Proteins

Proteins are essential parts of living organisms and participate in virtually every process in cells.

Proteins

Which are made of

Amino Acids

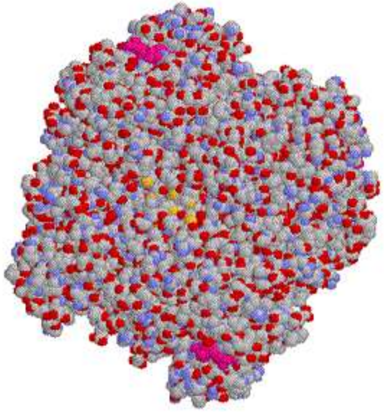
which contain

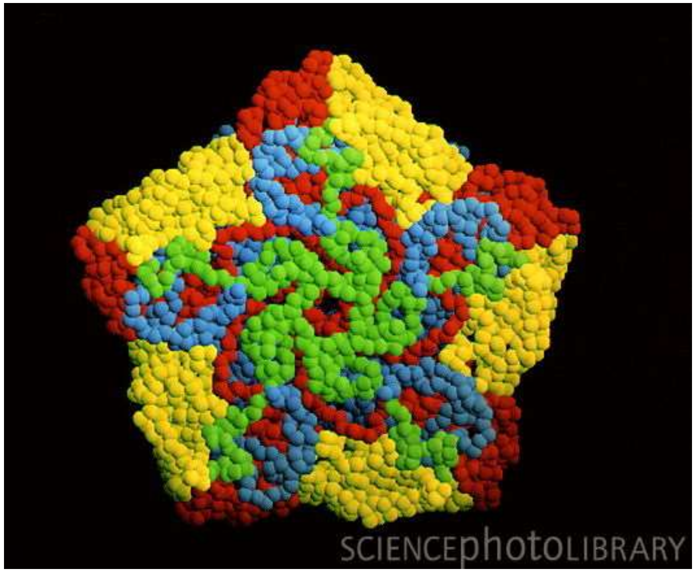
Carbon, hydrogen, oxygen, nitrogen,

main function

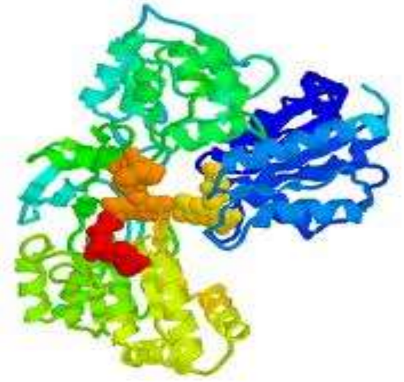
CATALYSIS & STRUCTURE /SUPPORT

This is the Enzyme Catalase





Protein coat of polio virus

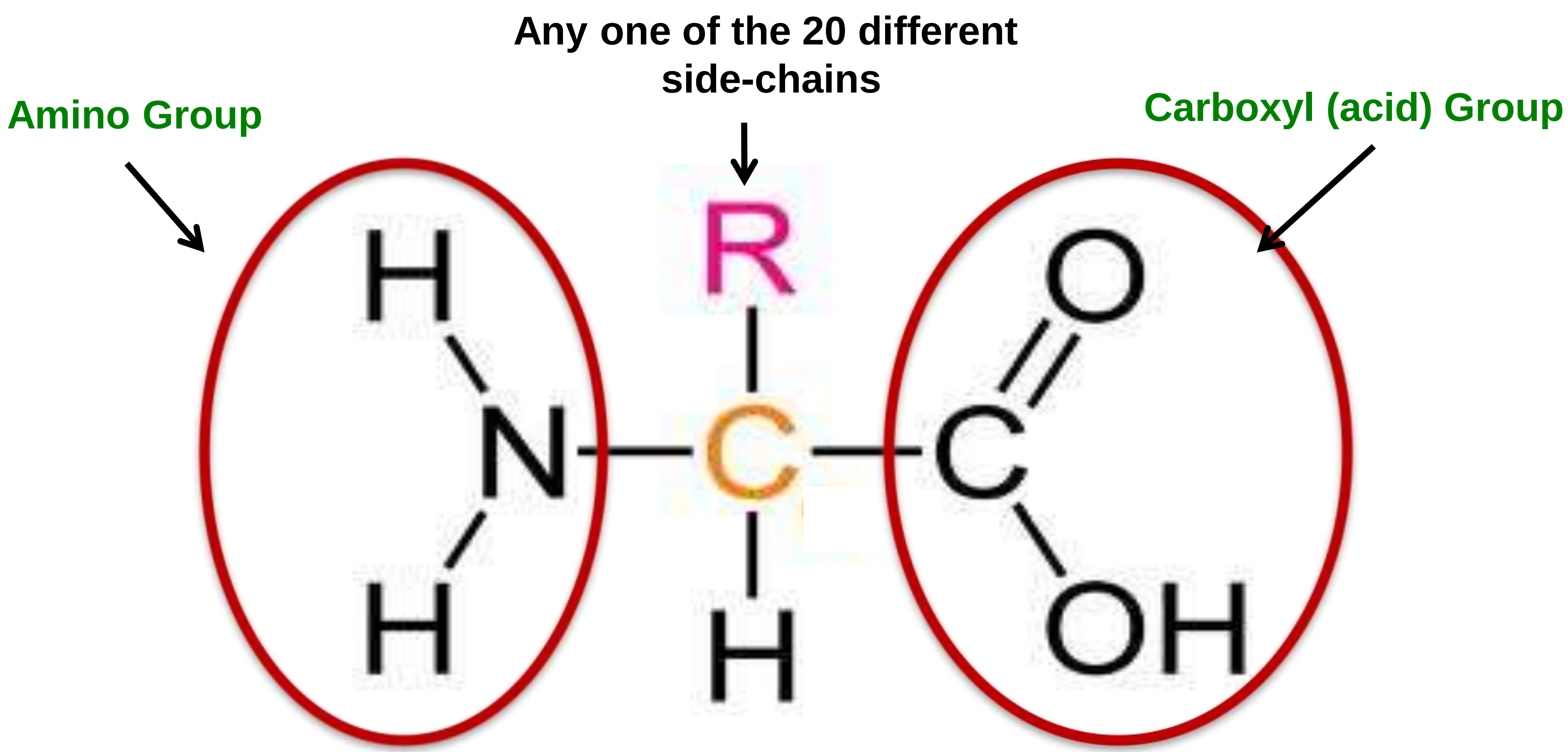


Types	Function/Example
Enzymatic Catalytic	**Acceleration of chemical reactions** **E.g., digestive enzymes (lactase, amylase), cellular respiration**
Structural	Collagen & elastin, keratin in hair and nails
Transport	**Transport of other substances** E.g., hemoglobin transports O_2 to cells
Hormonal	**Cellular communication** E.g., insulin secreted by the pancreas
Contractile	**Movement** E.g. actin and myosin in muscle cells
Defensive	**Protect against disease** E.g., antibodies (such as immunoglobulin) combat viruses and bacteria

Proteins and their subunits

Amino acids are the building blocks of proteins

Amino Acid Structure



Proteins and their subunits

20 Major Amino Acids

8 are considered "essential"

