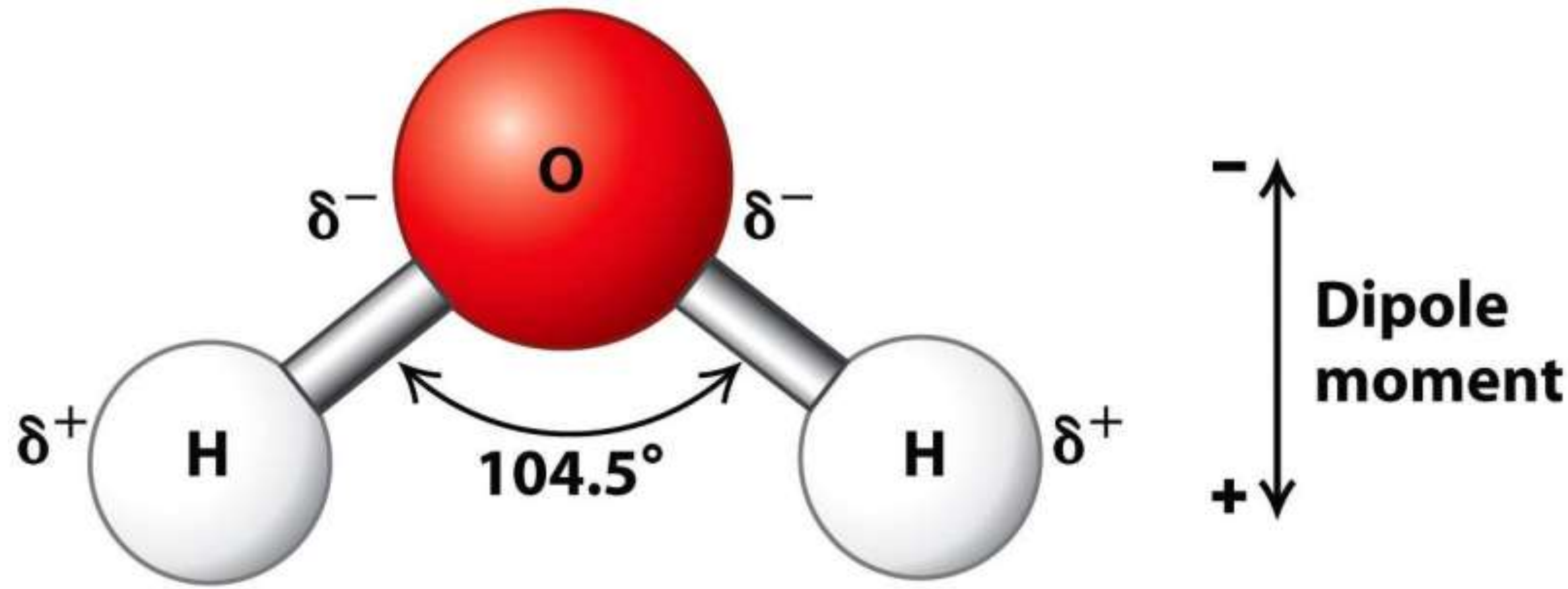
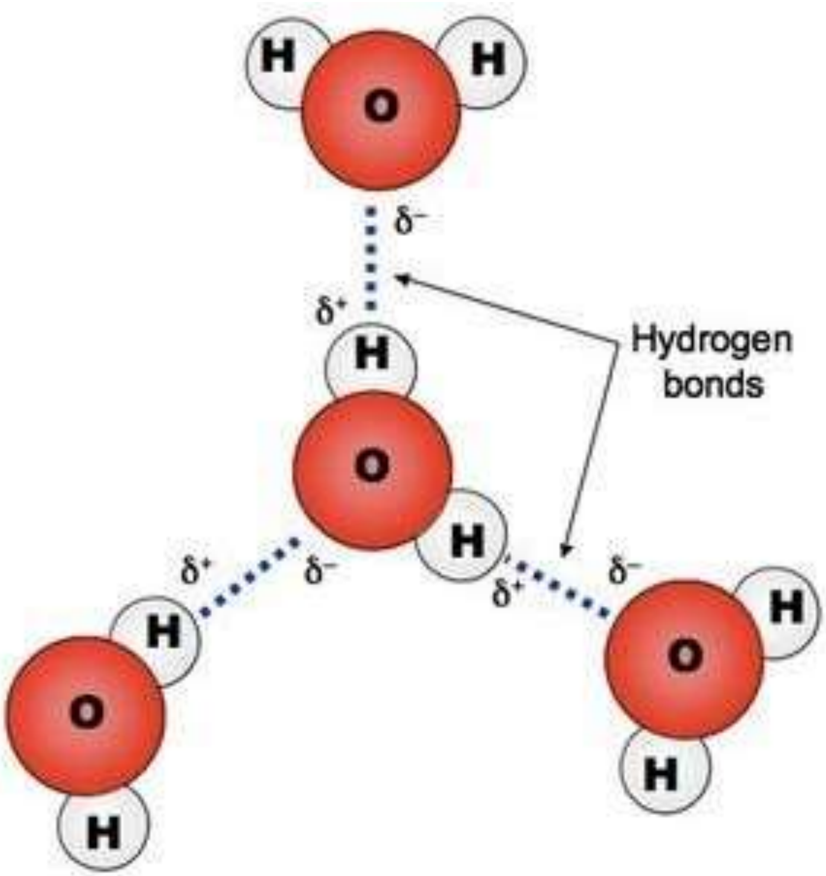
LECTURE 2 &3

