BIOLOGY

My Name: Laura Mascia

Master degree in Biological Sciences at University of Pisa

PhD in Neurobiology at Scuola Normale Superiore in Pisa

Post Doc EMBO fellowship at Technische Universitaet Munchen, Department Biopolymer Chemistry

Research fields metabolism, proteins in nervous system, protein expression in vitro, proteomics

Teaching at school (Biology, Earth sciences, Mathematics). Primary and secondary school

FCS: Biology course since 2017.

Biology course

- The chemicals of life. Water and its properties. Biological molecules: carbohydrates.
- Biomolecules. Lipids: cholesterol, Proteins, nucleic acids Nuclei acid: DNA and RNA structure. Examples of proteins. Biomolecules as nutrients.
- Cell structure. Prokaryotic and eukaryotic cells. Cell organelles
- Cell structure. Different organelles, protein trafficking
- Cell membranes and transport. Structure of membranes. Features of the fluid mosaic model. Transport across cell membranes.
- Cell division. Mitosis and Meiosis. DNA replication
- Cell biology and microscopy. Laboratory safety rules. Chemical safety. Light and electron microscopy. The concept of mole

  LAB: Introduction to a scientific lab. Description of common lab instruments. Use of light microscope. Observation of a fresh preparation of onion cells. Preparation of 1M solution of sodium chloride.
- Inheritance and mendelian genetics.
- Nucleic acids and protein synthesis.

  LAB: DNA extraction from strawberries
- Revision of all the topics.

  TEST (multiple choice questions)

Biology course

- Molecular genetics. Trancription and translation
- Genetic technology. Gene cloning and protein expression. Agarose gel electrophoresis. PCR. CRISPR technology
- Microorganisms. Bacteria, Viruses, Protozoa and Fungi. How to grow bacteria

  LAB: Growing bacteria. Preparation of nutrient agar plates. Inoculation of bacteria

  LAB: Analysis of the plates after overnight incubation. description of different types of bacteria. Observation of different preparation of protists (Amoeba, Paramecium, Euglena) with light microscope. Observation of pond water samples with light microscope.

- Multicellularity. Tissues and organs
- Digestive system. Anatomy and physiology. Importance of liver and pancreas in glucose homeostasis.
- Circulatory system. Anatomy and physiology.

  LAB: Dissection of a chicken to identify the different organs of the digestive system, circulatory system, scheletric system and muscular system.

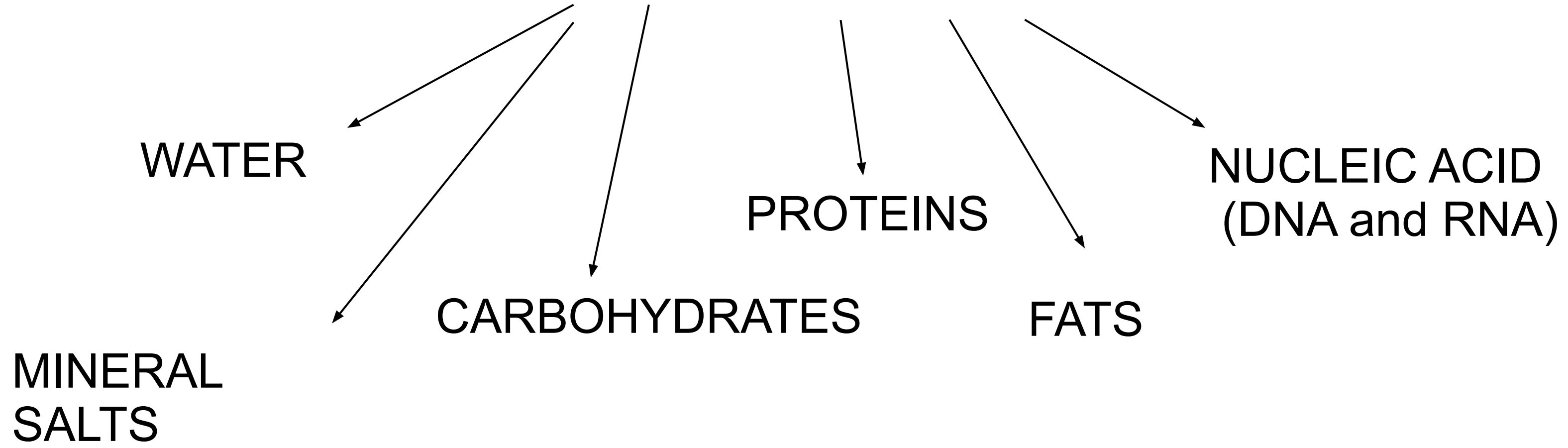
- Circulatory system. Blood test. Blood composition. Different cells in blood
- Respiratory system. Anatomy and physiology.
- Energy metabolism in living organism. Energy flow and biological significance of photosynthesis, glycolisis, fermentation and aerobic respiration. The importance of ATP.
- Nervous system. Anatomy. Neurons and signal trasmission Neurotrasmitter release.
- Biodiversity and classification

FINAL TEST (multichoice questions)

Biomolecules

The chemicals of life

What are we made of?

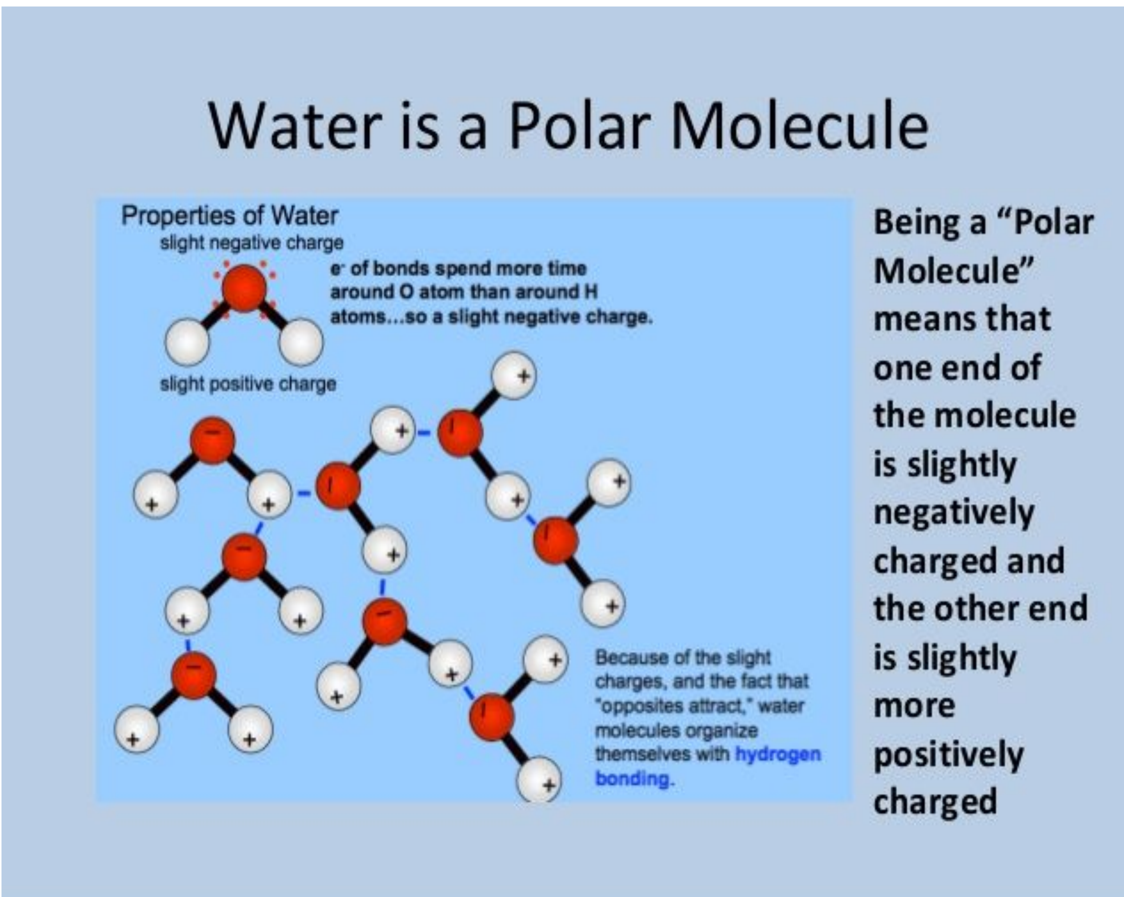


- Most of our bodies are made up of WATER (about 60%)
- Our cells also contain carbohydrates, proteins, fats and nucleic acid. Each of them is vital for life

Water

- Three quarters of our planet is covered by water. Earth is the blue (water) planet

- Water is a polar molecule



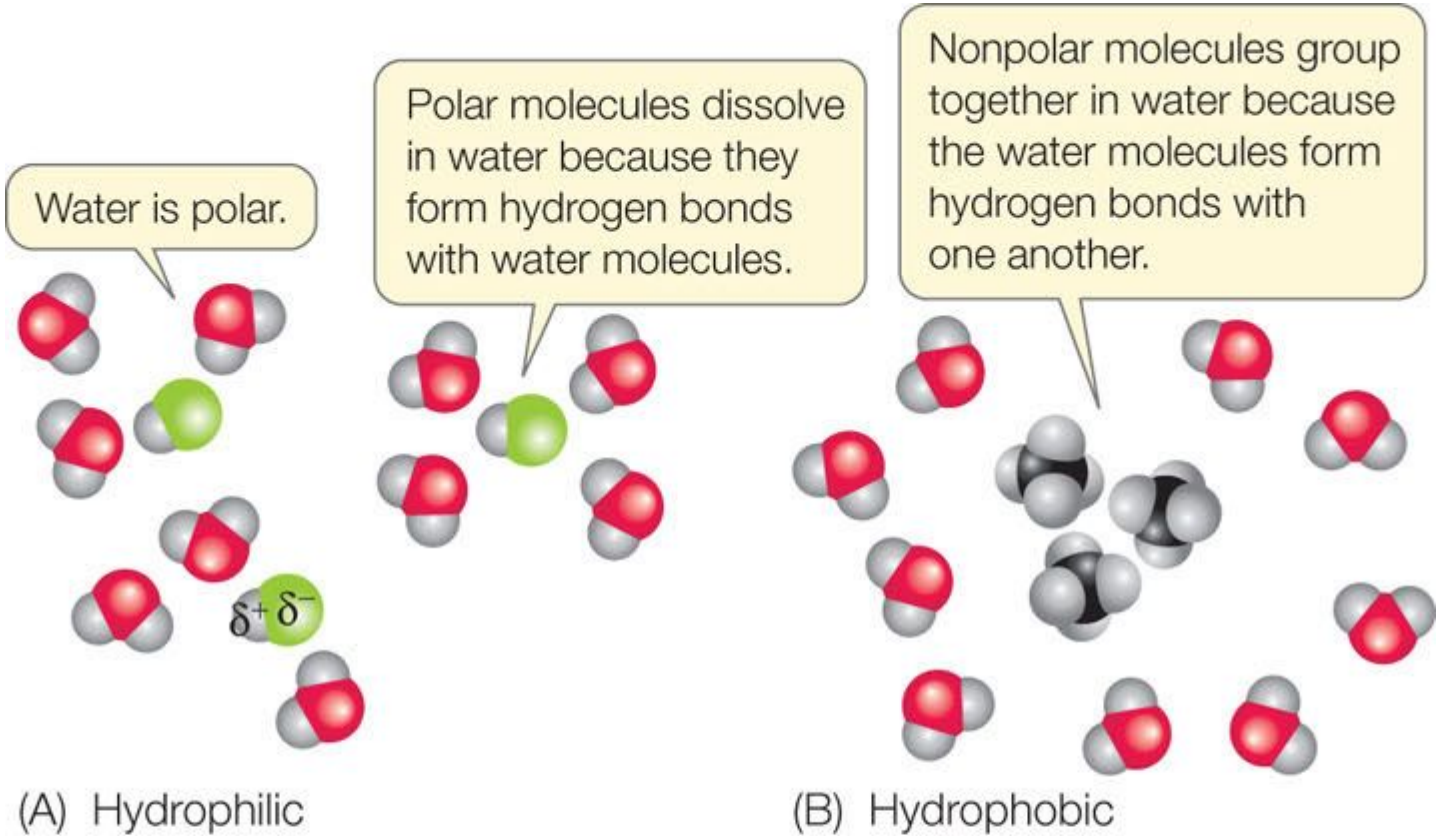
- Water is a liquid. It provides a medium for molecules and ions to mix in, a medium in which life can evolve

Water

- Water is an excellent solvent for ions and polar molecules

Water

- Polar molecules are soluble in water
- Non-polar molecules are insoluble in water



Water as a transport medium

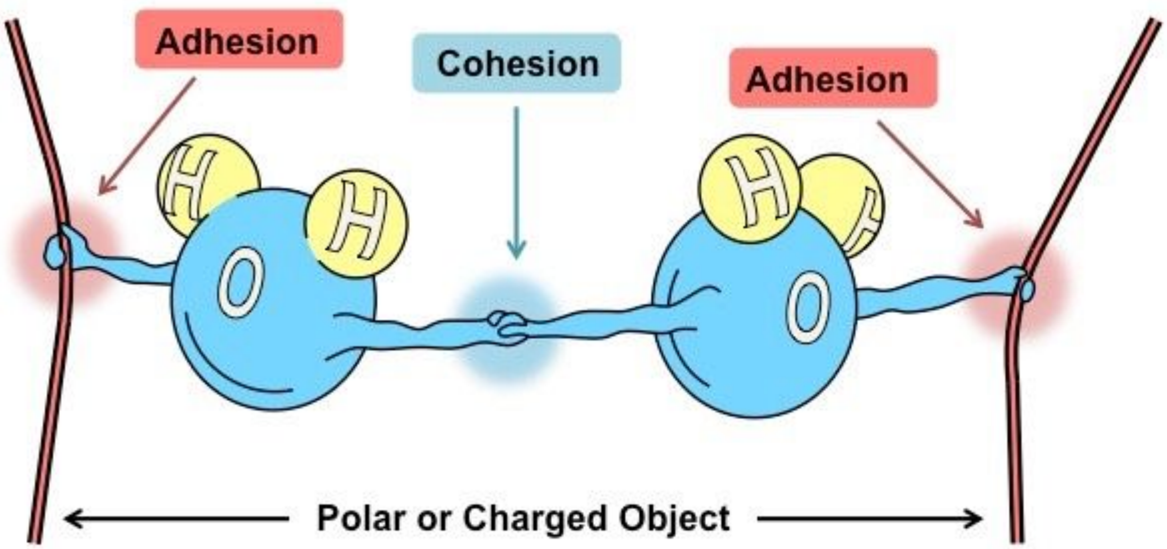
- Inside every living organism metabolic reactions can only take place if the chemicals are dissolved in water. Water is the most important solvent, if the cells dry out the reactions stop and the organism dies
- Plasma, the liquid part of the blood, contains a lot of water where many substances like glucose, are transported.
- In the alimentary canal water is required for dissolving enzymes and nutrients.
- The kidneys remove the waste product (urea) from our body dissolving it in water (and forming urine).

Important chemical properties

- Cohesion: attraction between molecules of the same substance.

Water is cohesive because the H-bonds hold the molecules together.

