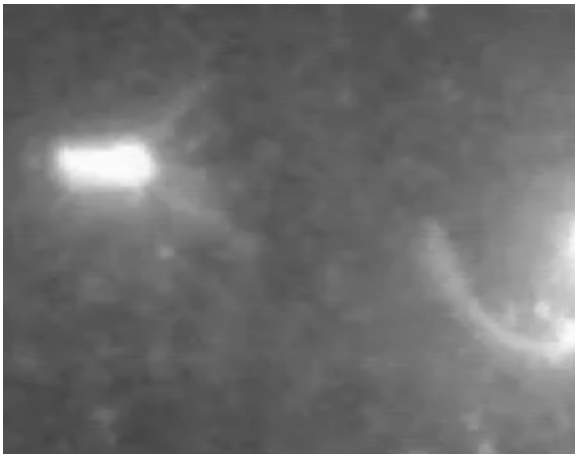
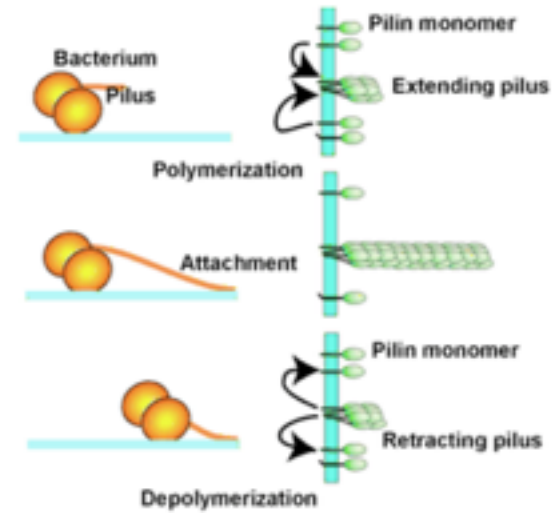


