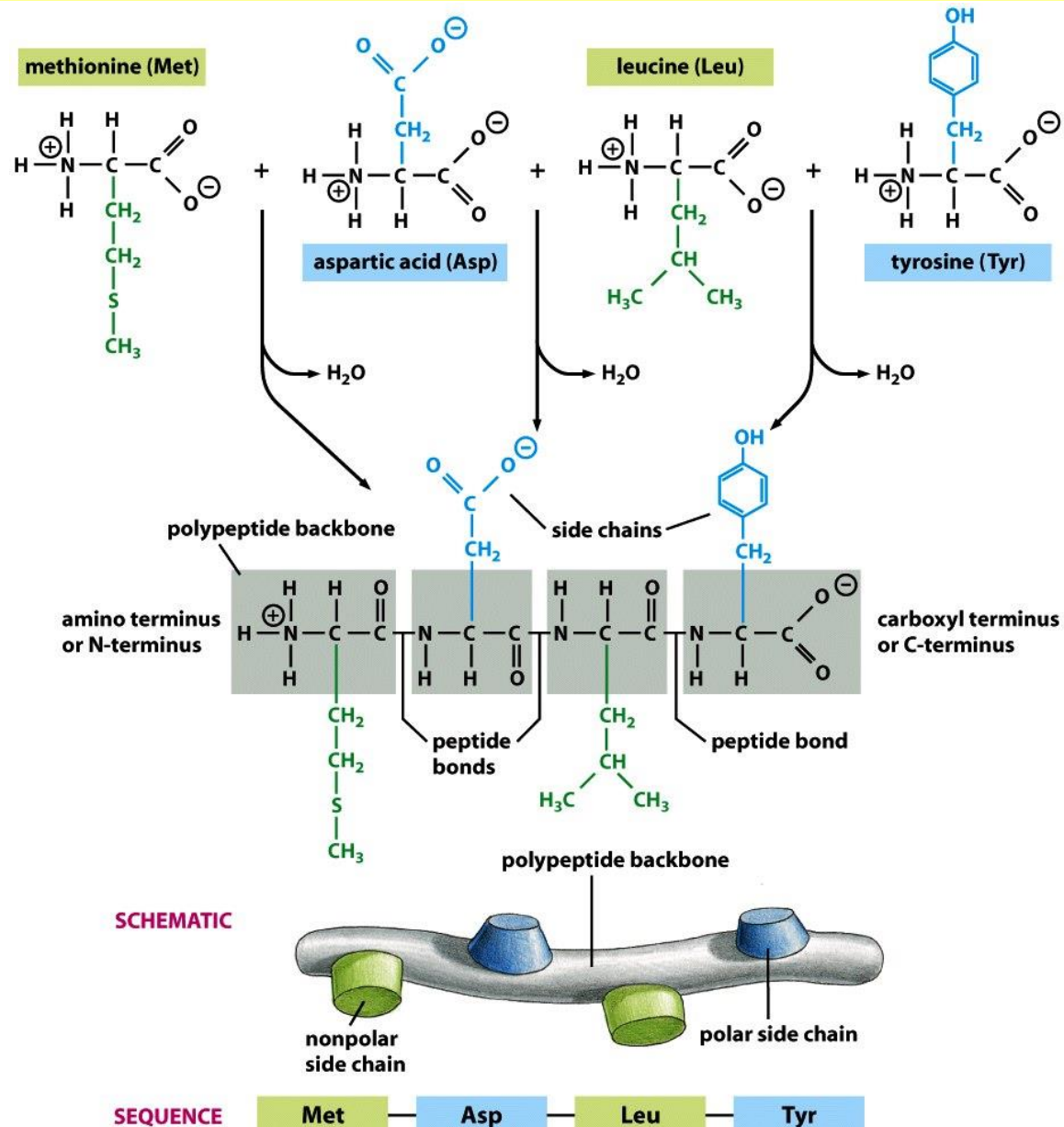


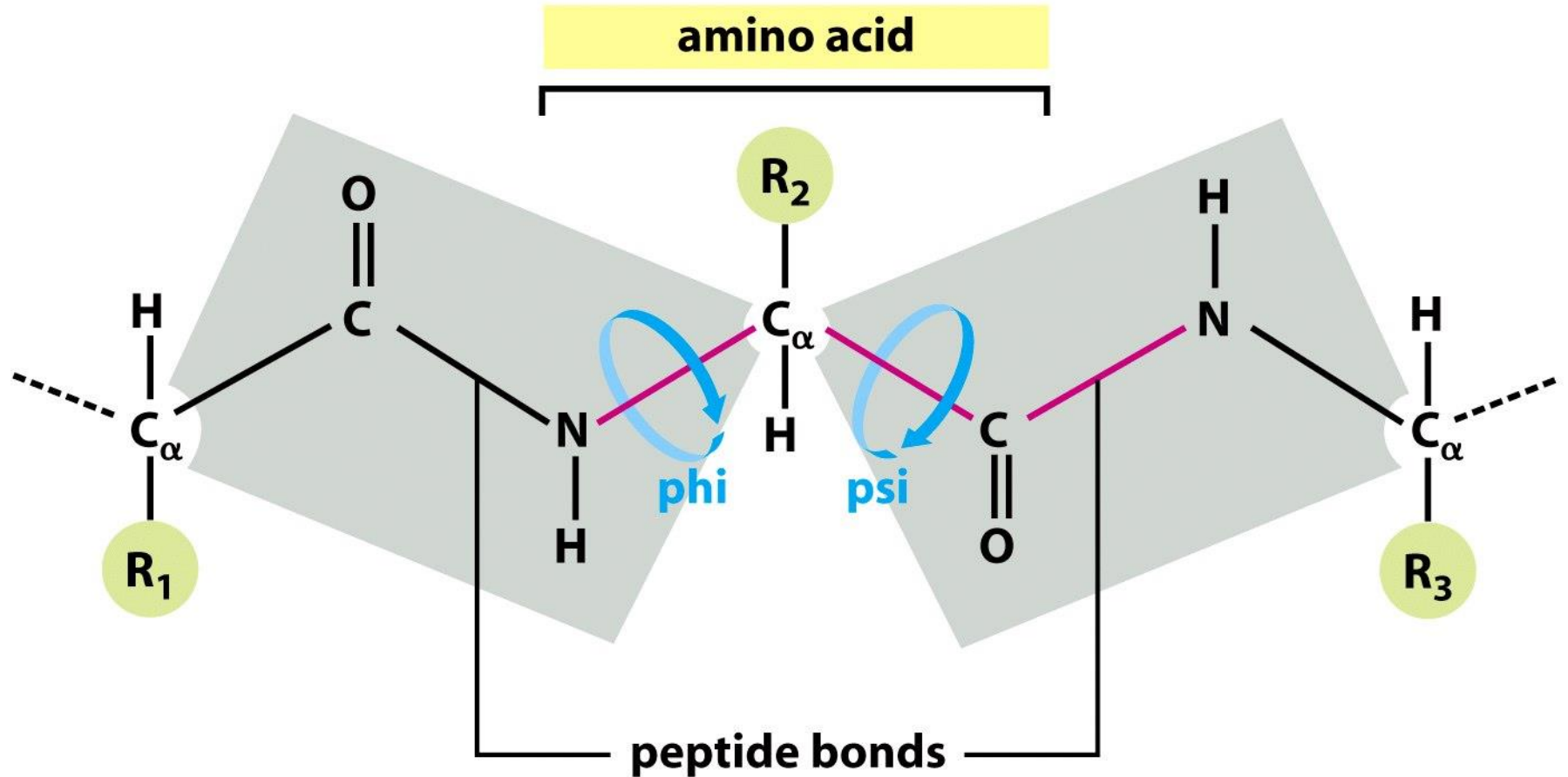


# Proteins

# Condensation reactions of amino acids



# The peptide bond



# The intermolecular interactions

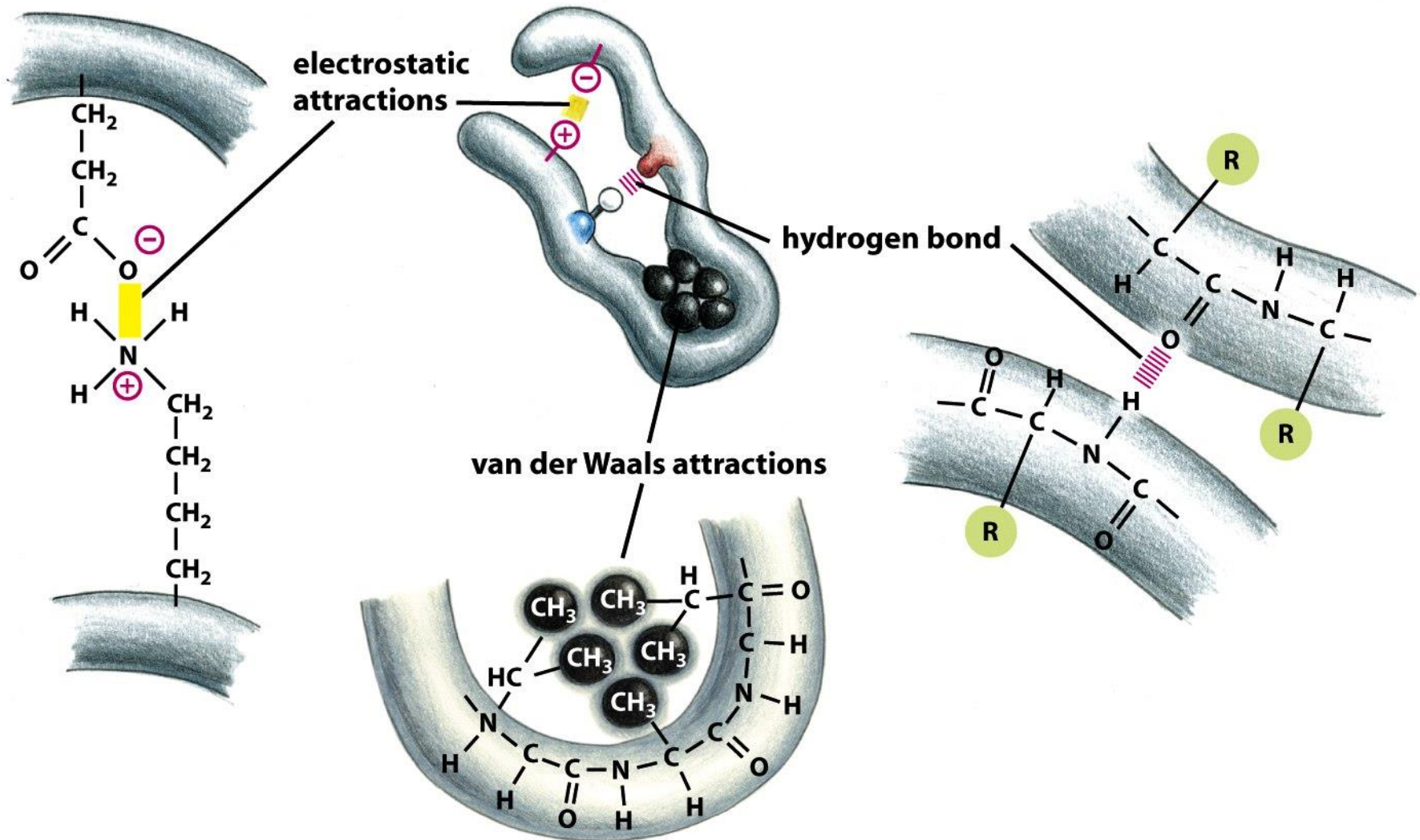
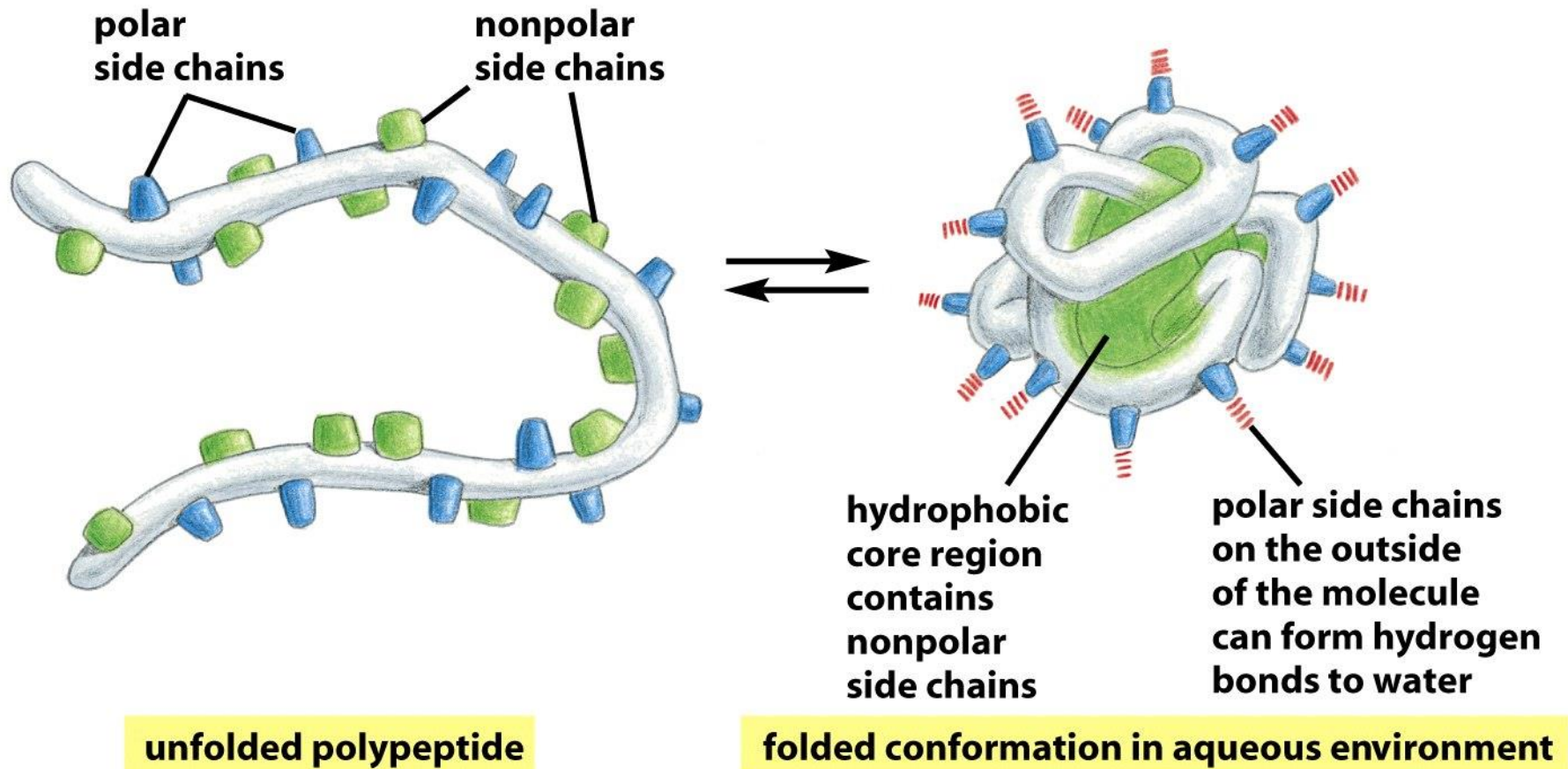
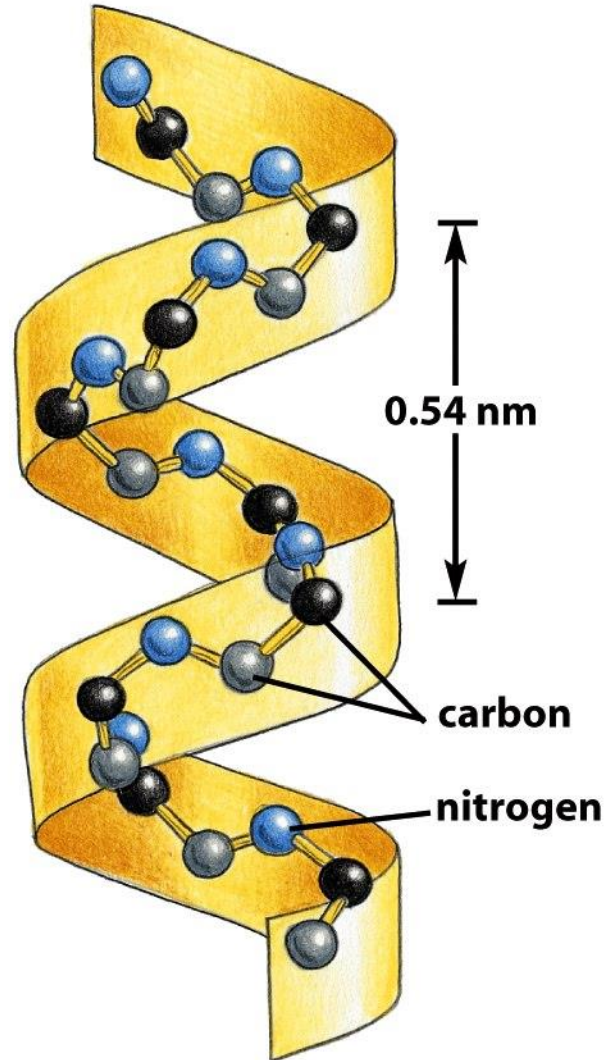