1. Phenylalanine
2. Valine
3. Threonine
4. Tryptophan
5. Isoleucine
6. Methionine
7. Leucine
8. Lysine

The other 12

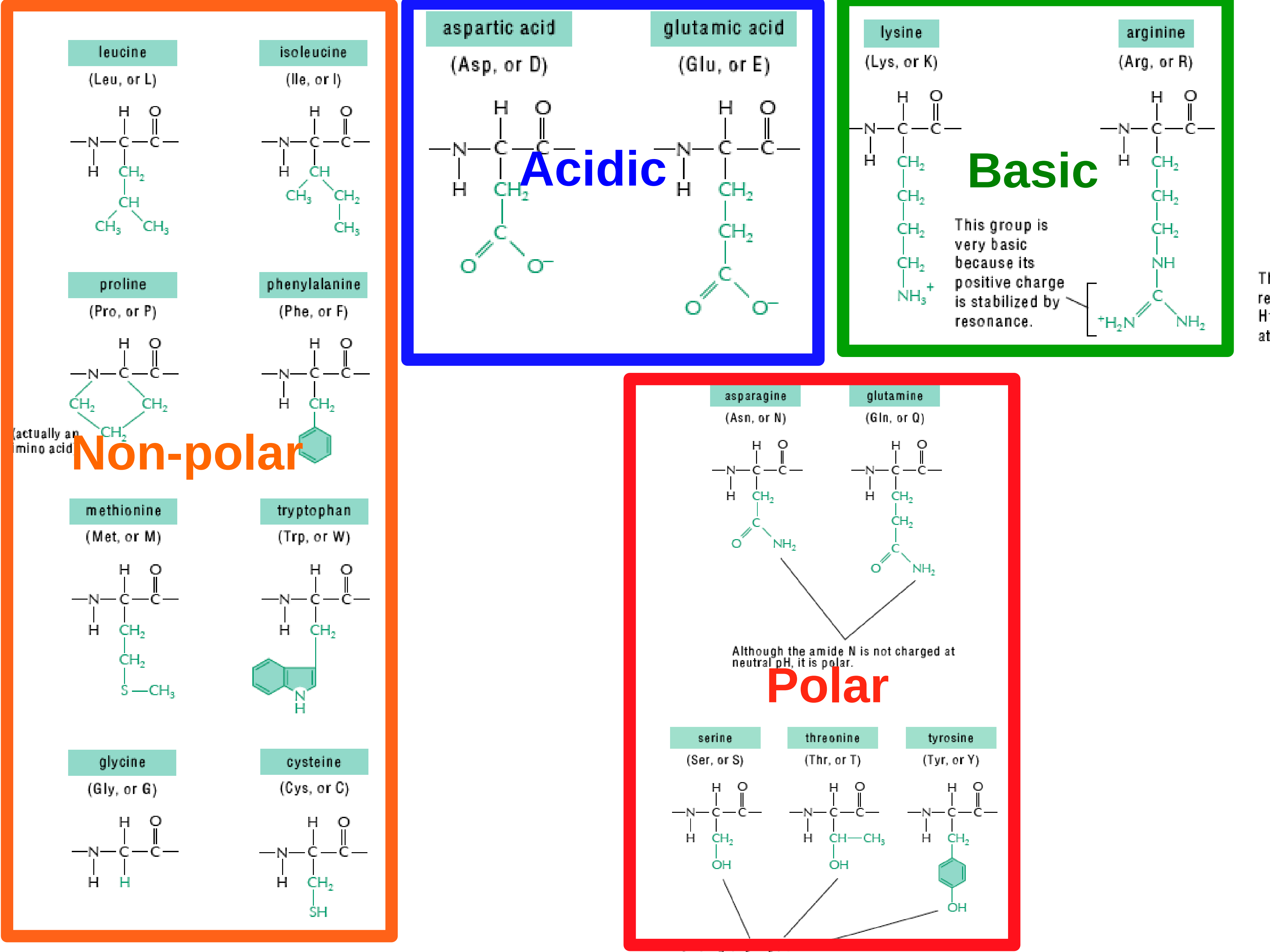
1. Glycine
2. Alanine
3. Proline
4. Serine
5. Cysteine
6. Asparagine
7. Glutamine
8. Histidine
9. Tyrosine
10. Aspartic acid
11. Glutamic acid
12. Arginine

Types of Amino Acids

Non-polar
Polar
Acidic
Basic

Amino acids each have their own unique chemical properties.

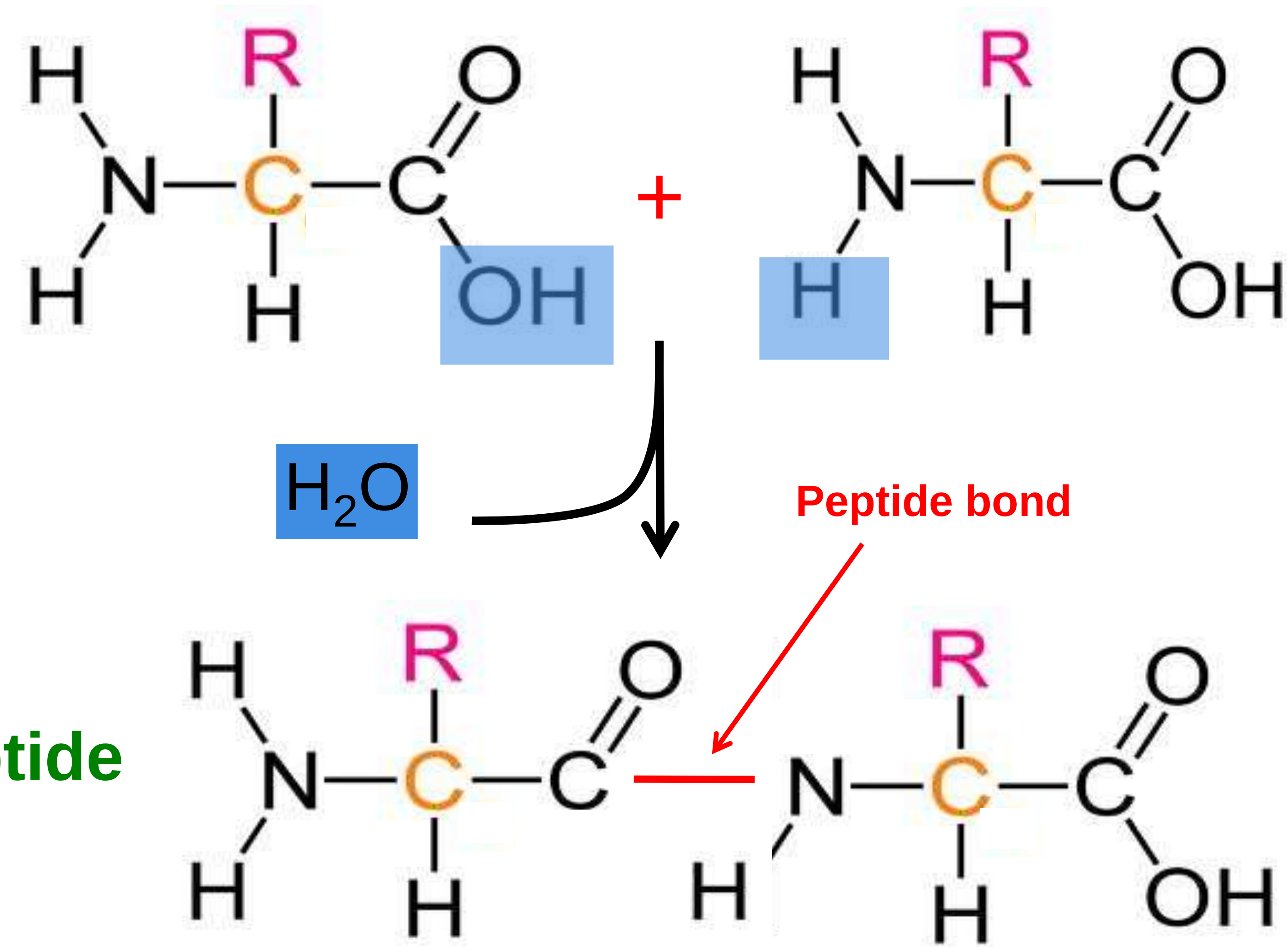
Some dissolve in water – some do not. This is essential for transport and storage.


