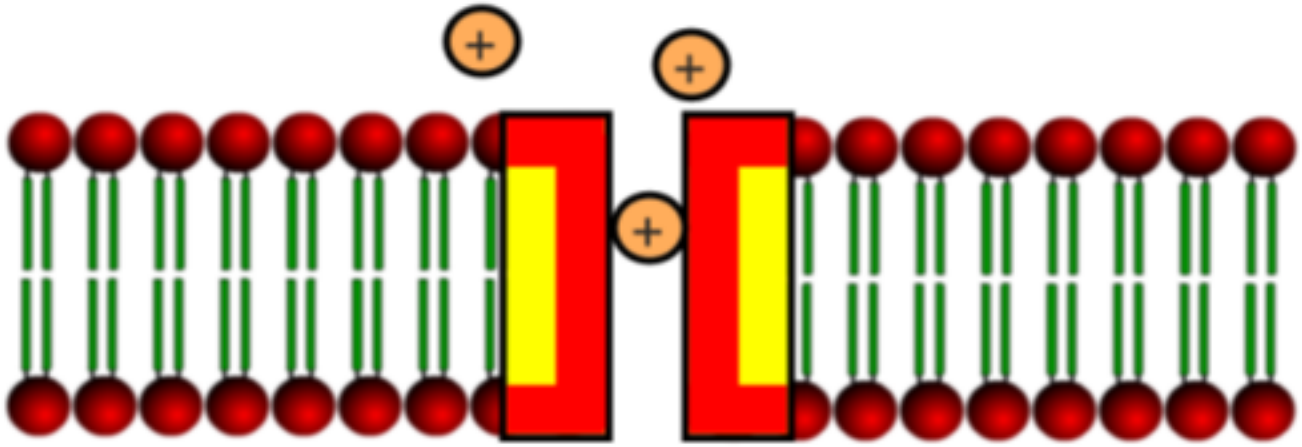
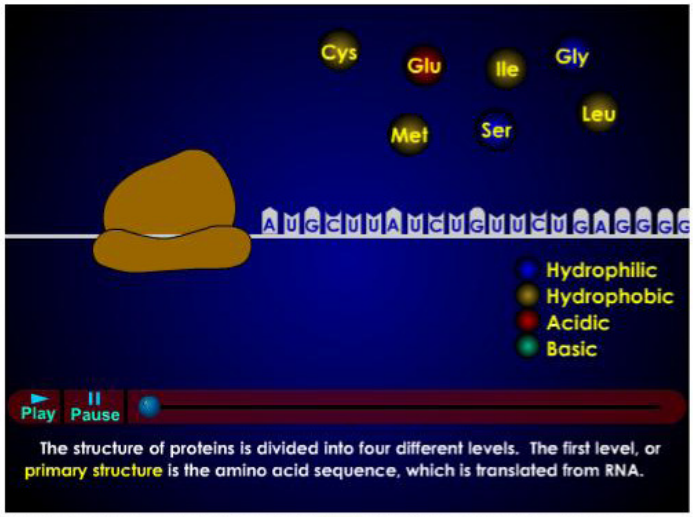
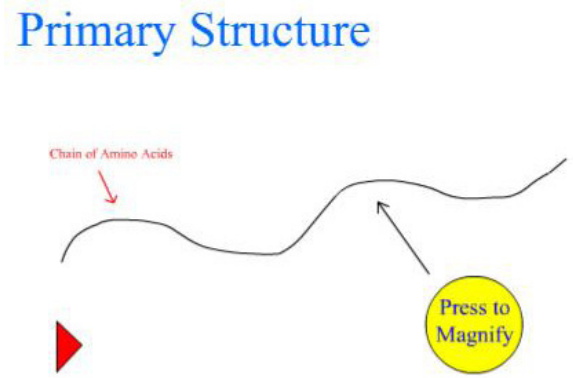


Proteins (7.5 & C.1)

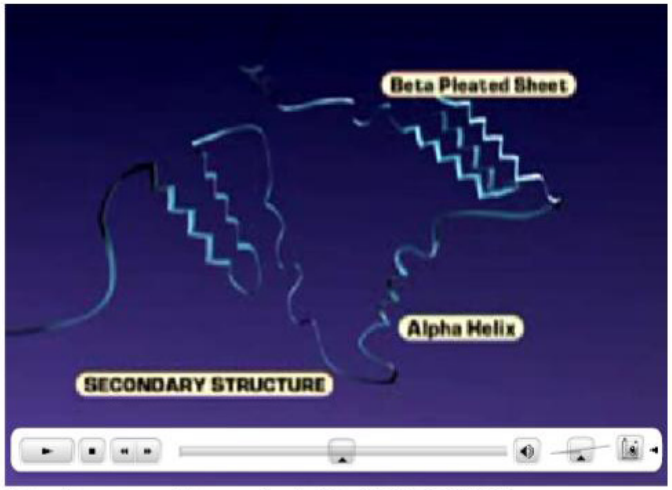
Protein folding and structure animations:



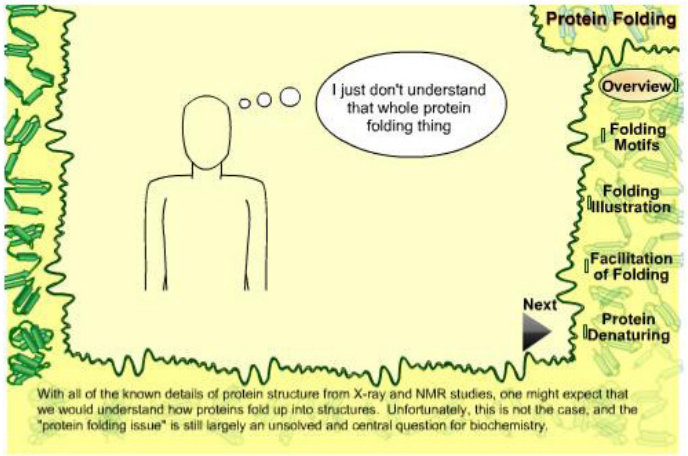
https://mywebspace.wisc.edu/jonovic/web/proteins/Proteins.swf



http://www.stolaf.edu/people/giannini/flashanimat/proteins/protein%20structure.swf



http://www.youtube.com/watch?v=lijQ3a8yUYQ



http://www.wiley.com/legacy/college/boyer/0470003790/animations/protein_folding/protein_folding.swf

- http://www.youtube.com/watch?v=lijQ3a8yUYQ
- http://www.stolaf.edu/people/giannini/flashanimat/proteins/protein%20structure.swf
- http://www.wiley.com//legacy/college/boyer/0470003790/
- http://www.stolaf.edu/people/giannini/flashanimat/proteins/hydrophobic%20force.swf

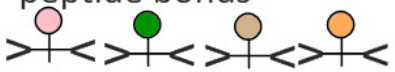
Proteins are the stable, folded 3D structure of polypeptides.

Polypeptides are the chain of amino acids that fold into proteins.

There are four levels of protein structure.

Primary (1°)

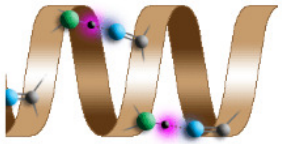
- amino acid sequence
- peptide bonds



Secondary (2°)

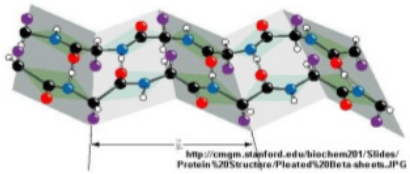
- repeating local structures
- held by H-bonds

α-helix



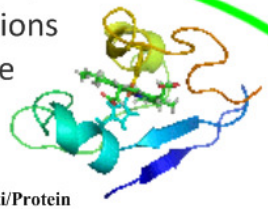
http://www.brooklyn.cuny.edu/bc/ahp/LAD/C4b/C4b_proteinShape.html

β-pleated sheet



Tertiary (3°)

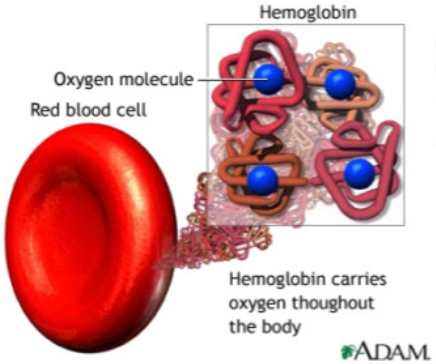
- folding of a single protein
- R-group interactions
- hydrophobic core



http://en.wikipedia.org/wiki/Protein

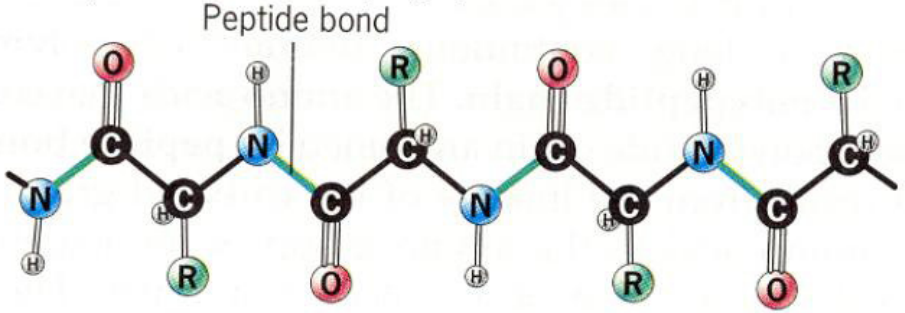
Quaternary (4°)

- protein complex
- made of two or more subunits



Primary (1°) Structure of proteins: The polypeptide

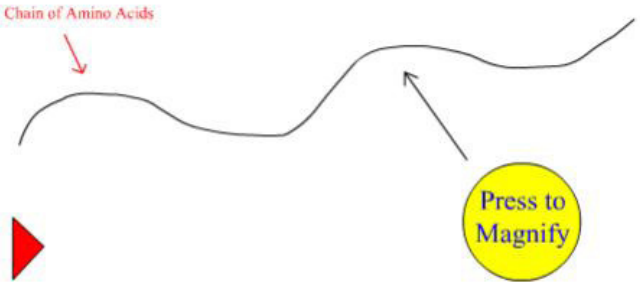
How many amino acids in this polypeptide?