- Adhesion: attraction between molecules of water and different molecules



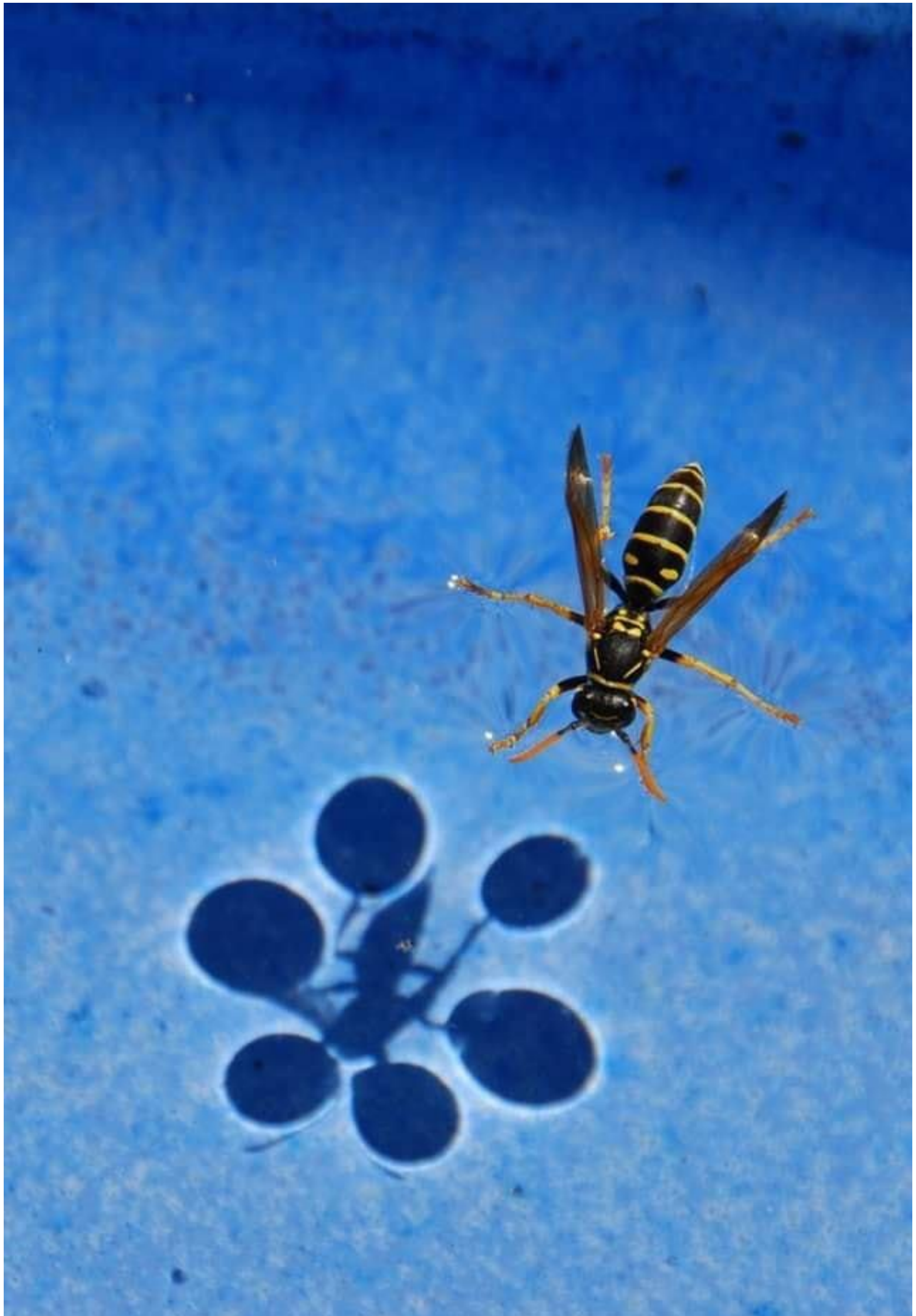
Important chemical properties

- Cohesion results in Surface tension: a measure of the strength of water's surface

Surface Tension

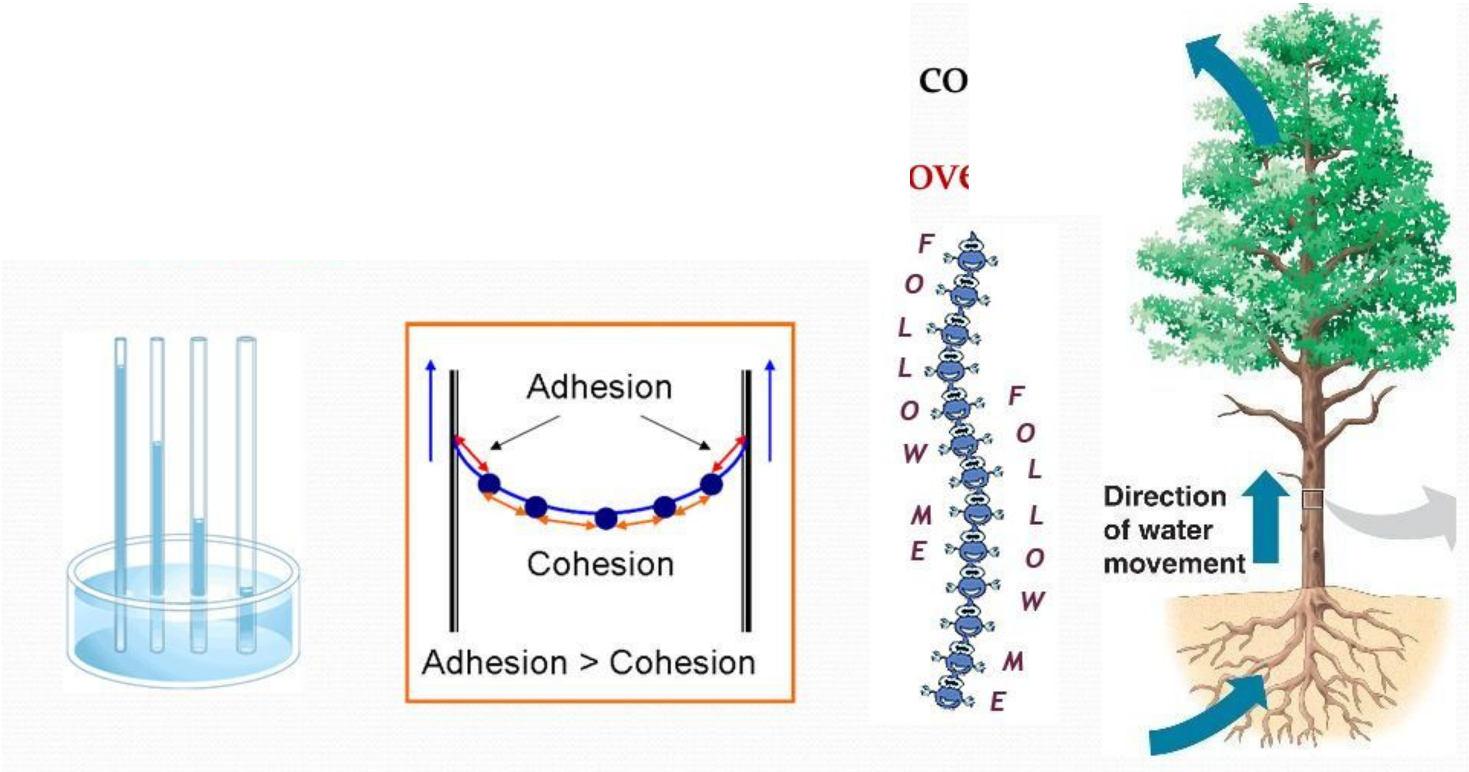
- Surface tension is the force of the hydrogen bonds in water along the surface of the water. The hydrogen bonds on the top of the water are linked together like the ropes of a net. Some animals can distribute their weight properly and walk in to of the hydrogen bonds without breaking them like some water insects.

Surface tension

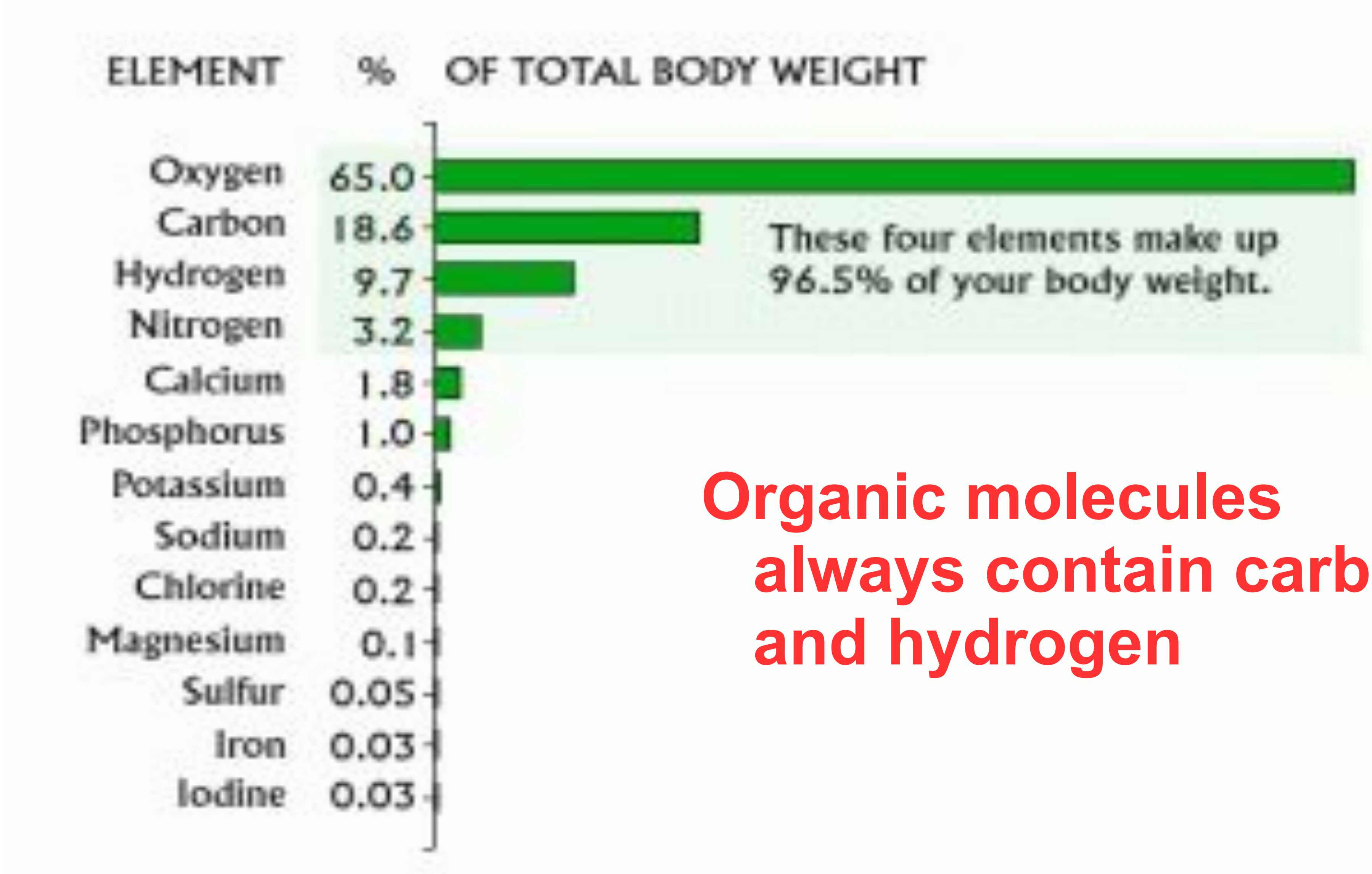


IMPORTANT BIOLOGICAL PROPERTIES OF WATER

- Adhesion+ Cohesion------Capillary action
- Capillary action forces water to move high into trees



The four most common elements in living organisms



Organic molecules always contain carbon and hydrogen

The chemicals of life: Biomolecules

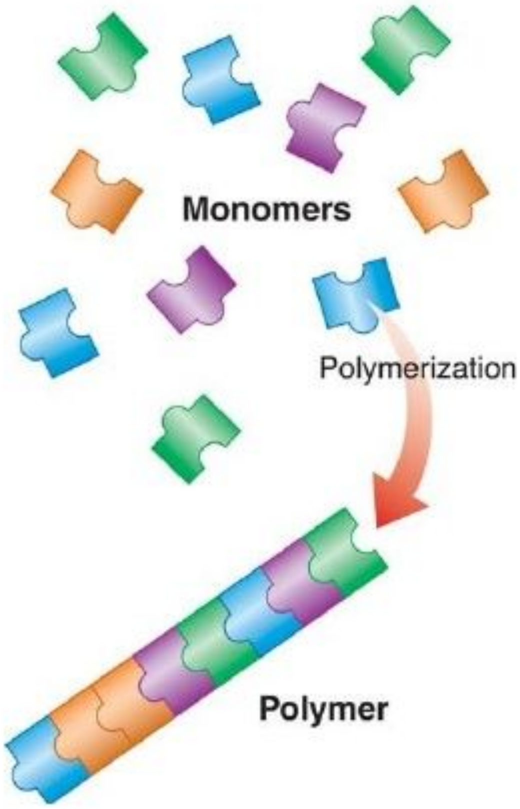
Biomolecules

- **Carbohydrates (sugars)**
- **Lipids (or fats)**
- **Nucleic acid (DNA and RNA)**
- **Proteins**
- Vitamins and hormones

Biomolecules are macromolecules

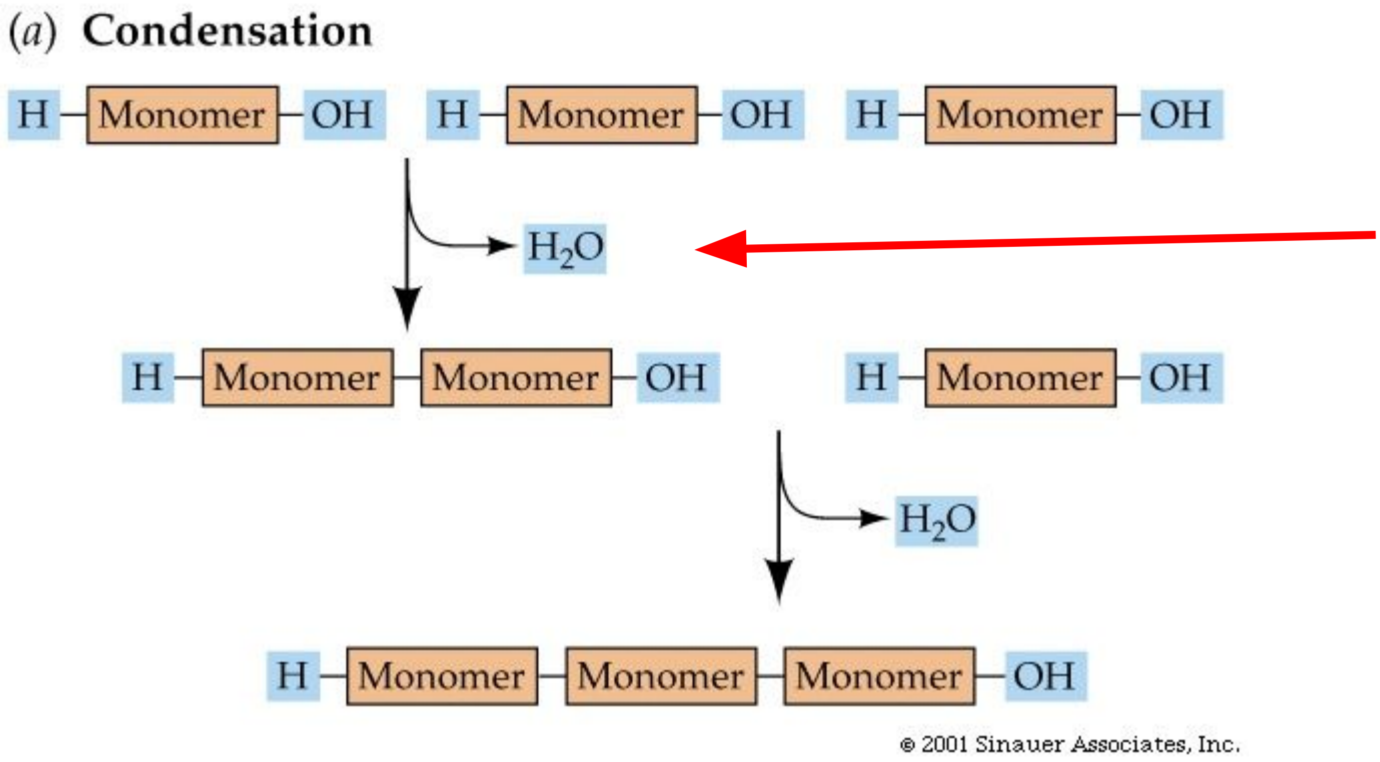
Macromolecules

- **Monomers**= single units
- **Polymer**= many monomers bound together
- **Monomers,** the *single units*, are **polymerized** (*joined together*) to form a **polymer**



Biomolecules: Monomers and polymers

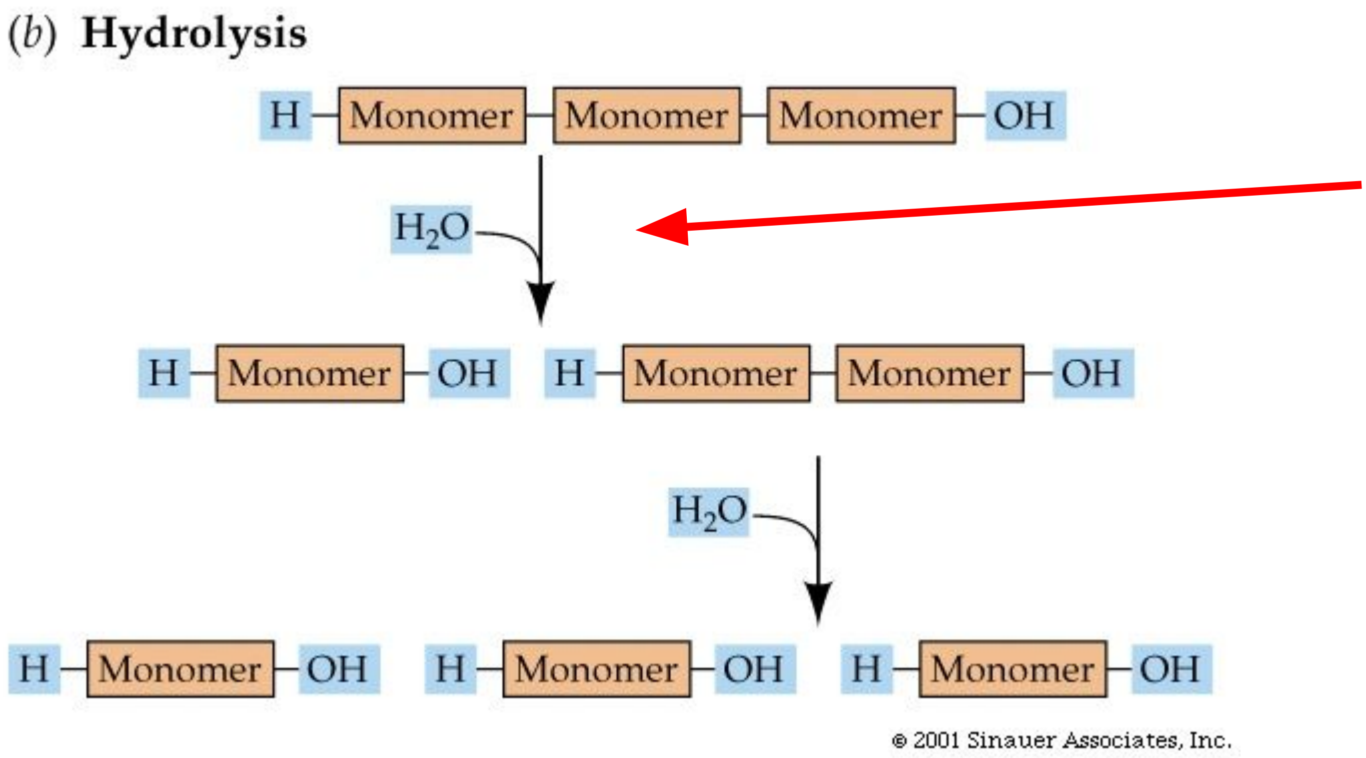
Monomers are joined together by condensation reaction to form polymers