Non-polar
leucine
(Leu, or L)
isoleucine
(Ile, or I)
proline
(Pro, or P)
(actually an imino acid)
phenylalanine
(Phe, or F)
methionine
(Met, or M)
tryptophan
(Trp, or W)
glycine
(Gly, or G)
cysteine
(Cys, or C)
Acidic
aspartic acid
(Asp, or D)
glutamic acid
(Glu, or E)
Basic
lysine
(Lys, or K)
arginine
(Arg, or R)
This group is very basic because its positive charge is stabilized by resonance.
Polar
asparagine
(Asn, or N)
glutamine
(Gln, or Q)
Although the amide N is not charged at neutral pH, it is polar.
serine
(Ser, or S)
threonine
(Thr, or T)
tyrosine
(Tyr, or Y)

Making and Breaking Proteins

Amino acids are linked together by peptide bonds

- a special covalent bond found in proteins



Dipeptide

Making and Breaking Proteins

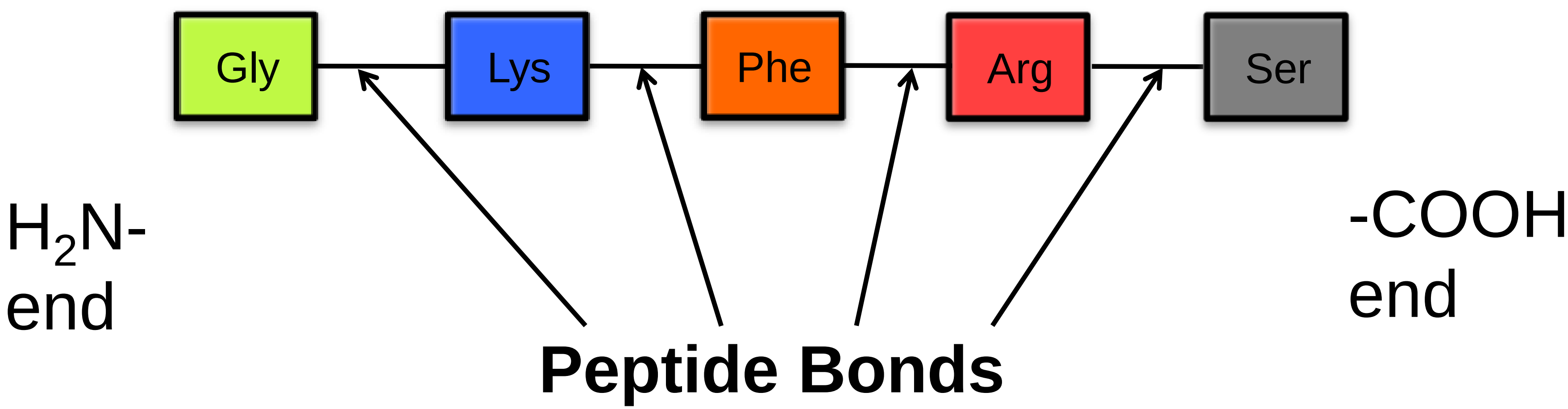
Condensation synthesis

- two amino acids join (dipeptide)
- a peptide bond is formed
- a water molecule is formed

Hydrolysis

- water is added
- a peptide bond is broken
- amino acids are split apart

A chain of amino acids is called a polypeptide



Making and Breaking Proteins

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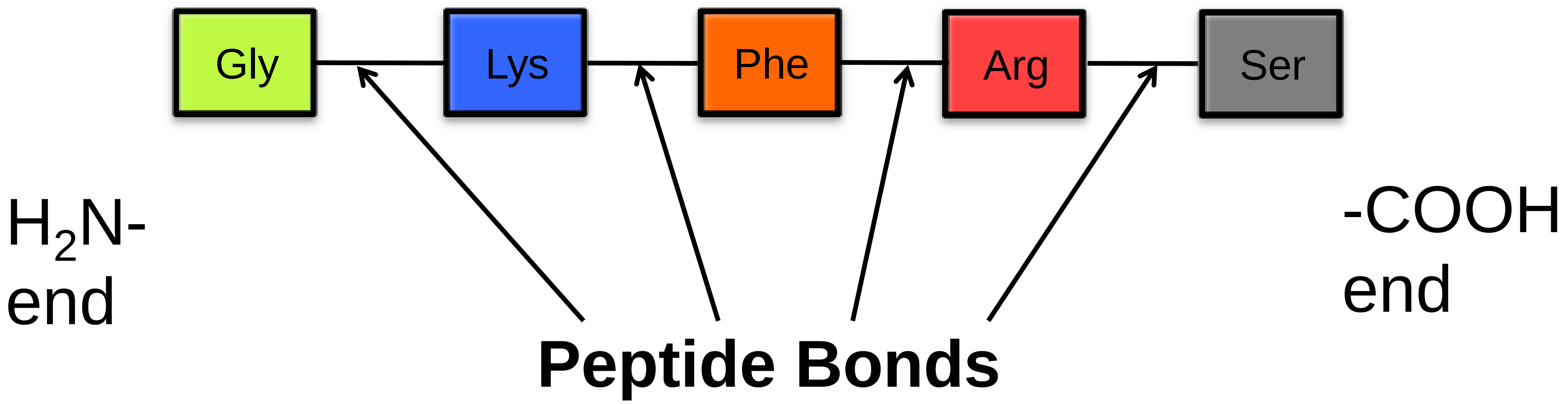
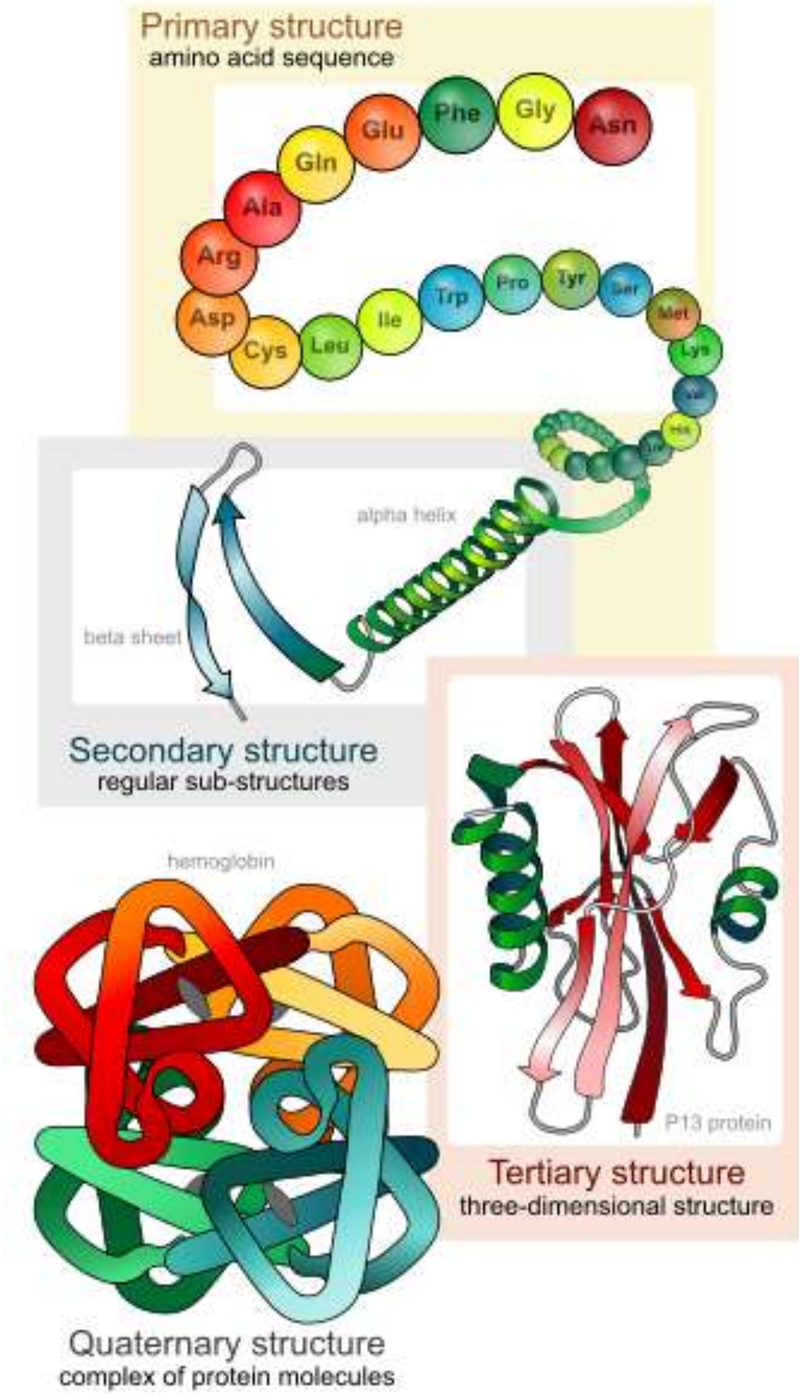


The type of protein is determined by:

✓ sequence of polypeptides

✓ orientation in space

✓ 3-D shape



Four levels of protein structure:

Primary - exact sequence of amino acids before folding.