http://www.bio.miami.edu/~cmallery/255/255amino/255aminoacids.htm

- Amino acid sequence
- Peptide bonds

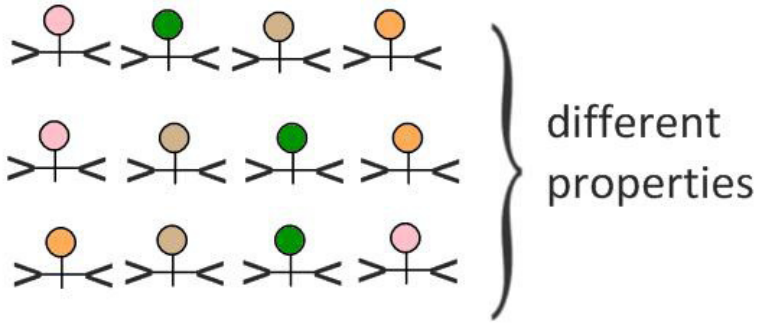
Primary Structure



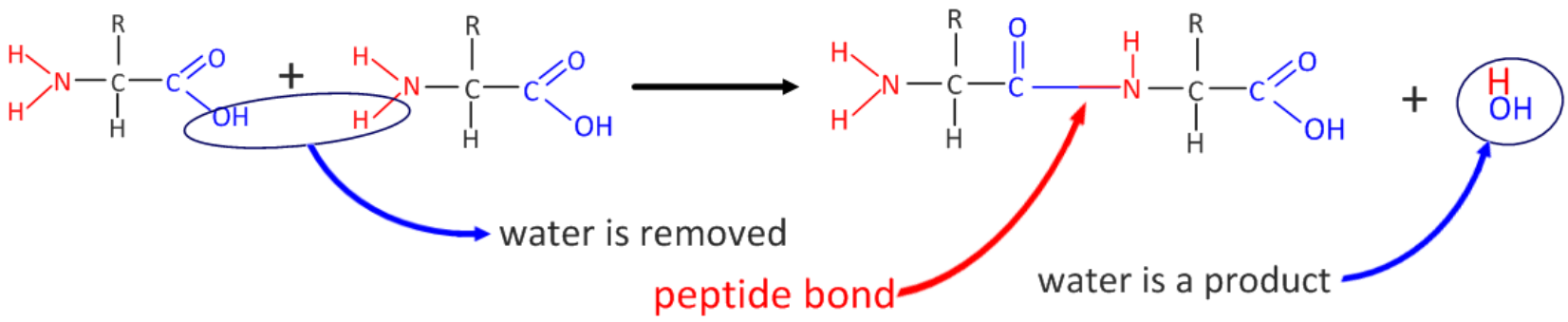
http://www.stolaf.edu/people/giannini/flashanimat/proteins/protein%20structure.swf

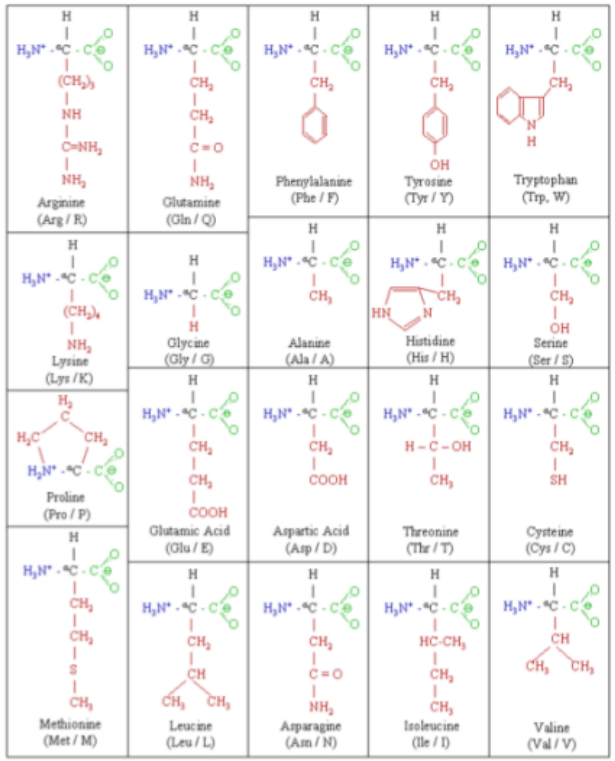
Why are there infinite possibilities of polypeptides?

- 20 different amino acids
- could be any length
- amino acids can be in any order



Polypeptides are chains of amino acids joined by peptide bonds:





http://upload.wikimedia.org/wikipedia/commons/thumb/c/c5/Amino_acids_2.png/483px-Amino_acids_2.png

There are 20 different amino acids.

These can be combined in any order.

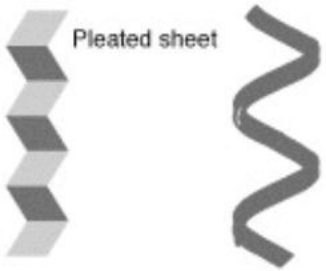
Each amino acid has unique properties:

- some a polar (hydrophilic)
- some are non-polar (hydrophobic)
- some are positively or negatively charged
- some contain sulphur

The properties of the amino acids determine how a polypeptide folds up into a protein.