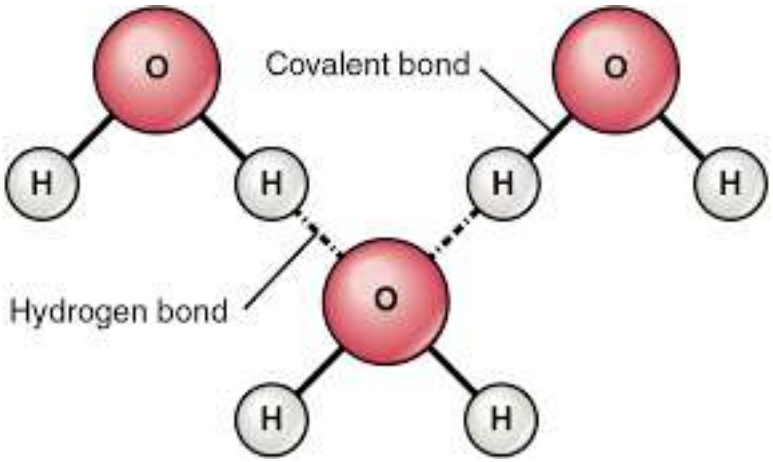
BIOMOLECULES

Molecules that make up living things

Structure and properties of water

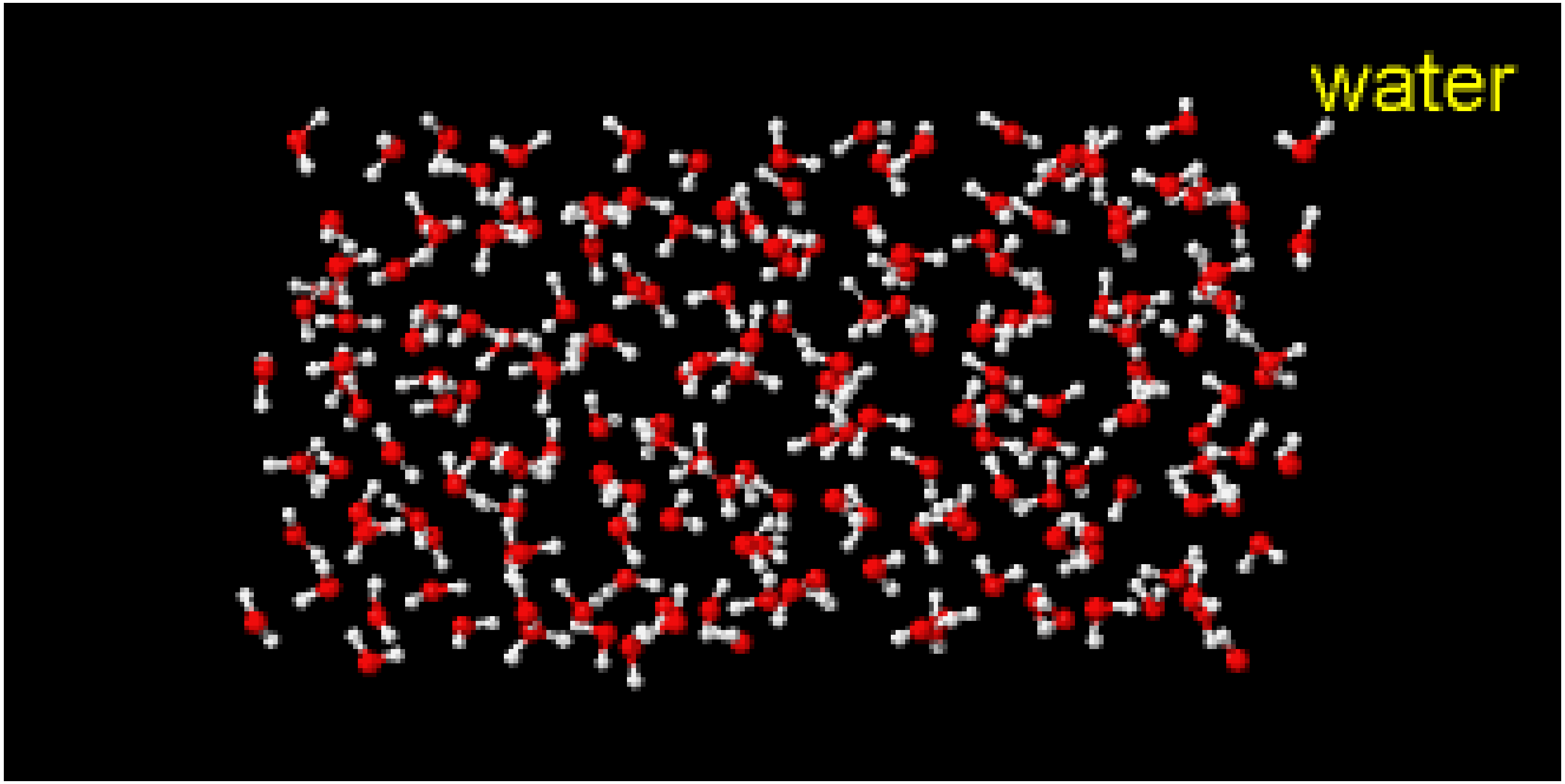


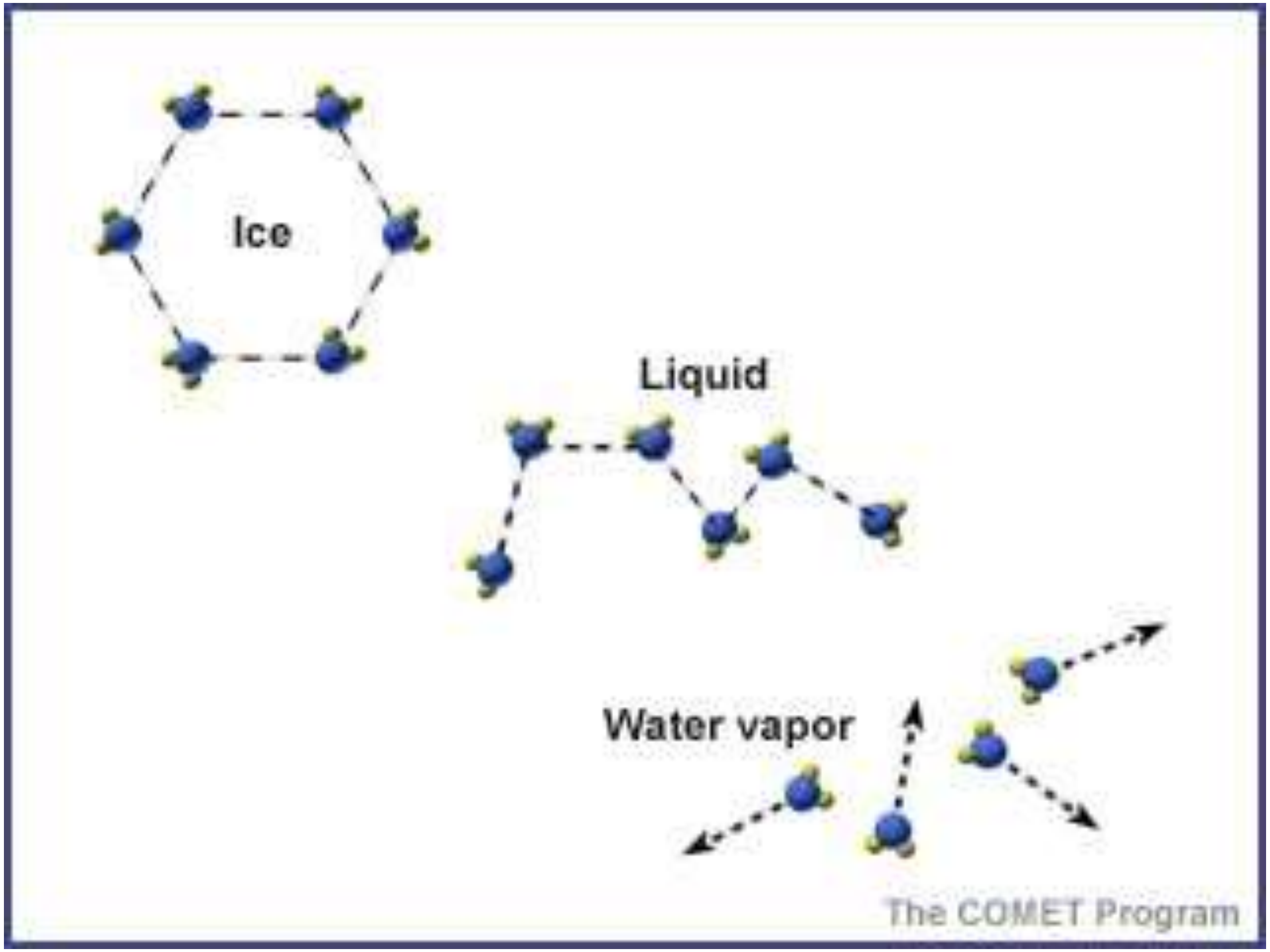

H
H
O
δ⁻
δ⁺
H
Hydrogen
bonds
O
H
δ⁺
δ⁻
δ⁻
δ⁺
H
H
O
O
H
H


O
Covalent bond
O
H
H
H
H
O
Hydrogen bond
H
H

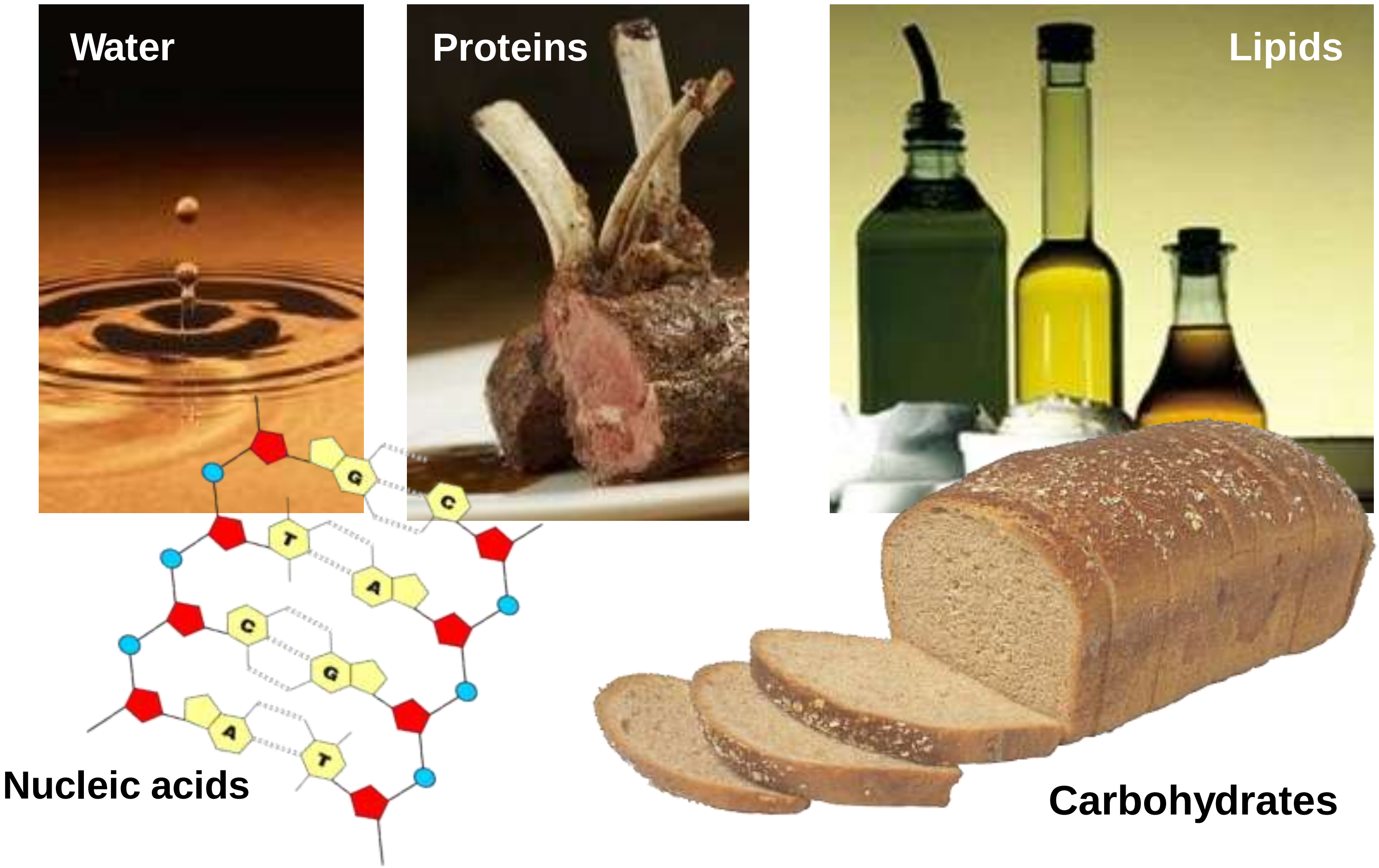
Anomalous properties of water

- High specific heat (Heat capacity)-water takes longer to heat up and to cool down
- Large thermal buffer capacity
- High heat of vaporization
- High boiling point
- High surface tension
- High specific heat and heat of vaporization helps in the dissipation of large amounts of heat produced


water


Ice
Liquid
Water vapor
The COMET Program

Types of Biological Molecules



Organic Compounds

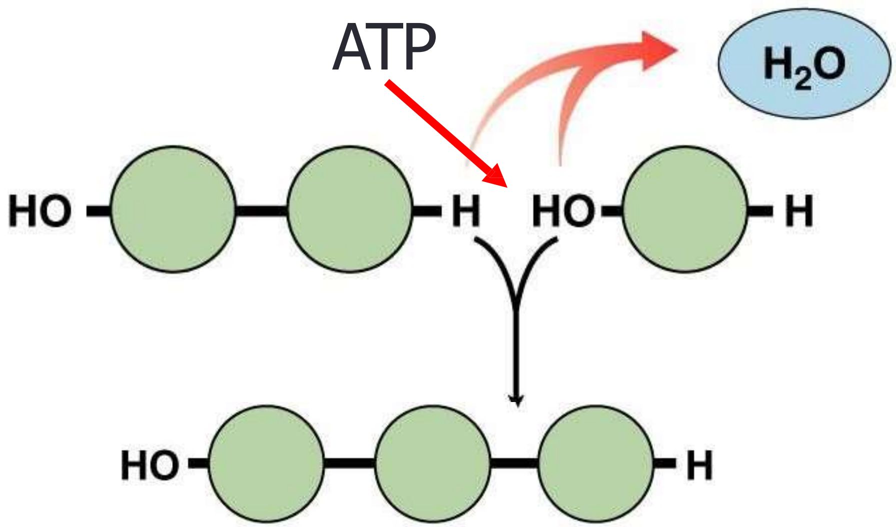
- Most Biomolecules are organic
- They are based on Carbon and include hydrogen
- Includes
  - carbohydrates, lipids, proteins and nucleic acids
- Also includes vitamins

Macromolecules

- Large biomolecules
- Many of these are polymers.
  - Polymers: long molecules built by linking together small, similar subunits (monomers)

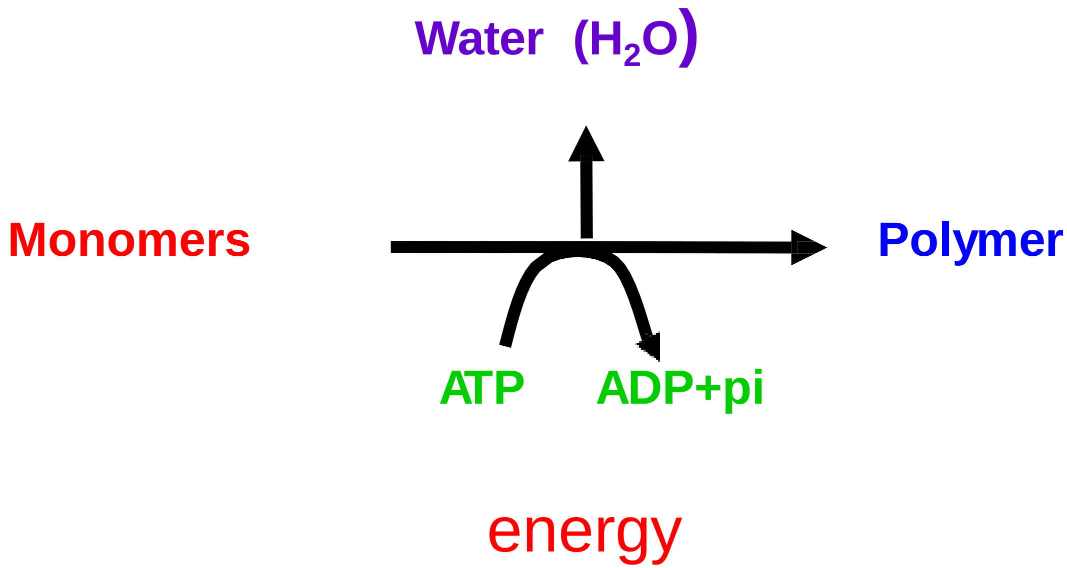
Building up polymers

- Condensation polymerization (dehydration synthesis) removes an OH and H during synthesis of a new molecule.



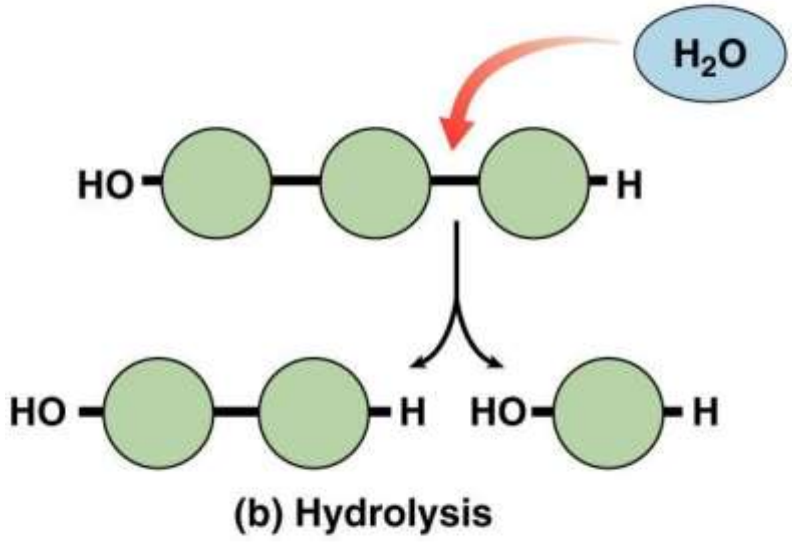
Polymerization

- Water is formed and ATP is required



Breaking down polymers

- Hydrolysis breaks a covalent bond by adding OH and H from a water molecule



Hydrolysis

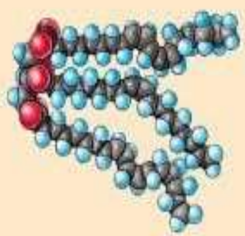
- Water is required

Water (H_2O)

$$\text{Polymer} \xrightarrow{H_2O} \text{Monomers}$$

Types of Biomolecules

- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids

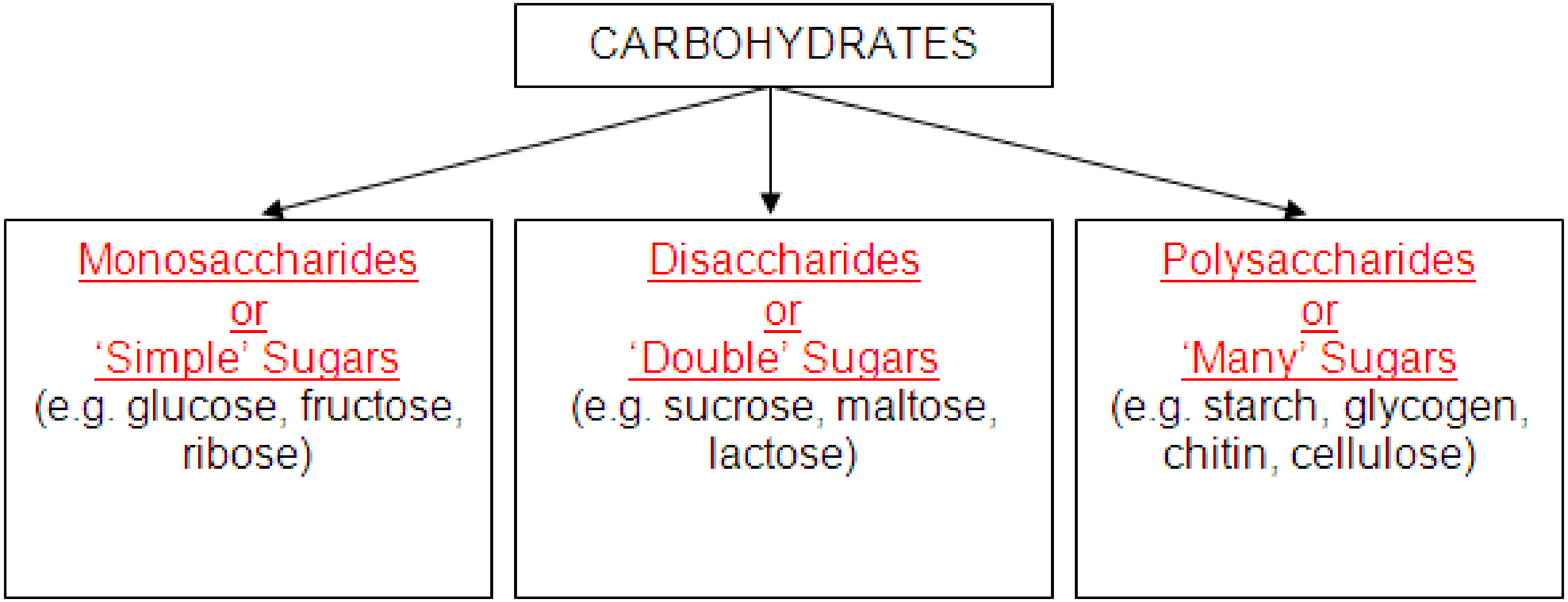
Macromolecule	Subunit	Function	Example
PROTEINS 			
Functional	Amino acids	Catalysis; transport	Hemoglobin
Structural	Amino acids	Support	Hair; silk
NUCLEIC ACIDS 			
DNA	Nucleotides	Encodes genes	Chromosomes
RNA	Nucleotides	Needed for gene expression	Messenger RNA
LIPIDS 			
Fats	Glycerol and three fatty acids	Energy storage	Butter; corn oil; soap
Phospholipids	Glycerol, two fatty acids, phosphate, and polar R groups	Cell membranes	Lecithin
Prostaglandins	Five-carbon rings with two nonpolar tails	Chemical messengers	Prostaglandin E (PGE)
Steroids	Four fused carbon rings	Membranes; hormones	Cholesterol; estrogen
Terpenes	Long carbon chains	Pigments; structural	Carotene; rubber
CARBOHYDRATES 			
Starch, glycogen	Glucose	Energy storage	Potatoes
Cellulose	Glucose	Cell walls	Paper; strings of celery
Chitin	Modified glucose	Structural support	Crab shells