Secondary - simple folding create simple structures.

Tertiary - folding results in complex 3D structures.

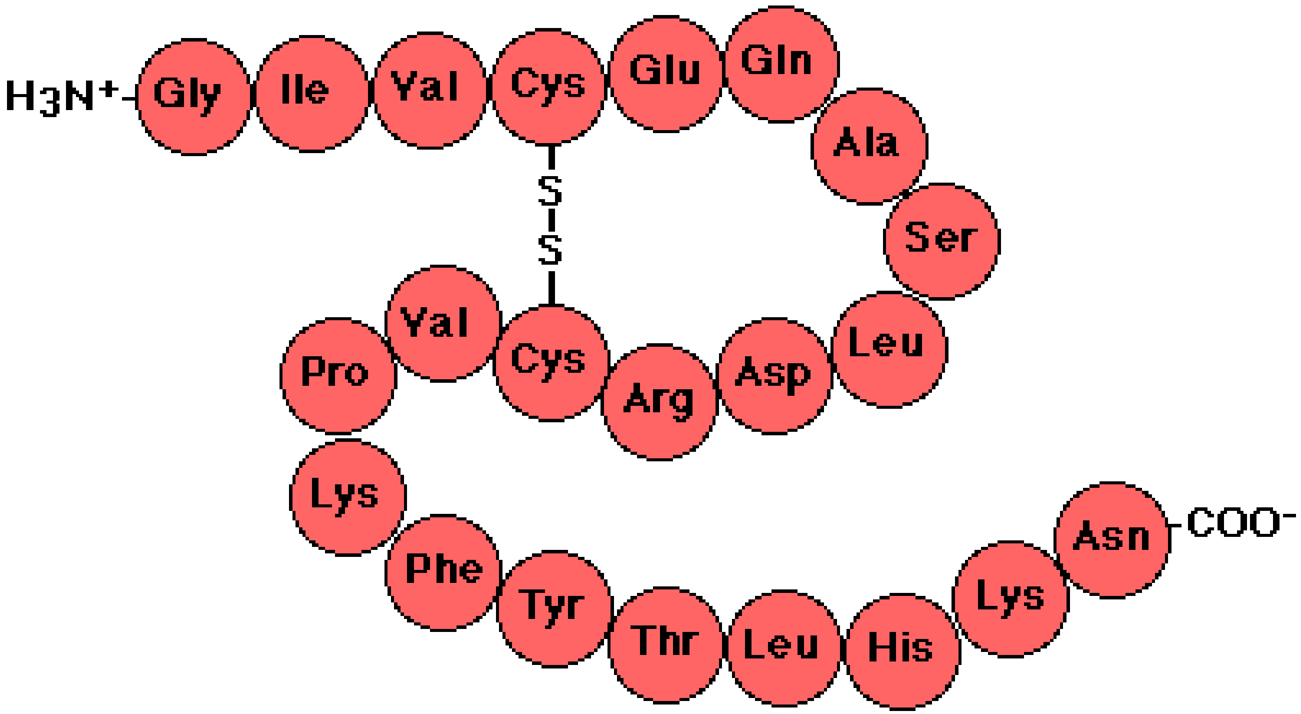
Quaternary - multiple 3D subunits organized into a bigger structure.

Sulfhydryl (-SH) functional groups can form disulfide (-S-S) bonds which contribute to a proteins tertiary structure.

Primary Structure (1º)