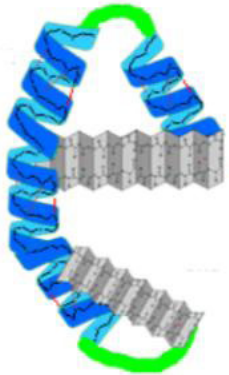
Secondary (2°)structure: Repeating Units

- Repeating local structures
- Held by H-bonds



Secondary protein structure
occurs when the sequence of amino acids are linked by hydrogen bonds

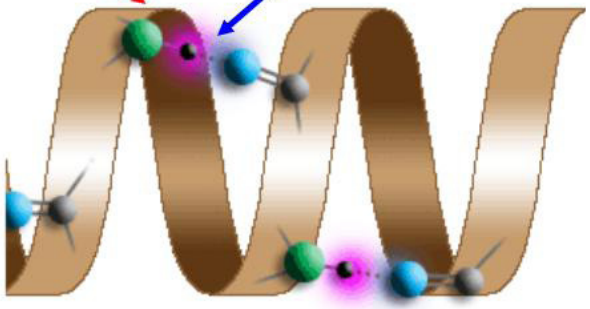
http://andromeda.rutgers.edu/~huskey/563_lec.html



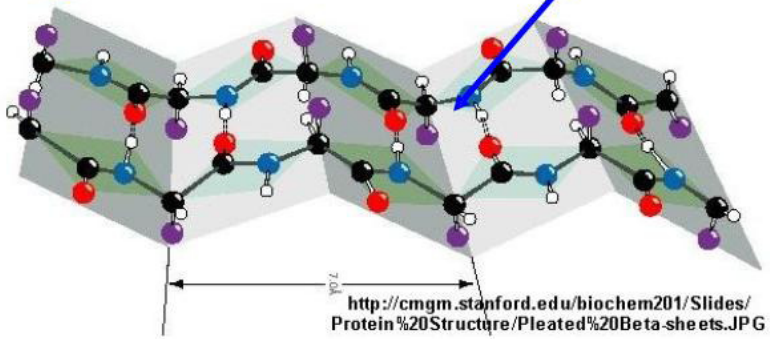
α-helix

β-pleated sheet

H-bonds



H-bonds



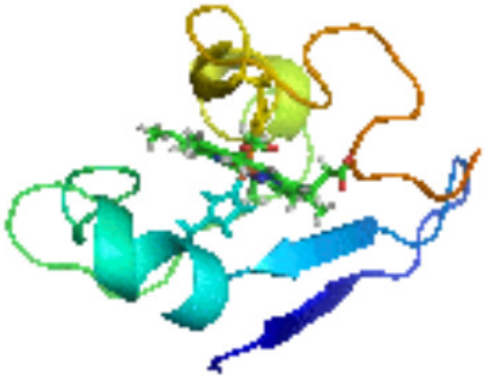
http://www.brooklyn.cuny.edu/bc/ahp/LAD/C4b/C4b_proteinShape.html

http://cmgm.stanford.edu/biochem201/Slides/Protein%20Structure/Pleated%20Beta-sheets.JPG

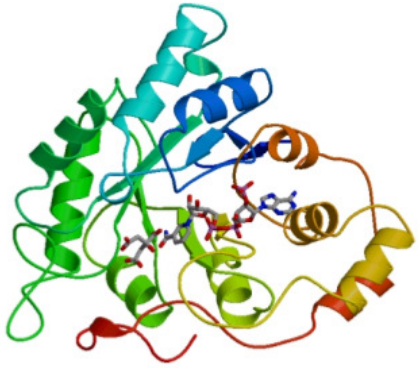
Tertiary structure (3°): 3D Folded Structure

- Folding of a single protein into a 3D structure
- Hydrophobic core

This 3D structure gives proteins their functional properties, such as active sites on enzymes.

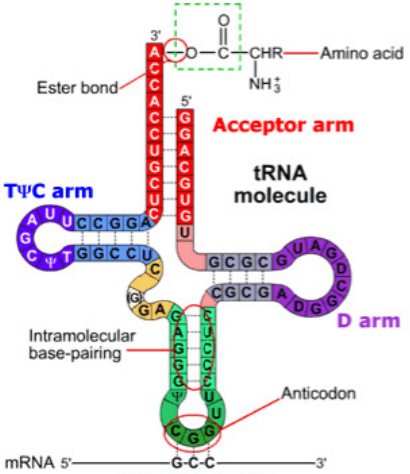


http://en.wikipedia.org/wiki/Protein



http://shelx.uni-ac.gwdg.de/~fabio/endwkcon.htm

- R-group interactions:
  - -hydrophilic polar amino acids orient to the outside
  - - hydrophobic non-polar amino acids protected in the core
  - - oppositely-charged ions attract
  - - disulphide bridges formed between sulphur-containing amino acids



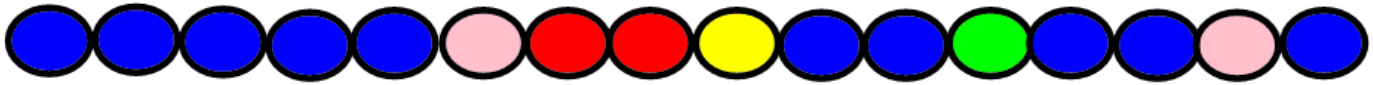
http://www3.interscience.wiley.com:8100/legacy/college/boyer/0471661791/structure/tRNA/trna.htm

tRNA is an example of a tertiary

Modeling protein folding

colour					
number	11	1	1	2	2
e.g.	serine	lysine	aspartic acid	cysteine	valine
	SER	LYS	ASP	CYS	VAL
property	polar	$^{+}$ve	$^{-}$ve	contains S	non-polar

What is the primary structure of this section of a polypeptide?