Carbohydrates

- Carbohydrate means “hydrated” carbon
- Composing elements C, H, O
- Hydrogen and Oxygen are in a ratio of 2:1
- Can be simple monomers like glucose
- Can be complex polymers like cellulose

Groups of Carbohydrates

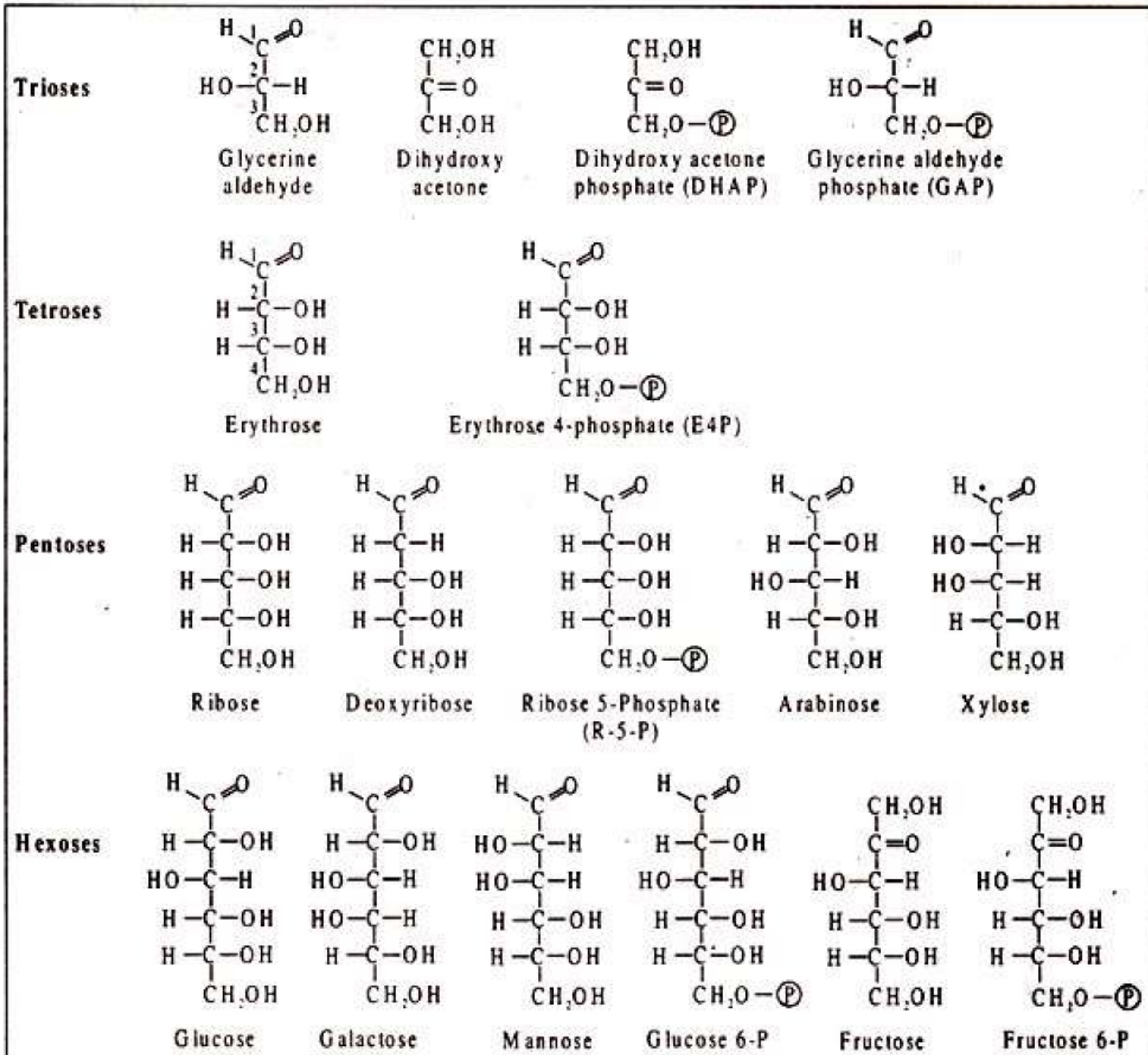
- Carbohydrates
  - sugars
    - Monosaccharides (monomers)
    - Disaccharides (Dimers)
  - Polysaccharides (polymers)


CARBOHYDRATES
Monosaccharides
or
'Simple' Sugars
(e.g. glucose, fructose, ribose)
Disaccharides
or
'Double' Sugars
(e.g. sucrose, maltose, lactose)
Polysaccharides
or
'Many' Sugars
(e.g. starch, glycogen, chitin, cellulose)

Monosaccharides

A. Structure and Nomenclature

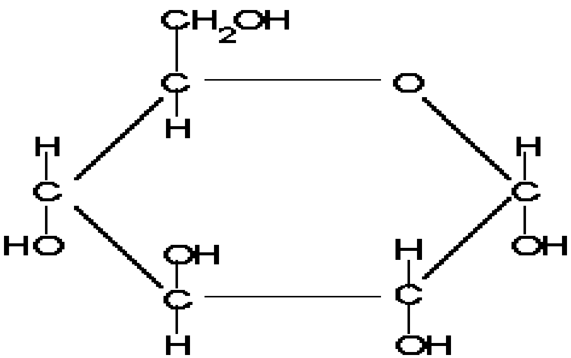
- The general formula $C_nH_{2n}O_n$
- with one of the carbons being the carbonyl group of either an aldehyde or a ketone.
- The most common monosaccharides have three to eight carbon atoms.
- The suffix-ose indicates that a molecule is a carbohydrate, and the prefixes *tri-*, *tetr-*, *pent-*, and so forth indicate the number of carbon atoms in the chain.
- Monosaccharide containing an aldehyde group are classified as aldoses; those containing a ketone group are classified as ketoses.
- A ketose can also be indicated with the suffix ulose; thus, a five- carbon ketose is also termed a Pentulose.


Trioses
Glycerine aldehyde
Dihydroxy acetone
Dihydroxy acetone phosphate (DHAP)
Glycerine aldehyde phosphate (GAP)
Tetroses
Erythrose
Erythrose 4-phosphate (E4P)
Pentoses
Ribose
Deoxyribose
Ribose 5-Phosphate (R-5-P)
Arabinose
Xylose
Hexoses
Glucose
Galactose
Mannose
Glucose 6-P
Fructose
Fructose 6-P

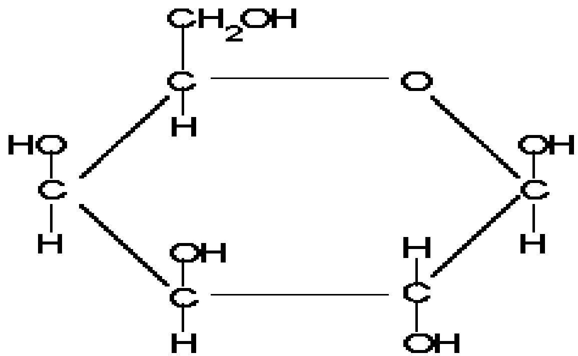
Monosaccharides

$C_6H_{12}O_6$

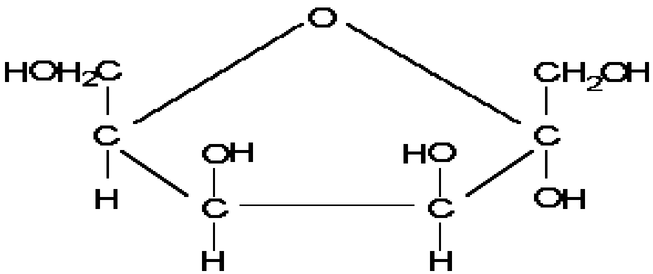
- Fructose
- Galactose
- Glucose



Glucose



Galactose



Fructose

Importance:

- Energy source: used as a reactant in respiration
- Monomer Unit: used to form:
  - Dimers (disaccharides) and
  - Polymers (polysaccharides)

Disaccharides

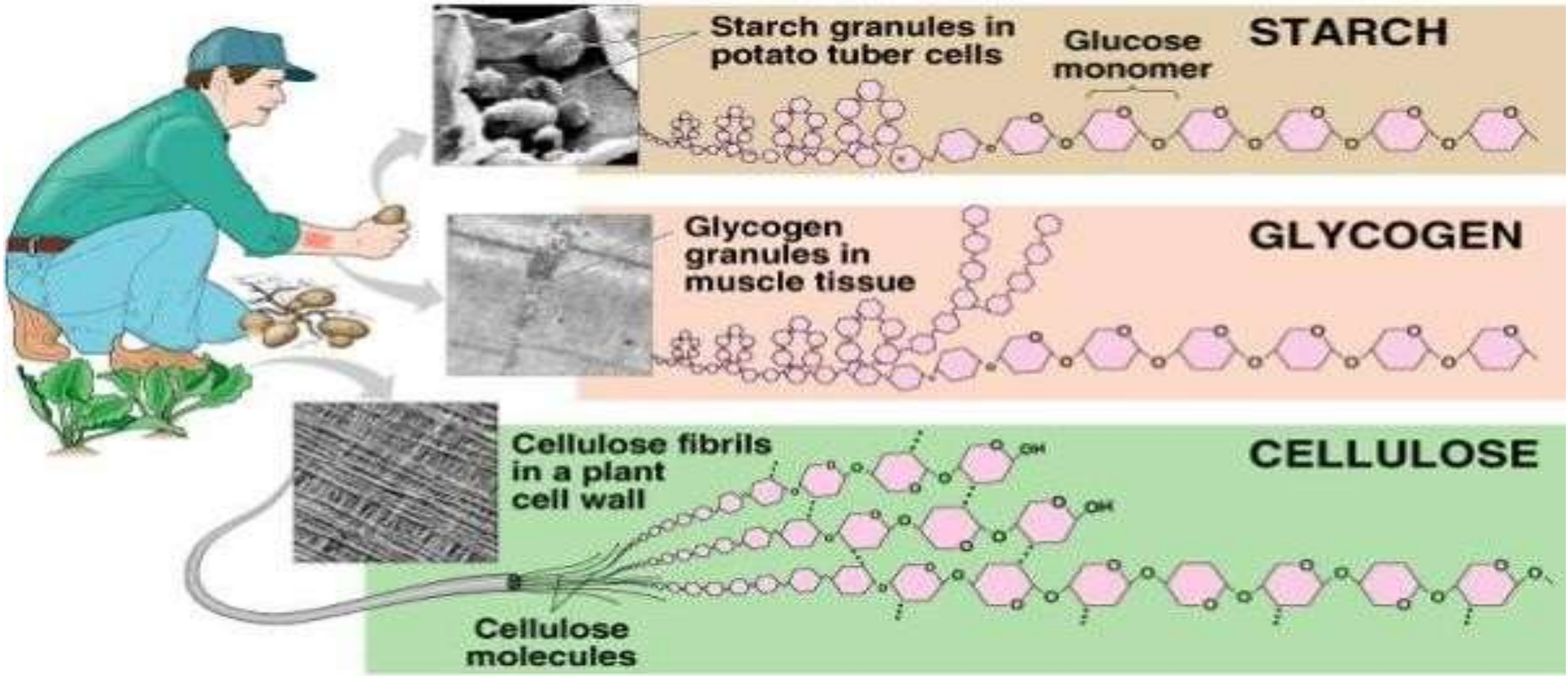
- Lactose: glucose + galactose
- Maltose: glucose + glucose
- Sucrose: glucose + fructose