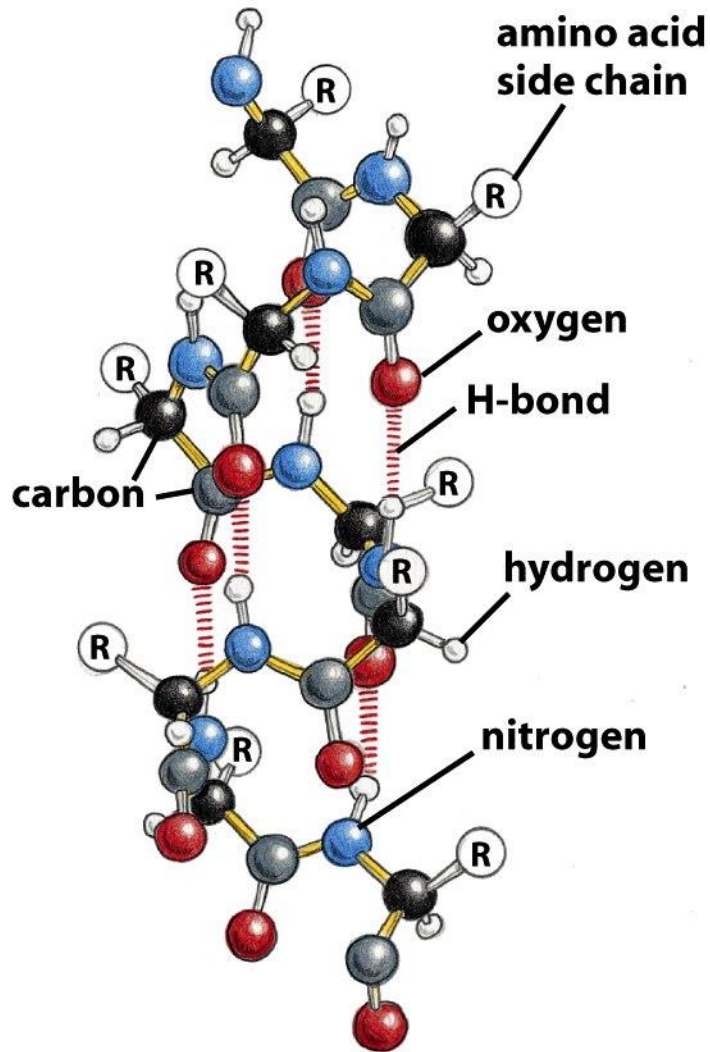


Figure 3-4 *Molecular Biology of the Cell* (© Garland Science 2008)

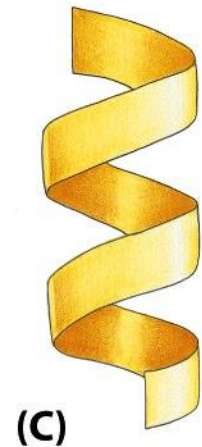
# Protein folding



# Folding patterns



$\alpha$  helix



(A)

(B)

(C)

# Folding patterns

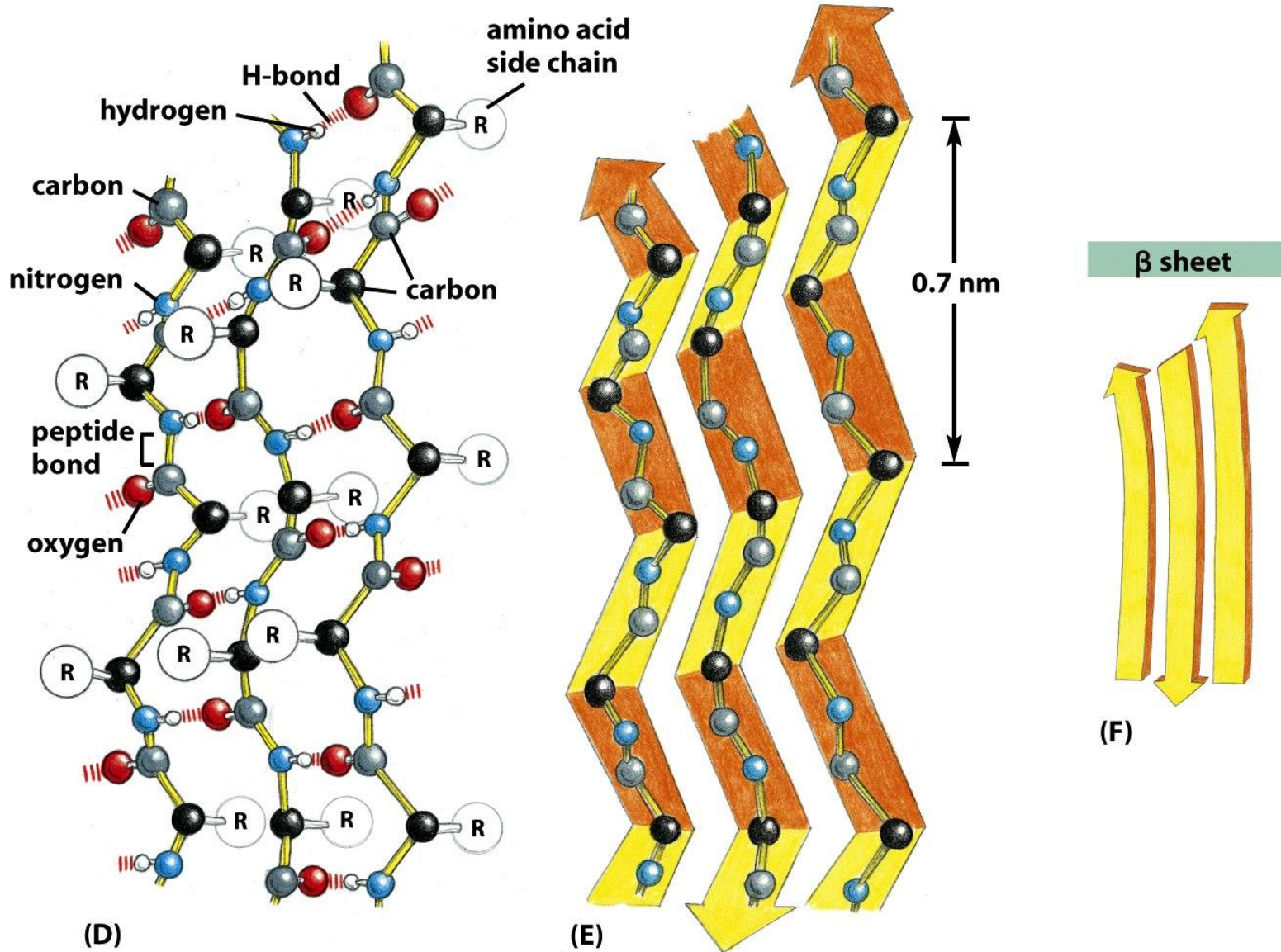
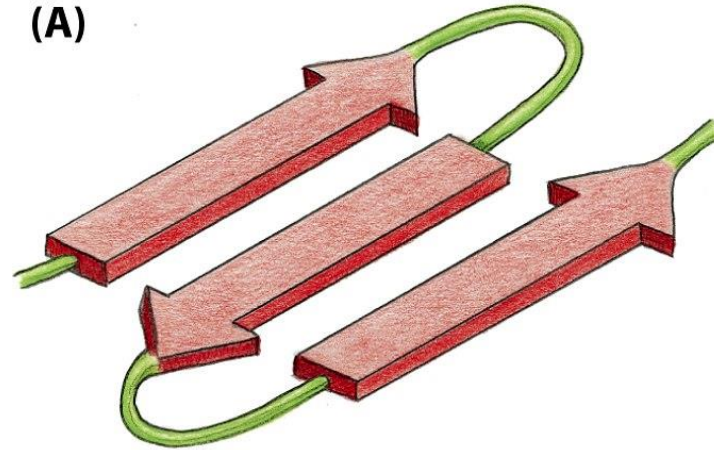