Lab webpages: Howard Berg & Keiichi Namba

Proton driven motor movie

<http://www.fbs.osaka-u.ac.jp/labs/namba/npn/>

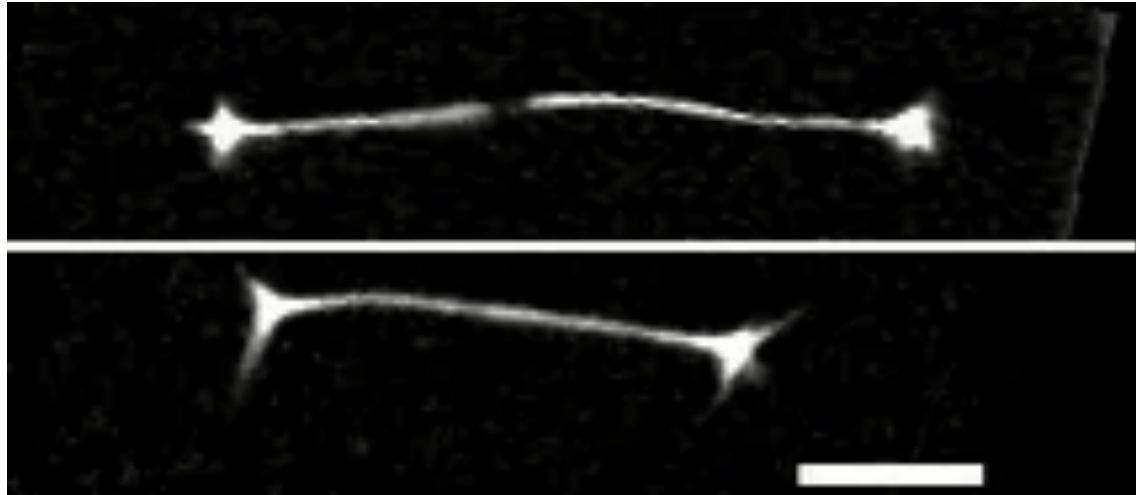
Bacterial Type IV Pili



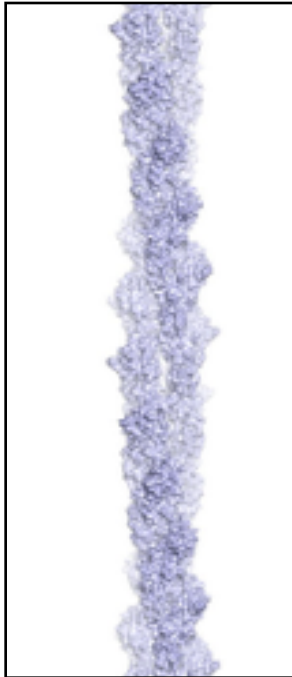
Lab webpage: Howard Berg

Lab webpages: Shi; Holtz & Kurre

A simple DNA segragating machine

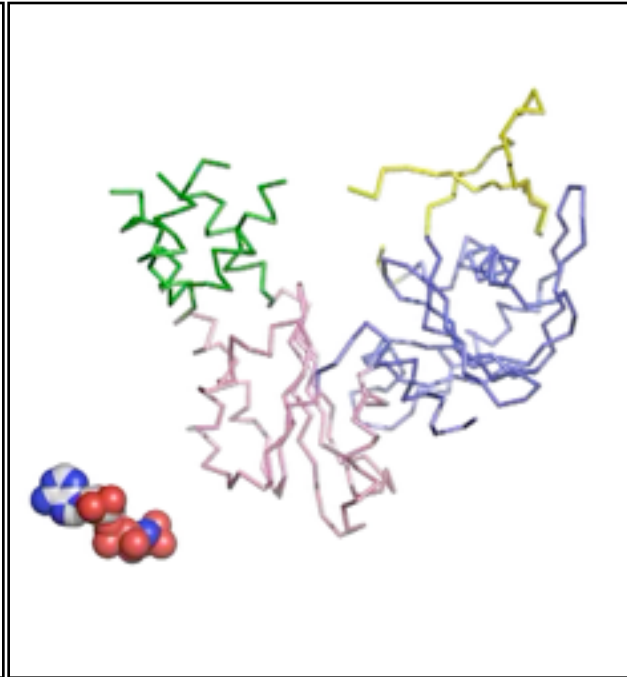


**Cryoelectron
microscopy**



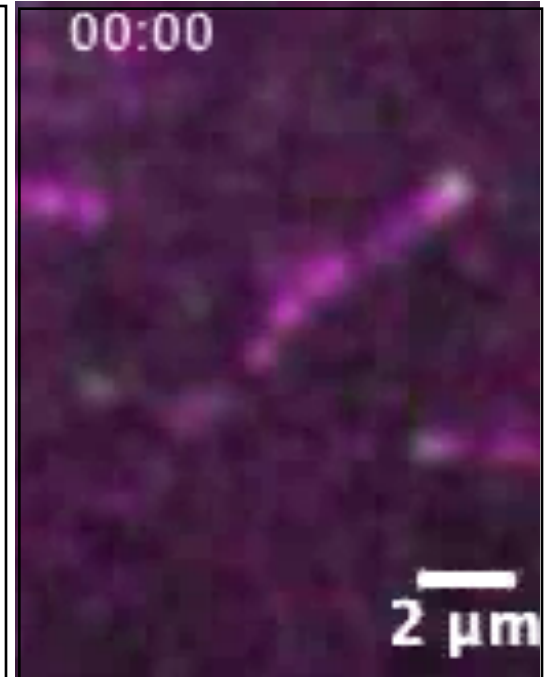
**Macromolecular
assembly**

**X-ray
crystallography**



**Snapshots of conformational states
of components**

TIRF microscopy



**Dynamics of assembly/ in vitro
reconstitution**

Molecular mechanism behind fundamental biological processes