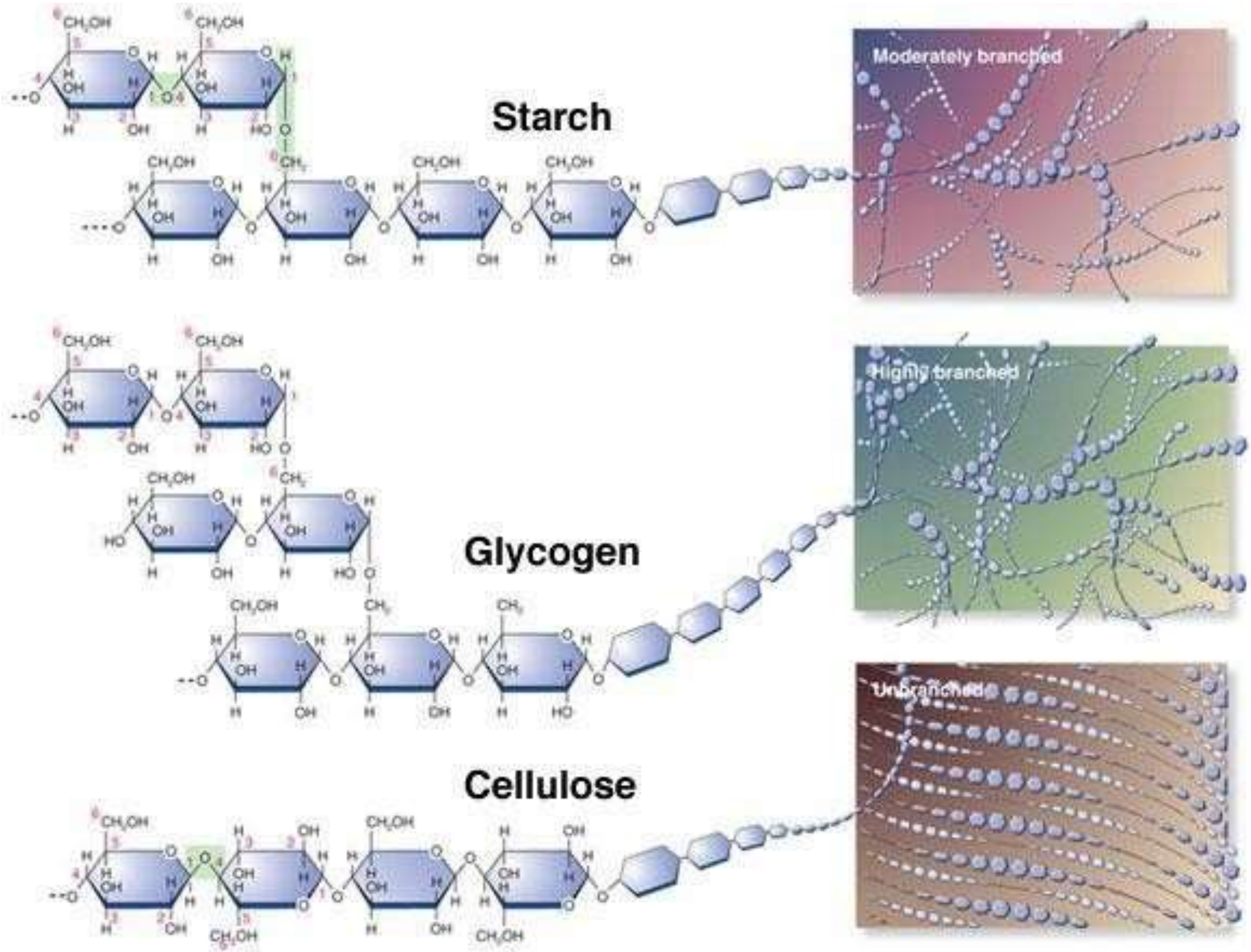
Importance:

- Energy storage: sucrose is a store of energy in sugarcane and sugar beets


- Energy transport: carbohydrate is transported in plants as sucrose

Polysaccharides




Starch
Moderately branched
Glycogen
Highly branched
Cellulose
Unbranched

- Starch, glycogen and cellulose are all polymers of glucose.
- They differ in the type of glucose present and the bonds which link the glucose monomers together.

Characters	Starch	Glycogen	Cellulose
Monomer	a-glucose	a-glucose	b-glucose
Type of bond between monomers	1,4 glycosidic bond (amylose) + 1,4 and 1,6 glycosidic bond (amylopectin)	1,4 and 1,6 glycosidic bonds	1,4 glycosidic bond
Nature of chain	Amylose is coiled unbranched Amylopectin is long branched chains, some coiling	Short many branched chains, some coiling	Straight, long unbranched chains form H-bonds, with adjacent chains
Occurrence	In plants	In animals and fungi	In plants
Function	Carbohydrate energy store	Carbohydrate energy store	Structural
General form	Grains	Small granules	Fibres

Structural Carbohydrates

Chitin – arthropod exoskeleton and fungal cell wall

- modified form of cellulose

Central dogma

- Amino acids are JOINED together by
- PEPTIDE BONDS
- Following a sequence dictated by the DNA

DNA

$\downarrow$ Transcription

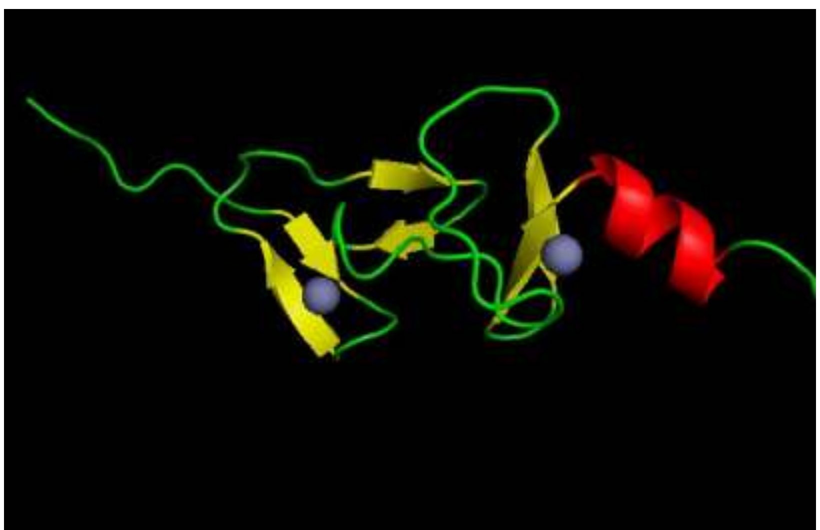
mRNA

$\downarrow$ Translation

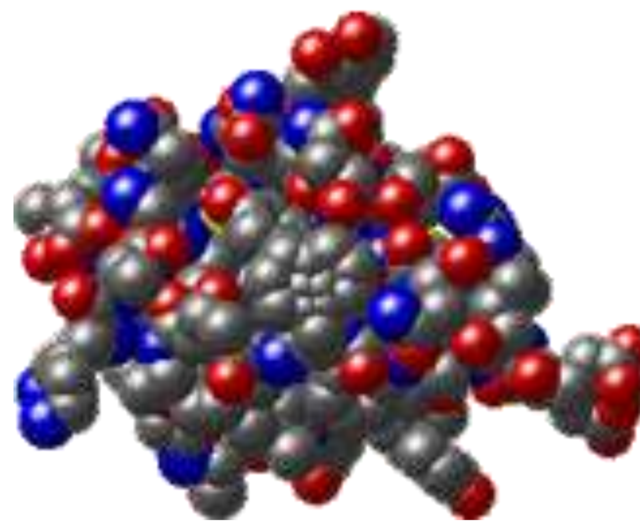
Polypeptide/
Protein

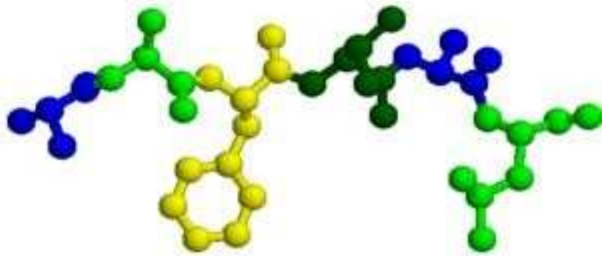
Protein

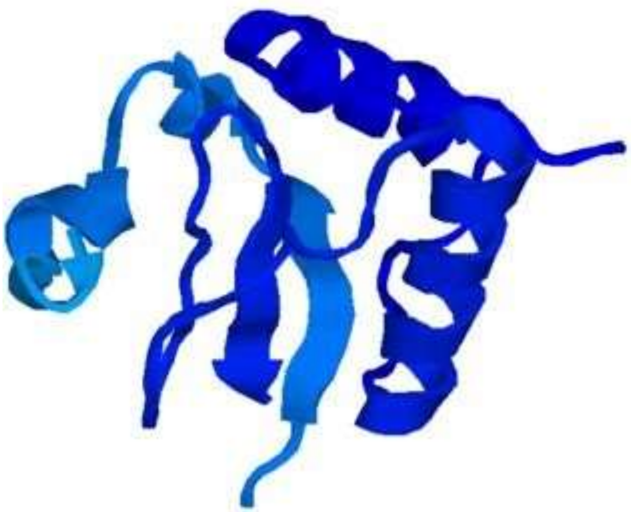
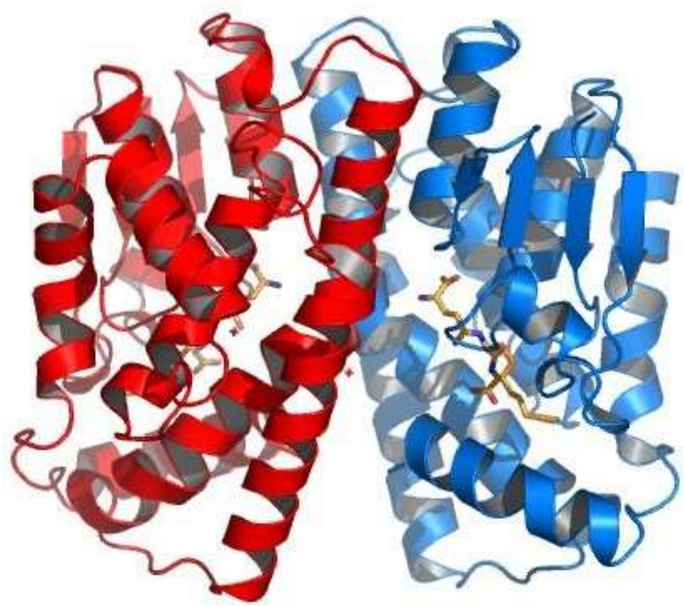
- C,H,O,N and some have S
- insulin:$C_{254}H_{377}N_{65}O_{76}S_{6}$