Two molecules react with each other with the concurrent loss of a molecule of water

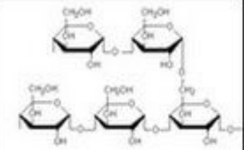
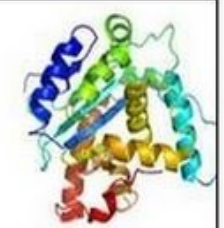
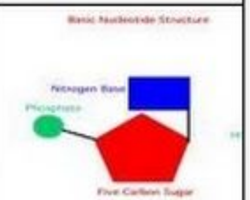
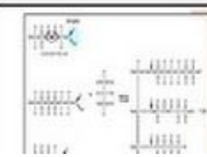
Biomolecules: Monomers and polymers

Hydrolysis reactions break polymers into monomers

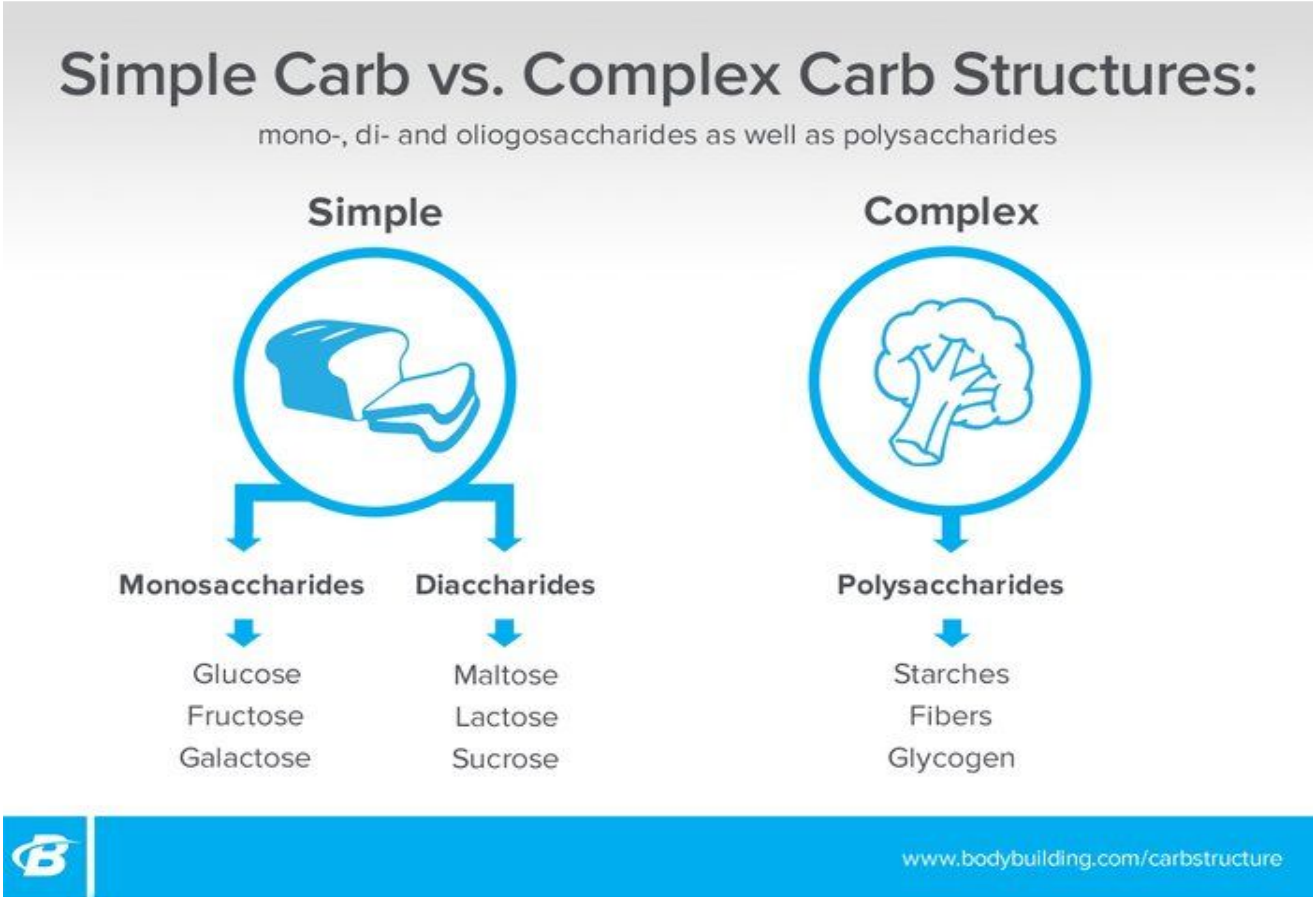


Hydrolysis adds a water molecule to break a bond

Biomolecules

Biomolecule	Elements/Chemical Formula	Function	Monomer/Polymer	Examples	Other
Carbohydrates -end in -ose	Carbon, Hydrogen, Oxygen $C_6H_{12}O_6$ = glucose	Main source of energy	Monomer = sugar or monosaccharide Polymer = starch or polysaccharide	Glucose, fructose, galactose Sugar, starch (potatoes, pasta, etc.)	
Proteins *one of the most important Biomolecules ***Nitrogen** makes it different	Carbon, Hydrogen, Oxygen and <u>Nitrogen</u>	*control rate of chemical reactions through ENZYMES *Bones and muscles *transport things in and out of cells	Monomer = amino acids Polymer = protein/polypeptide chain	Meat, poultry, eggs, beans, soy, nuts, peanut butter, enzymes	
Nucleic Acids ***phosphorus** makes it different	Carbon, Hydrogen, Oxygen, Nitrogen and <u>Phosphorus</u>	*stores and transmits genetic information	Monomer = nucleotide Polymer = nucleic acid (DNA)	DNA = deoxyribonucleic acid RNA = ribonucleic acid	
Lipids *no true polymers	Primarily Carbon and Hydrogen	*stores energy and make up biological membranes and waterproof coverings	Made up of 3 Fatty Acids and 1 glycercol	Fats, oils, waxes, membranes	

Carbohydrates


Simple Carb vs. Complex Carb Structures:
mono-, di- and oliogosaccharides as well as polysaccharides
Simple
Complex
Monosaccharides
Diaccharides
Polysaccharides
Glucose
Fructose
Galactose
Maltose
Lactose
Sucrose
Starches
Fibers
Glycogen
www.bodybuilding.com/carbstructure

GOOD

COMPLEX CARBS

HIGH IN FIBER
METABOLISM BOOSTER
FEEL FULLER, LONGER

FOOD EXAMPLES

WHOLE GRAIN BREAD
BROWN RICE
QUINOA
BEANS
NUTS / SEEDS
OATMEAL
FRUITS
SWEET POTATO
VEGETABLES

BAD

SIMPLE CARBS

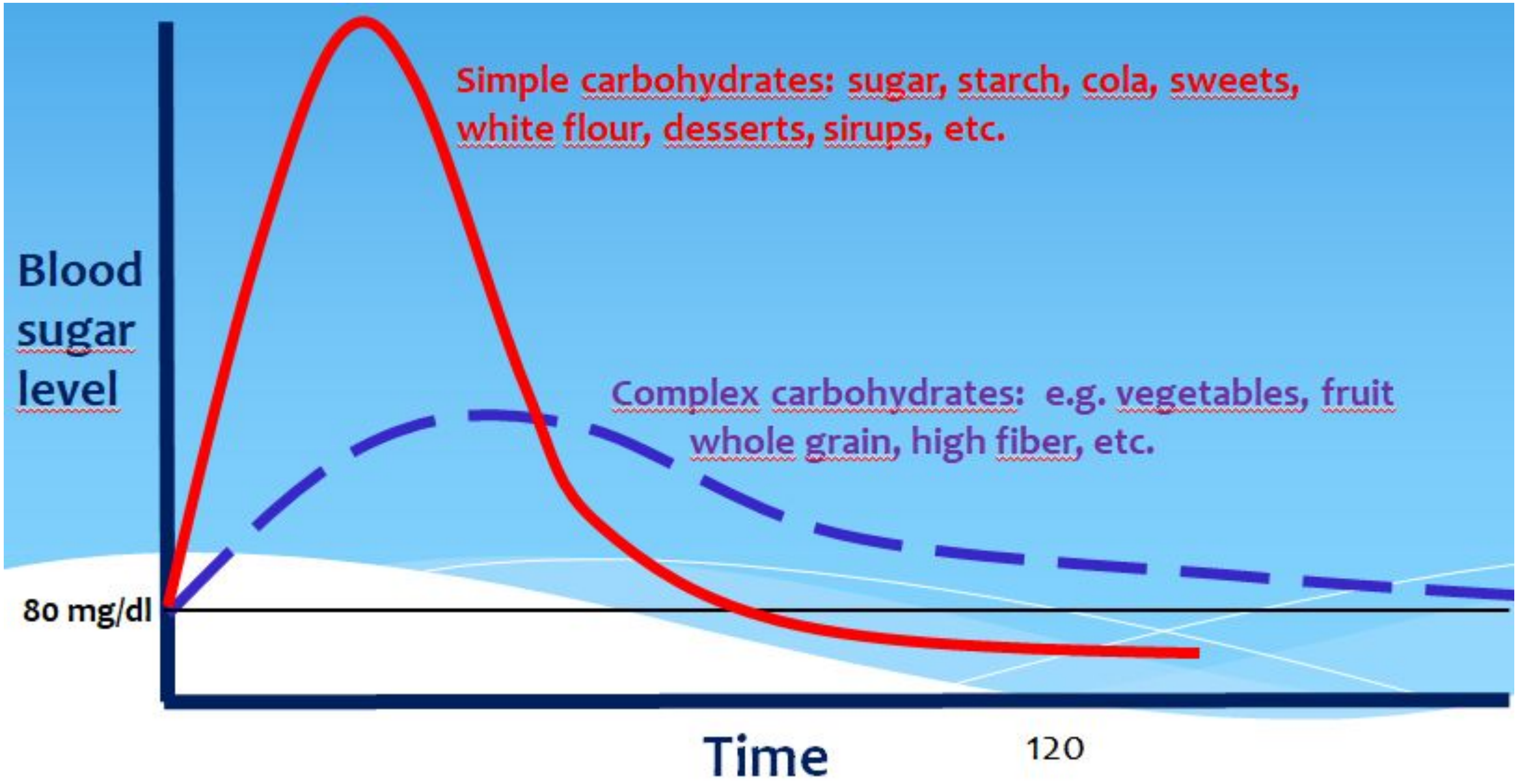
LOW IN FIBER/NUTRIENTS
EMPTY CALS TURN TO FAT
FEEL TIRED

FOOD EXAMPLES

WHITE BREAD
SUGAR, BROWN/WHITE
FRUIT JUICES
WHITE RICE
MUFFINS
CANDY
COOKIES
PRETZELS/CHIPS
SUGARY CEREALS


GOOD CARBS
VS
BAD CARBS
HELPFUL CARBOHYDRATE GUIDE
GOOD CARB EXAMPLES
Fresh Fruits
Fresh Vegetables
Legumes
Beans
peas
lentils
Whole Grains
brown rice
quinoa
pure oats
Pumpkin Seeds
chia seeds
sunflower seeds
sweet potatoes
potatoes
walnuts
peanuts
almonds
macadamia nuts
hazelnuts
WHY?
High fiber
Natural sugars
Low glycemic
Low insulin levels
Slow digestion
Prolonged energy
Keeps you full longer
Help with weight loss
BAD CARB EXAMPLES
Fruit Juices
Soda or Pop
Cookies
pastries
cakes
White bread
white crackers
Regular pasta
Chocolates and any other candy
Ice cream
frozen yogurt
any other frozen sweet treat
Potato chips
French fries
WHY?
Low fiber
Refined/Processed
Fast Digestion
Hunger comes quicker
Energy levels deplete quicker
Added sugars
High insulin levels
High glycemic
Carbs convert into fat cells
Causes weight gain

Simple and complex carbohydrates



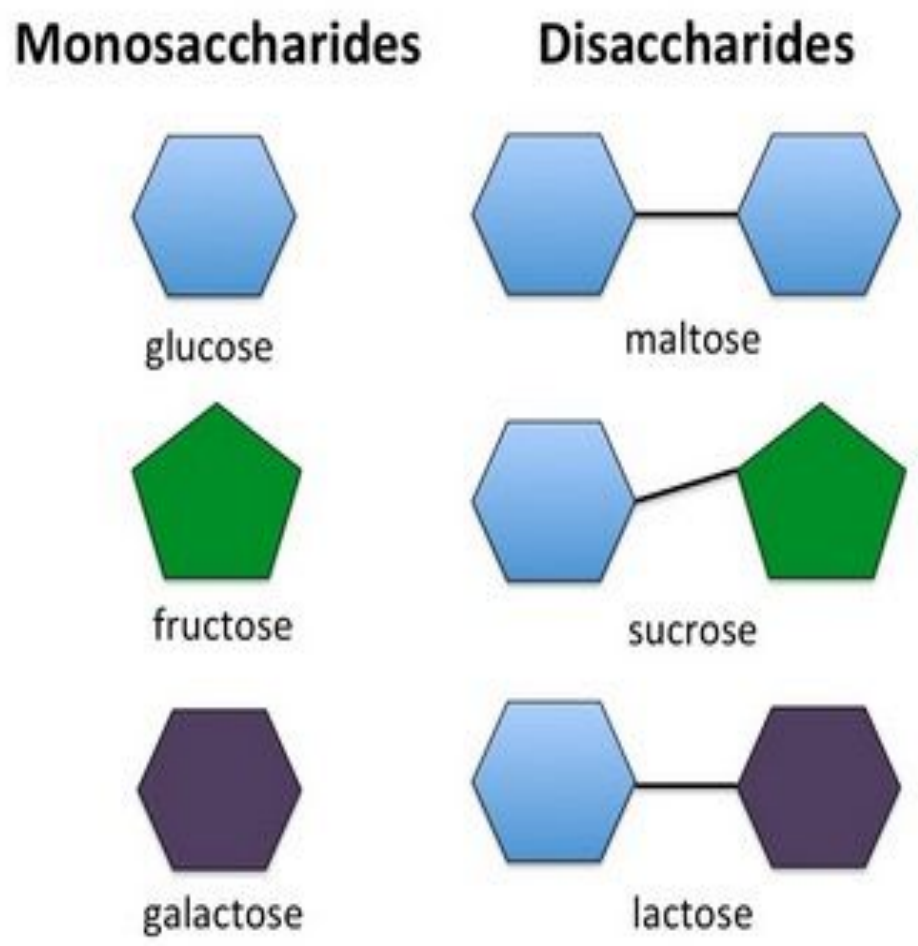
Biomolecules: Carbohydrates

Chemical composition: C,H,O

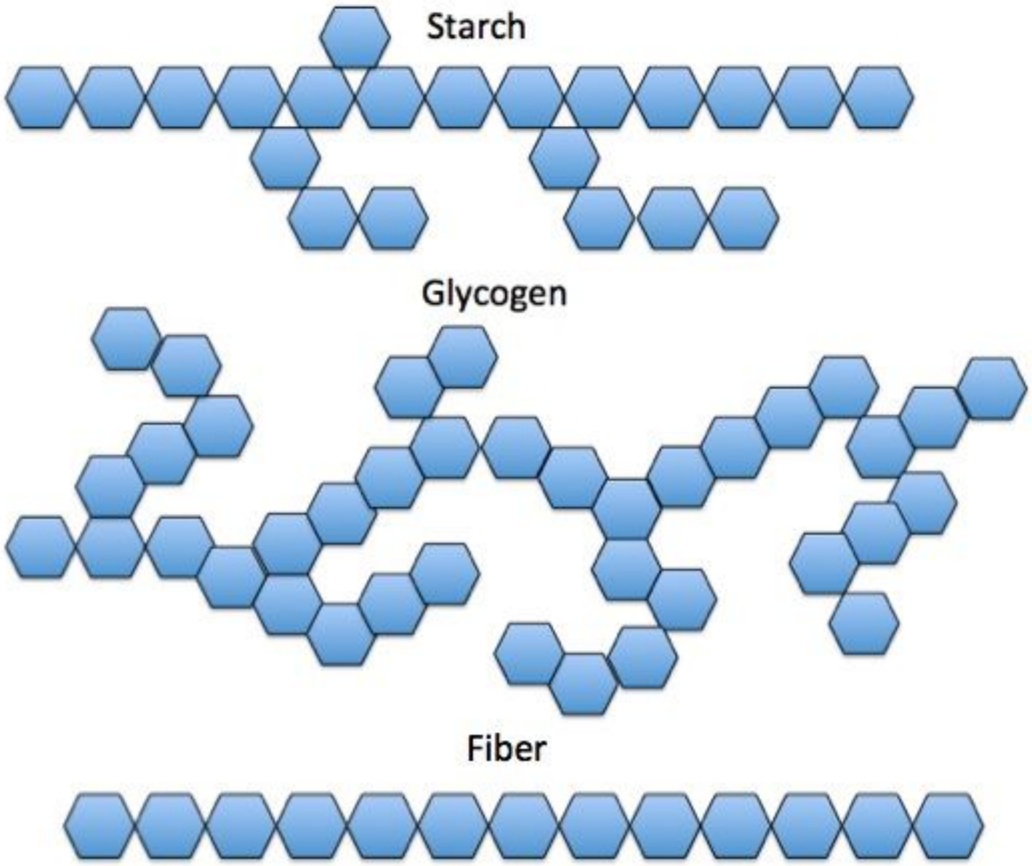
Carbohydrates (sugars)