The amino acid sequence, starting from the N-terminus

Proteins differ in the variety, number and order of amino acids

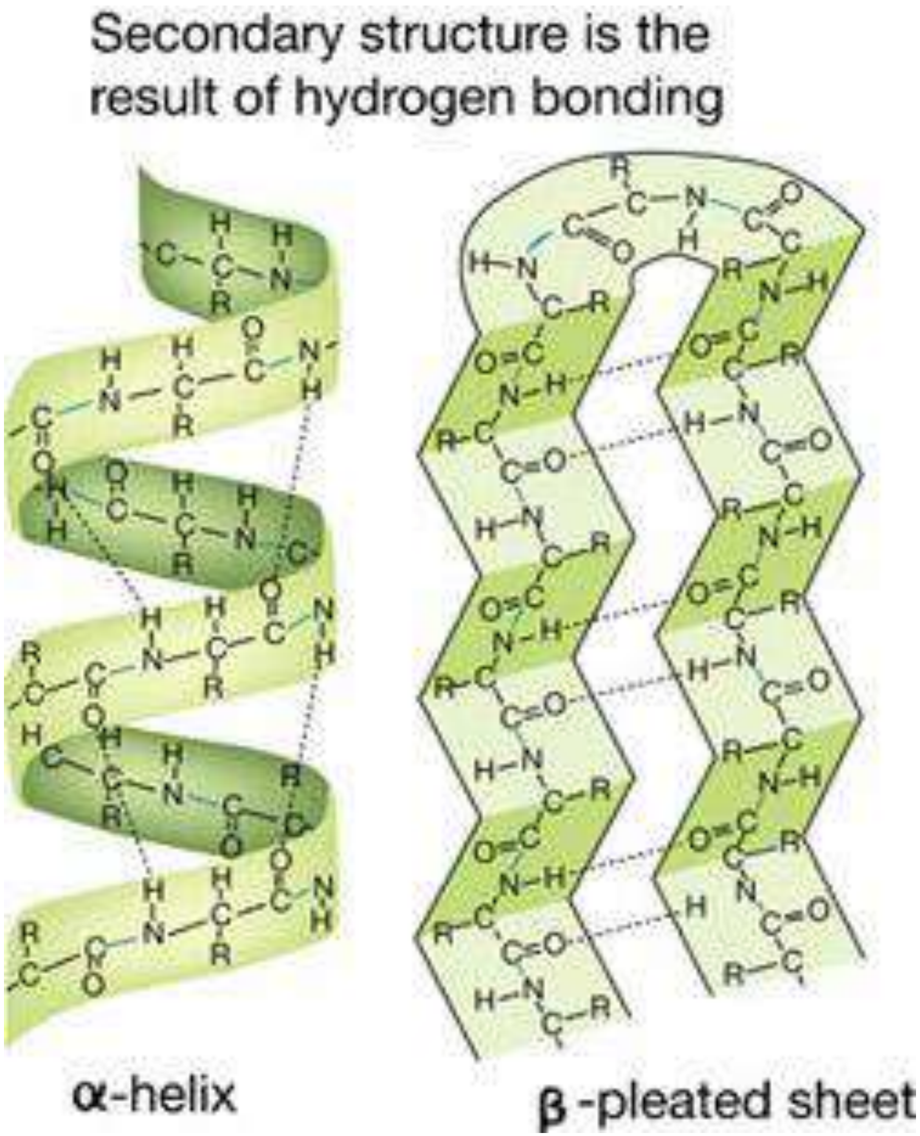


Titin - 34350 amino acids

Insulin - 51 amino acids

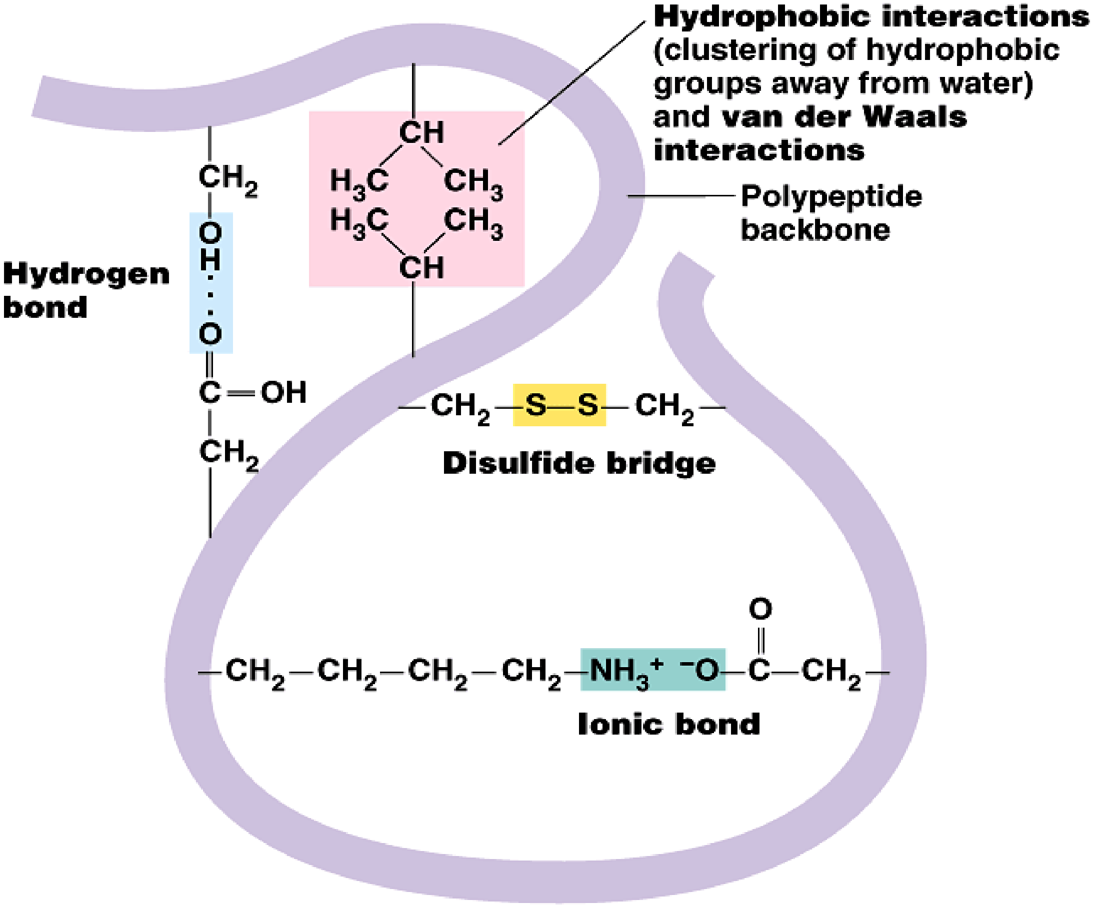
Secondary Structure (2º)

- The way the polypeptide chain is shaped
- Due to formation of H-bonds between the carboxyl O of one aa and the amino H of another aa
- Does **not** involve R-groups



Tertiary Structure (3º)

- ➢Compact folding due to interactions between R-groups
- ➢Unique to each proteins
- ➢Important for determining specificity of enzymes



4 bonding types:

1) **H-bonds** between polar side chains

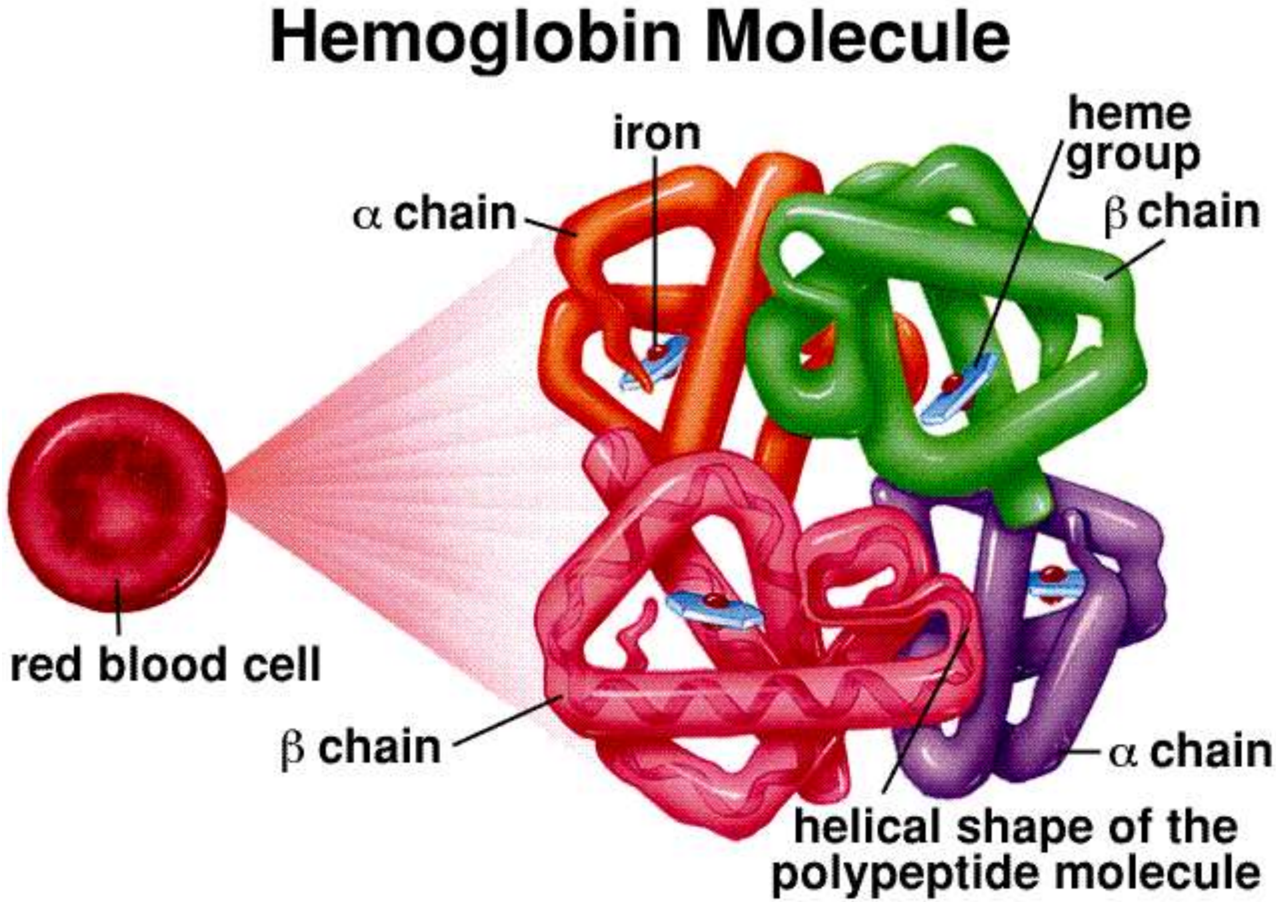
2) **Van der Waals** forces among hydrophobic side chains

3) **Covalent bonds** between two -SH groups of cysteine side chains → forms disulfide bridges

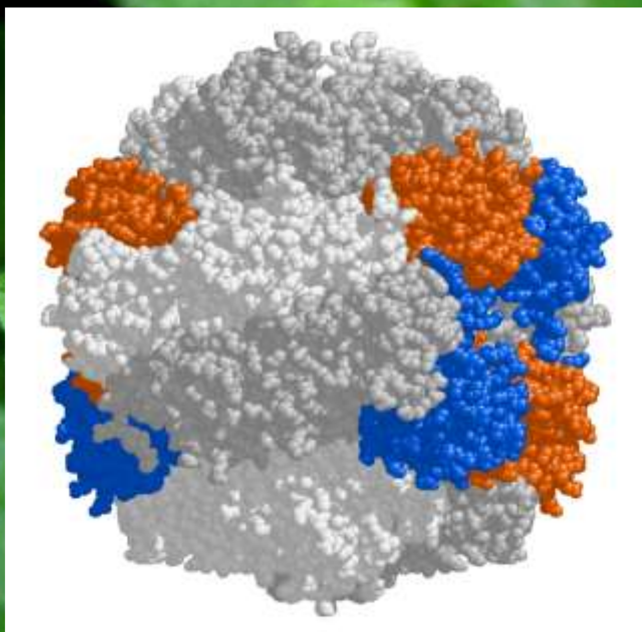
4) **Ionic bonds** between + and - side chains

Quaternary Structure (4º)

- Two or more polypeptide chains together
- Often has non-polypeptide groups →conjugated protein
- Not all proteins have a quaternary structure