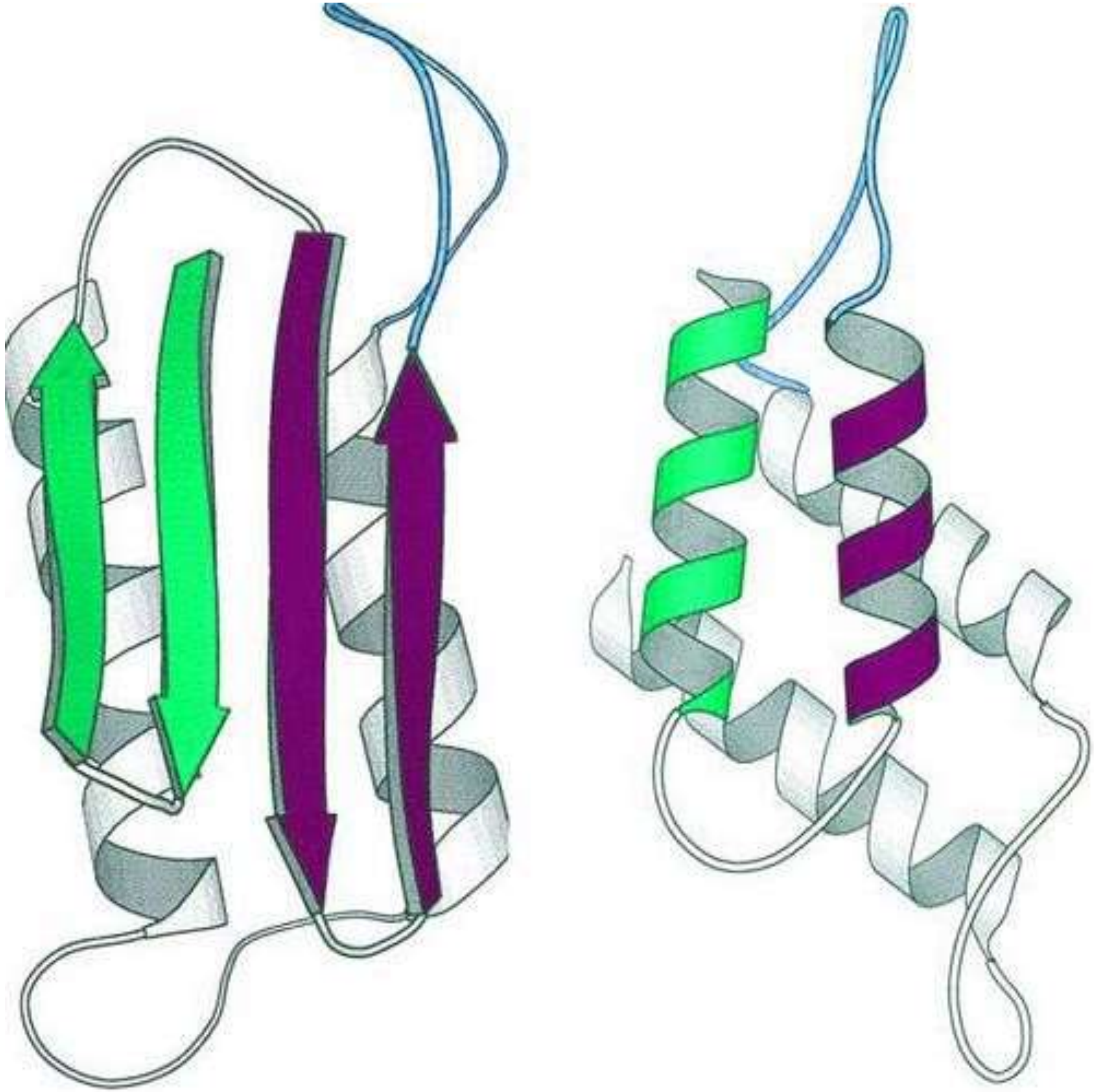


Insulin
$C_{254}H_{377}N_{65}O_{76}S_{6}$

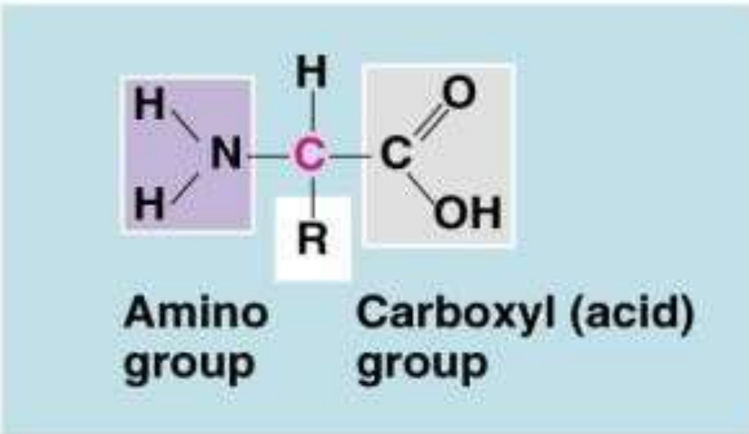




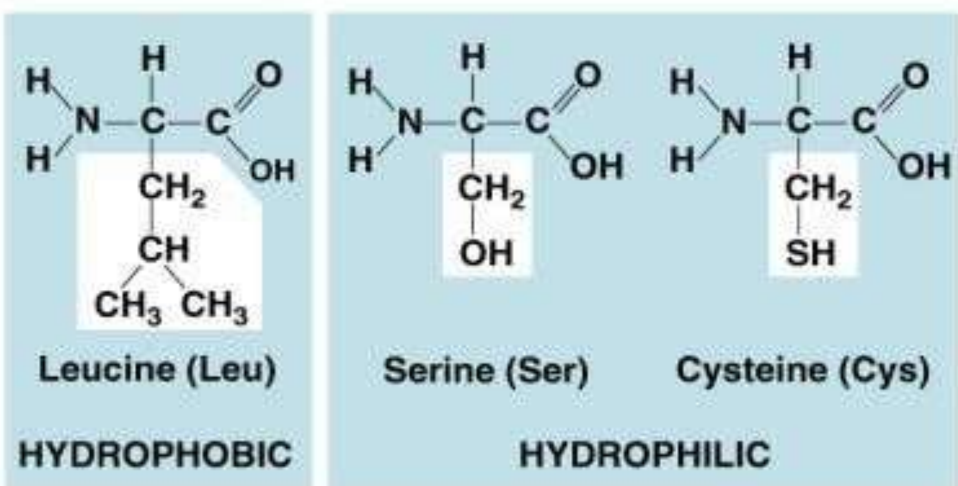


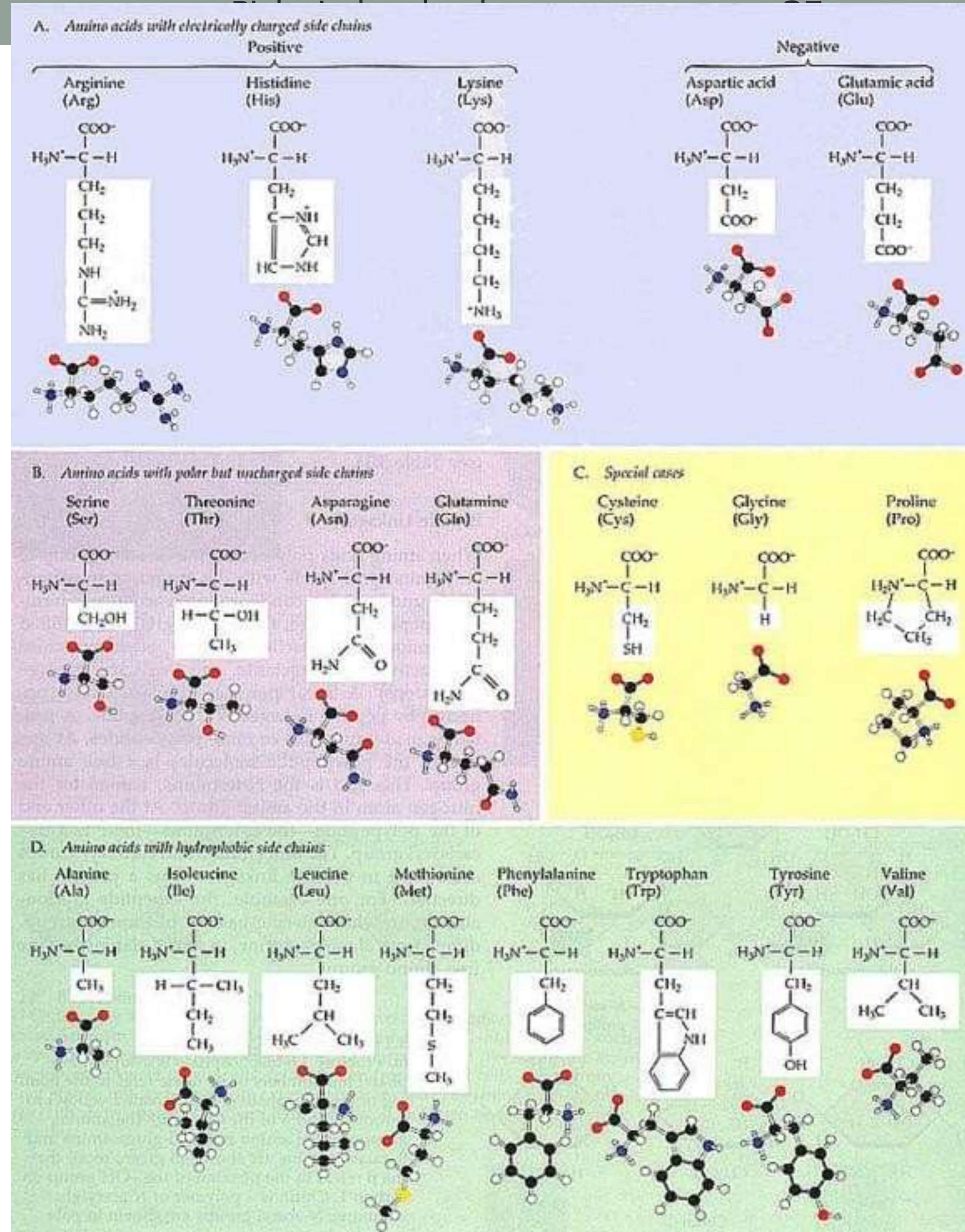
Amino Acids



- **Building blocks of proteins**
- **Contain nitrogen**
- **20 naturally occurring and encoded by DNA**
- **R group determines chemical properties**

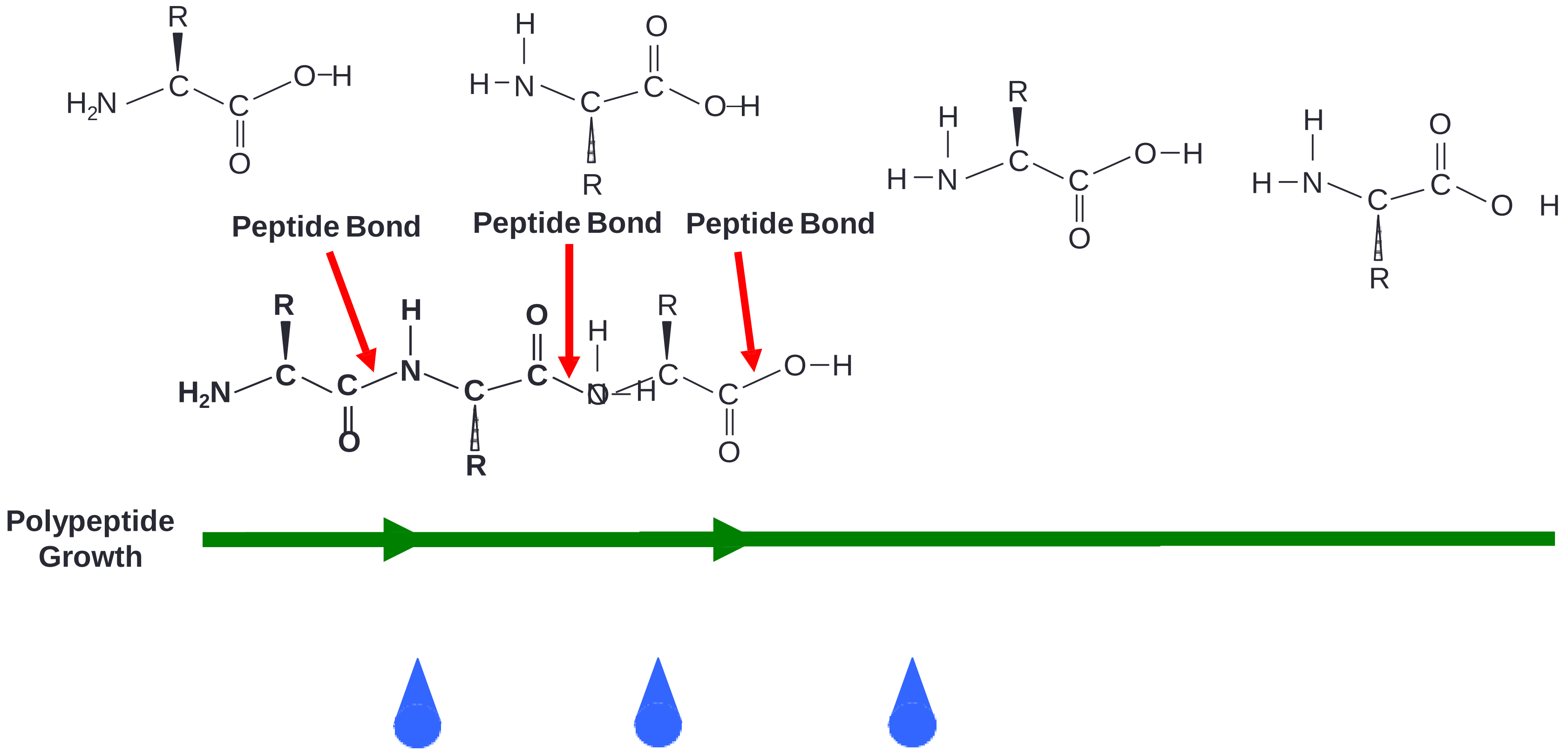
About half can be made by our body and about half need to be consumed(Between 8-10 are essential)



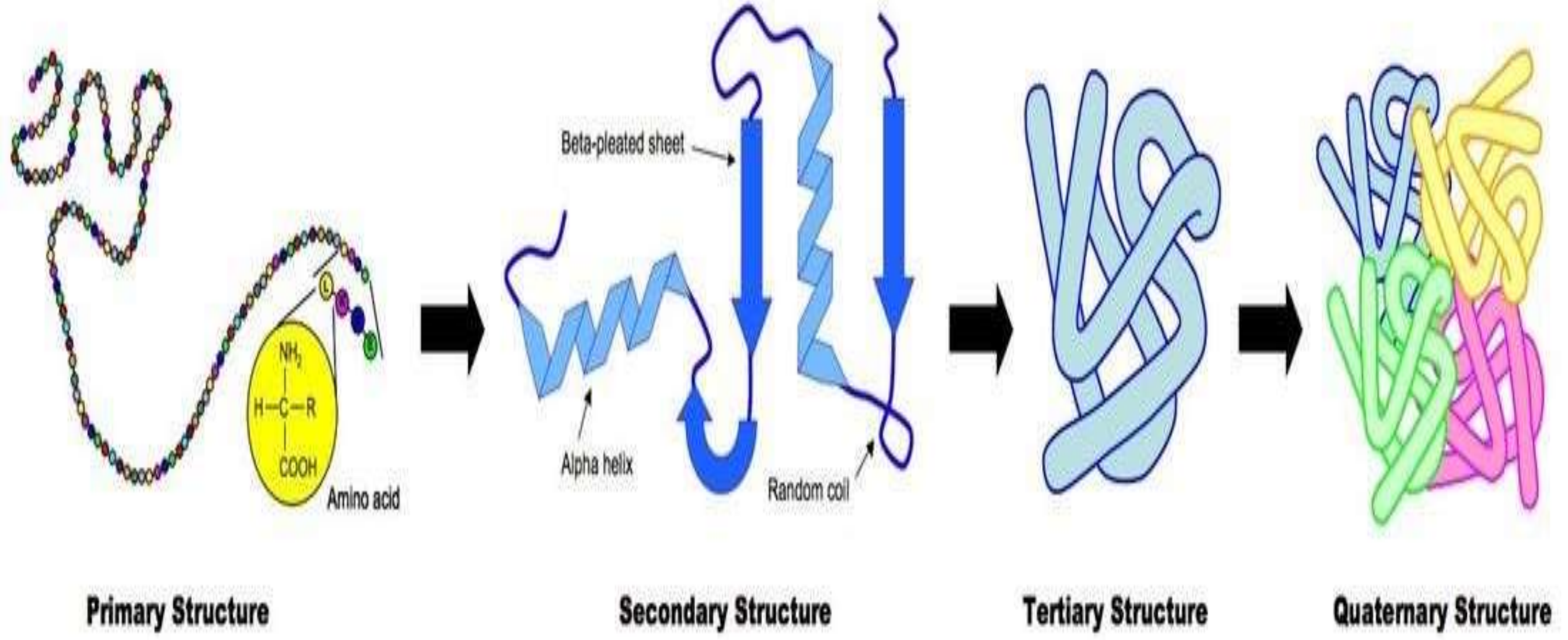


20 different amino acids encoded by the DNA

Making a Polypeptide



Polypeptide production = Condensation Reaction



NH2
H—C—R
COOH
Amino acid
Beta-pleated sheet
Alpha helix
Random coil
Primary Structure
Secondary Structure
Tertiary Structure
Quaternary Structure