- Simple sugars
  - Monosaccharides
    - Ribose
    - Glucose, Fructose, Galactose
  - Disaccharides
    - Maltose, Lactose, Sucrose
- Complex sugars
  - Polysaccharides
    - Starch, Cellulose, Glycogen

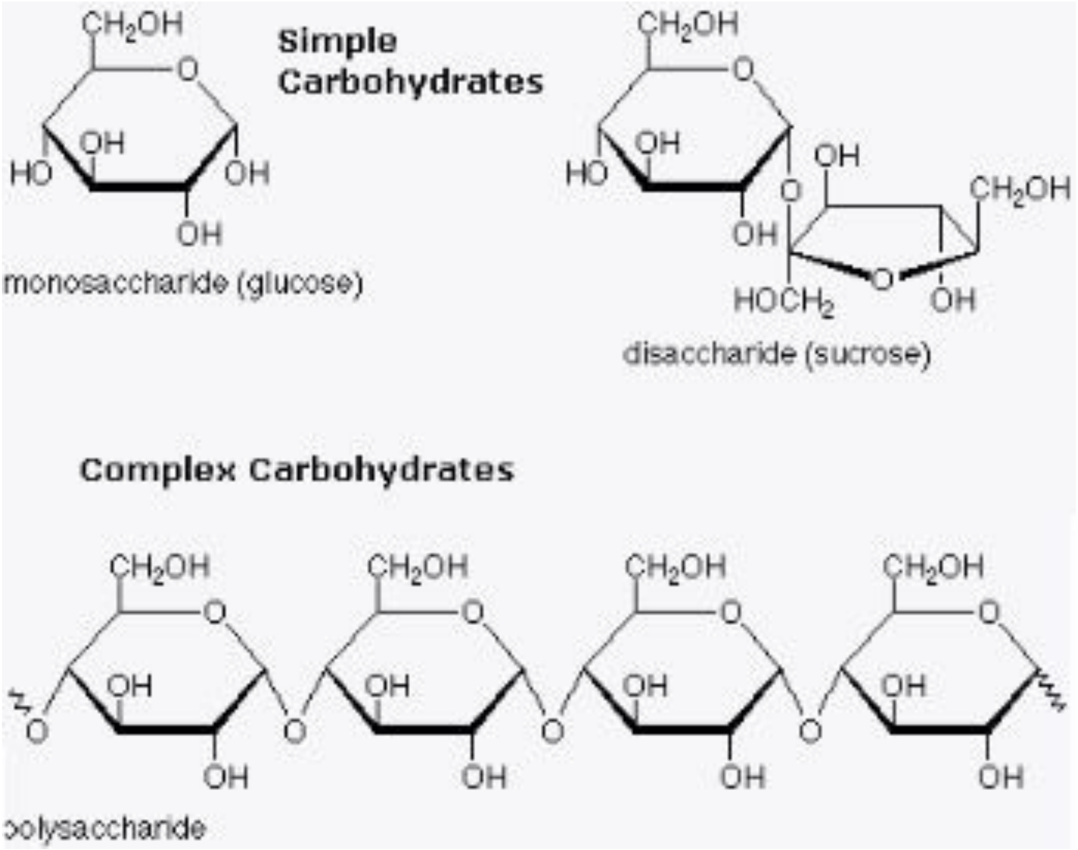
Biomolecules: Simple carbohydrates
Disaccharides



Biomolecules: complex carbohydrates



Biomolecules: Carbohydrates



Biomolecules: Carbohydrates

Polysaccharides are polymers of monosaccharides

Storage

↓

Starch in plants

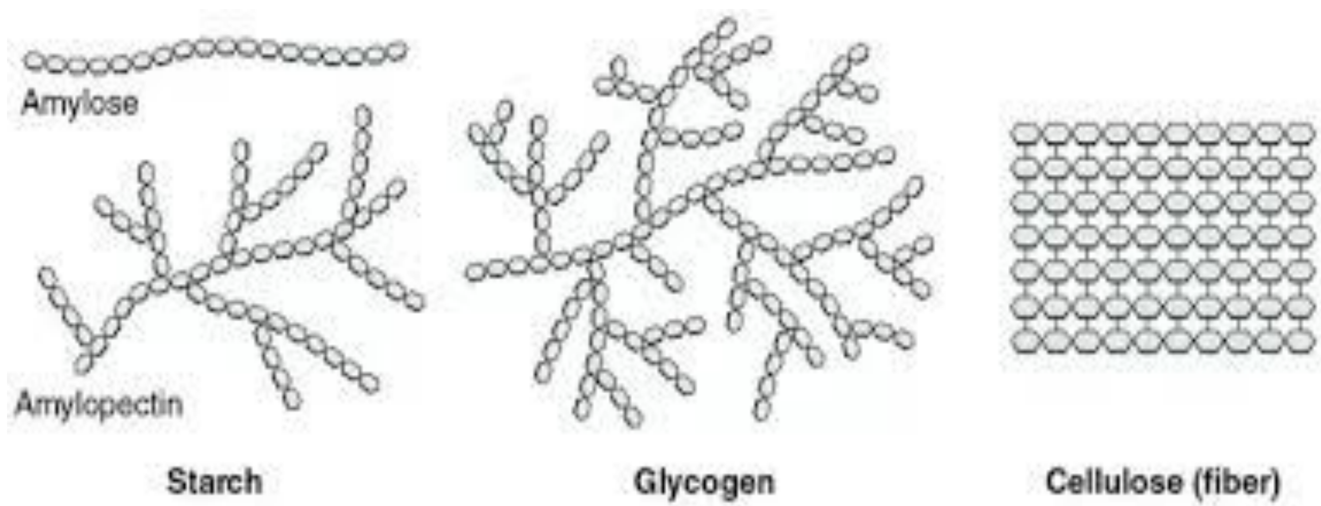
Glycogen in animals

Structural

↓

Cellulose (fiber)

Chitin



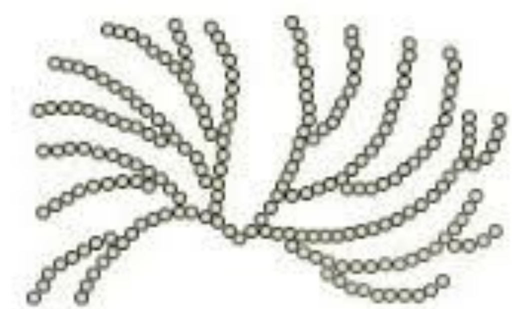
Starch in plants

Starch: is a polymer of alpha-glucose and it is a mixture of two different polysaccharides: amylose and amylopectin

Starch

- Amylose — long **unbranched** chain of glucose units
- Amylopectin — highly branched chain of glucose units

Amylose

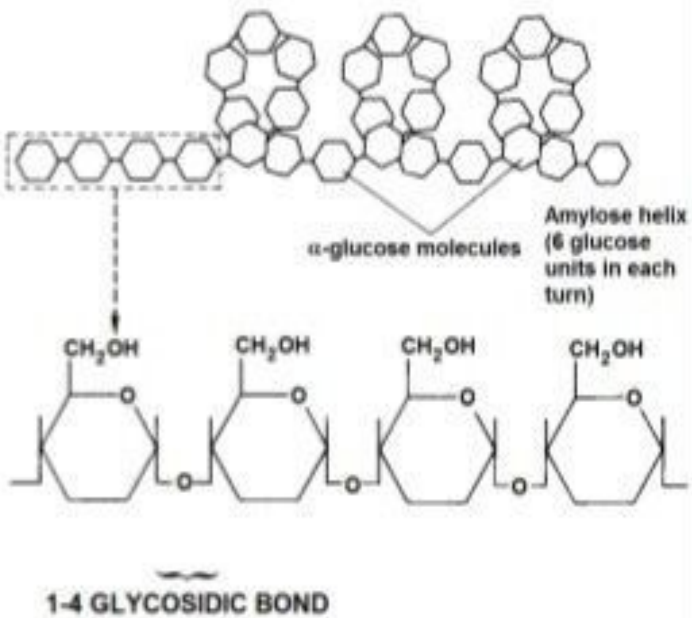


Amylopectin

AMYLOSE

Stains deep blue with iodine
Relative molecular mass up to 50 000
Up to 300 glucose units/molecules
Unbranched helical chain

STRUCTURE OF MOLECULE

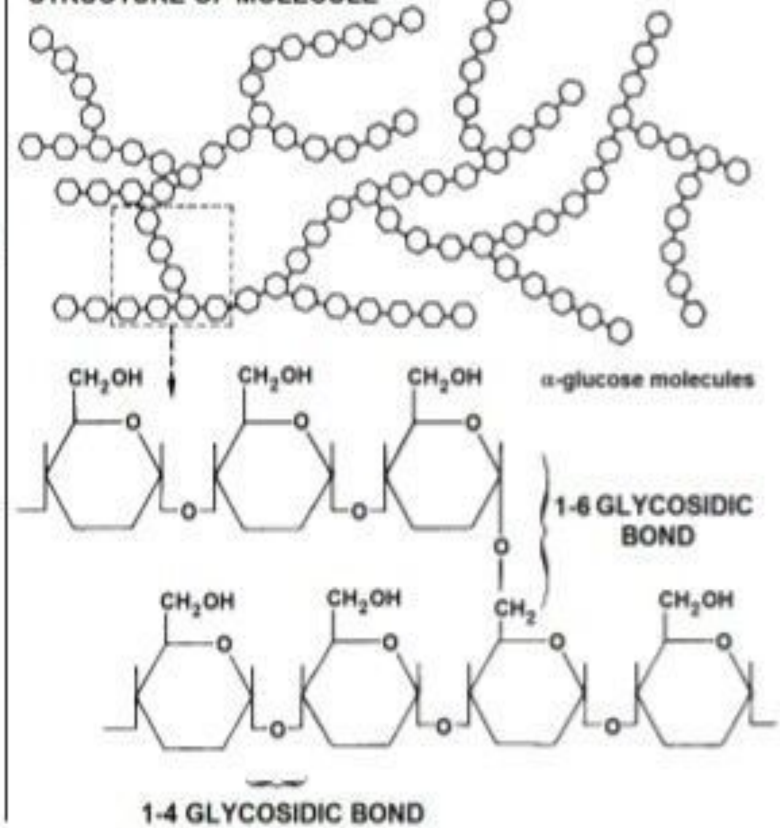


Linear molecule

AMYLOPECTIN

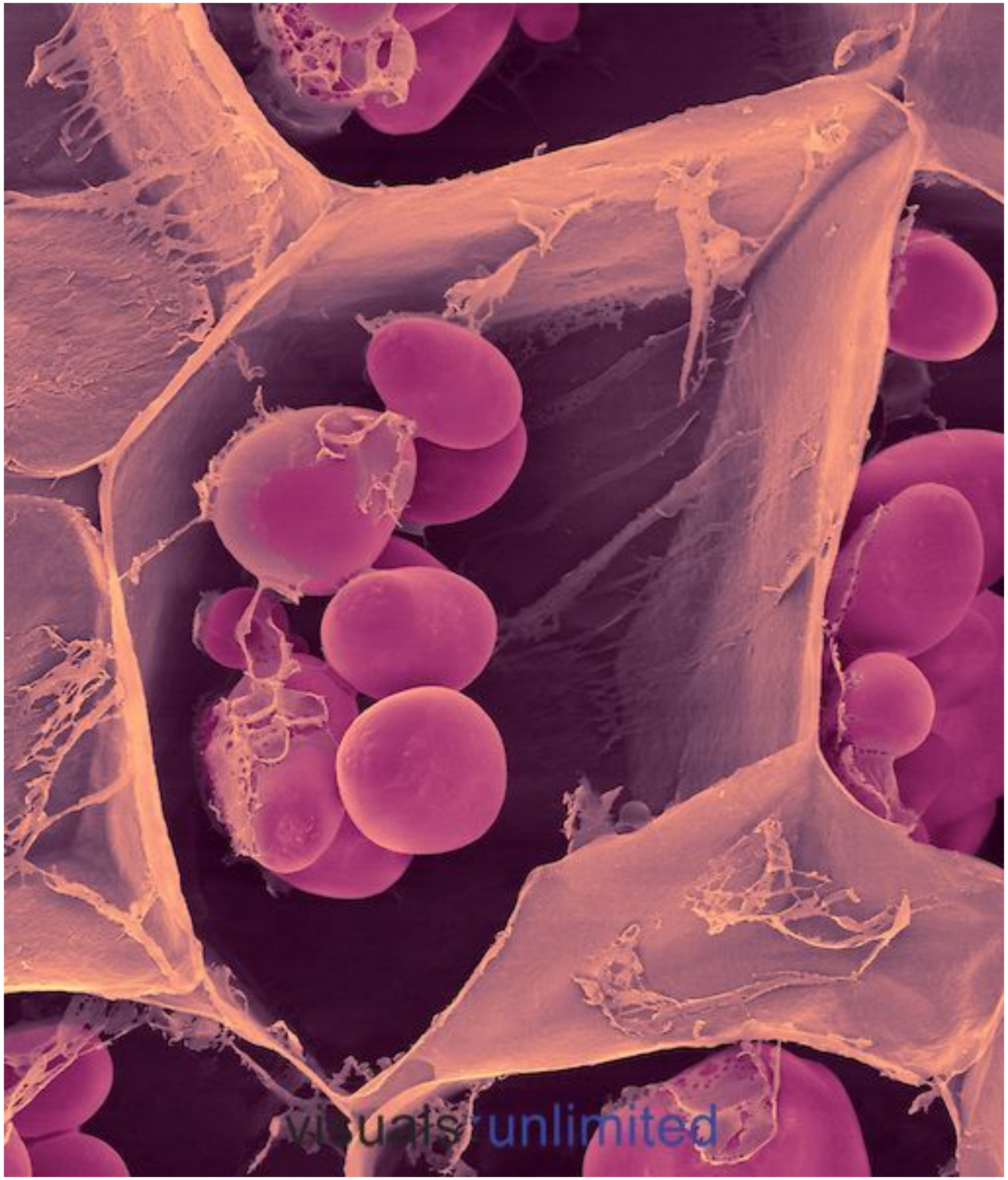
Stains red to purple with iodine
Relative molecular mass up to 500 000
1300-1500 glucose units/molecules
Branched chain

STRUCTURE OF MOLECULE



Branched molecule

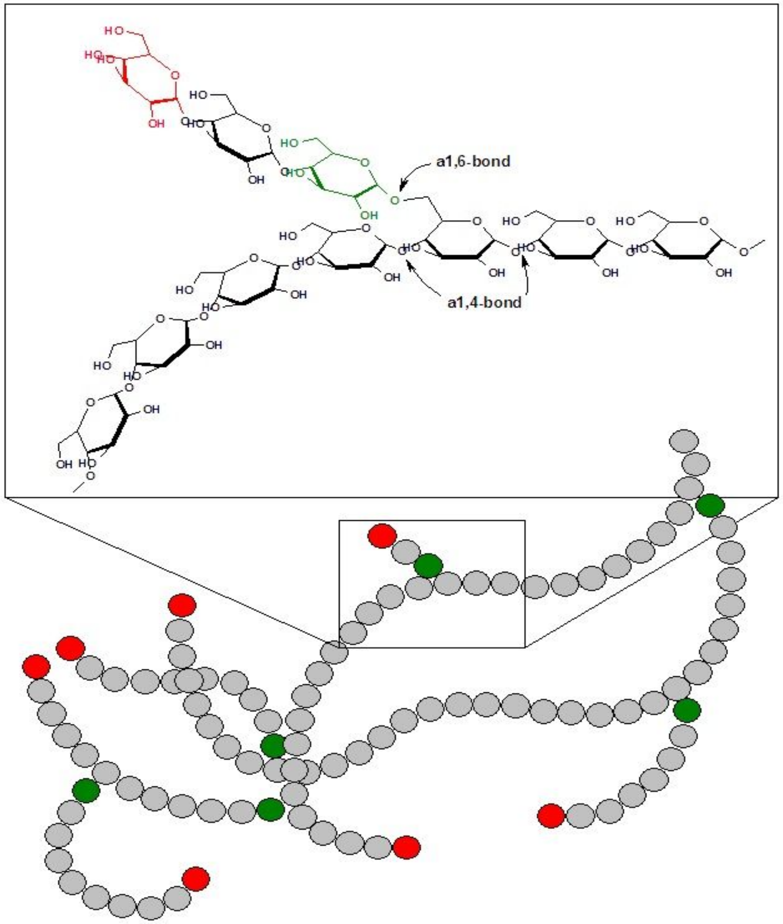
Starch grains in raw potatoes



Biomolecules: Carbohydrates
Polysaccharides

Glycogen

- Storage form of glucose in animals. Hydrolysis of glycogen releases glucose when the demand of sugar increases, providing energy.
- Glycogen helps maintaining glucose blood concentration constant, by releasing sugar in the blood stream if needed. If there is too much sugar in the blood, some of the glucose can be converted back to glycogen to save for later