Rubisco



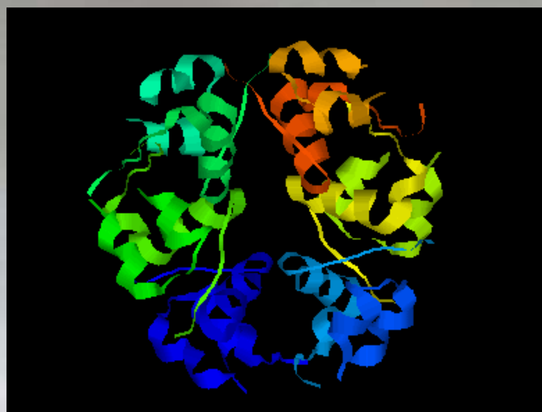
- Full name ribulose bisphosphate carboxylase
- Enzyme - catalyses the reaction that fixes carbon dioxide from the atmosphere
- Provides the source of carbon from which all carbon compounds, required by living organisms, are produced.
- Found in high concentrations in leaves and algal cells

http://upload.wikimedia.org/wikipedia/commons/b/b0/Mint-leaves-2007.jpg

http://upload.wikimedia.org/wikipedia/commons/thumb/7/74/Rubisco.png/220px-Rubisco.png

Insulin

- A hormone – signals many cells (e.g. liver cells) to absorb glucose and help reduce the glucose concentration of the blood.
- Affected cells have receptor (proteins) on their surface to which insulin can (reversibly) bind to.
- Secreted by β cells in the pancreas and transported by the blood.



The pancreas of type I diabetics don't produce sufficient insulin therefore they must periodically inject synthetically produced insulin to correct their blood sugar concentration.

https://en.wikipedia.org/wiki/File:Inzul%C3%ADn.jpg

http://www.biotopics.co.uk/as/insulinproteinstructure.html

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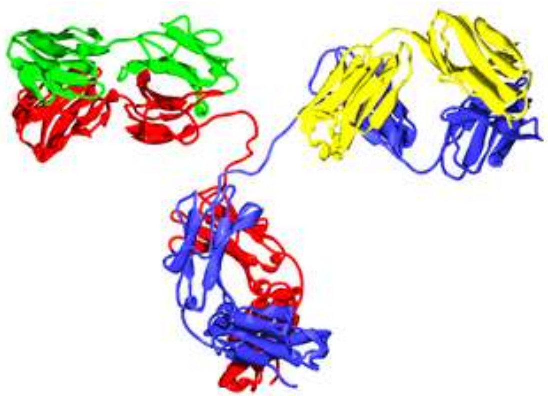
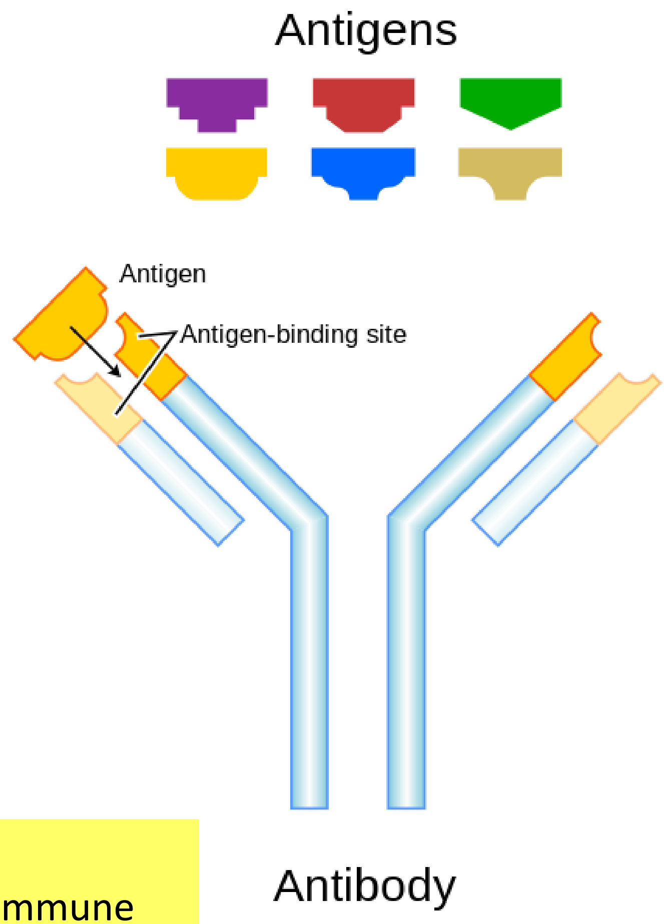
immunoglobulins