Modeling protein folding

try it with plasticene

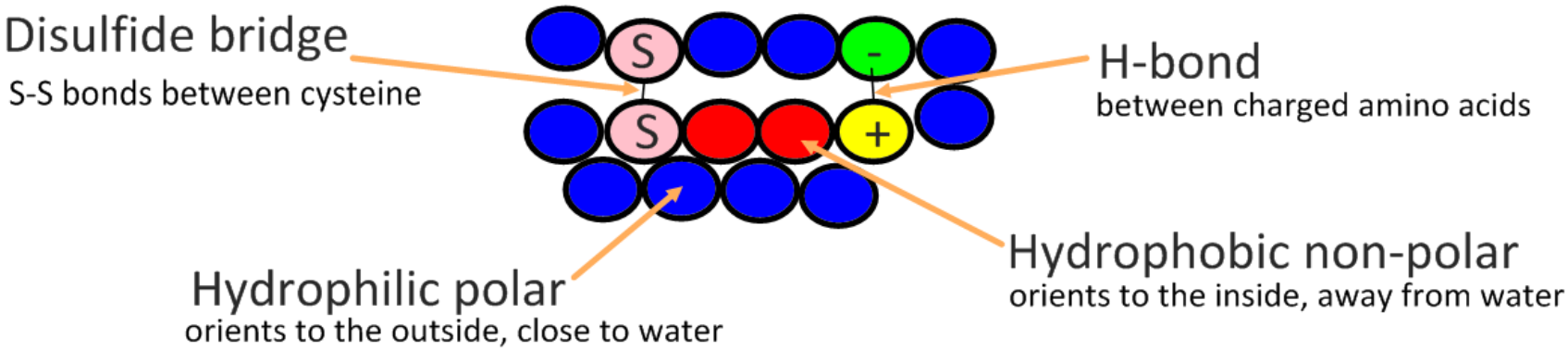
colour					
number	11	1	1	2	2
e.g.	serine	lysine	aspartic acid	cysteine	valine
	SER	LYS	ASP	CYS	VAL
property	polar	$^{+}$ve	$^{-}$ve	contains S	non-polar

What is the primary structure of this section of a polypeptide?

How would the polypeptide fold if placed in water?

1. polar groups outside
2. non-polar groups inside
3. positive near negative
4. disulfide bridges

Modeling protein folding:

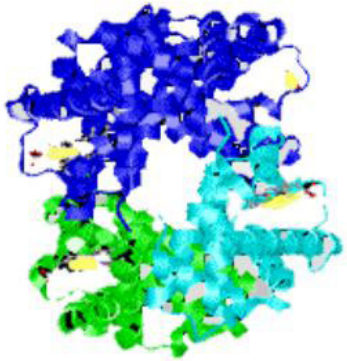


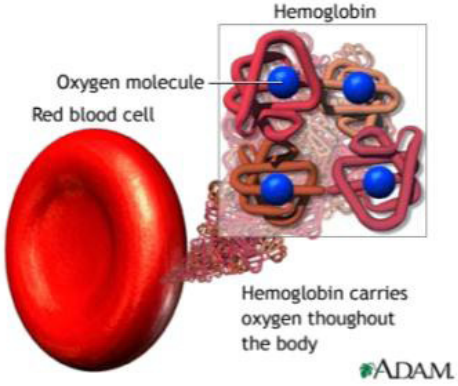
colour					
number	11	1	1	2	2
e.g.	serine	lysine	aspartic acid	cysteine	valine
	SER	LYS	ASP	CYS	VAL
property	polar	$^{+}$ve	$^{-}$ve	contains S	non-polar

Quaternary structure (4°): Multiple Subunits

- Protein complex
- Made of two or more subunits

e.g. haemoglobin



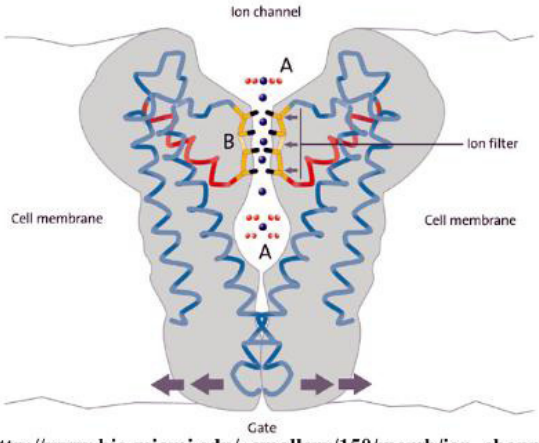


http://www.bmb.uga.edu/wampler/tutorial/prot4.html

e.g. DNA Polymerase

http://en.wikipedia.org/wiki/DNA_polymerase

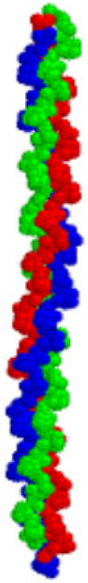
e.g. Ion channels in the plasma membrane



http://www.bio.miami.edu/~cmallery/150/memb/ion_channels.htm

- The heme is a small but important non-protein molecule, or prosthetic ***group***, that binds an ***iron*** atom in the ferrous (+2) oxidation state.