Biomolecules: Carbohydrates
Polisaccharides: Cellulose

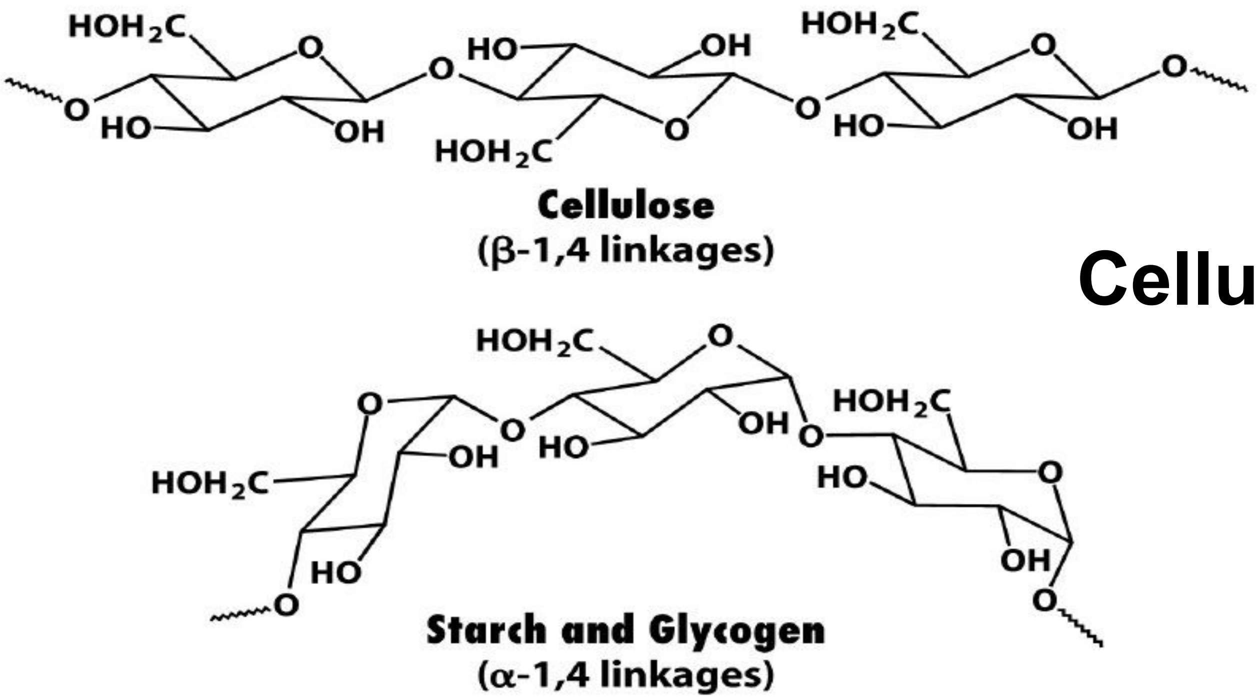
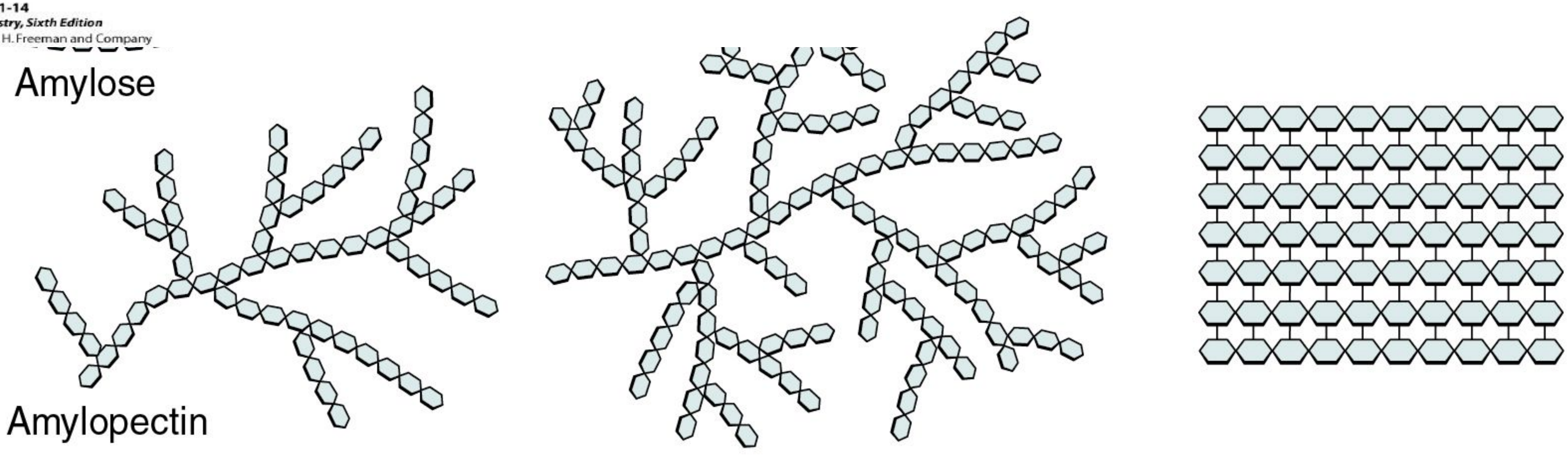


Figure 11-14
Biochemistry, Sixth Edition

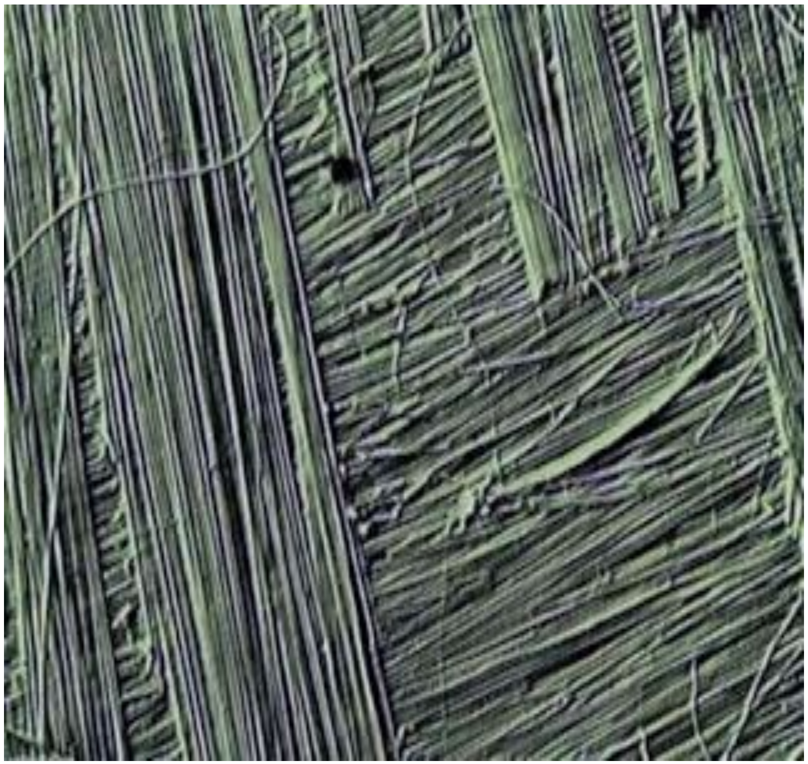
Cellulose is a polymer of beta-glucose



Starch **Glycogen** **Cellulose (fiber)**

CELLULOSE

- makes up 50% of the plant cell wall
- about 2000 chains mass together to form microfibrils, which are visible under an electron microscope



Types of Complex Carbohydrates

- **Cellulose** – known as fiber in the diet
  - Provides bulk in food – good for digestive functioning
  - Cannot be a food source for humans like it is for cows or termites since humans lack the digestive enzymes needed to digest

  - Forms rigid structure of plants – strings in celery and membranes surrounding kernels of corn are largely made up of cellulose.

Chitin

- - Found in arthropod exoskeletons and fungal cell walls
- - Long chains of beta-glucose, but on each monomer the OH-group is substituted by a nitrogenous group (NHCOCH3)

Lipids

Lipids

- Lipids are a very varied group of chemicals
- They are all organic molecules that are insoluble in water
- The most familiar lipids are fats and oils
- Fats are solid at room temperature, while oils are liquid

Major Classes of Lipids

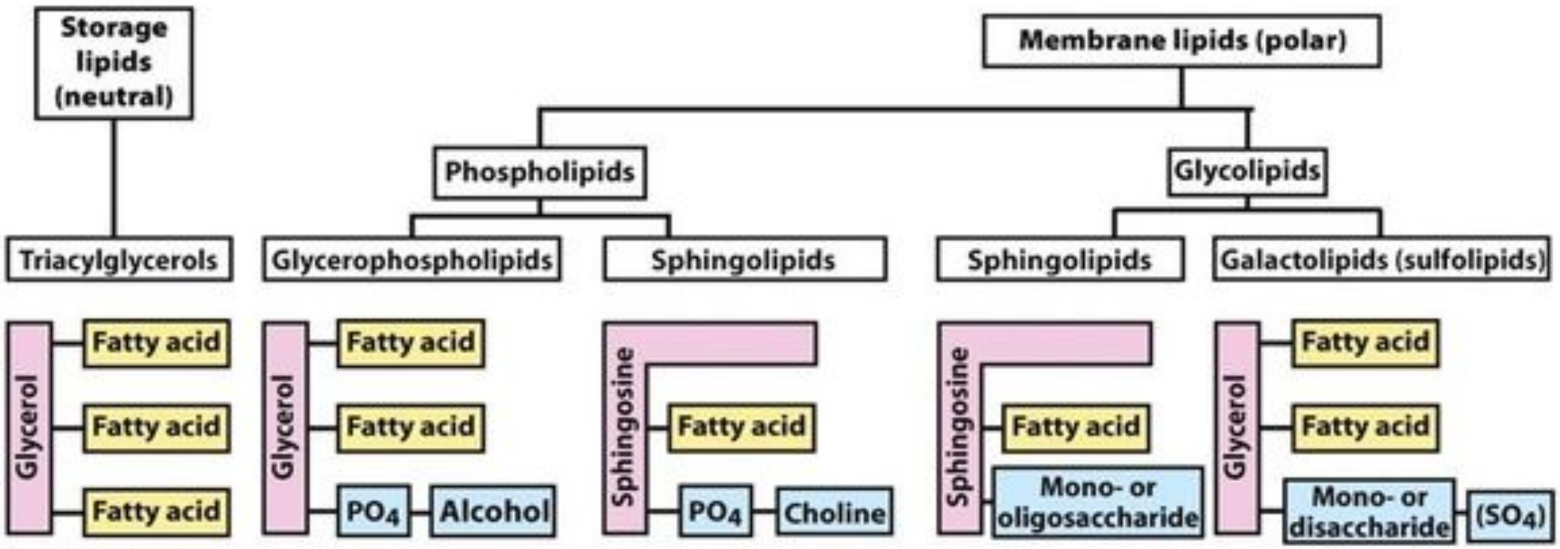
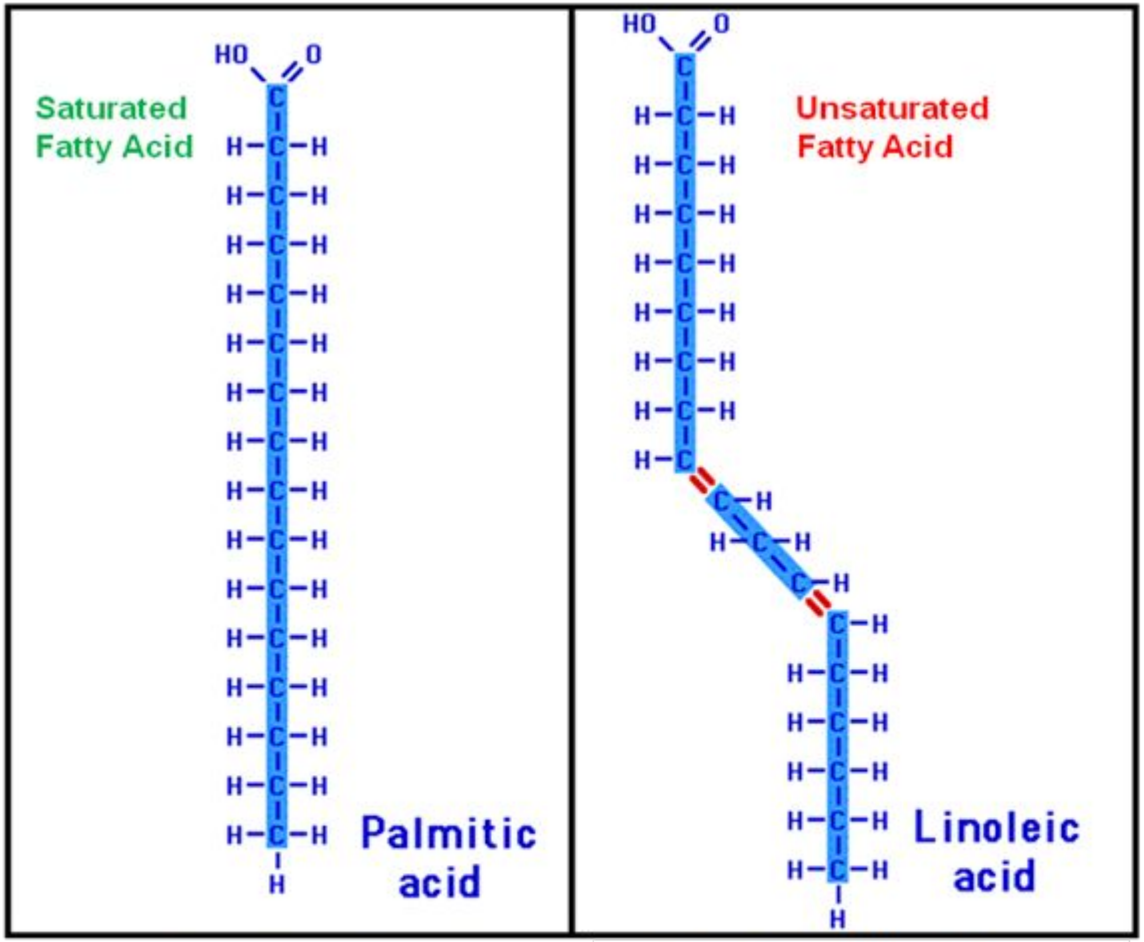


Figure 10-7
Lehninger Principles of Biochemistry, Fifth Edition

Biomolecules: Lipids
Fatty acid



Type of Fatty Acid	Double Bonds	Diagram
Saturated	None	
Monounsaturated	One	
Polyunsaturated	Multiple (>1)	

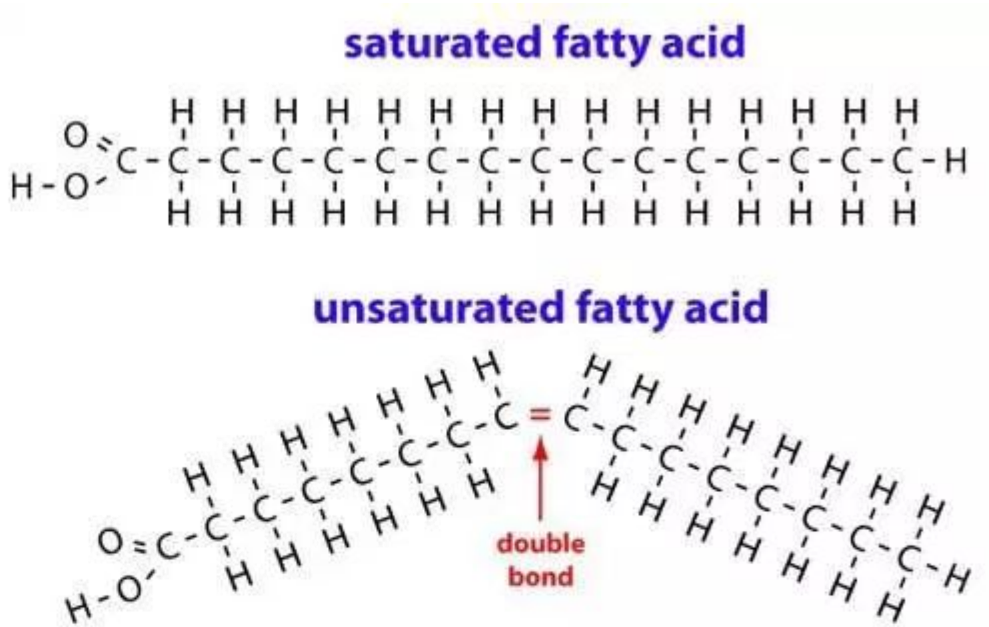
Saturated Fatty acid

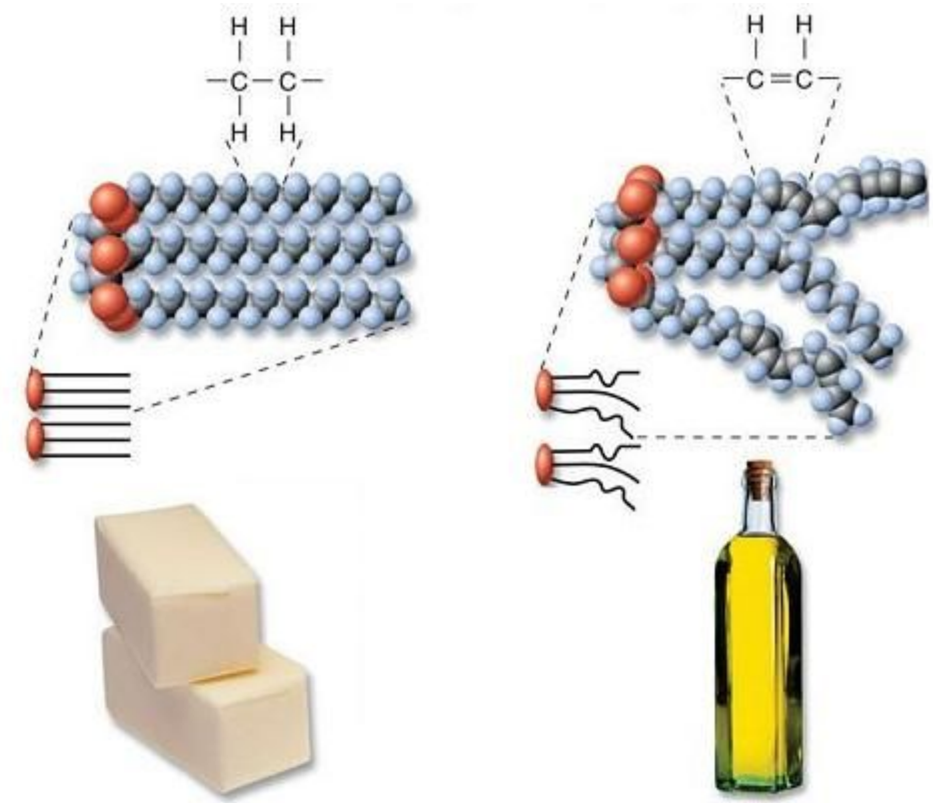
- Contain only single C–C bonds
- Closely packed
- Strong attractions between chains
- High melting points
- Solids at room temperature