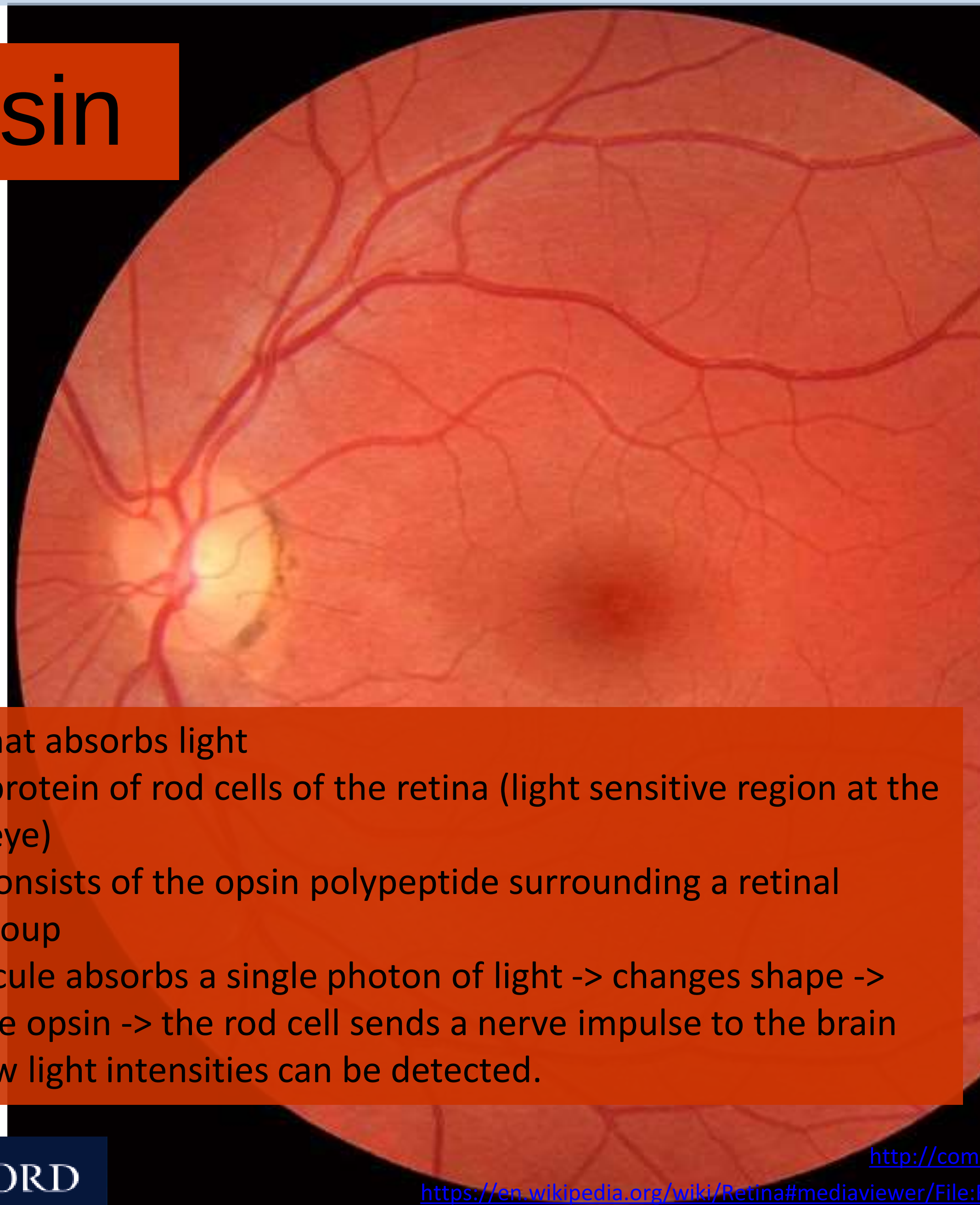


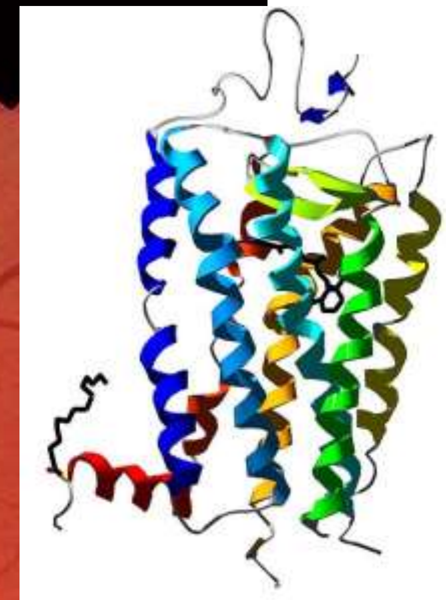


- Also known as antibodies.
- Two antigen (a molecule on the pathogen which provokes an immune response) binding sites - one on each ‘arm’
- Binding sites vary greatly between immunoglobulins (hypervariable) to enable them to respond a huge range of pathogens.
- Other parts of the immunoglobulin molecule cause a response, e.g. acting as a marker to phagocytes (which engulf the pathogen)

https://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/Antibody_IgG2.png/320px-Antibody_IgG2.png

rhodopsin



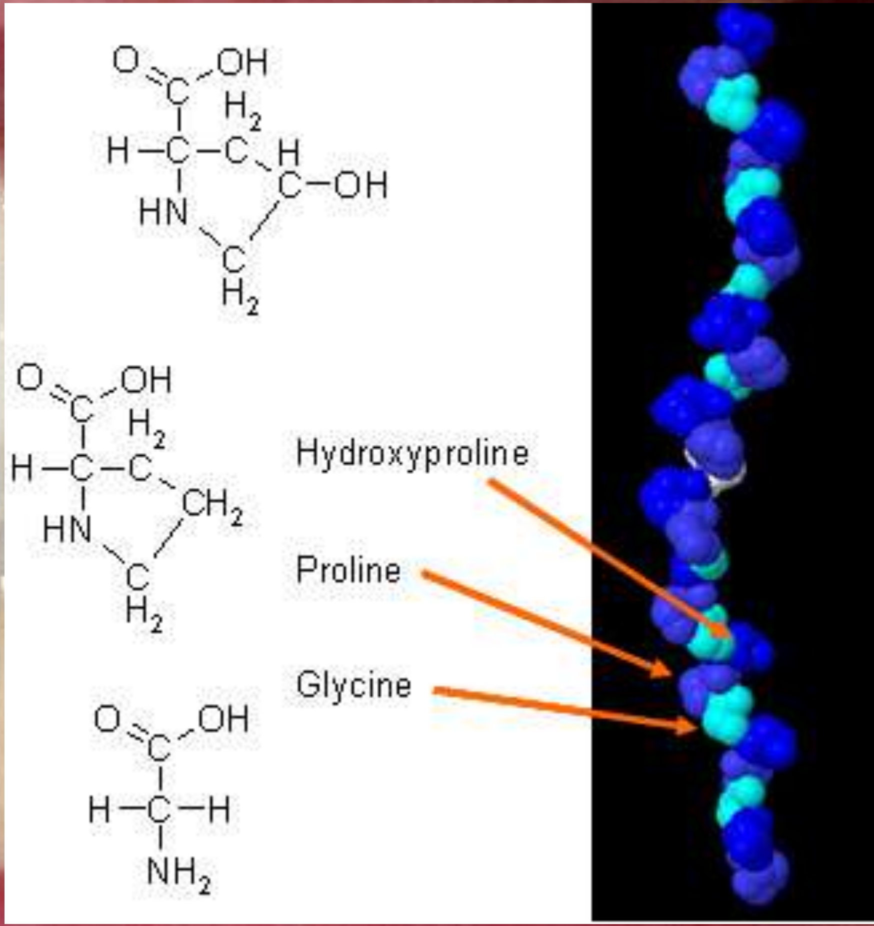


- A pigment that absorbs light
- Membrane protein of rod cells of the retina (light sensitive region at the back of the eye)
- Rhodopsin consists of the opsin polypeptide surrounding a retinal prosthetic group
- retinal molecule absorbs a single photon of light -> changes shape -> change to the opsin -> the rod cell sends a nerve impulse to the brain
- Even very low light intensities can be detected.

http://commons.wikimedia.org/wiki/File:Rhodopsin.jpg
https://en.wikipedia.org/wiki/Retina#mediaviewer/File:Fundus_photograph_of_normal_left_eye.jpg

collagen

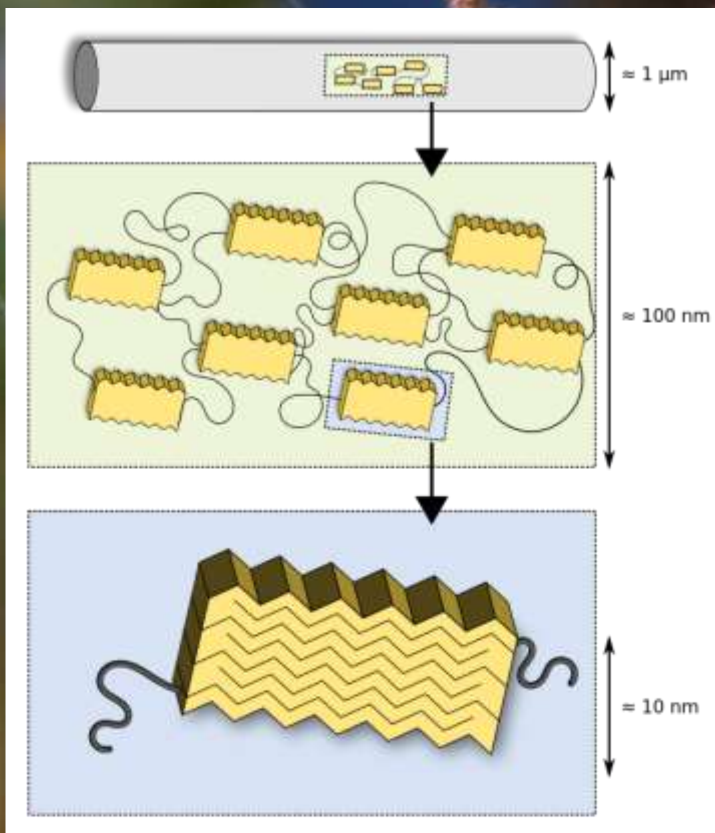
- A number of different forms
- All are rope-like proteins made of three polypeptides wound together.
- About a quarter of all protein in the human body is collagen
- Forms a mesh of fibres in skin and in blood vessel walls that resists tearing.
- Gives strength to tendons, ligaments, skin and blood vessel walls.
- Forms part of teeth and bones, helps to prevent cracks and fractures to bones and teeth



https://en.wikipedia.org/wiki/Tooth_(human)#mediaviewer/File:Teeth_by_David_Shankbone.jpg
ttp://chempolymerproject.wikispaces.com/file/view/collagen_%28alpha_chain%29.jpg/34235269/collagen_%28alpha_chain%29.jpg

spider silk

- Different types of silk with different functions
- Dragline silk is stronger than steel and tougher than Kevlar
- When first made it contains regions where the polypeptide forms parallel arrays (bottom)
- Some regions seem like a disordered tangle (middle)
- When the stretched the polypeptide gradually extends, making the silk extensible and very resistant to breaking.