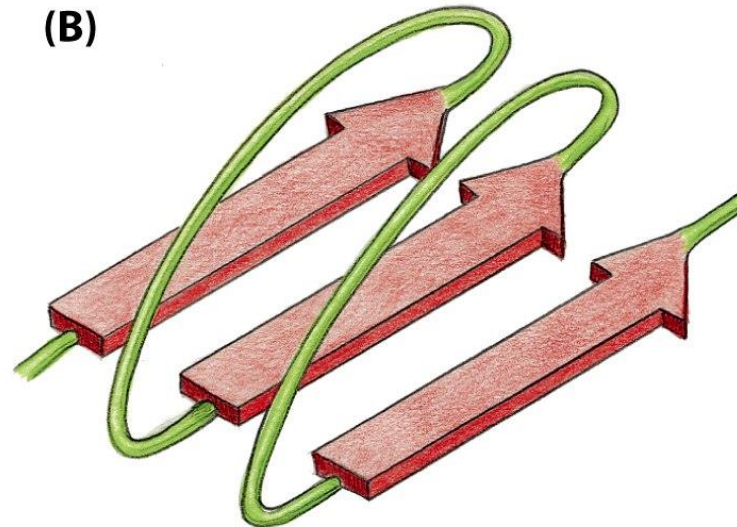
Figure 3-7 *Molecular Biology of the Cell* (© Garland Science 2008)

# $\beta$ -sheets

**Antiparallel**



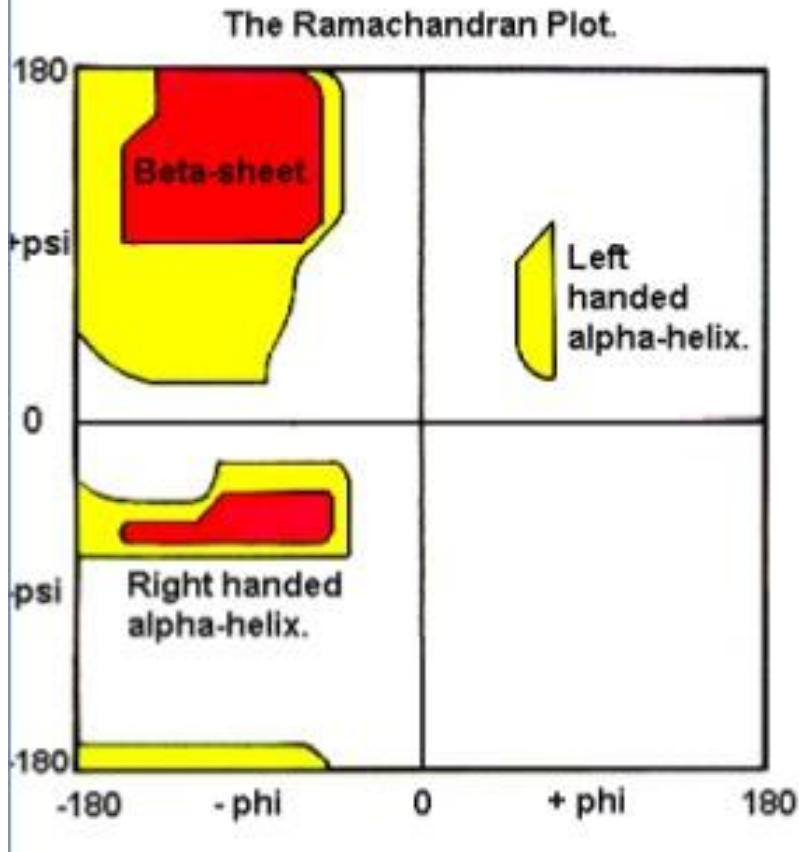
**Parallel**





# Ramachandran plot

A **Ramachandran plot** (also known as a **Ramachandran diagram** or a  **$[\phi, \psi]$  plot**), originally developed in 1963 by G. N. Ramachandran.

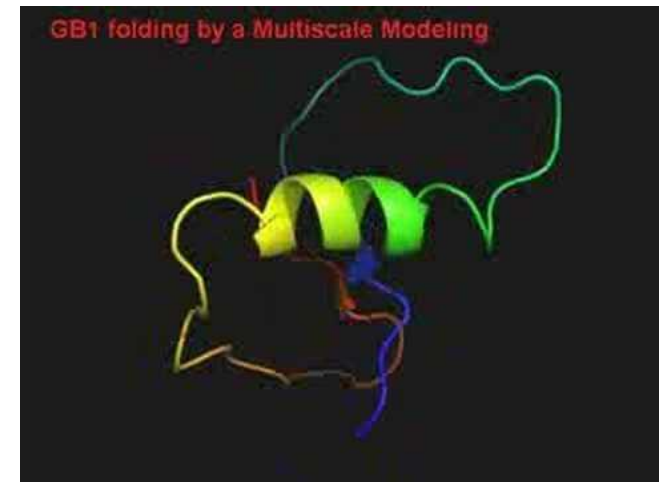
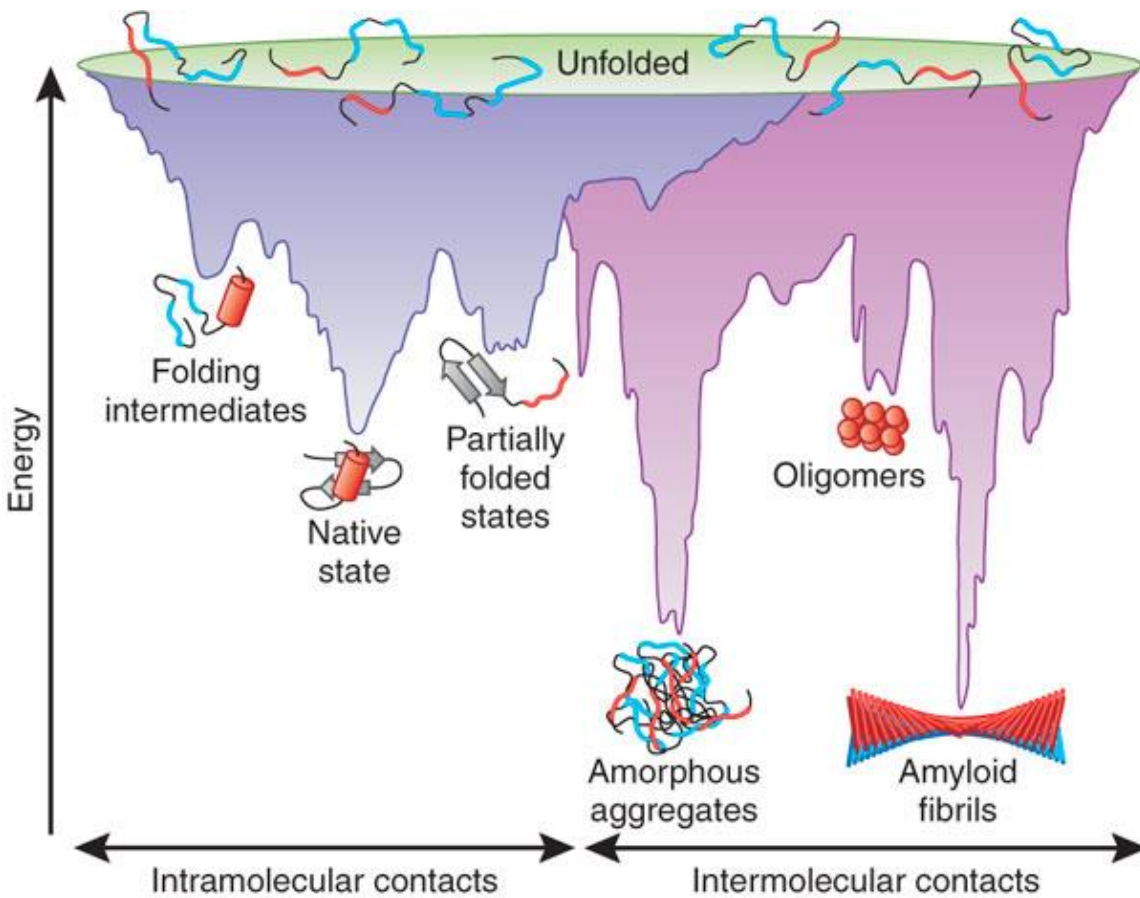


**White regions** : Sterically disallowed for all amino acids except glycine.

**Red regions** : allowed regions namely the  $\alpha$ -helical and  $\beta$ -sheet conformations.

**Yellow areas** : outer limit

# Folding process



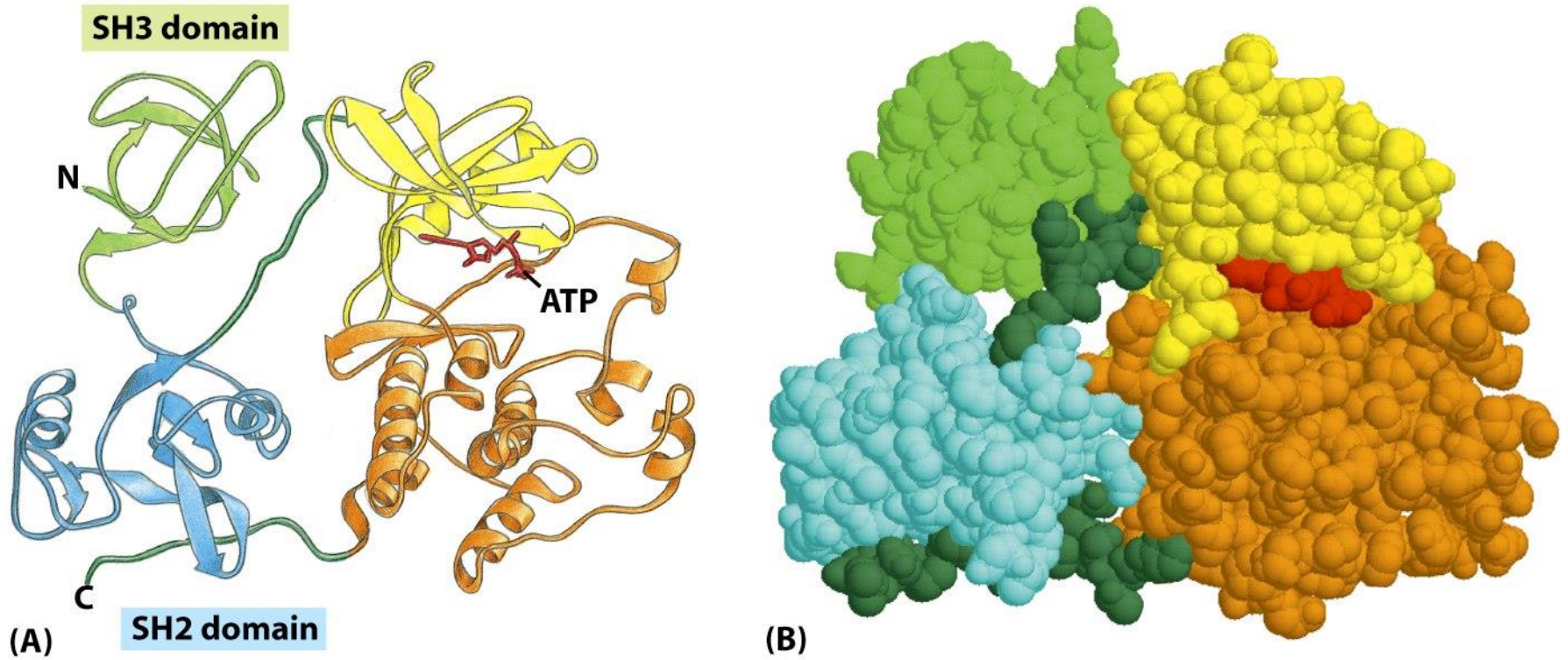
Ulrich Hartl, F; Hayer-Hartl, M.