Unsaturated Fatty acid

- Contain one or more double C=C bonds
- Nonlinear chains do not allow molecules to pack closely
- Few interactions between chains
- Low melting points
- Liquids at room temperature

Saturated fatty acid/unsaturated fatty acid





(b) Hard fat (saturated): Fatty acids with single bonds between all carbon pairs

(c) Oil (unsaturated): Fatty acids that contain double bonds between one or more pairs of carbon atoms

Saturated fatty acid/unsaturated fatty acid

FATS

THE GOOD, THE BAD & THE UGLY

American Heart Association | American Stroke Association
life is why™

Monounsaturated & Polyunsaturated Fats

- Can lower bad cholesterol levels
- Can lower risk of heart disease & stroke
- Can provide essential fats that your body needs but can't produce itself

SOURCE

Plant-based liquid oils, nuts, seeds and fatty fish

EXAMPLES

- **Oils** (such as canola, olive, peanut, safflower and sesame)
- **Avocados**
- **Fatty Fish** (such as tuna, herring, lake trout, mackerel, salmon and sardines)
- **Nuts & Seeds** (such as flaxseed, sunflower seeds and walnuts)

Saturated Fats

- Can raise bad cholesterol levels
- Can raise good cholesterol levels
- Can increase risk of heart disease & stroke

SOURCE

Most saturated fats come from animal sources, including meat and dairy, and from tropical oils

EXAMPLES

- **Beef, Pork & Chicken Fat**
- **Butter**
- **Cheese** (such as whole milk cheeses)
- **Tropical Oils** (such as coconut, palm kernel and palm oils)

Hydrogenated Oils & *Trans* Fats

- Can raise bad cholesterol levels
- Can lower good cholesterol levels
- Can increase risk of heart disease & stroke
- Can increase risk of type 2 diabetes

SOURCE

Processed foods made with partially hydrogenated oils

EXAMPLES

- **Partially Hydrogenated Oils**
- **Some Baked Goods**
- **Fried Foods**
- **Stick of Margarine**

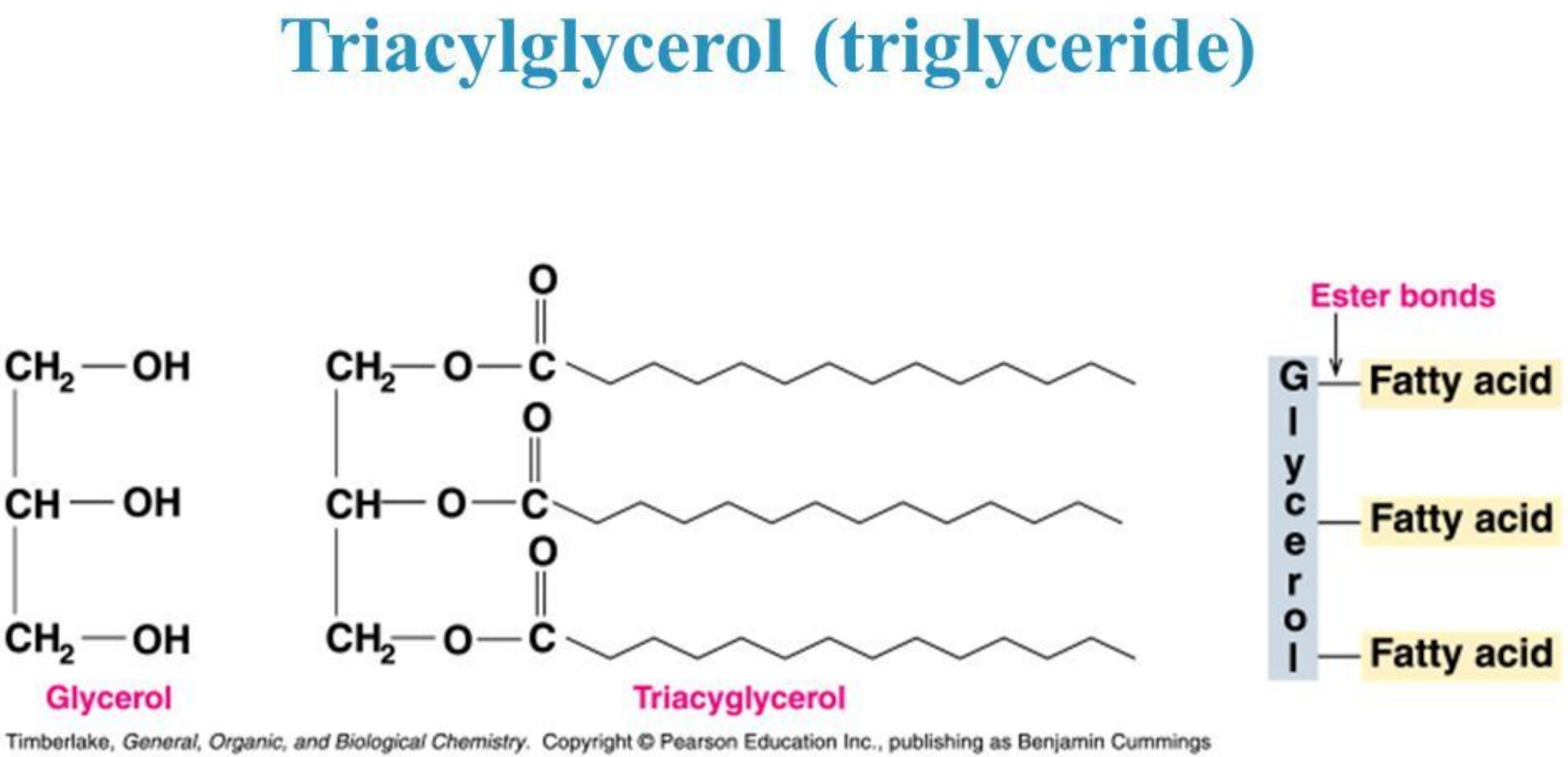
American Heart Association **Recommendation**

Eat a healthy dietary pattern that:

Includes **good fats** | *Limits* **saturated fats** | *Keeps trans fats* as **LOW** as possible

For more information, go to **heart.org/fats**

Biomolecules: Lipids
Triglycerides

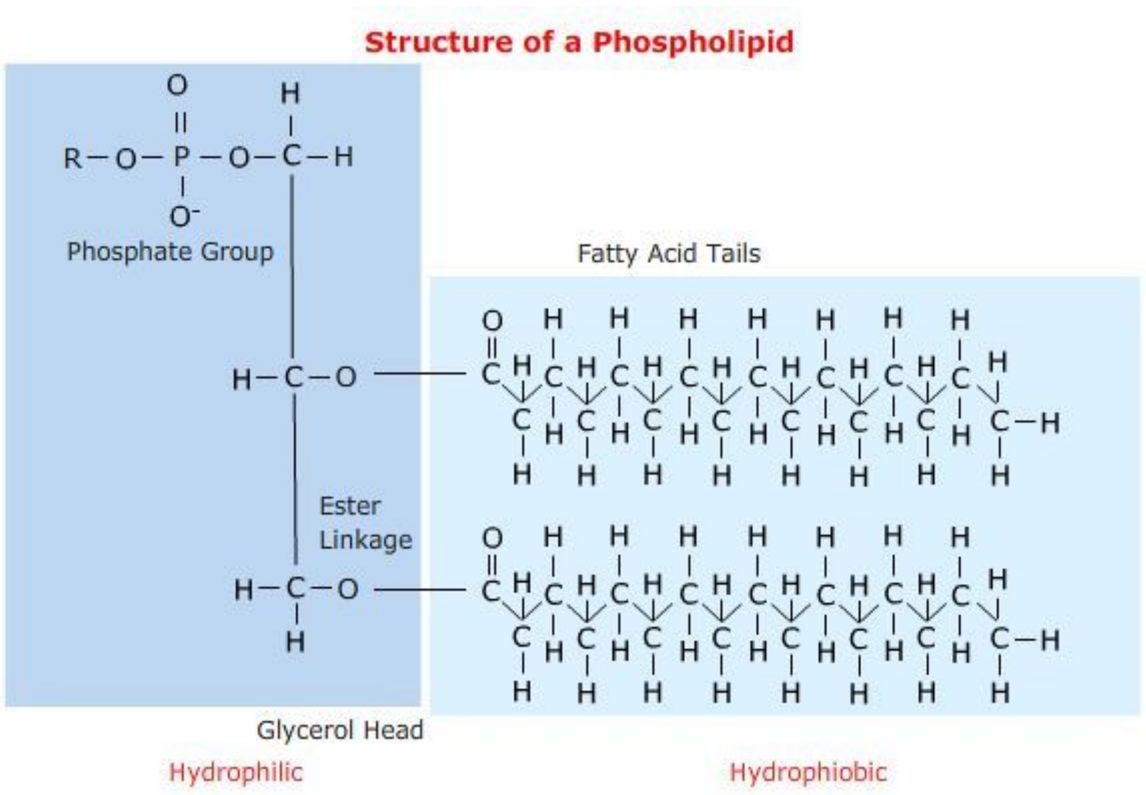


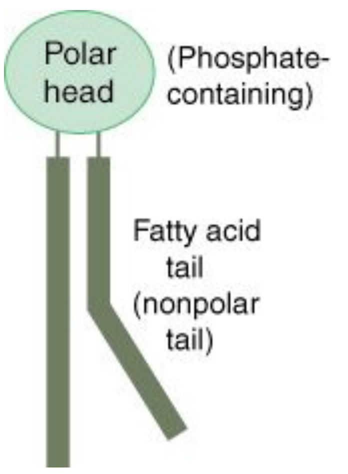
Triacylglycerol: Energy storage in adipocytes as fat droplets
Fats are good insulator against cold temperatures in animals that live in the cold or hybernate.

Roles of triglycerides

- Energy source- Lipids contain twice the enrgy content as carbohydrates
- Waterproofing- Lipids are insoluble, some plants have a waxy cuticle to keep out the water from leaves
- Insulation- Fats are good insulators to retain heat
- Protection- Fats are often stored around internal organs to protect them

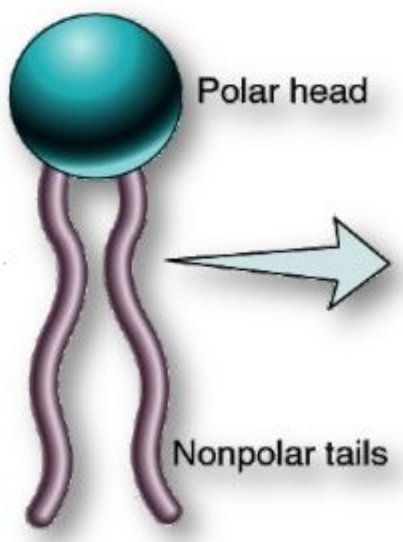
Biomolecules: Lipids
Phospholipids





Biomolecules: Lipids
Phospholipids

Phospholipid Structure

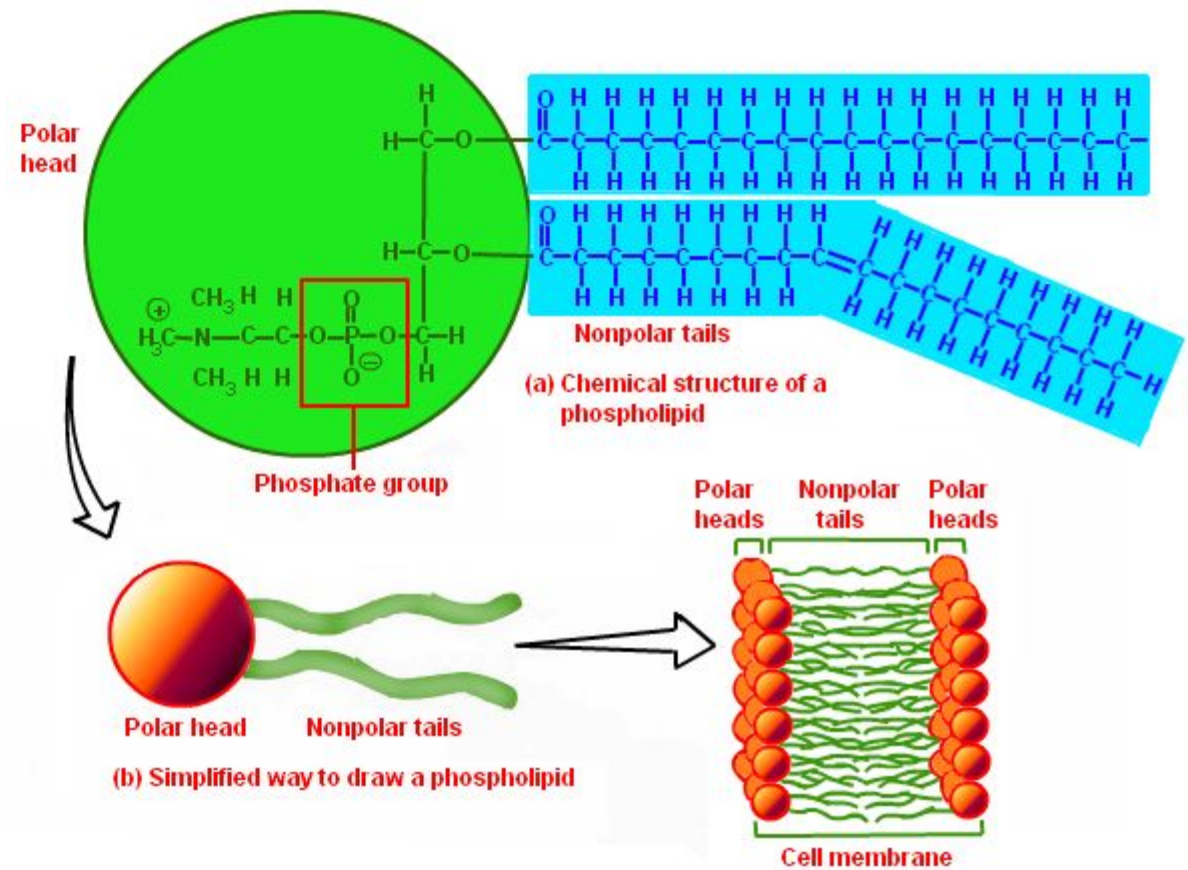


Head
- Polar
- Hydrophilic
- Glycerol & phosphate

Tails
- Nonpolar
- Hydrophobic
- 2 Fatty acids

Biomolecules: Lipids
Phospholipids

Cell membranes are composed of a phospholipid bilayer



Phospholipids are arranged in 2 layers (bilayer)