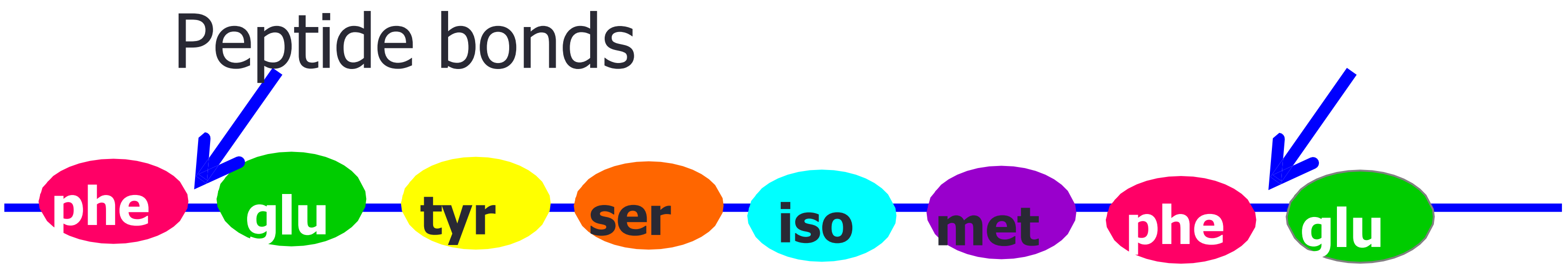
Folding of polypetides to form Proteins

- Shape of a proteins are important because
  - This determines how they interact with other molecules
  - This determines their particular function

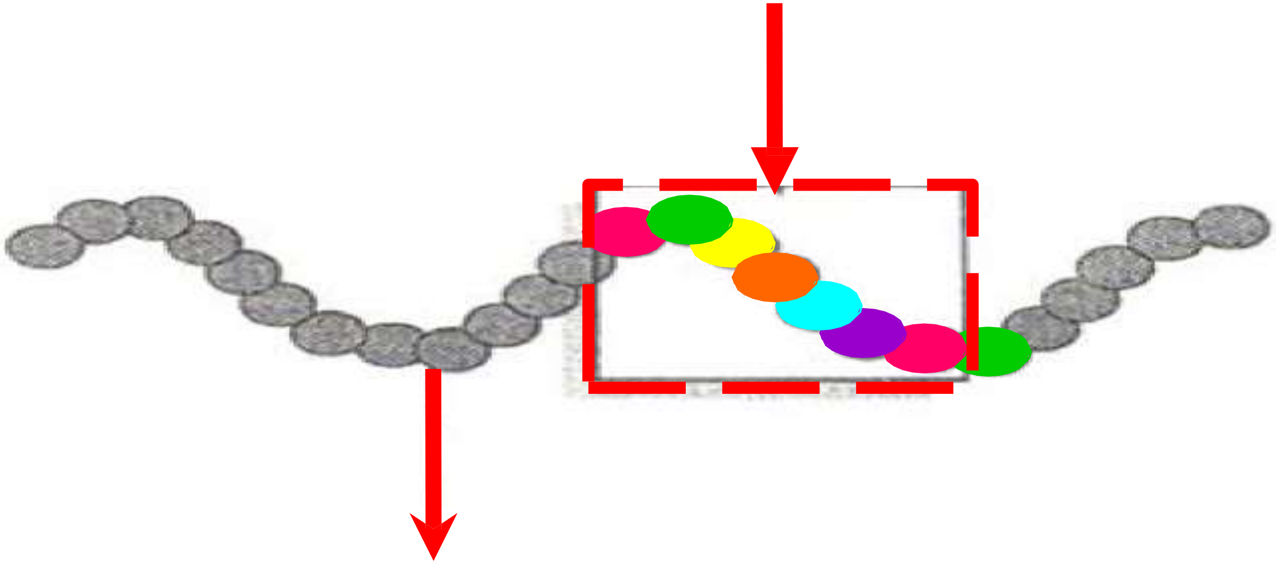
Protein Structure

- Primary Structure 1^o
  - Linear sequence of AA
- Secondary Structure 2^o
  - Repeating patterns (α helix, β pleated sheet)
- Tertiary Structure 3^o
  - Overall conformation of protein
- Quaternary Structure 4^o
  - Multichained protein structure

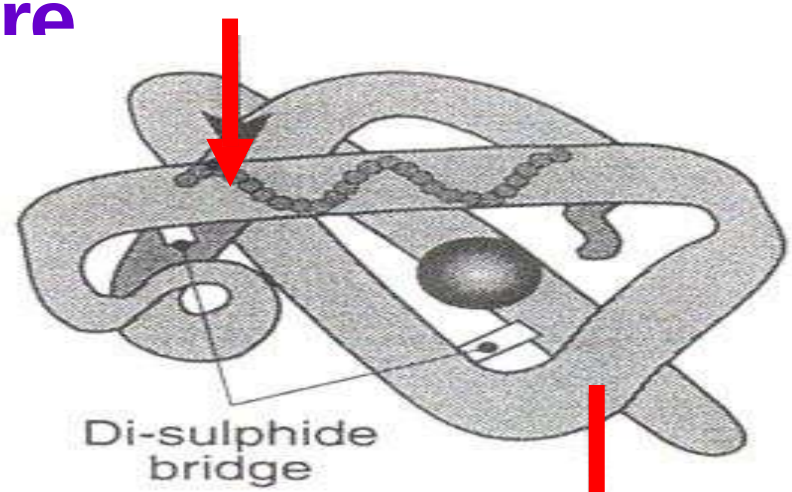
Primary Structure



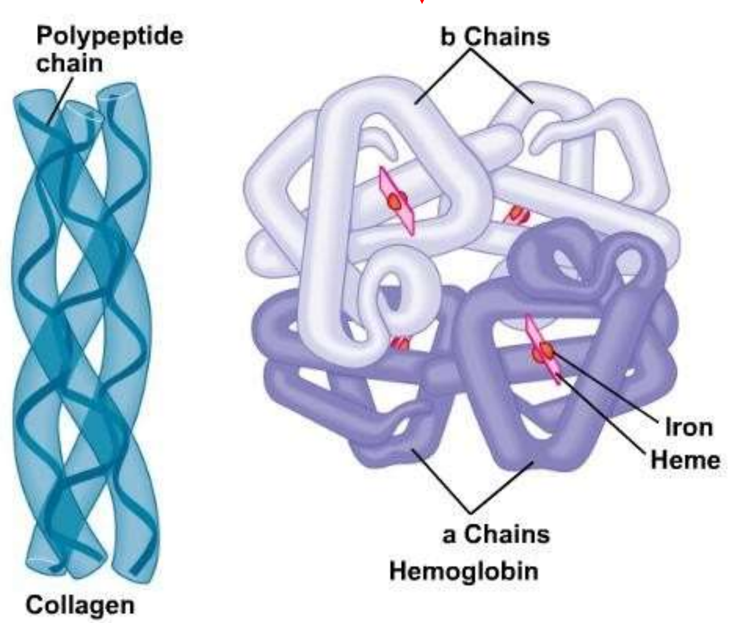
Secondary Structure



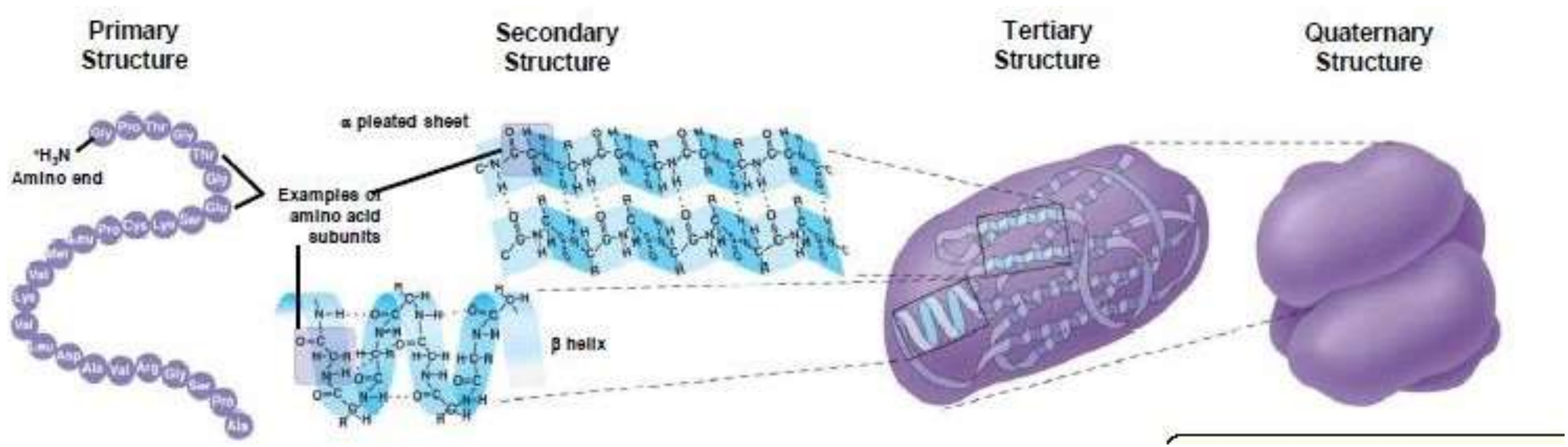
Tertiary Structure



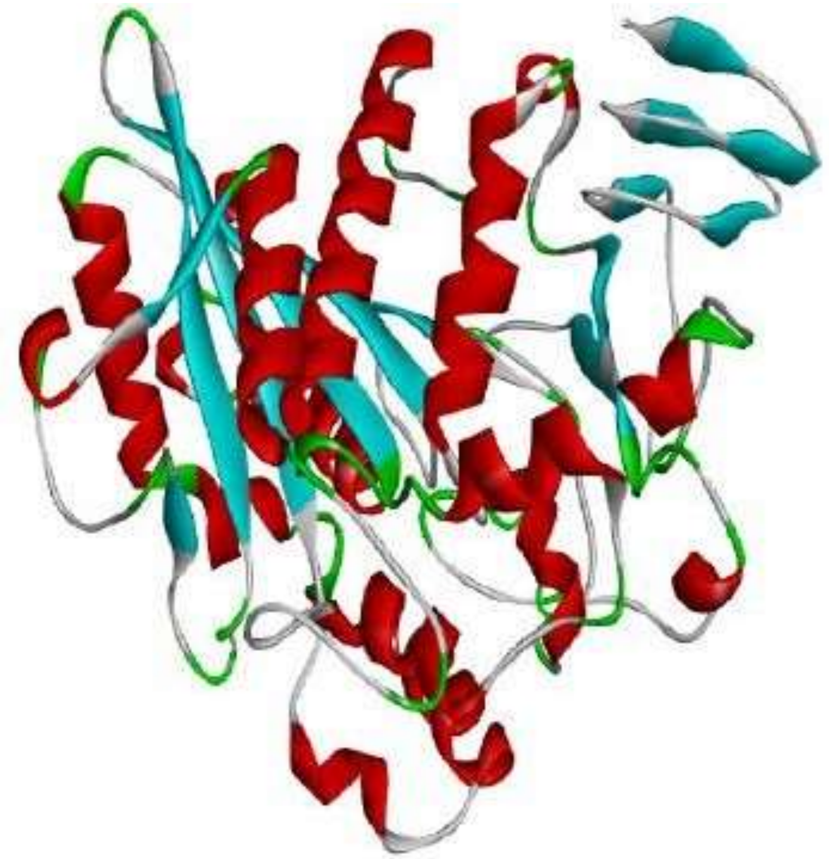
Quaternary Structure



Summary

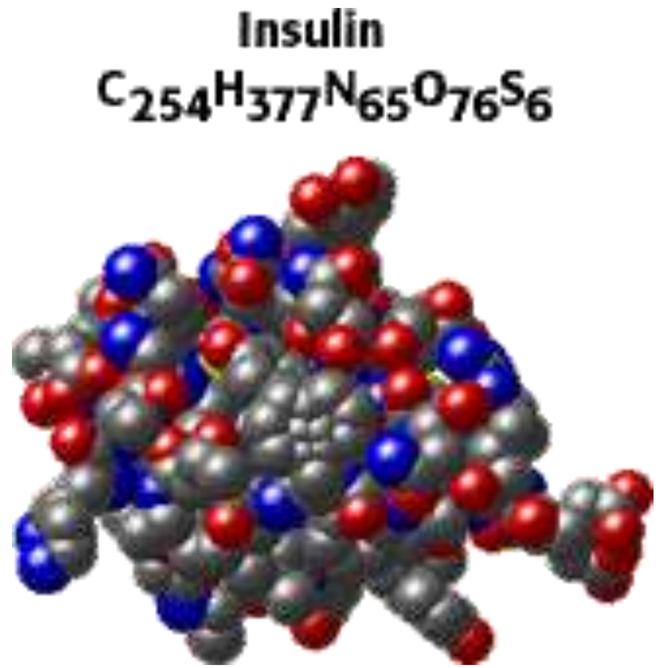

Primary Structure
Secondary Structure
Tertiary Structure
Quaternary Structure
α pleated sheet
+H3N
Amino end
Examples of amino acid subunits
β helix