Converging concepts of protein folding *in vitro* and *in vivo*

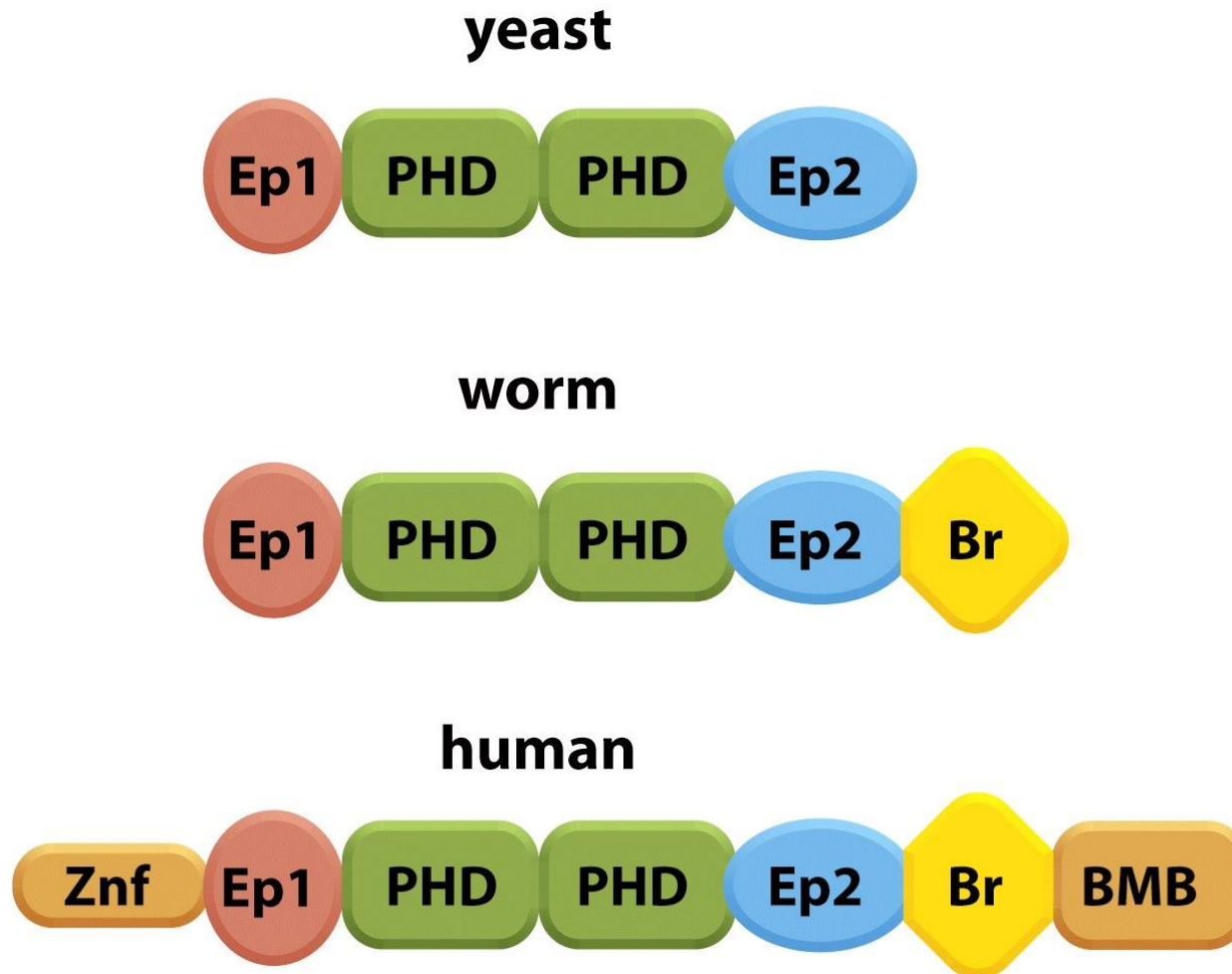
*Nat. Struct. Mol. Biol.* **2009** , 16, 574 [pdf](#)

<http://youtube.com/watch?v=meNEUTn9Atg>

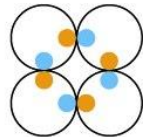
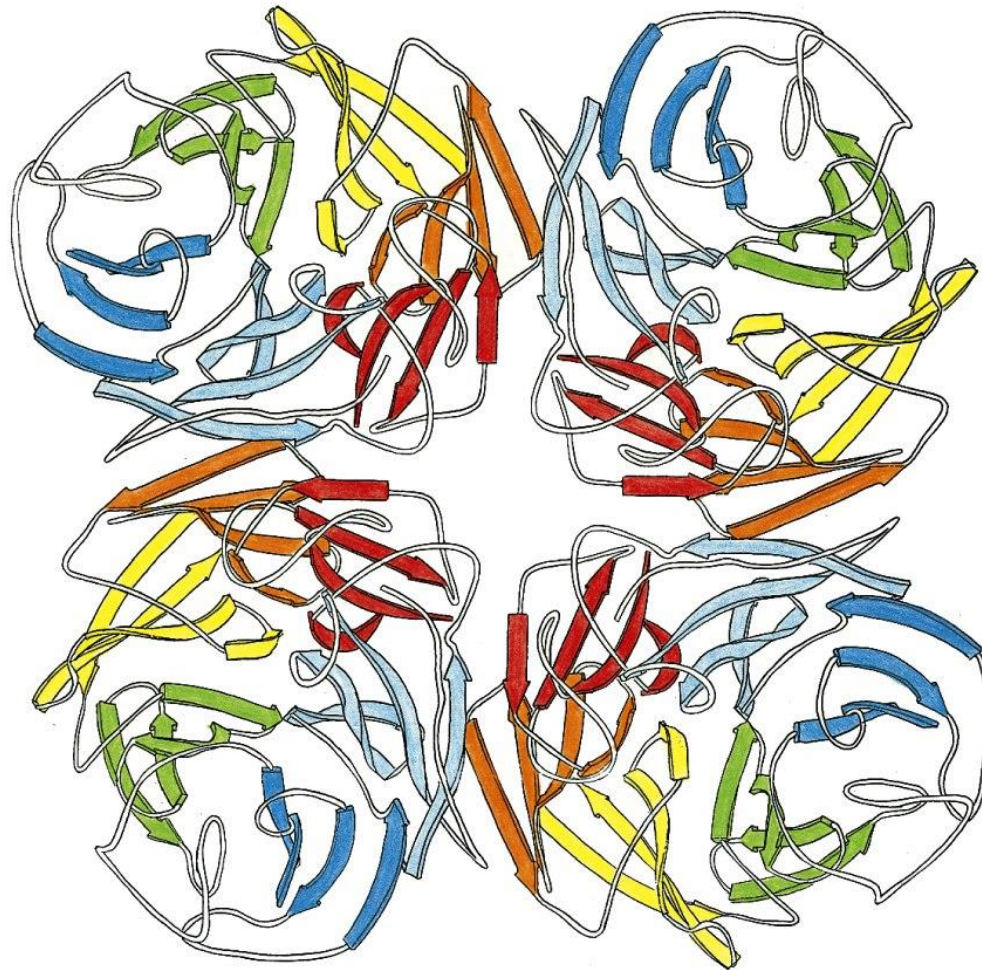
# Domains