Fibrous Proteins



insoluble in water

structural
(support, strength)

keratin (hair/nails)

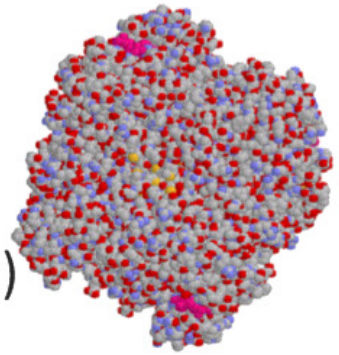
elastin (skin)

collagen (tissue strengthening)

Globular Proteins

can be soluble

functional
(enzymes, antibodies)



amylase (digests starch)

Insulin (blood sugar regulation)

haemoglobin

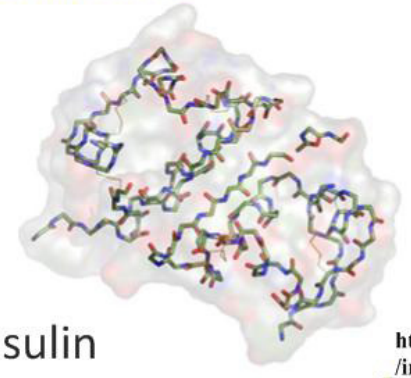
immunoglobulins (antibodies)

transport (Na^+/K^+ pump)

Uses of proteins:

Proteins can be structural or part of the plasma membrane.
They can also perform other diverse functions in an organism:

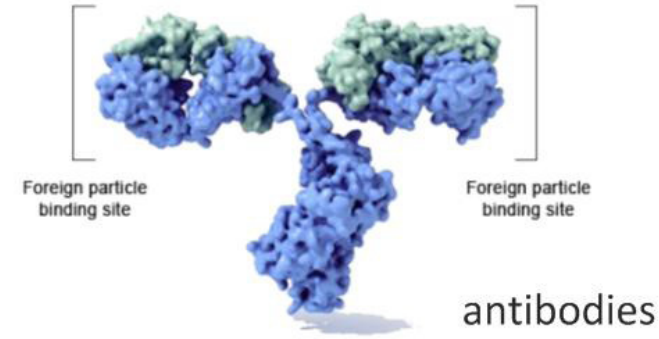
Hormones



insulin

http://www.3dchem.com
/imagesofmolecules/Insulin2.jpg

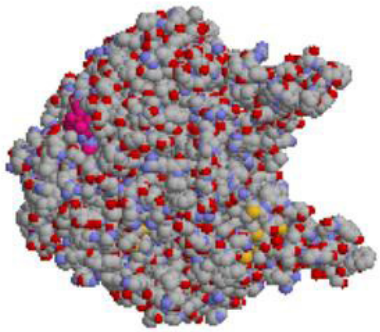
Immunoglobulin



antibodies

http://ghr.nlm.nih.gov/handbook/illustrations/igg.jpg

Enzymes

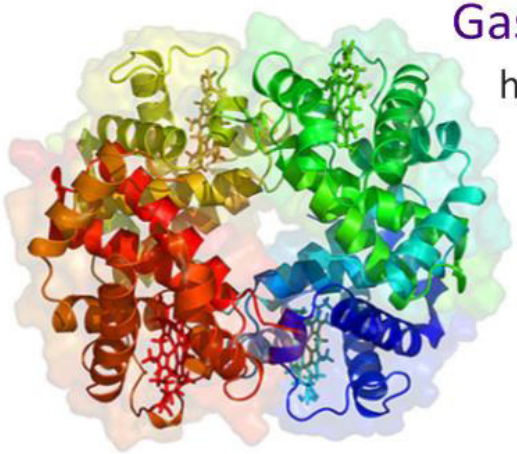


http://www.steve.gb.com/images
/molecules/proteins/catalase.gif

catalase

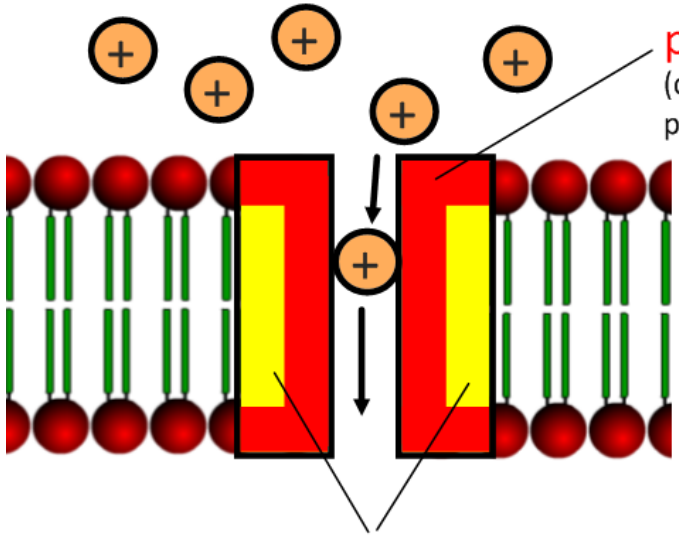
Gas transport

haemoglobin



http://chemistry.ewu.edu/jcorkill/biochem/48006.htm

Polar and non-polar amino acids are used in membrane channels:

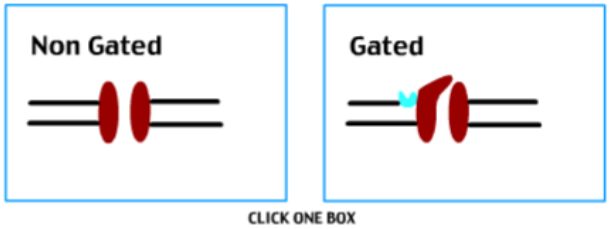


polar sections allow ions through
(charged or polar molecules cannot normally pass through the hydrophobic layers)

non-polar sections bond with hydrophobic tails

polar amino acids are positioned on external surfaces and line the protein channels for facilitated diffusion