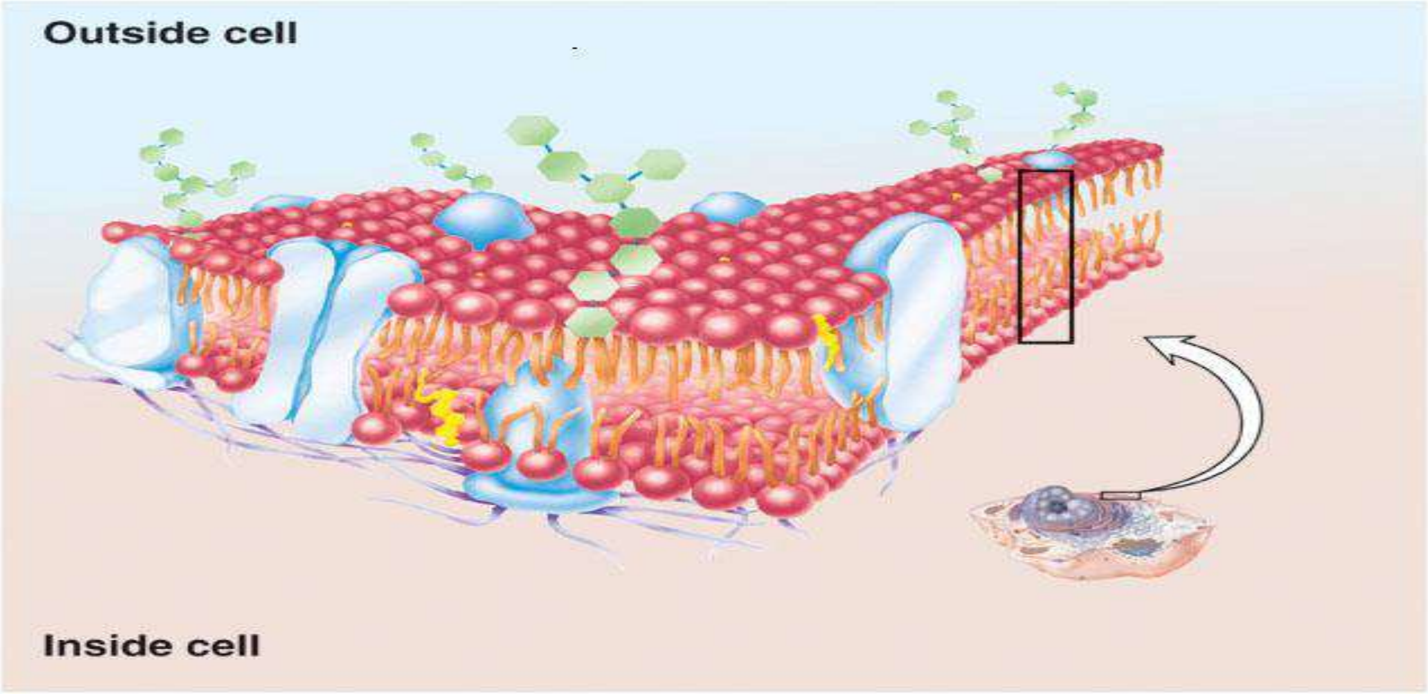
https://en.wikipedia.org/wiki/Spider_silk#mediaviewer/File:Araneus_diadematus_underside_1.jpg

https://en.wikipedia.org/wiki/Spider_silk#mediaviewer/File:Structure_of_spider_silk_thread_Modified.svg

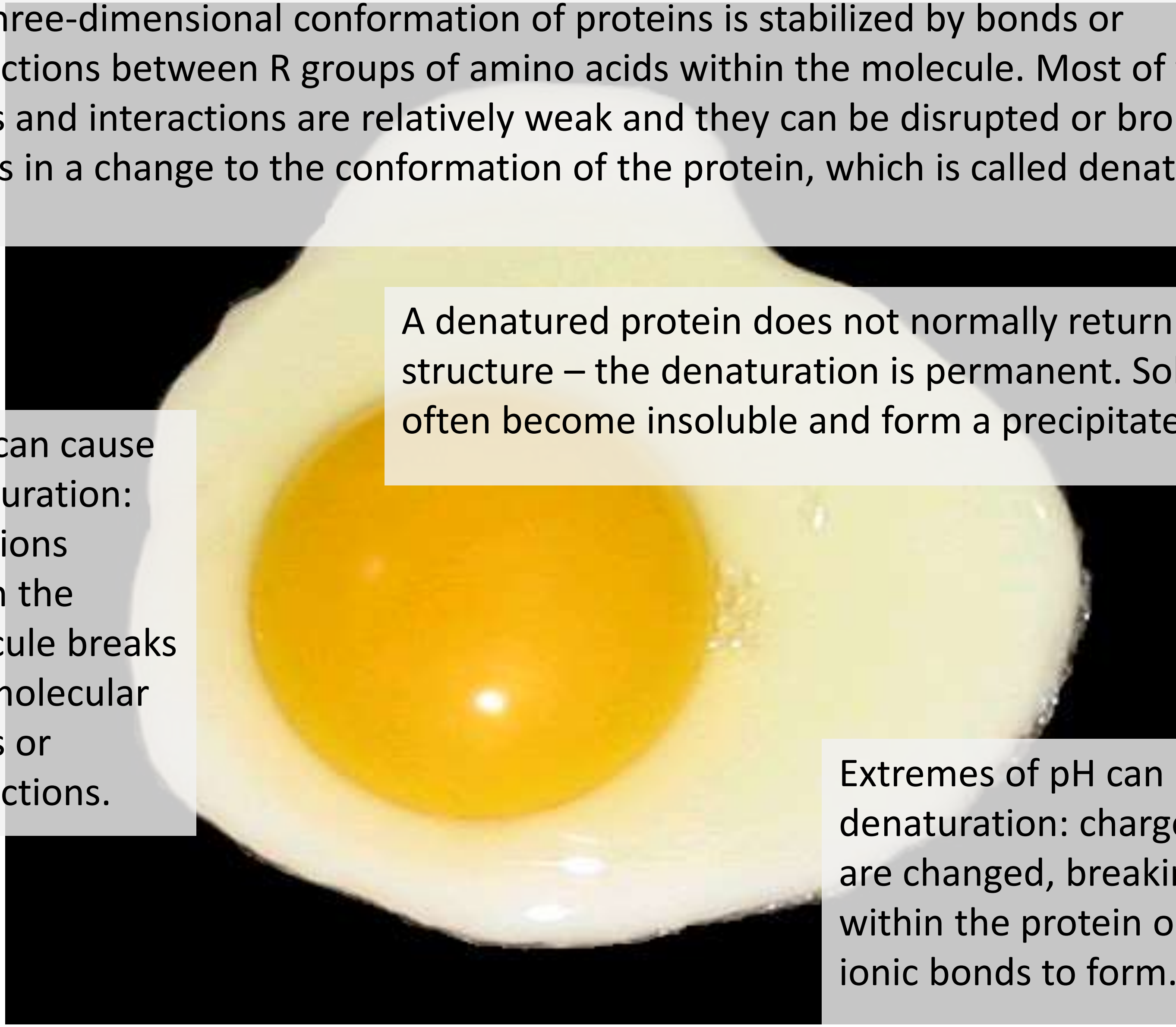
Polar and Non-polar Amino Acids

- AA's with **polar** R-groups= hydrophilic
- Linked to the hydrophilic areas of the cell membrane
- Create hydrophilic channels through the cell membrane which allow polar substances to move through cell membranes.
- Found on outside of cell membrane

- AA's with **non-polar** R-groups = hydrophobic
- Linked to the hydrophobic areas of the cell membrane
- Polar and non-polar aa's are important in determining the specificity of an enzyme. They act as enzyme binding sites (active sites)



2.4.A2 Denaturation of proteins by heat or by deviation of pH from the optimum.



The three-dimensional conformation of proteins is stabilized by bonds or interactions between R groups of amino acids within the molecule. Most of these bonds and interactions are relatively weak and they can be disrupted or broken. This results in a change to the conformation of the protein, which is called denaturation.

A denatured protein does not normally return to its former structure – the denaturation is permanent. Soluble proteins often become insoluble and form a precipitate.

Heat can cause denaturation: vibrations within the molecule breaks intermolecular bonds or interactions.

Extremes of pH can cause denaturation: charges on R groups are changed, breaking ionic bonds within the protein or causing new ionic bonds to form.

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http://upload.wikimedia.org/wikipedia/commons/2/22/Fried_egg%2C_sunny_side_up_%28black_background%29.PNG