# Domains in evolutionarily related proteins

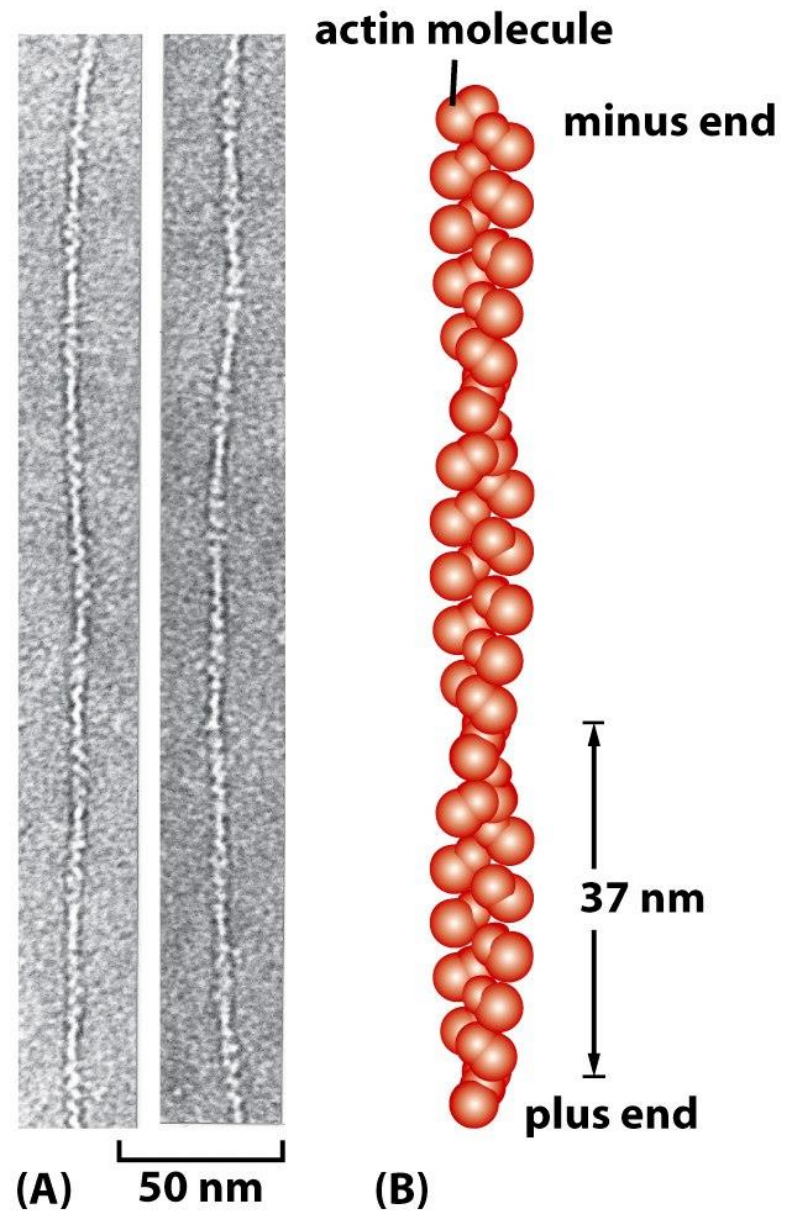


# 4D structure



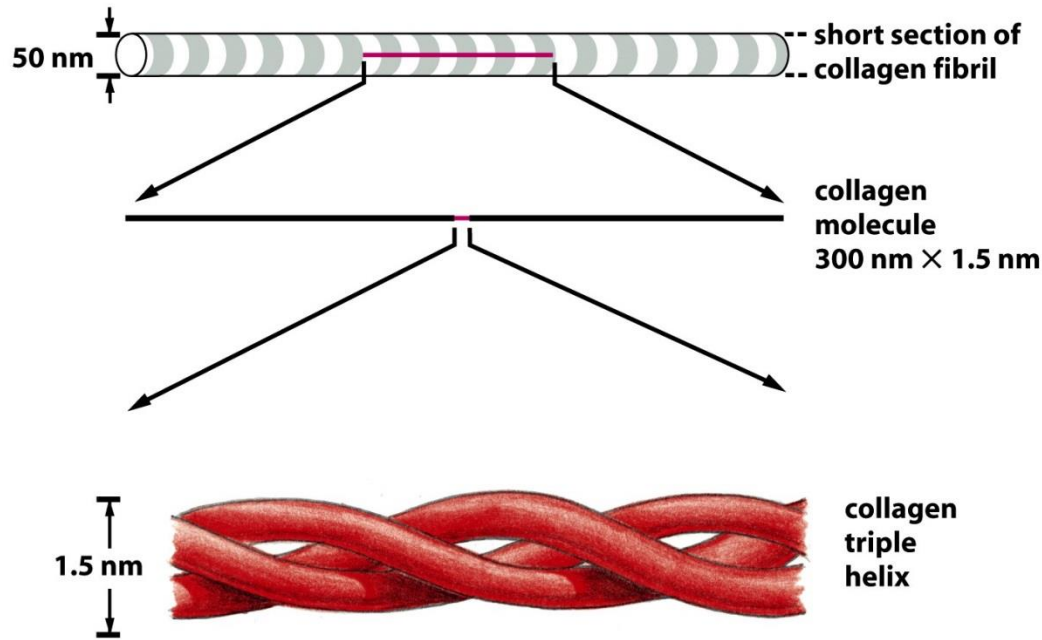
**tetramer of neuraminidase protein**

# Actin filaments

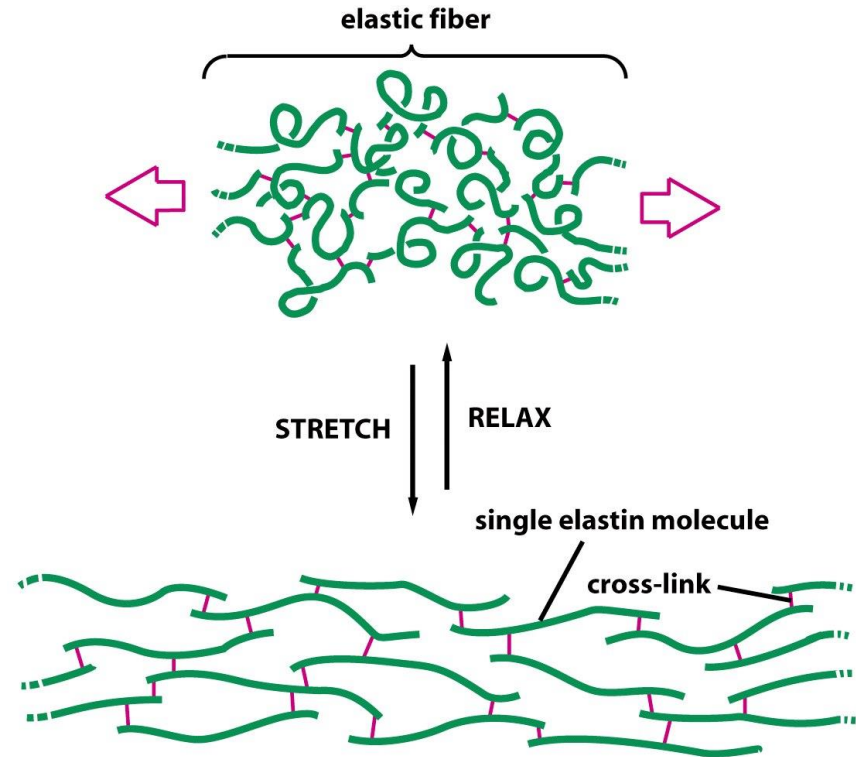


# Organization vs. disorganization

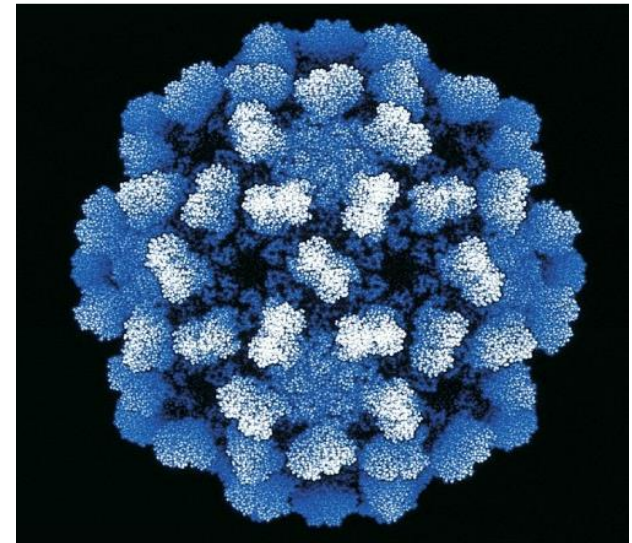
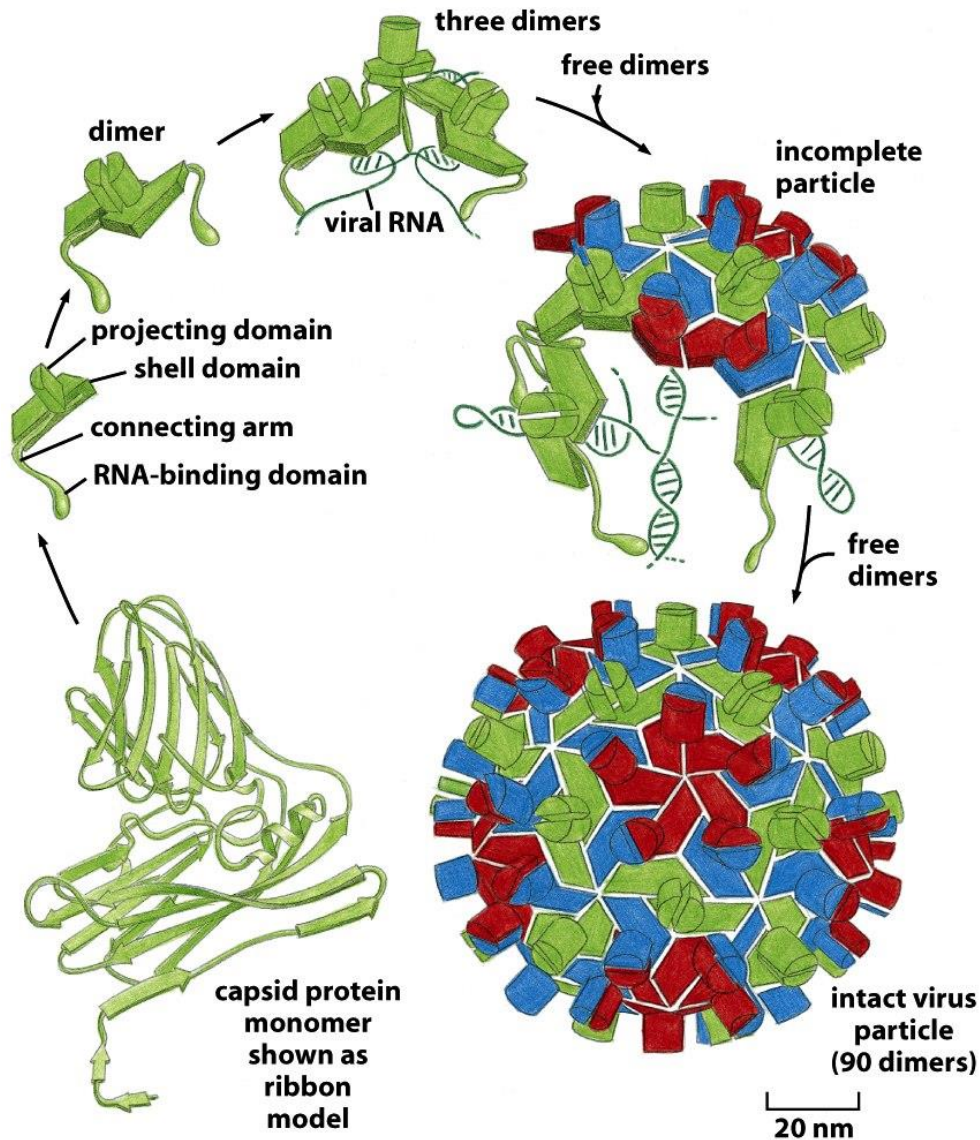
## Collagen