CATALYSTS
lipase

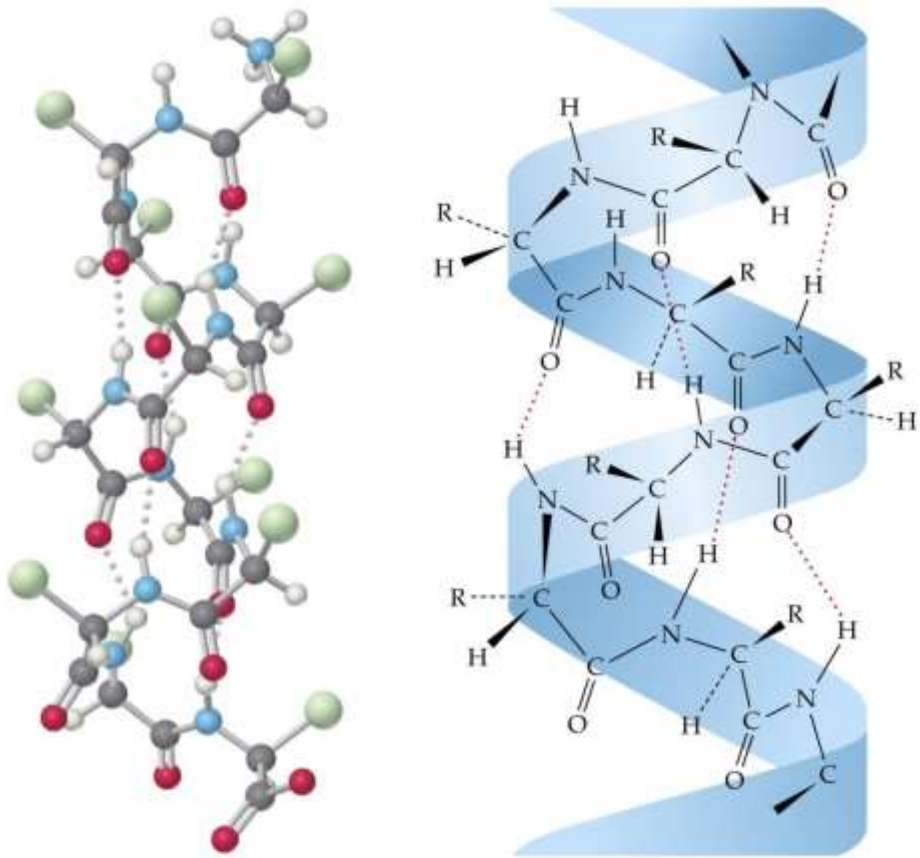


REGULATION (hormones)

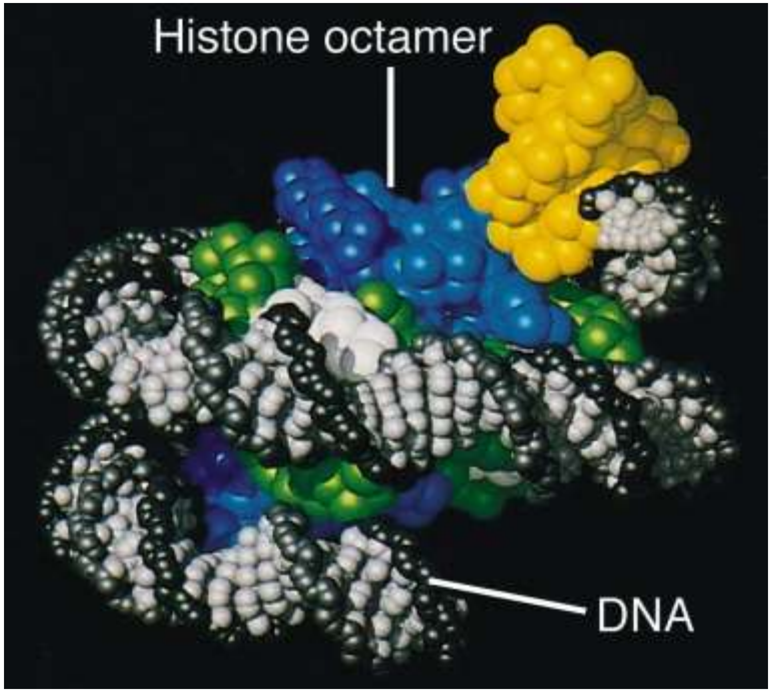
- Ex: Insulin



STRUCTURAL Ex: Keratin



STRUCTURAL Ex: Histone Protein



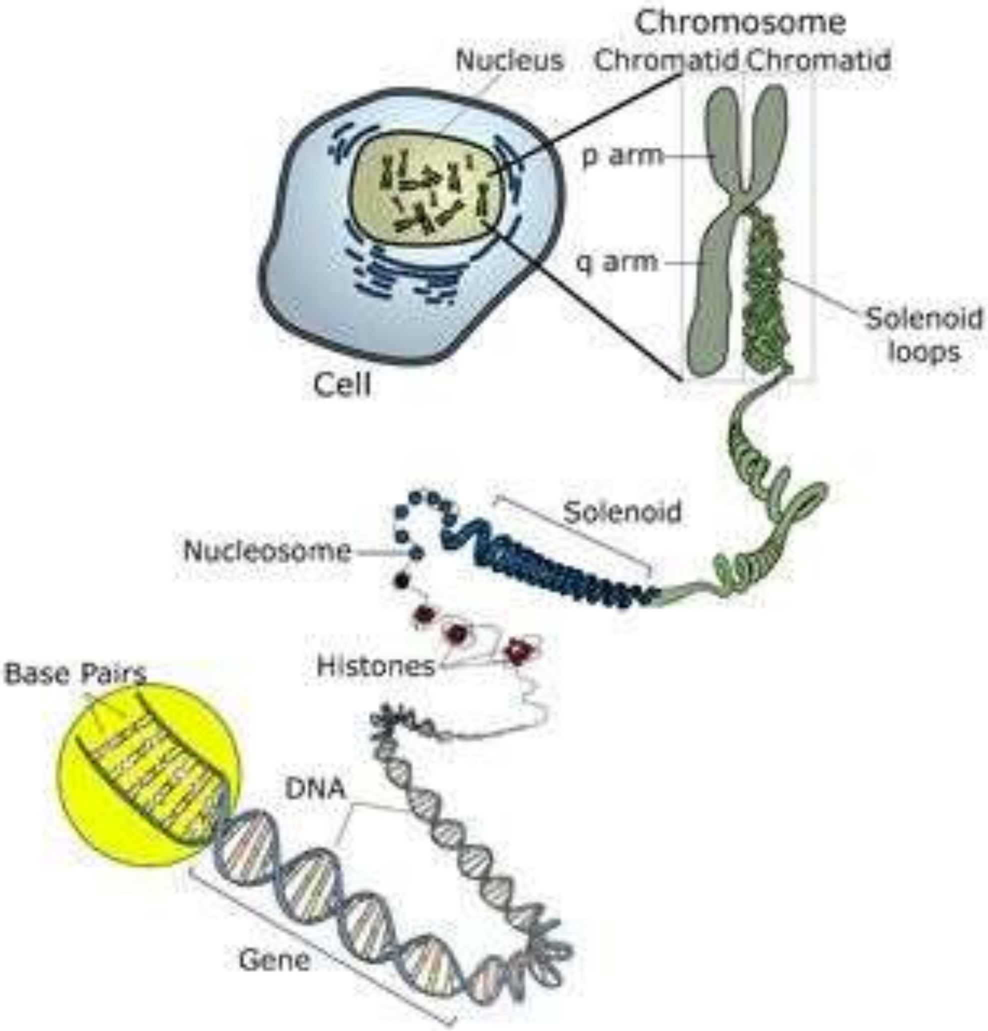
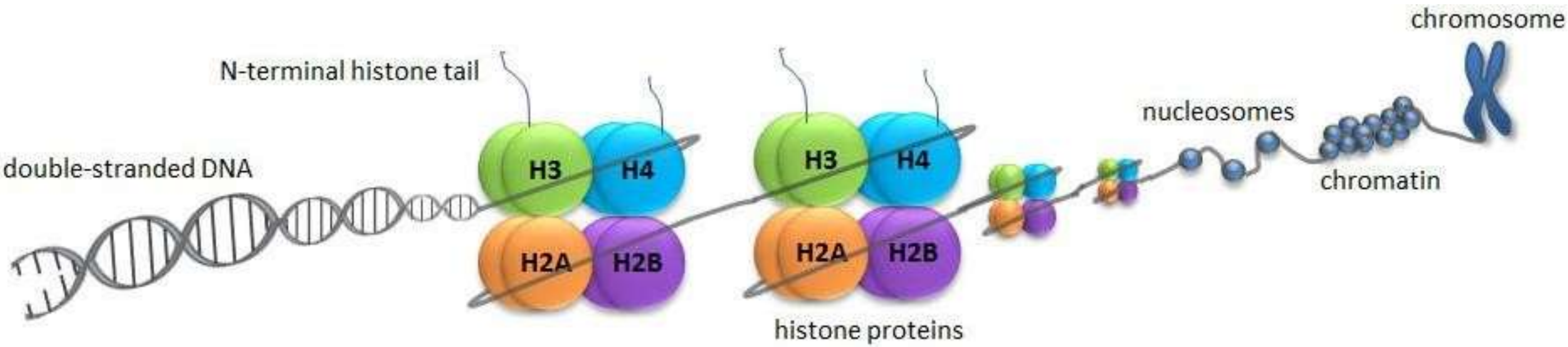
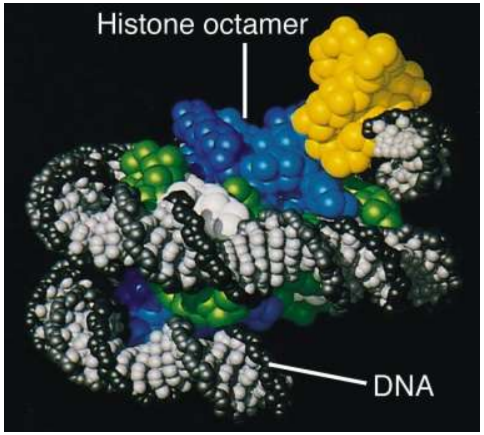


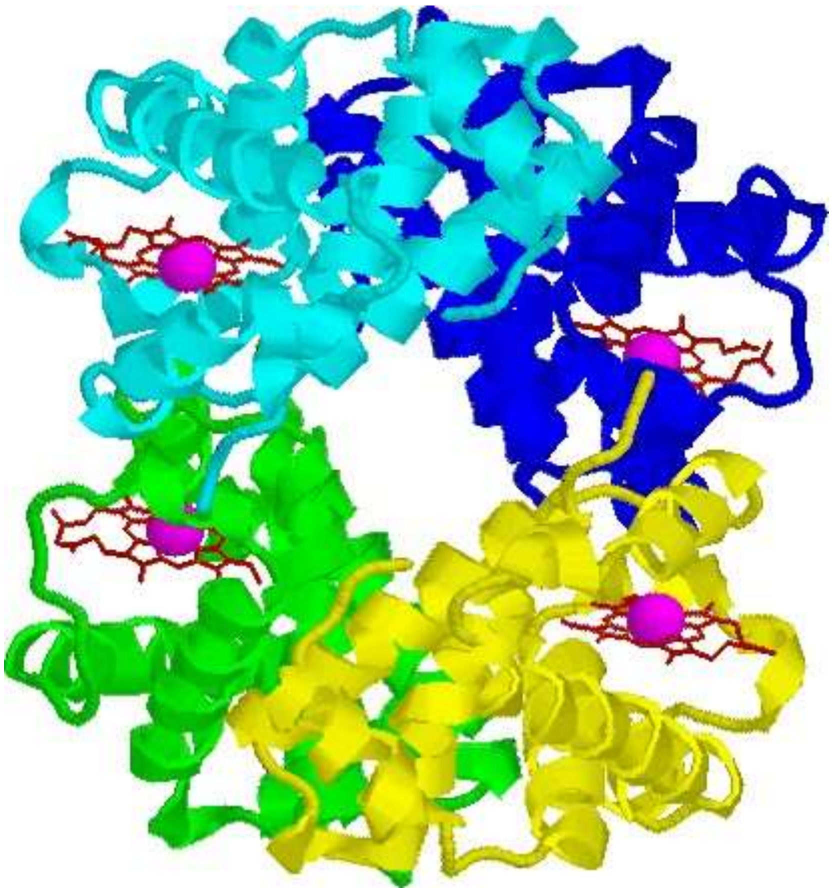
Image adapted from: National Human Genome Research Institute.