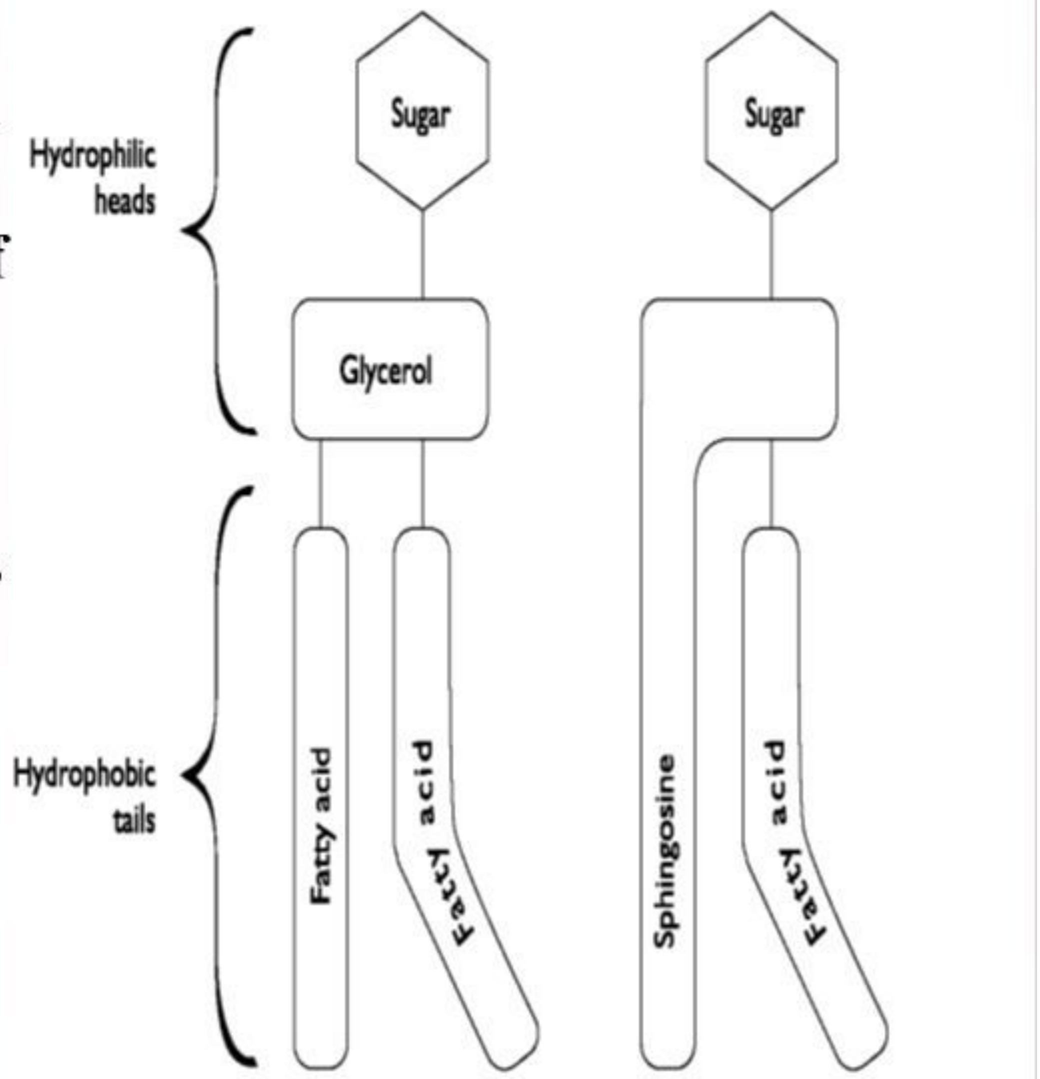
- **They arrange themselves so that the hydrophobic tails face away from water**
- **Bilayer is held together by weak hydrophobic interactions**
- **The lipid bilayer is flexible but strong**

Biomolecules: Lipids
Glicolipids

- They differ from phospholipids in hat glycolipids have a sugar, such s **glucose or galactose, instead of he phosphate-containing head.**

- found on the outer surface of the lasma membrane with their sugars xposed at the cell surface.

- **Function:** Cell – cell recognition.



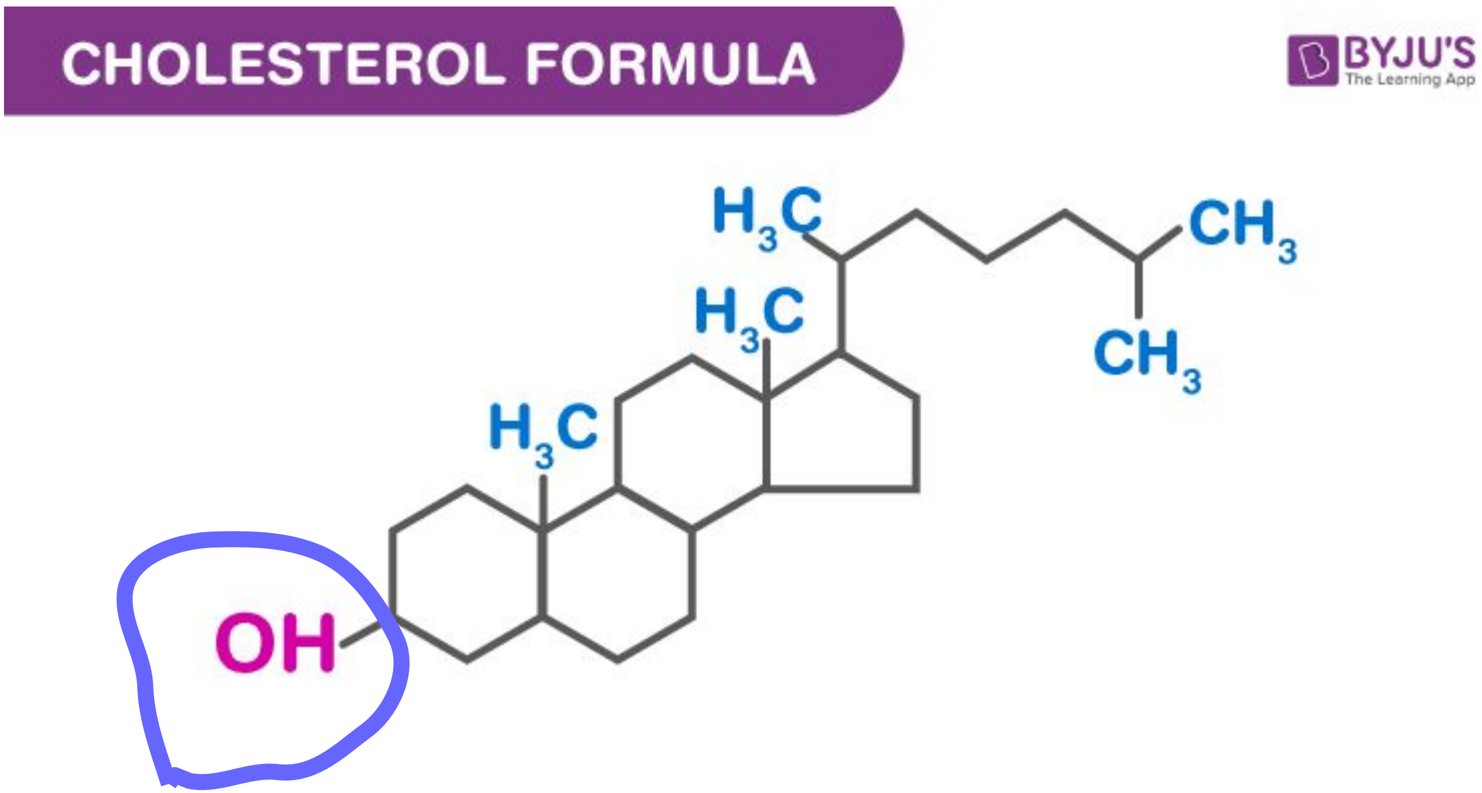
(a) Typical of glycolipid in animal membranes

(b) Typical of glycolipid in bacterial and plant membranes

Biomolecules: Lipids
Wax and steroids

Waxes and Steroids

- Wax – a type of structural lipid
  - A long fatty acid chain joined to a long alcohol chain.
  - Waterproof, protective coating
- Steroids – composed of four fused carbon rings with various functional groups
  - Cholesterol is an important one

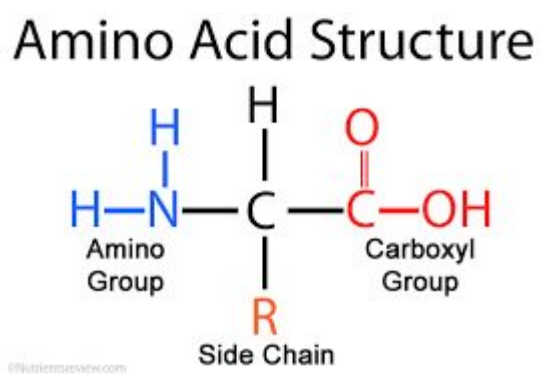


Water soluble region

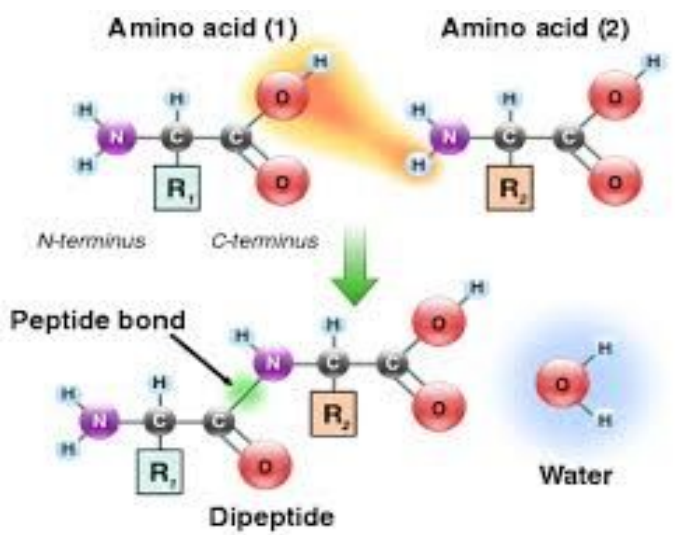
Proteins

Biomolecules: Proteins

- Proteins are polymers of amino acids
- Amino acid are formed mainly of carbon, hydrogen, oxygen and nitrogen
- Nitrogen is the characteristic component of proteins



Two amino acids condensate to form a dipeptide (peptide bond)

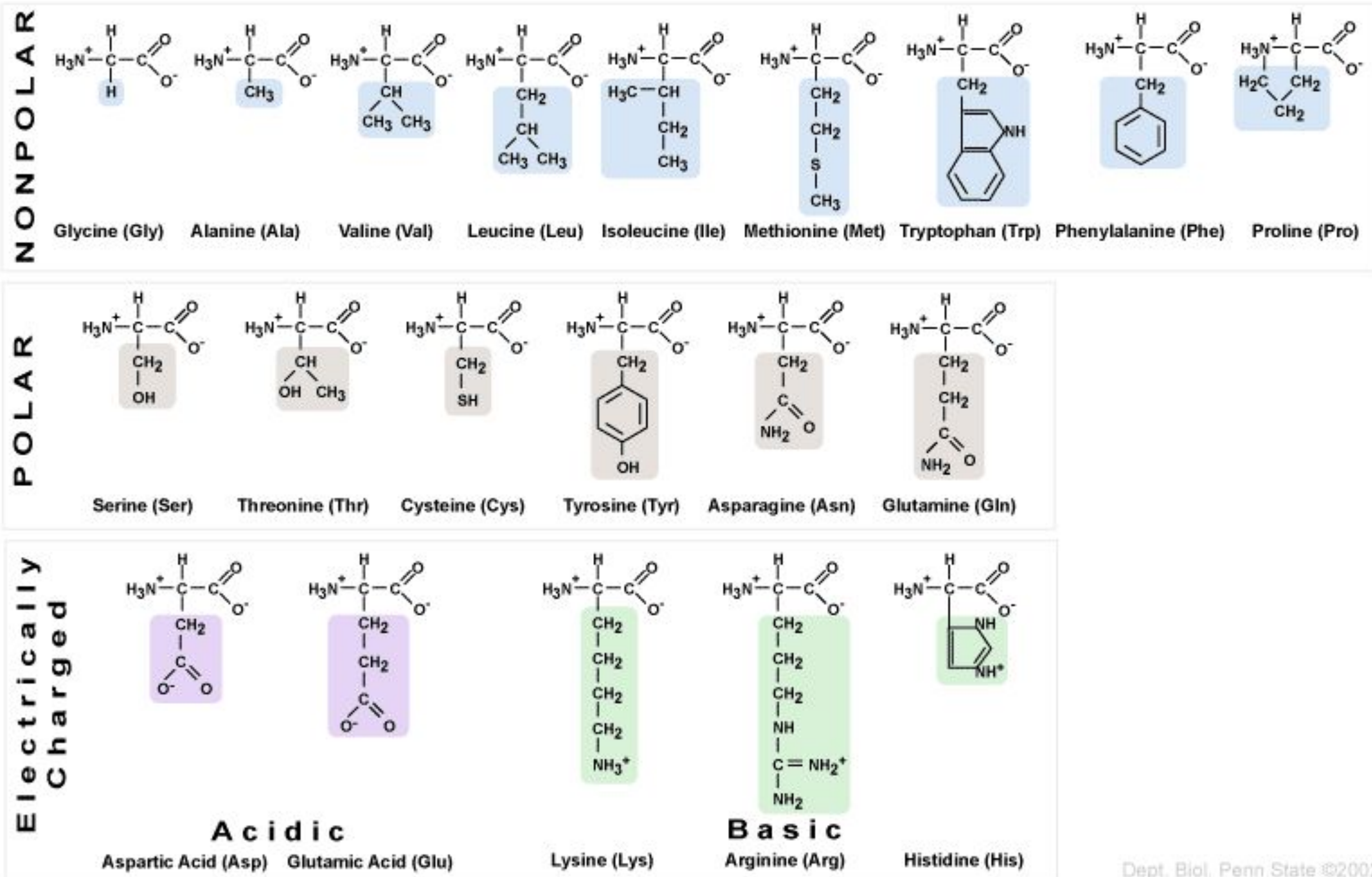


3 amino acids=tripeptide

more amino acids=polipeptide

more than 50 amino acids= protein

Biomolecules: All proteins are made up by a combination of 20 Aminoacids

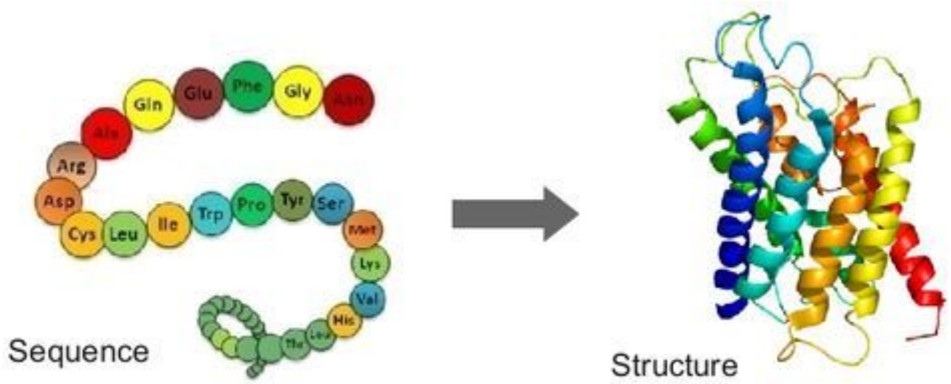


Biomolecules: Essential aminoacids

Arginine and Histidine are semi-essential. They can be synthesized by adults but not by growing children

Biomolecules: Proteins

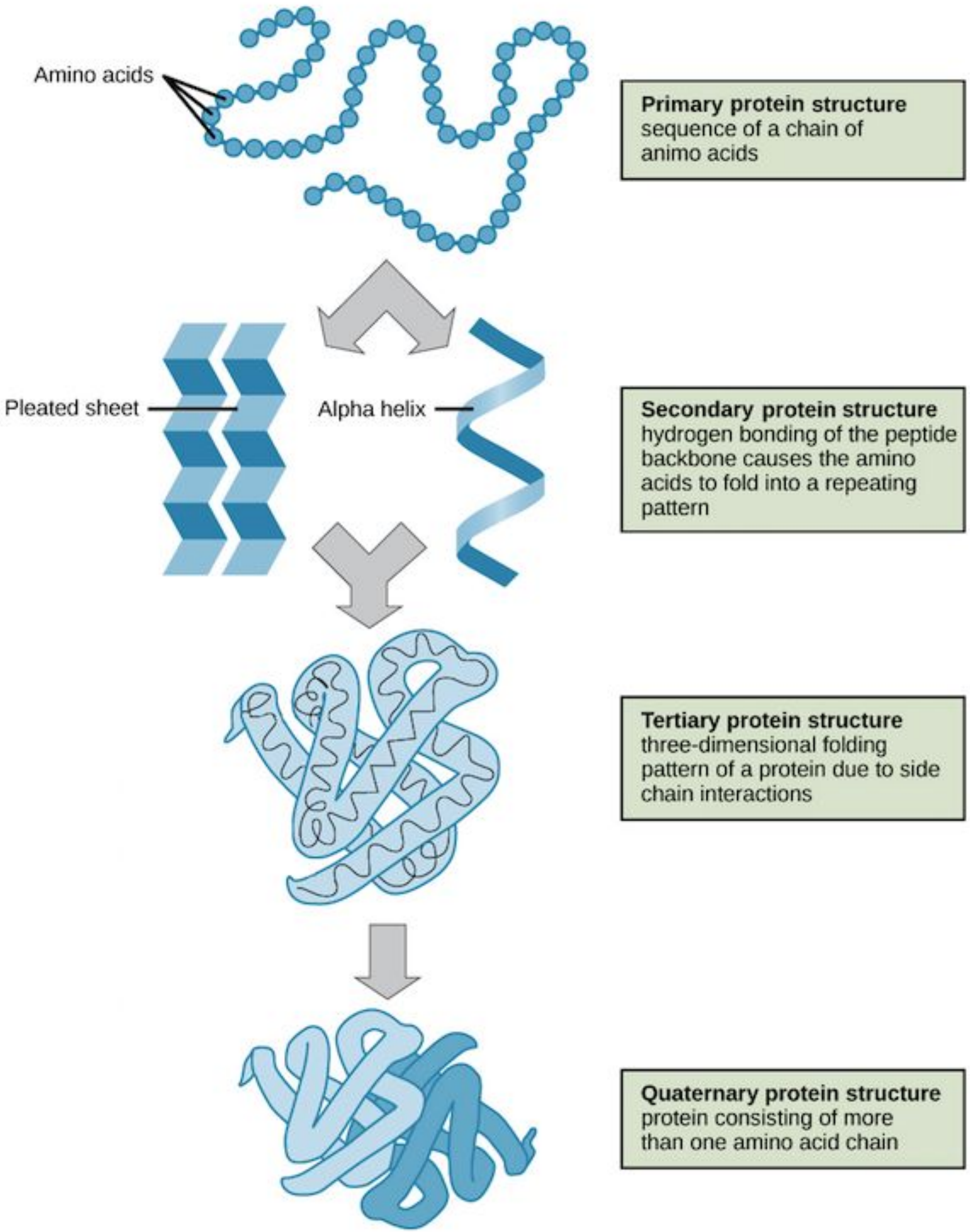
- Each protein is made of molecules with amino acids in a precise order. Even a small difference in the order of the amino acids makes a different proteins.