## Elastin



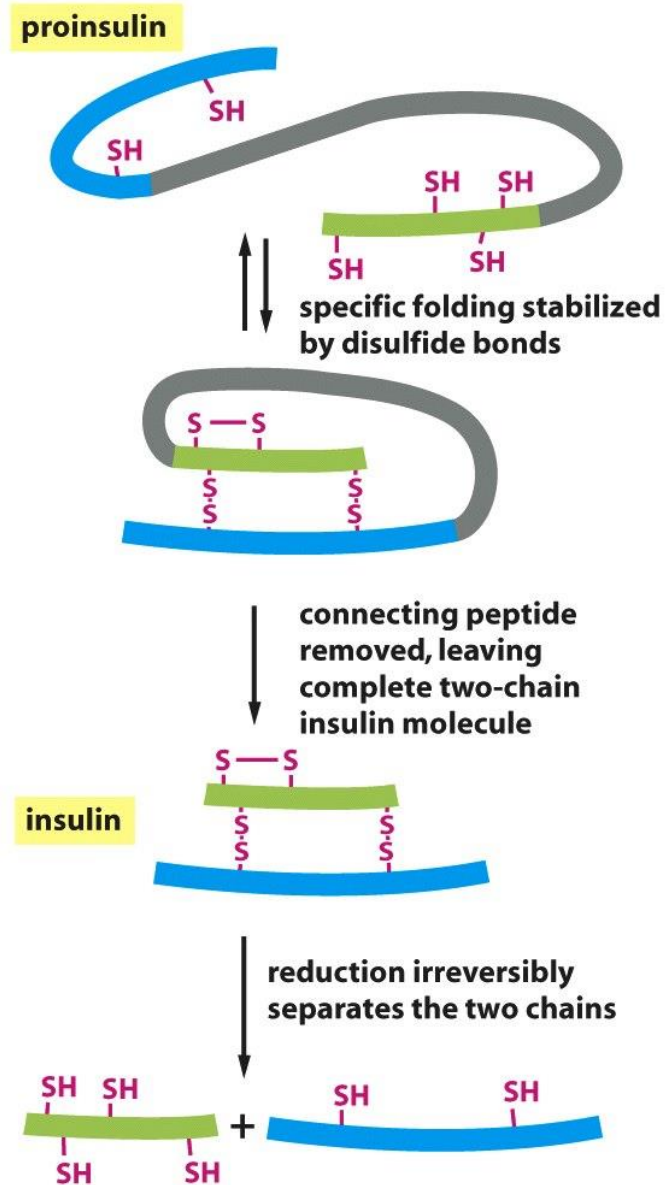
# Large structures



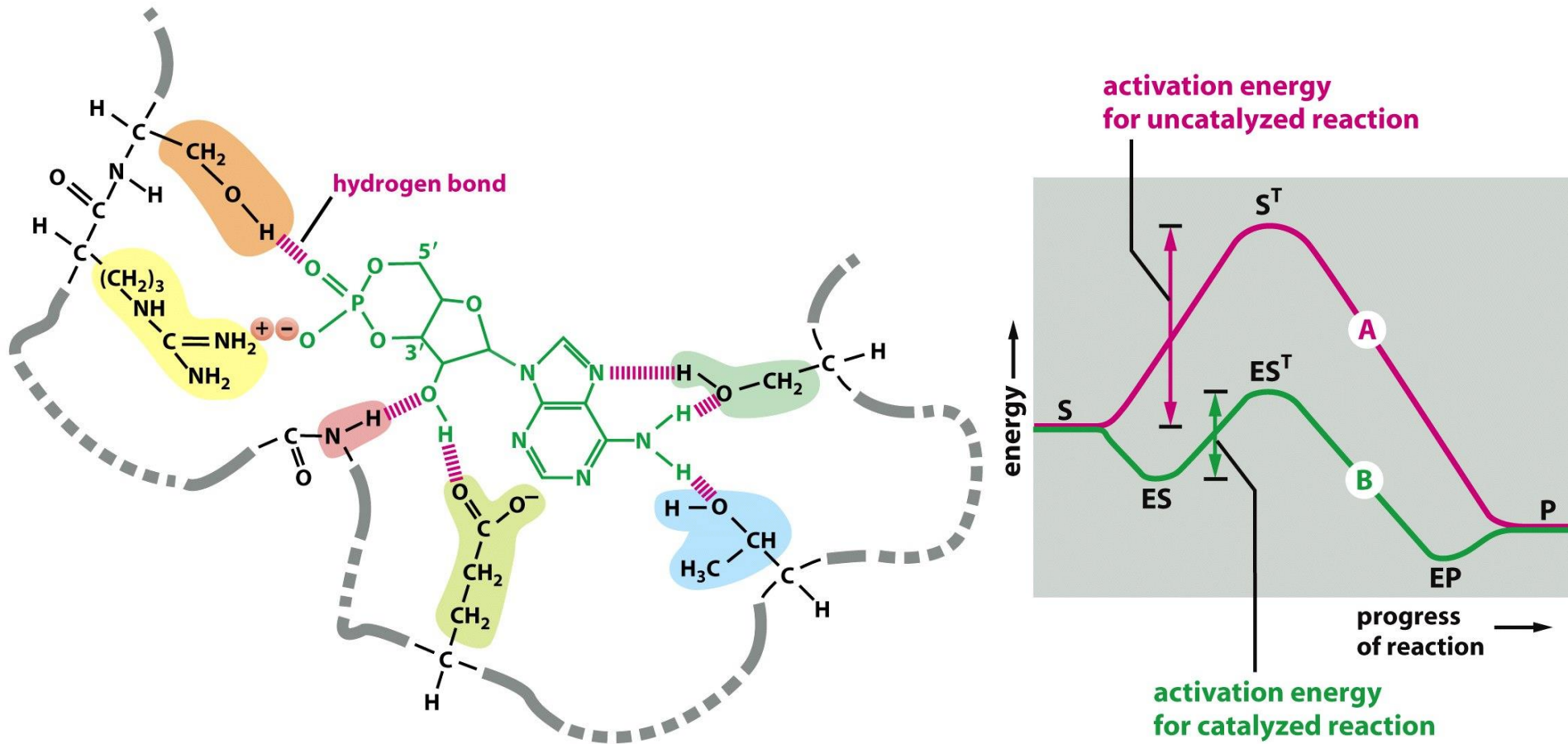
Tomato bushy stunt virus



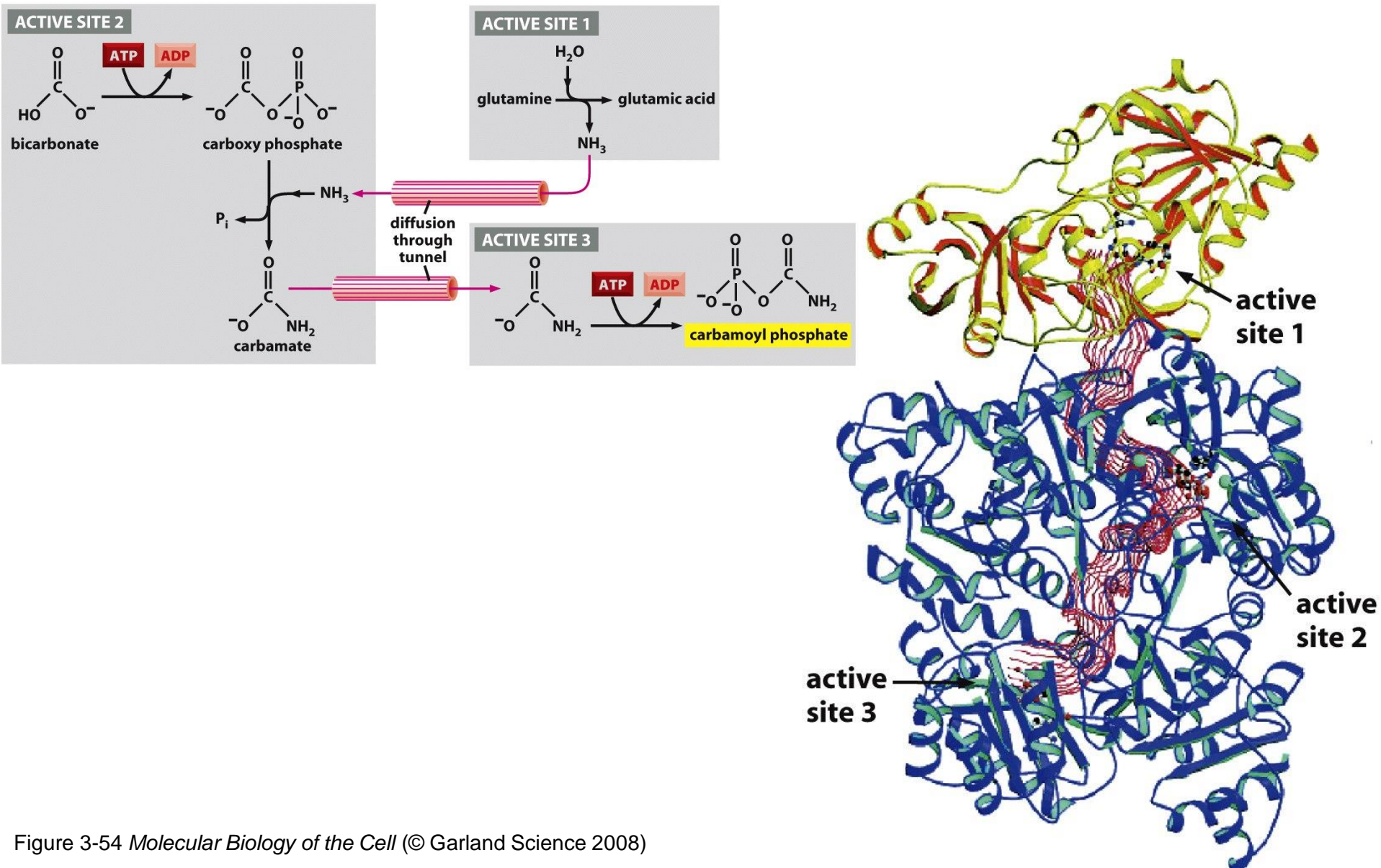
# Disulfide bond



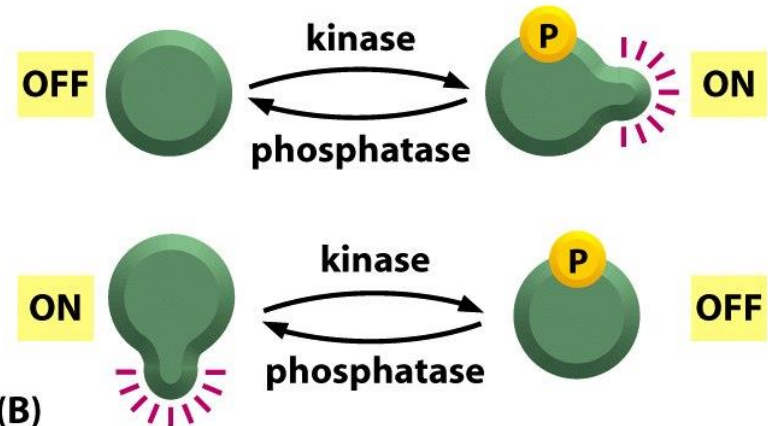
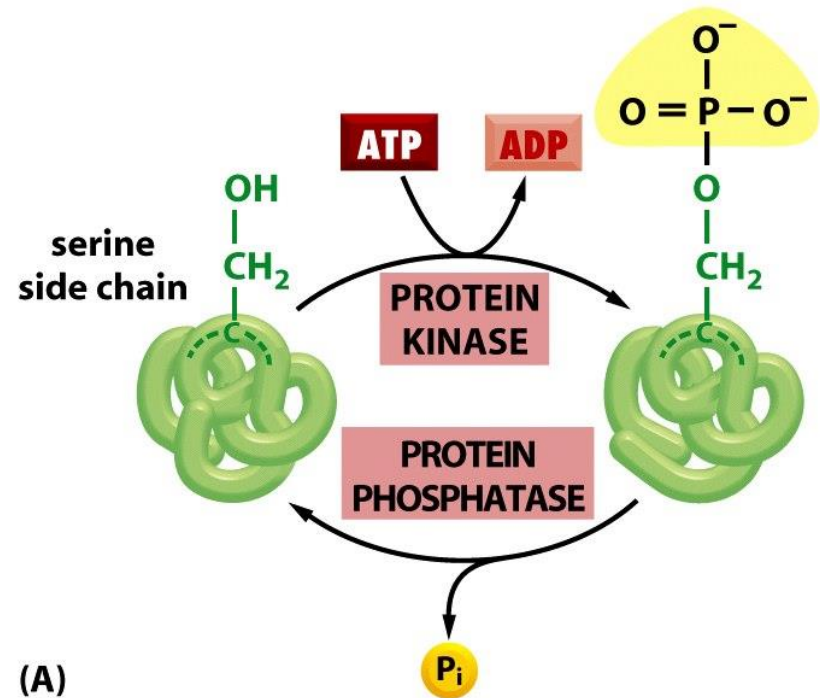
# Active site of an enzyme and catalysis



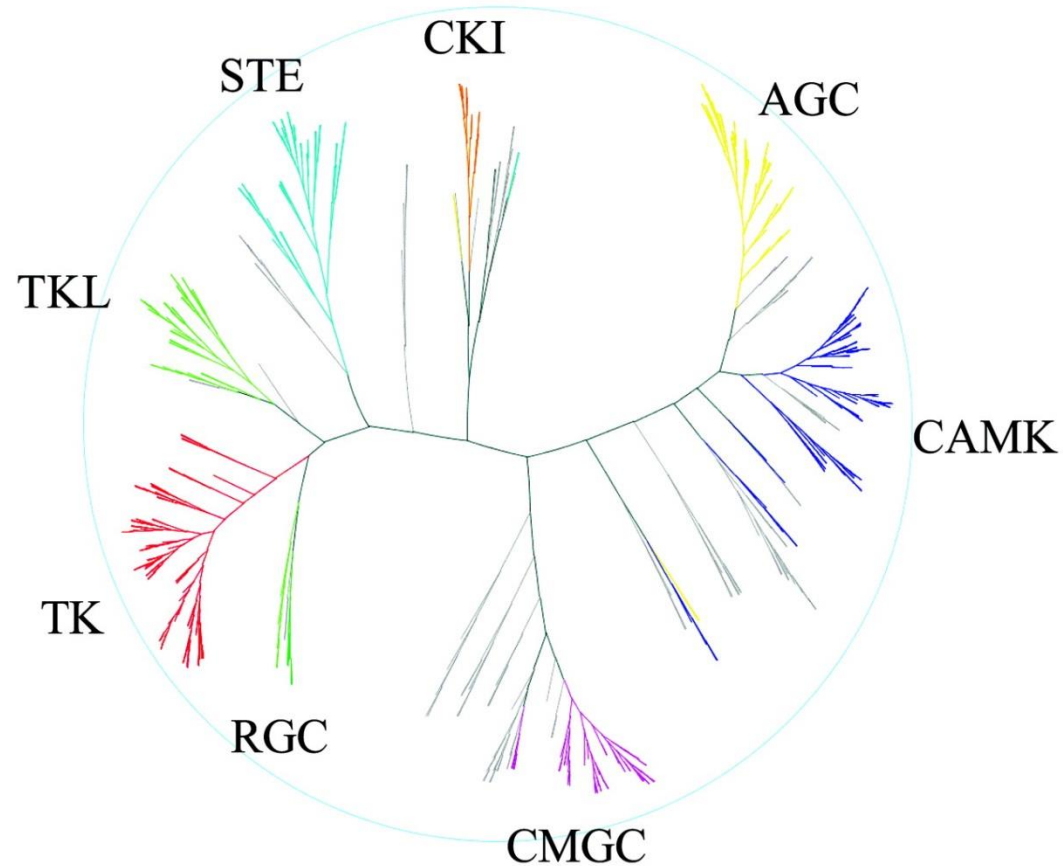
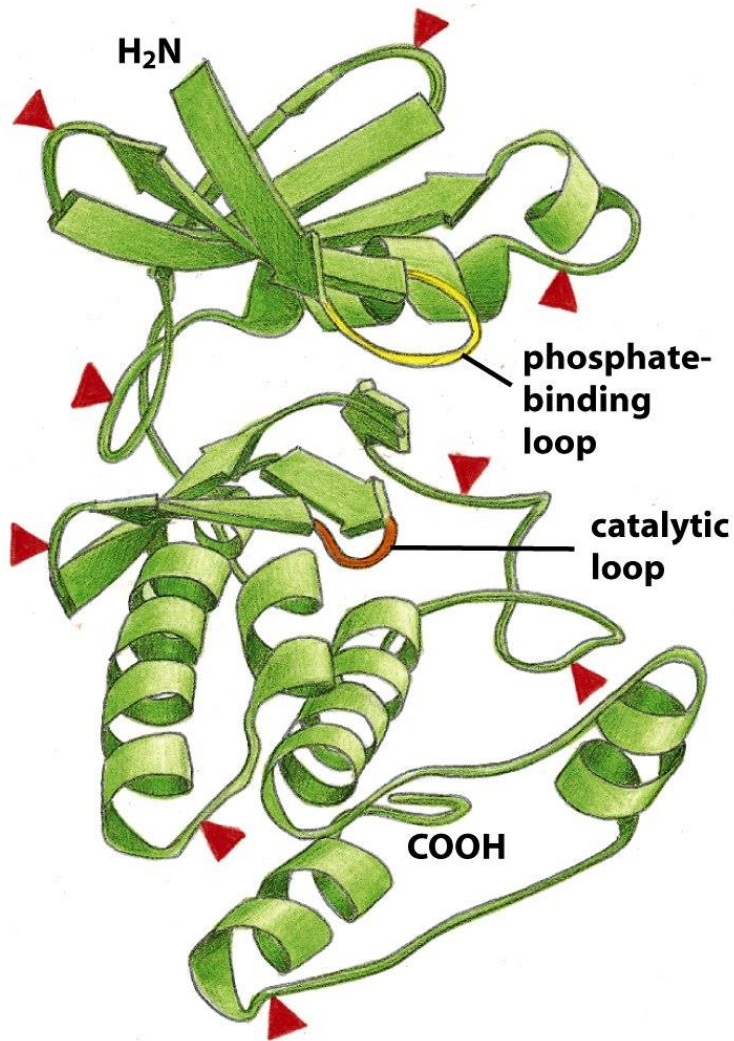
# Multiple reactions