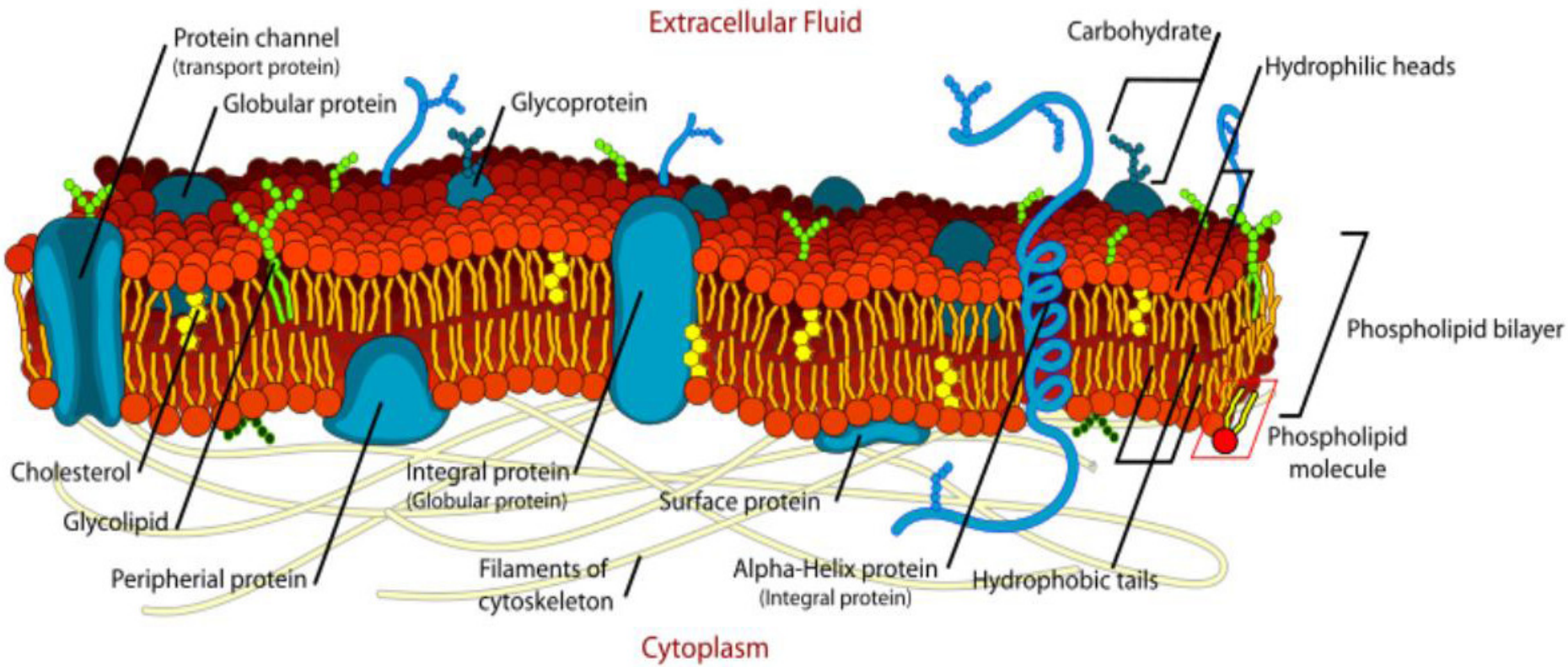
CHANNEL



http://www.stolaf.edu/people/giannini/flashanimat/transport/channel.swf

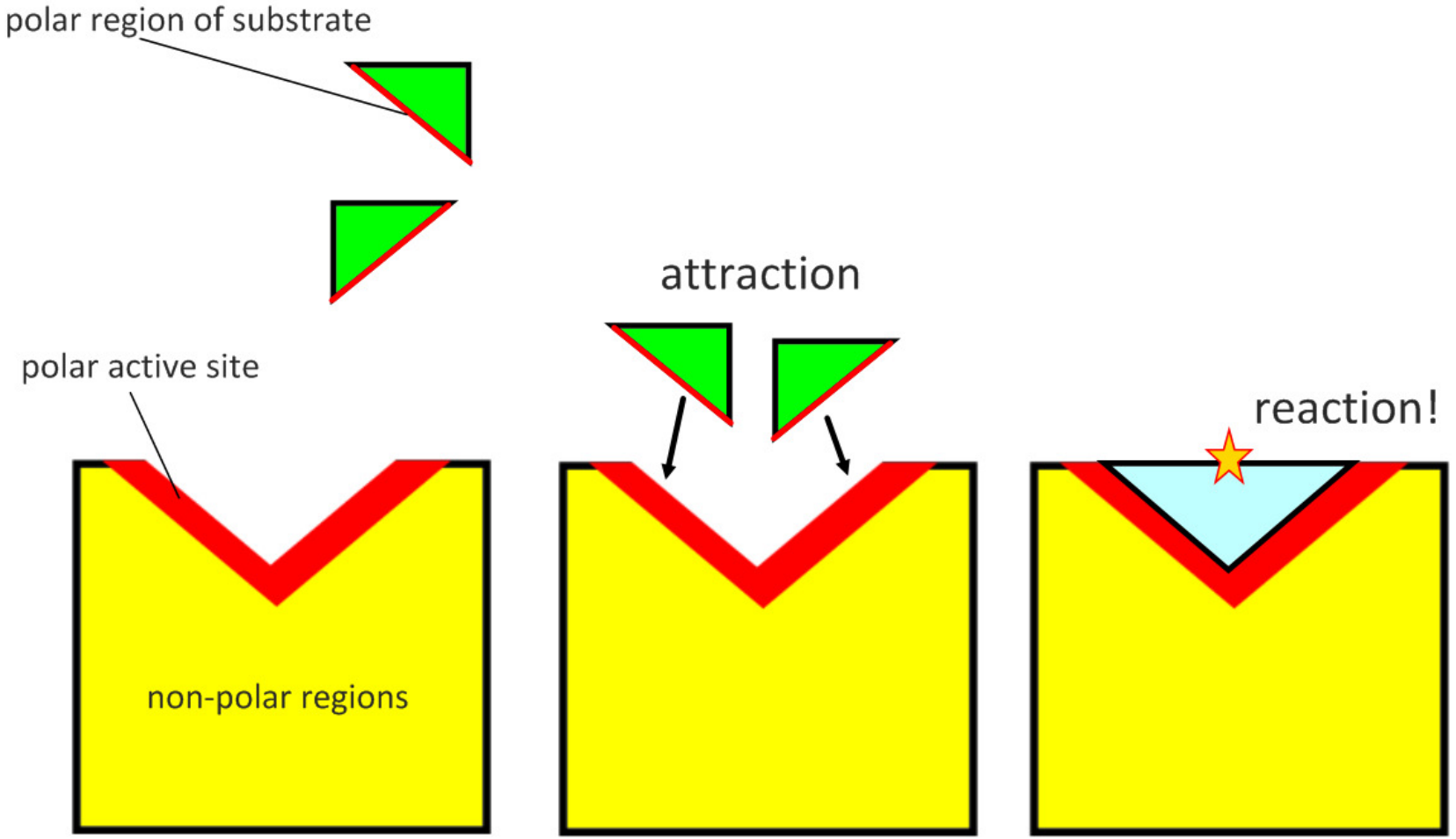
- http://www.stolaf.edu/people/giannini/flashanimat/transport/channel.swf

Non-polar amino acids help bond proteins to the plasma membrane

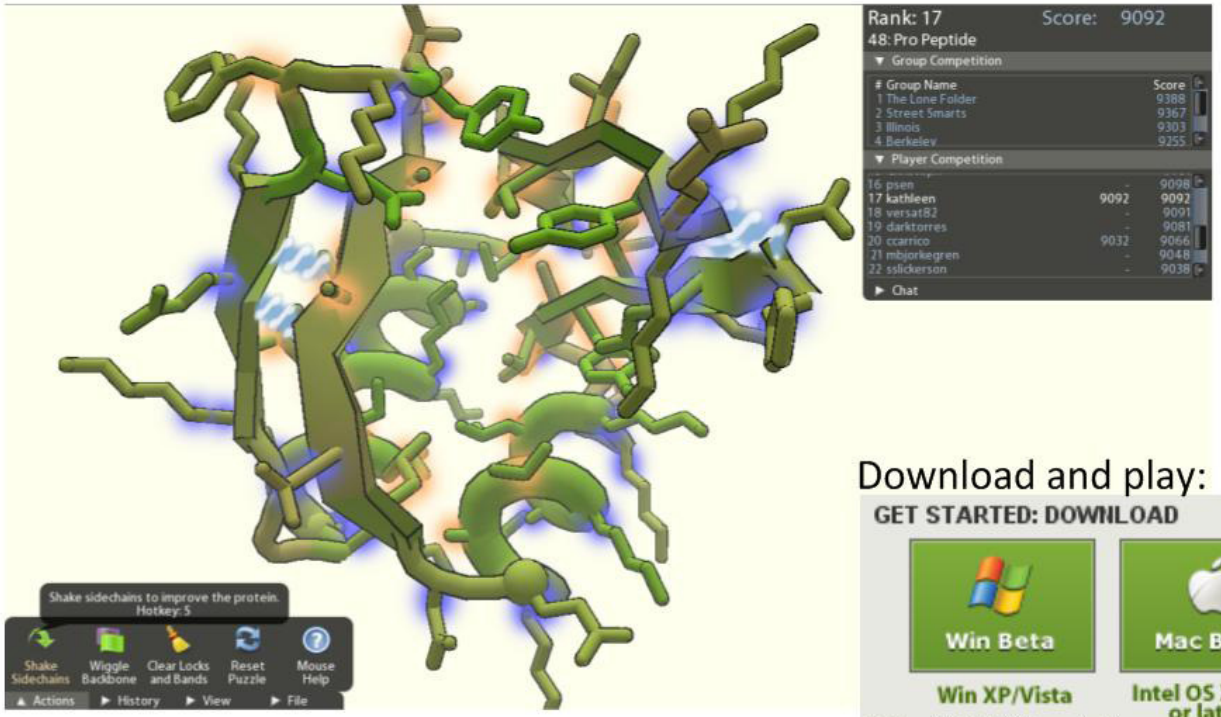


http://cellbiology.med.unsw.edu.au/units/science/lecture0803.htm

Polar amino acids in enzymes help bind the substrates for reaction:



Foldit: Solve puzzles for Science!



Download and play:

http://fold.it/portal/

RCSB PDB PROTEIN DATA BANK

You can see proteins in the protein data bank:
Can you make them in FoldIt?

http://www.pdb.org/pdb/home/home.do

- http://fold.it/portal/