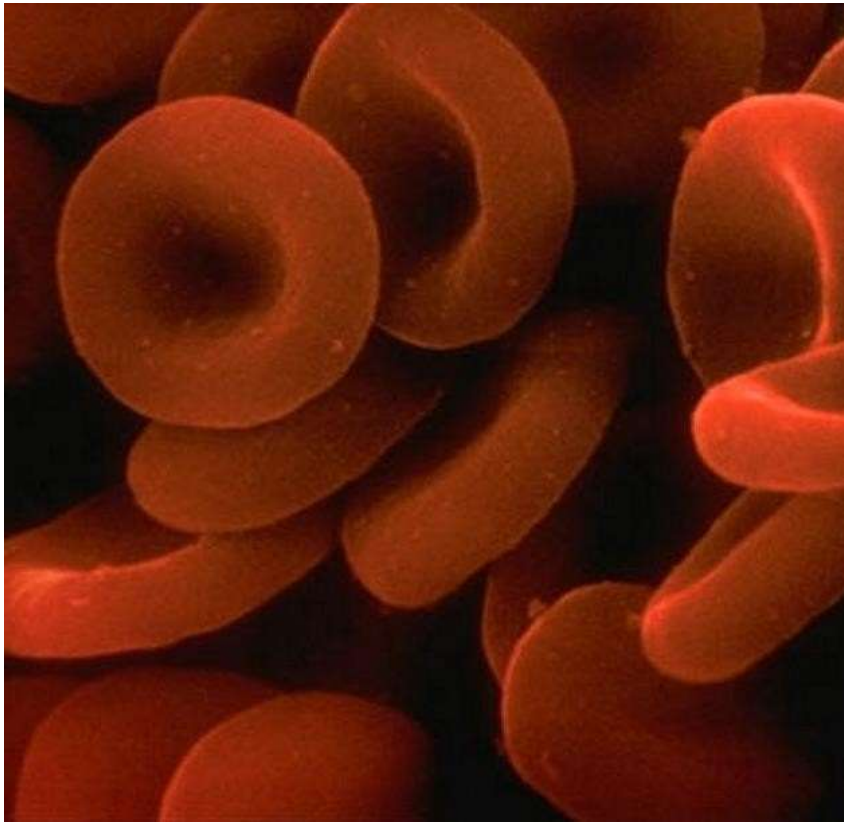
STRUCTURAL Ex: Histone Protein



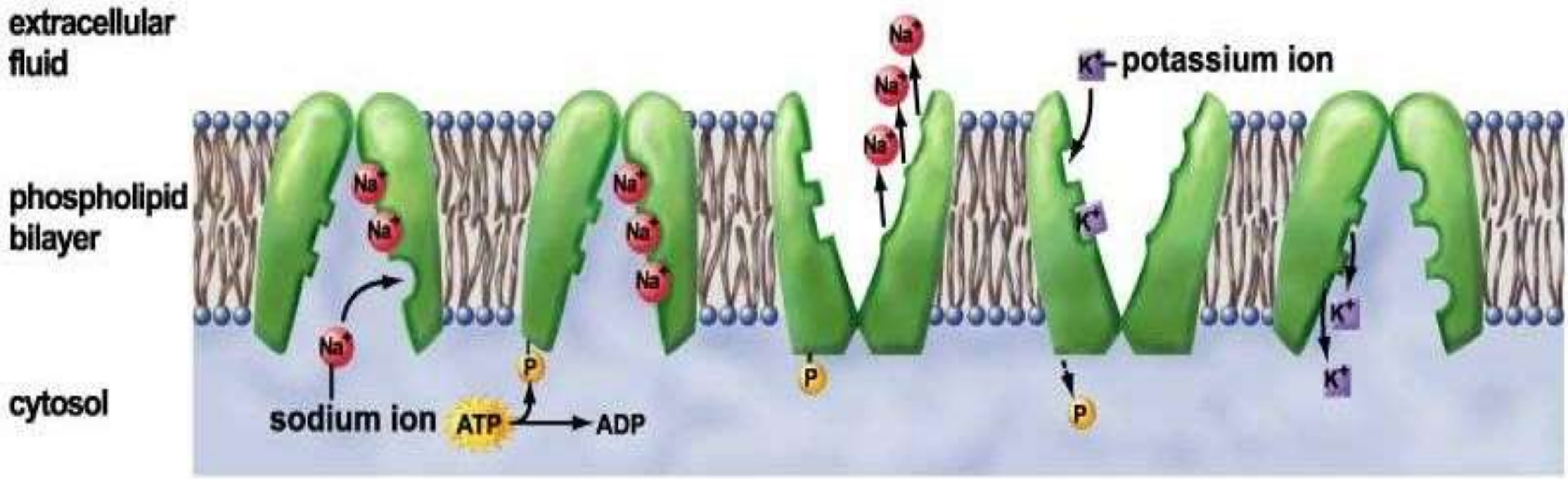


TRANSPORT: Ex: haemoglobin

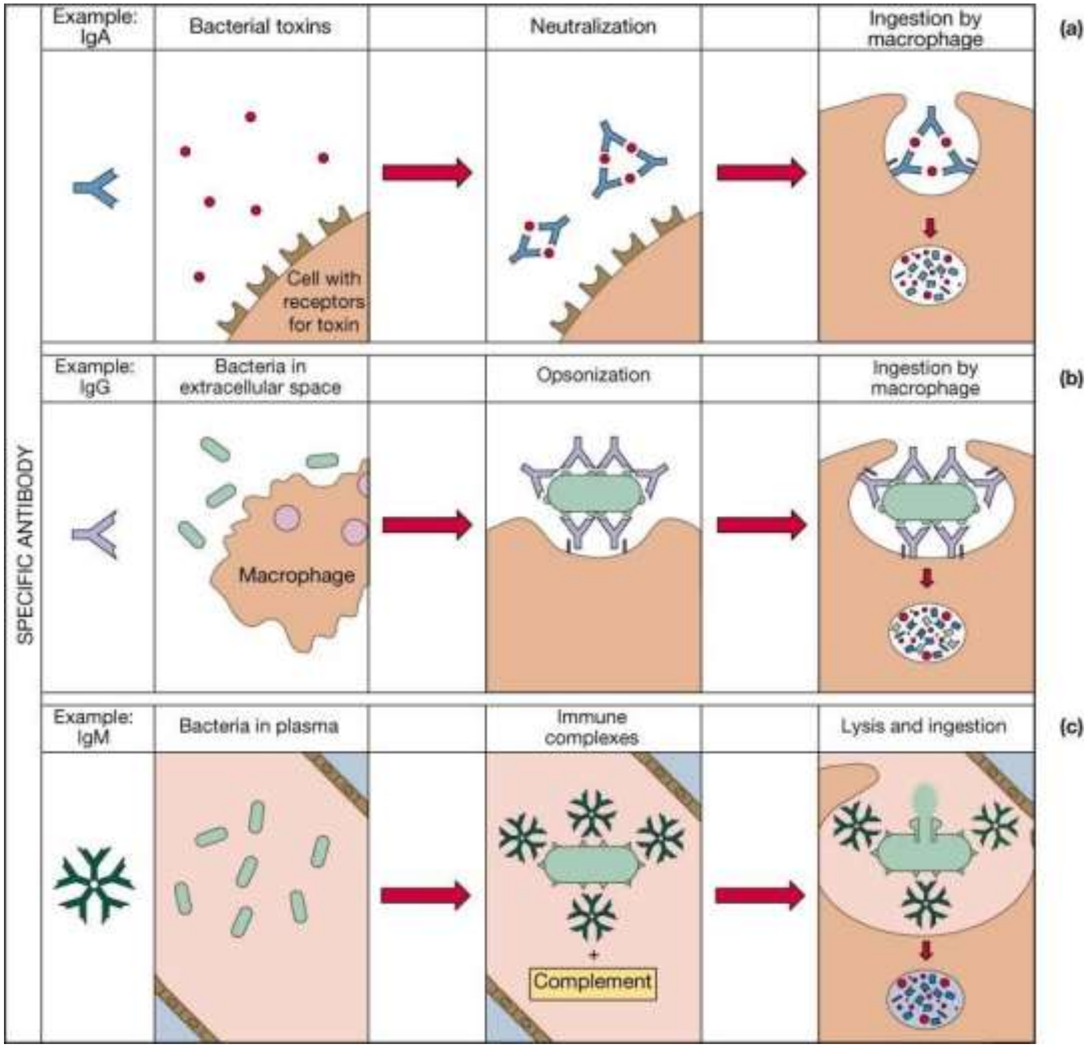




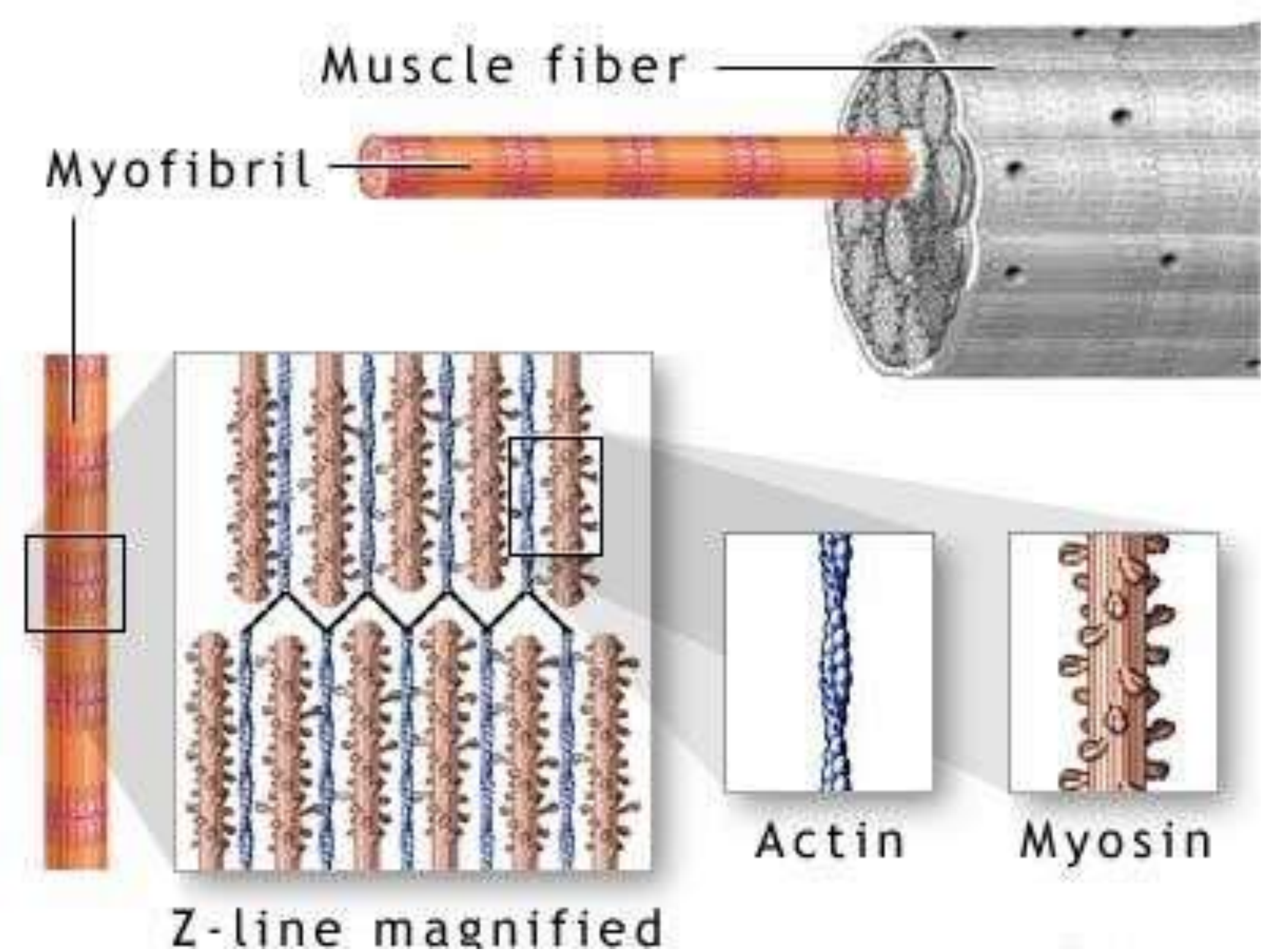
TRANSPORT: protein channels or carrier proteins



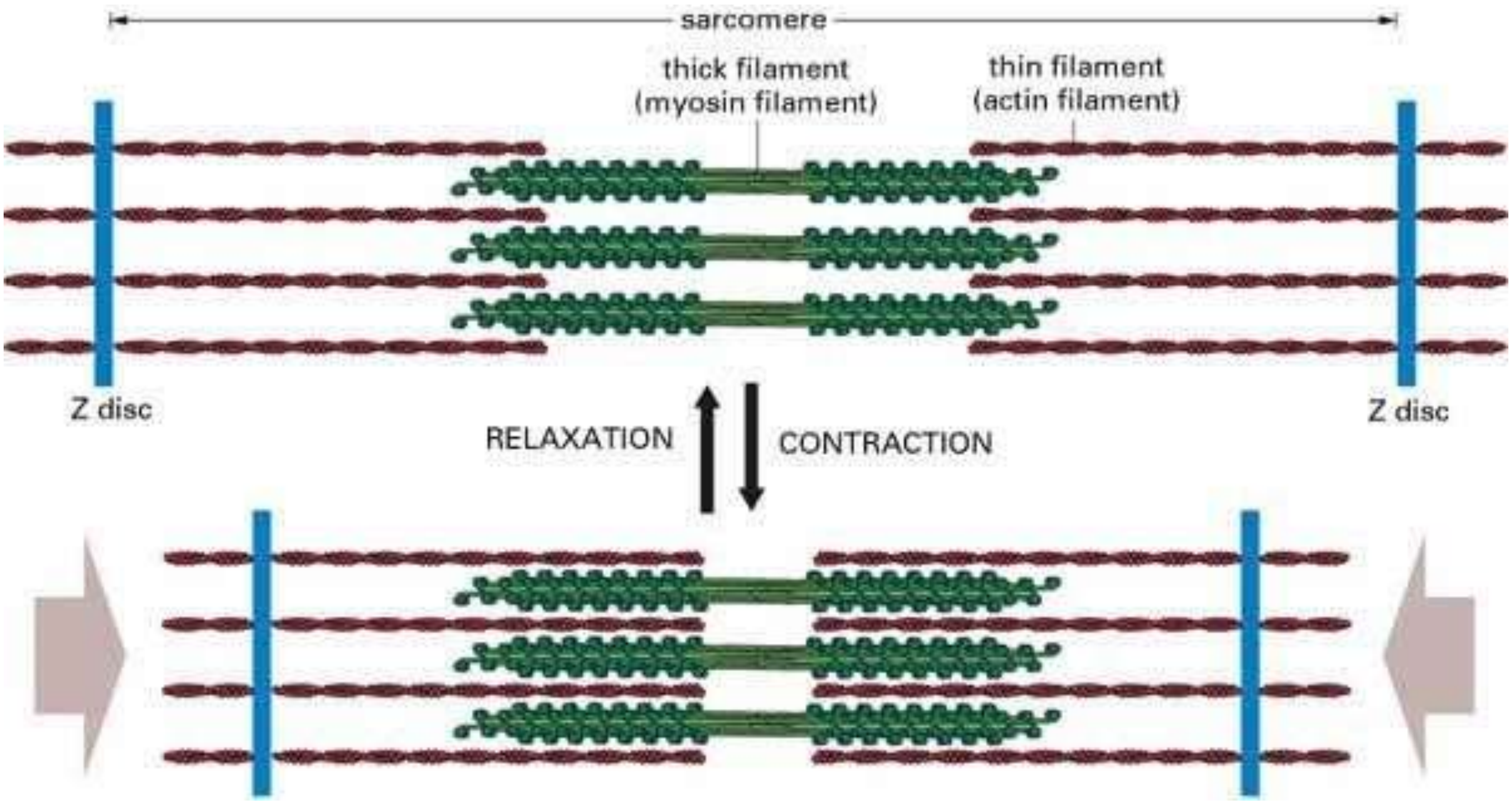
IMMUNITY: Ex: Antibodies



CONTRACTILE: Ex:Actin and Myosin



Muscle contraction and relaxation



Surface receptors