# On/Off states of proteins

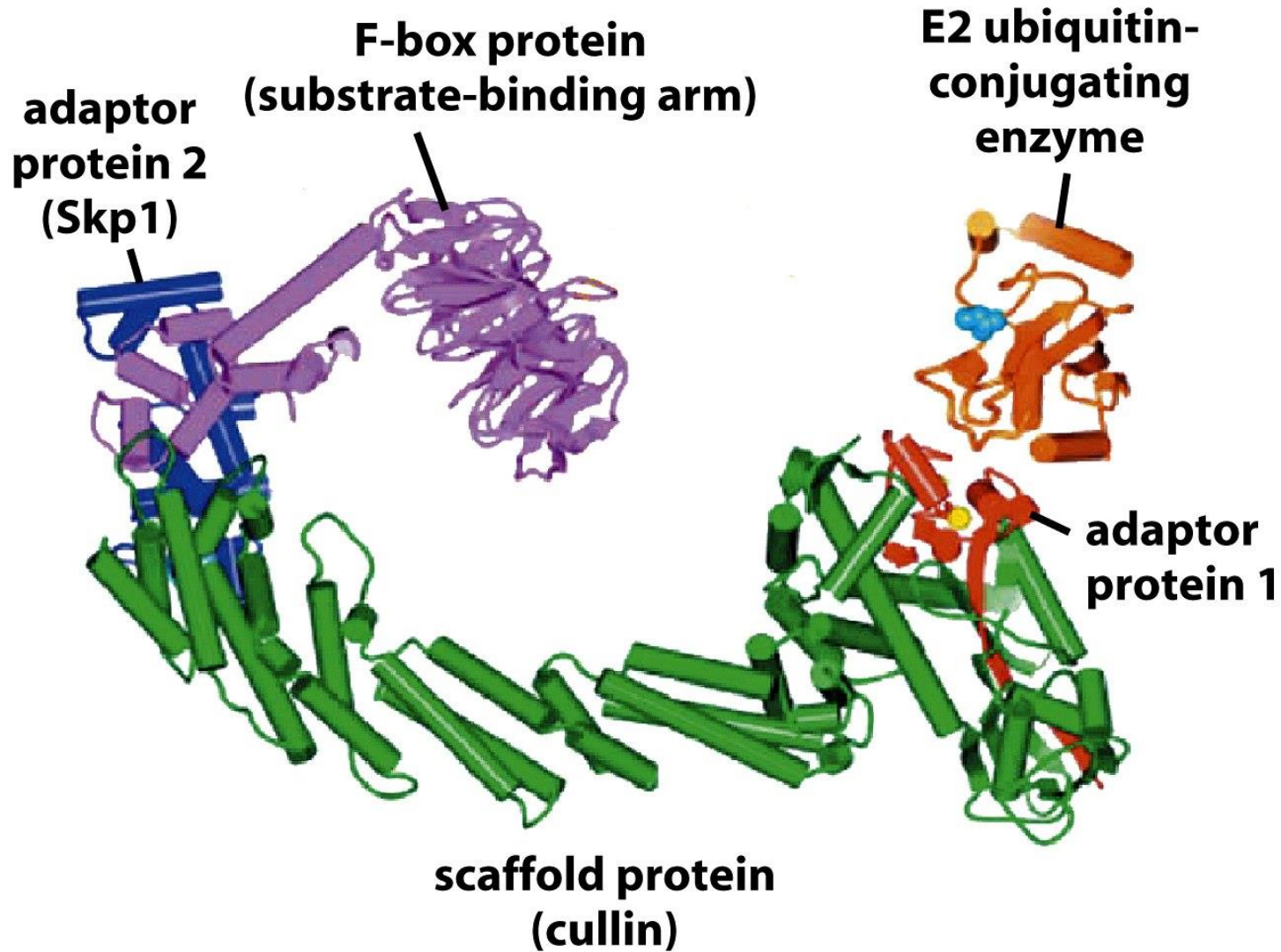


# Protein kinase and kinome

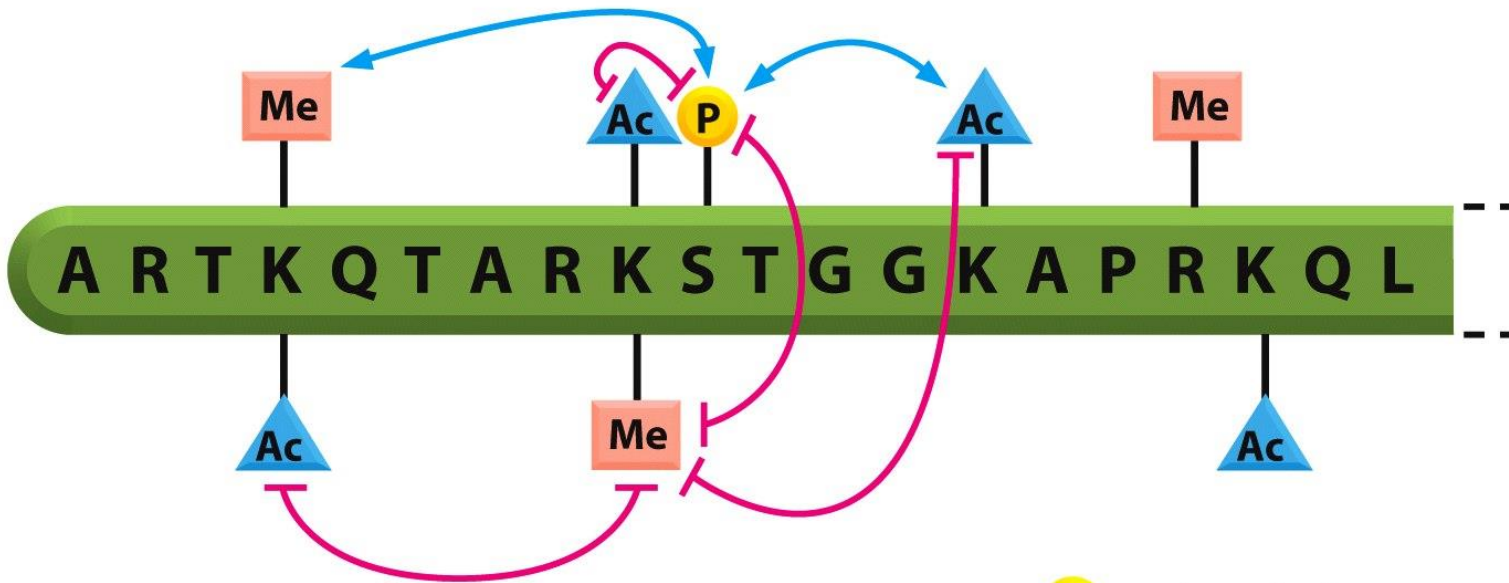


Manning, G.; Whyte, D.B.; Martinez, R.; Hunter, T.; Sudarsanam, S.  
The Protein Kinase Complement of the Human Genome  
*Science* **2002**, 298, 1912

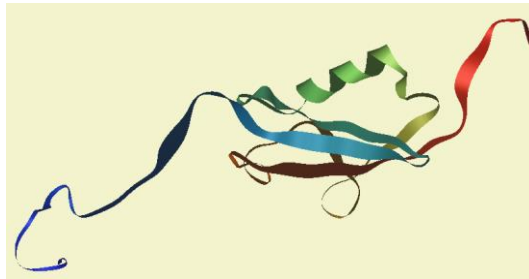
# Proteasome - ubiquitination



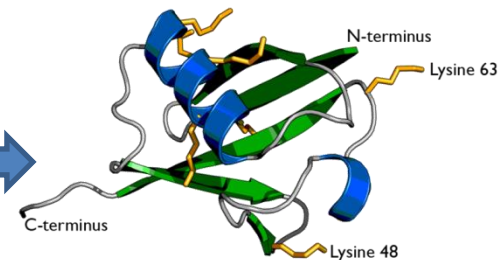
# Post-translational modifications of proteins



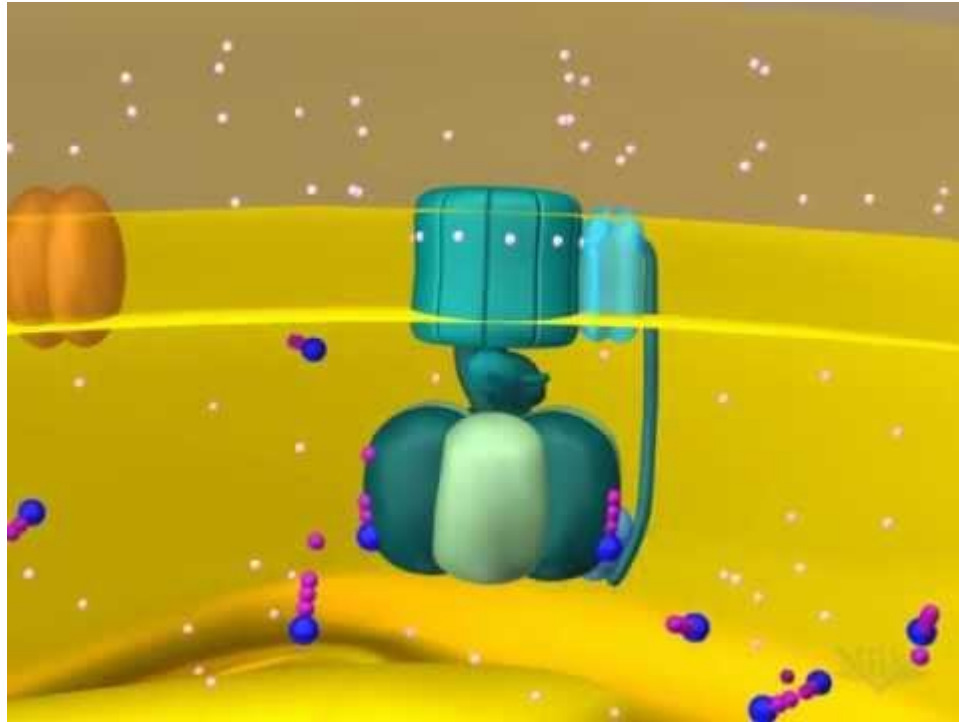
**HISTONE H3**



- P** phosphate
- Ac** acetyl
- S** SUMO
- U** ubiquitin
- Me** methyl



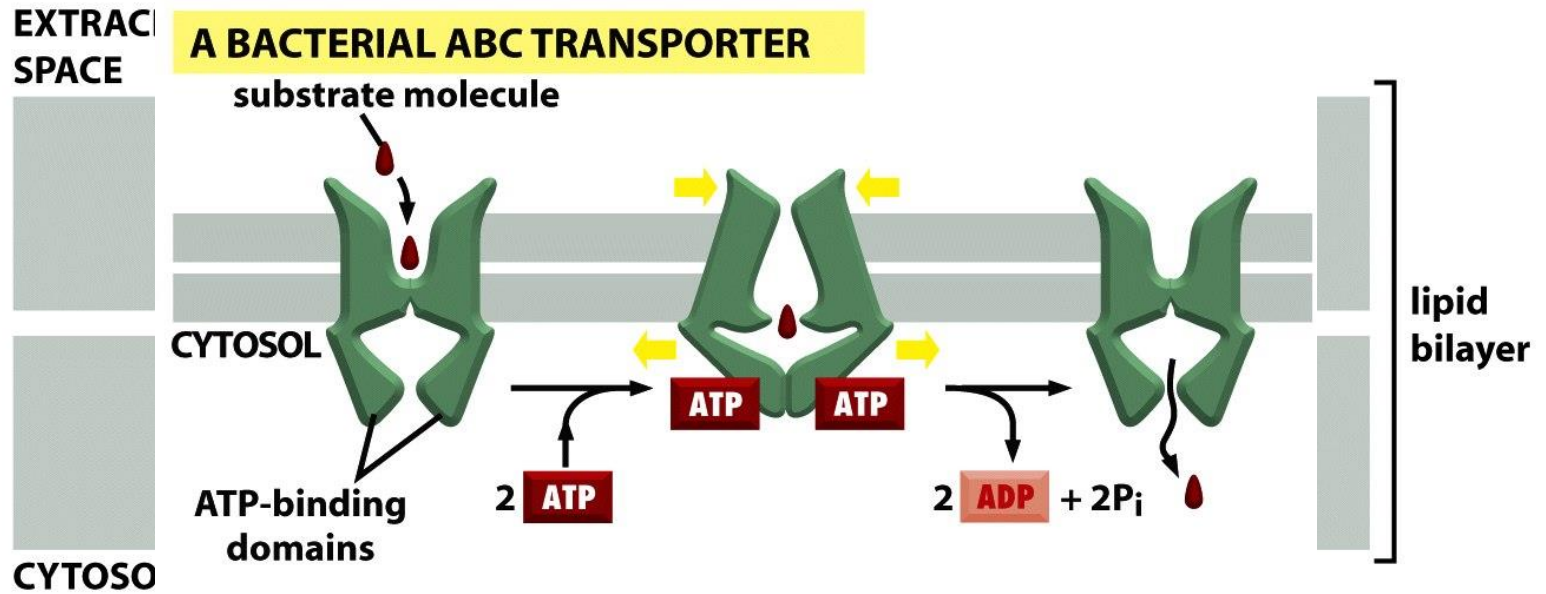
# Protein transmembrane rotors – ATP synthase



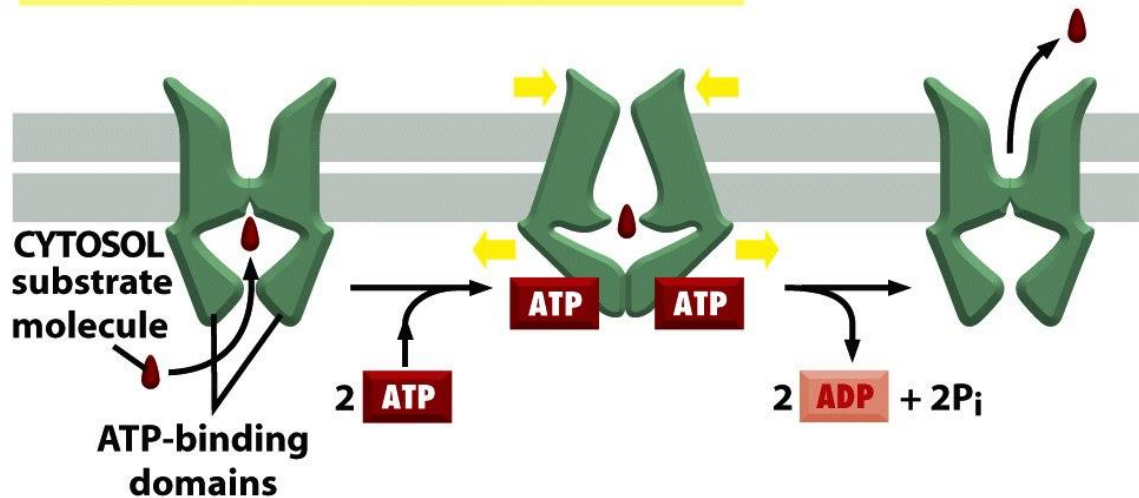
<https://www.youtube.com/watch?v=3y1dO4nNaKY>



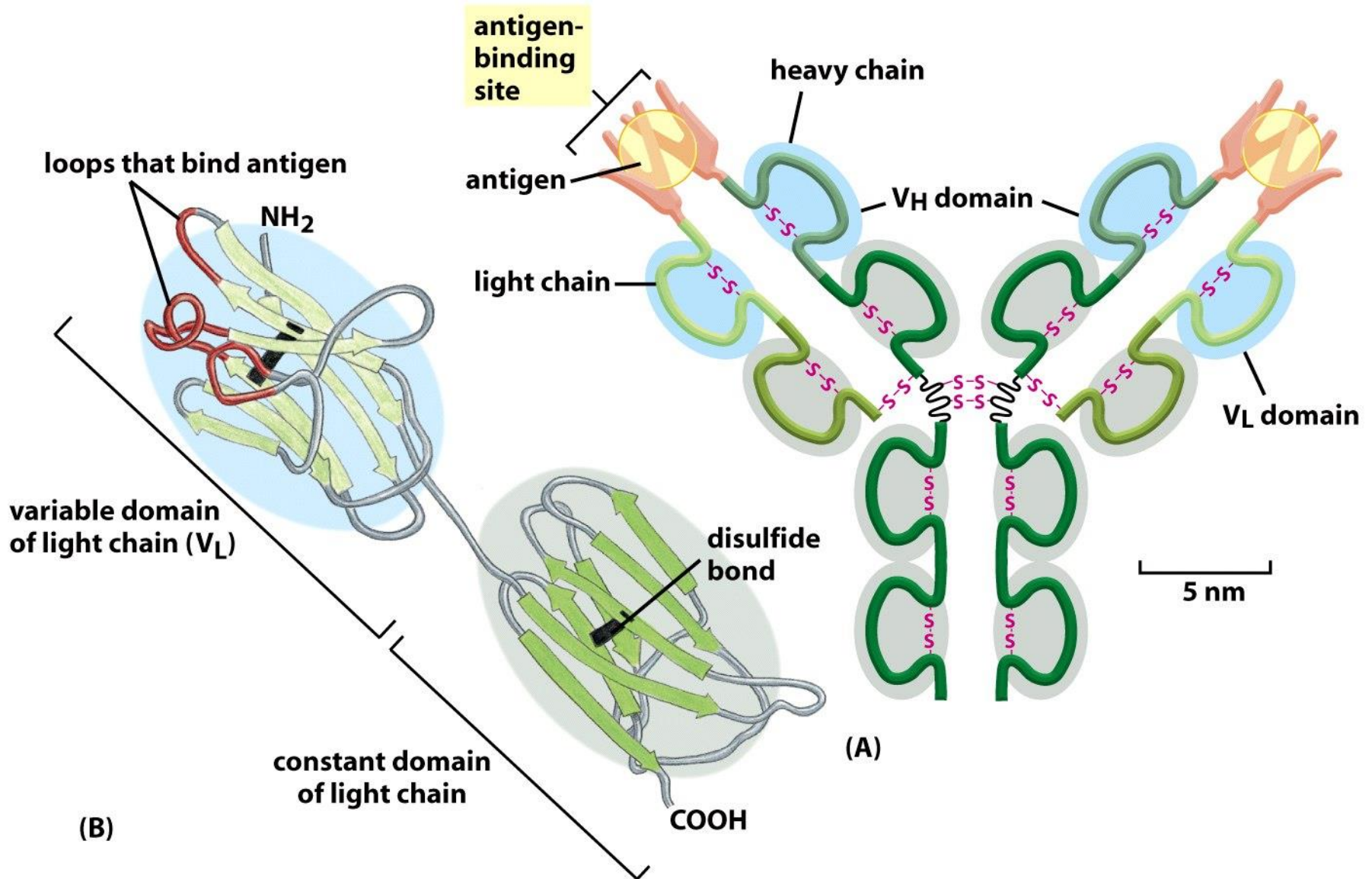
# Transmembrane protein - ABC transporter



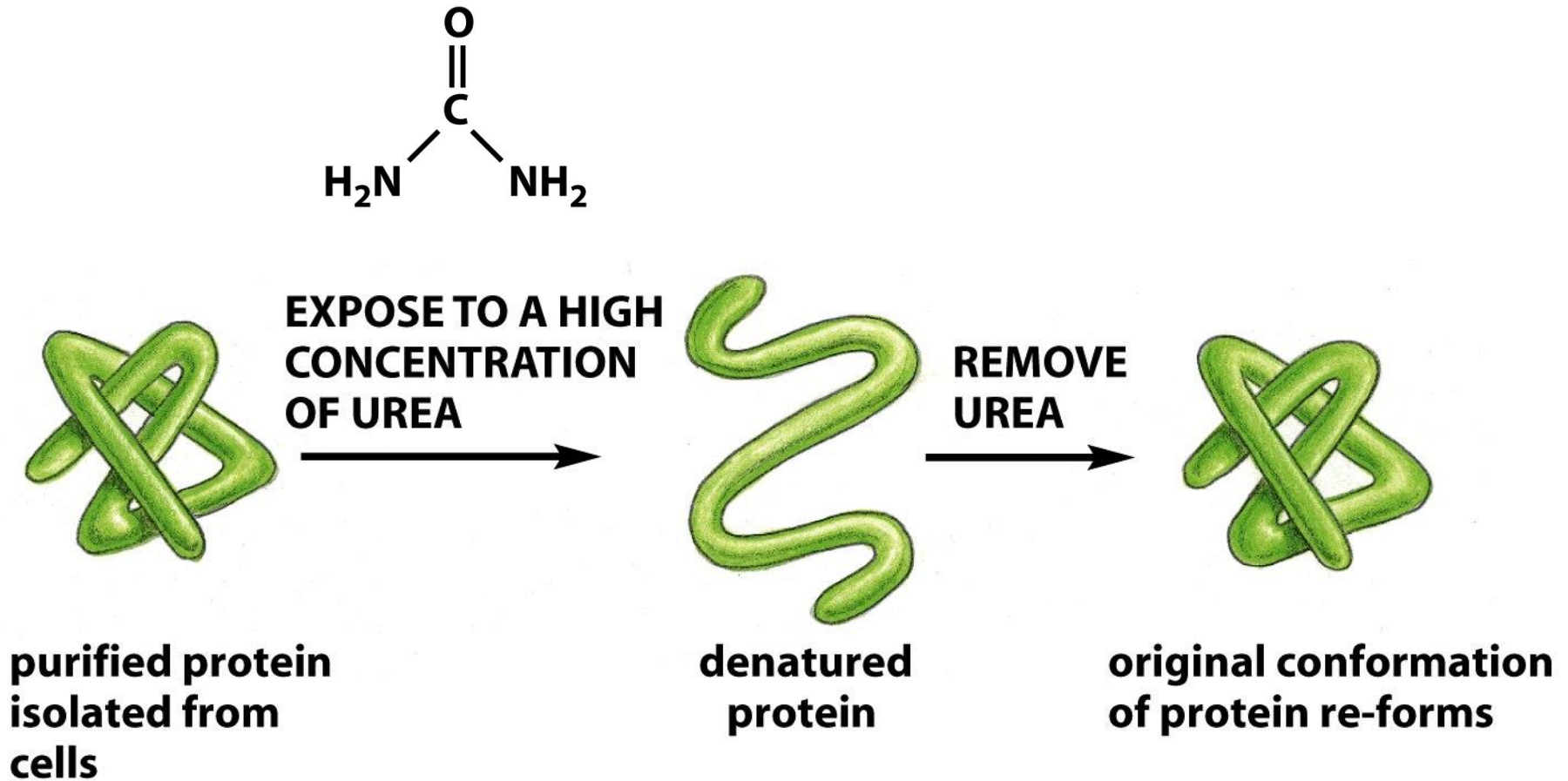
**A EUKARYOTIC ABC TRANSPORTER**



# Antibody (Ab)



# Protein denaturation



# Reading material

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- The shape and structure of the proteins
- ***Next class:***
- Membrane structure and membrane proteins
- Cell junction & cell adhesion

Good web source:

<https://www.ibiology.org/research-talks/cell-biology/>