- The long chains of amino acids can curl up into different shapes. The way in which the chain curls up (the 3D structure) is determined by the sequence of the amino acids in the chain.

- The shape of the protein directly affects their function

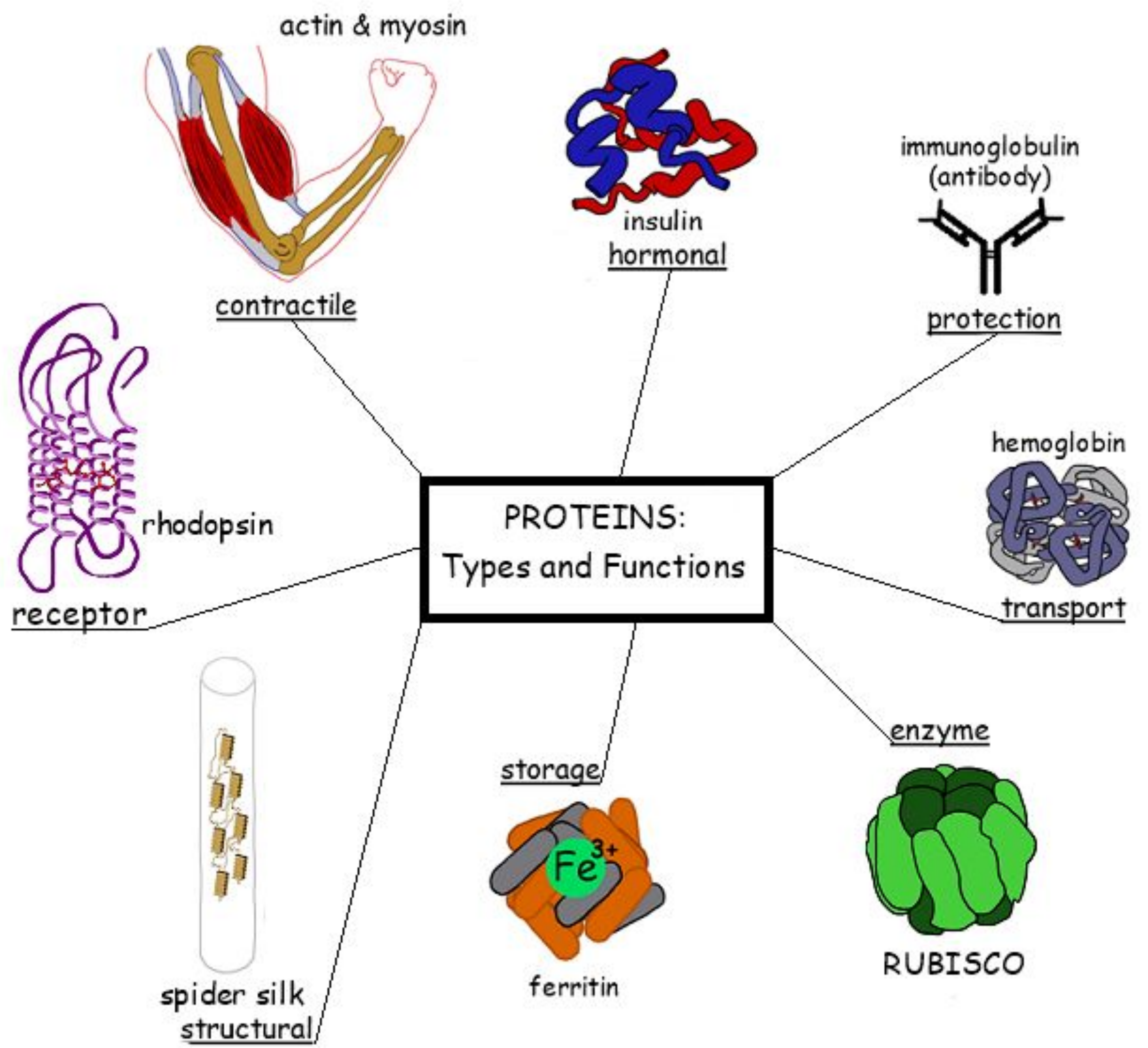
Biomolecules: Proteins



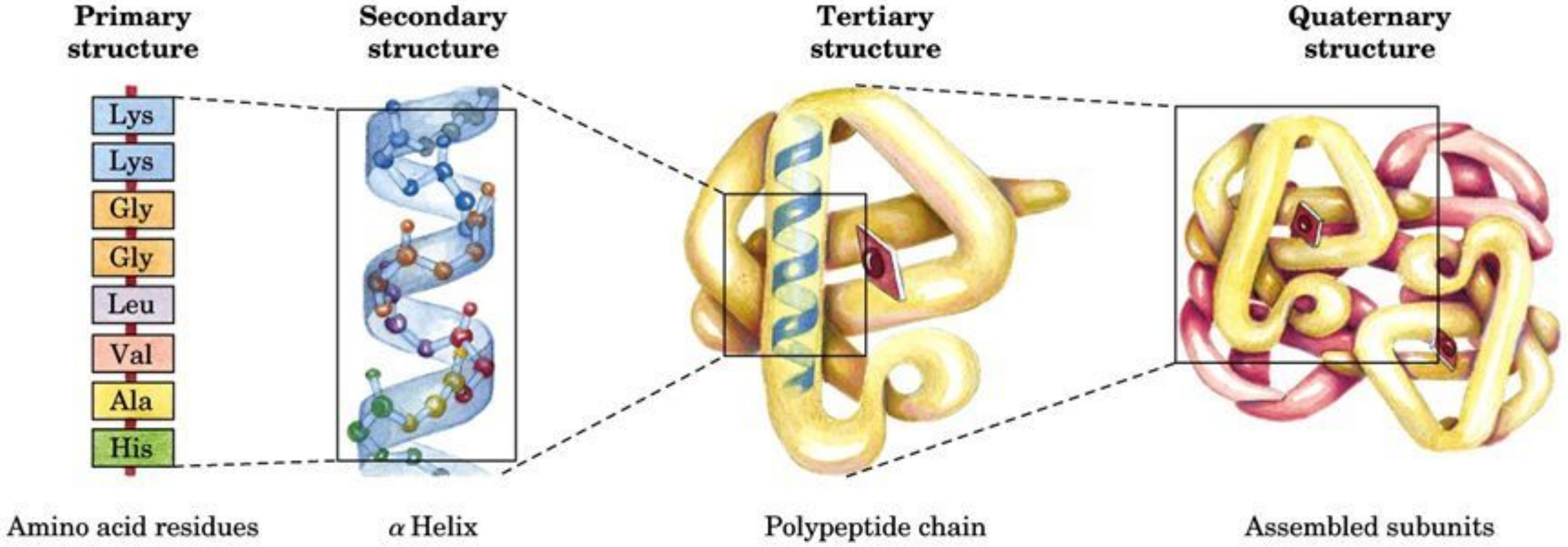
Protein structure

Primary
Secondary
Tertiary
Quaternary

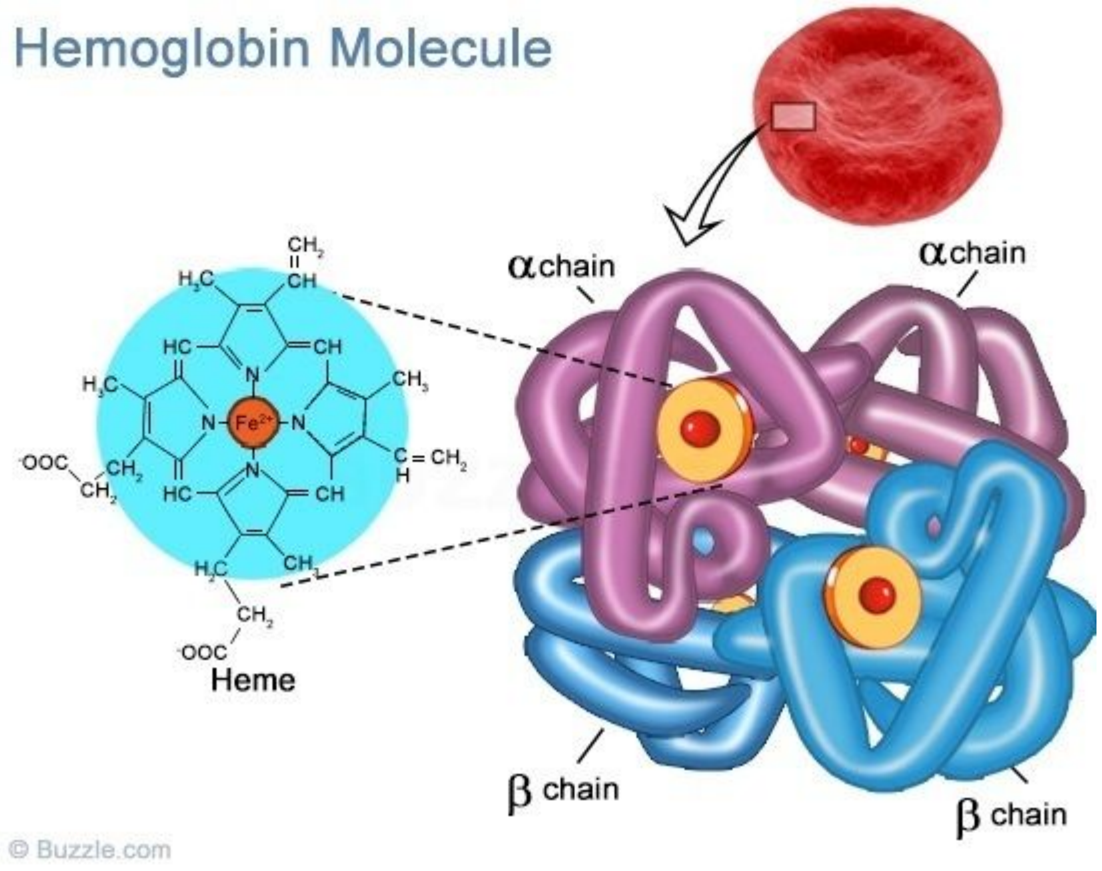
Biomolecules: Functions of Proteins



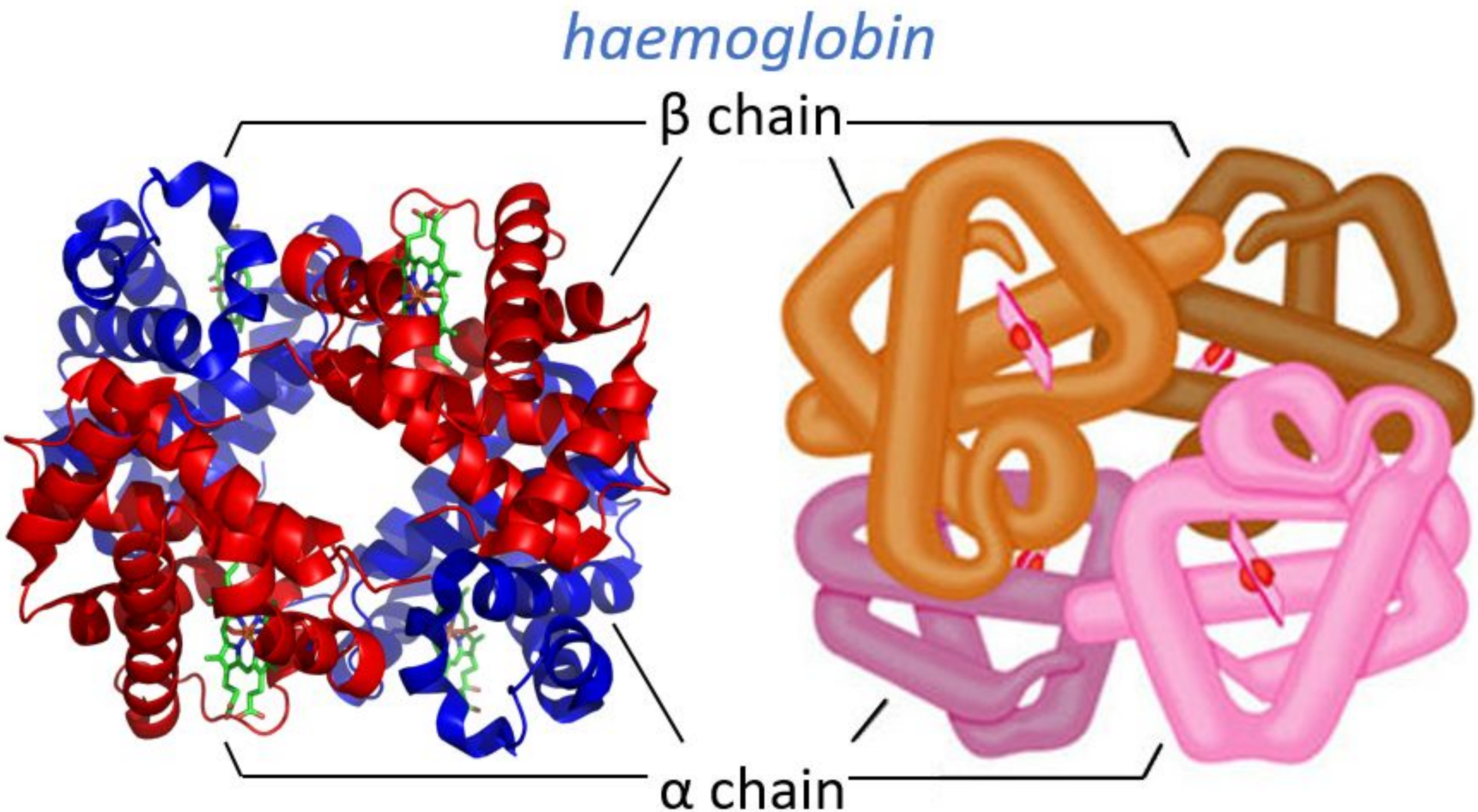
Levels of Protein Structure



Haemoglobin

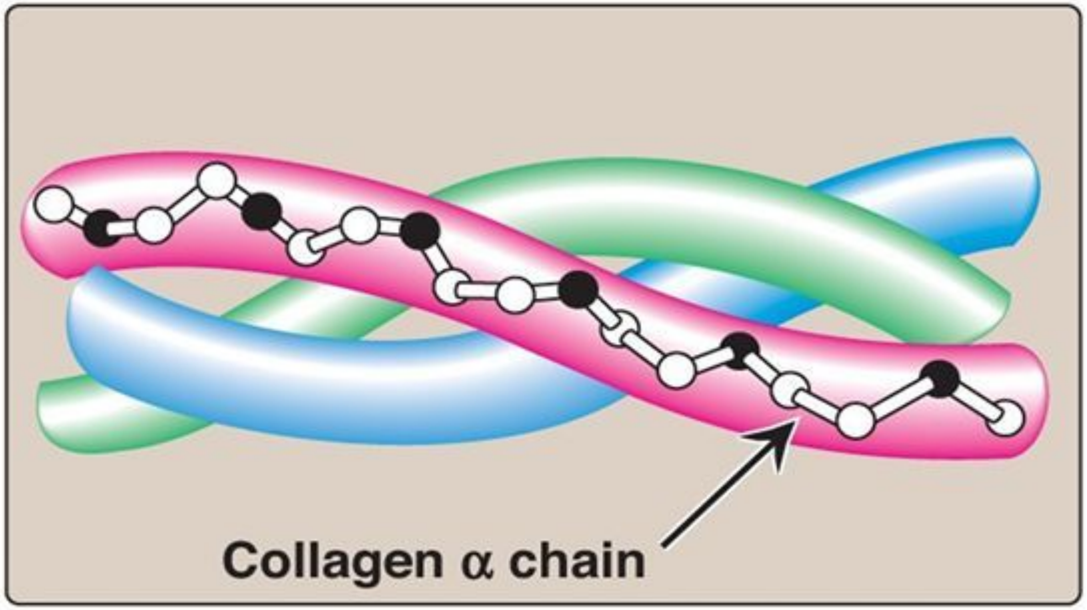


Haemoglobin structure

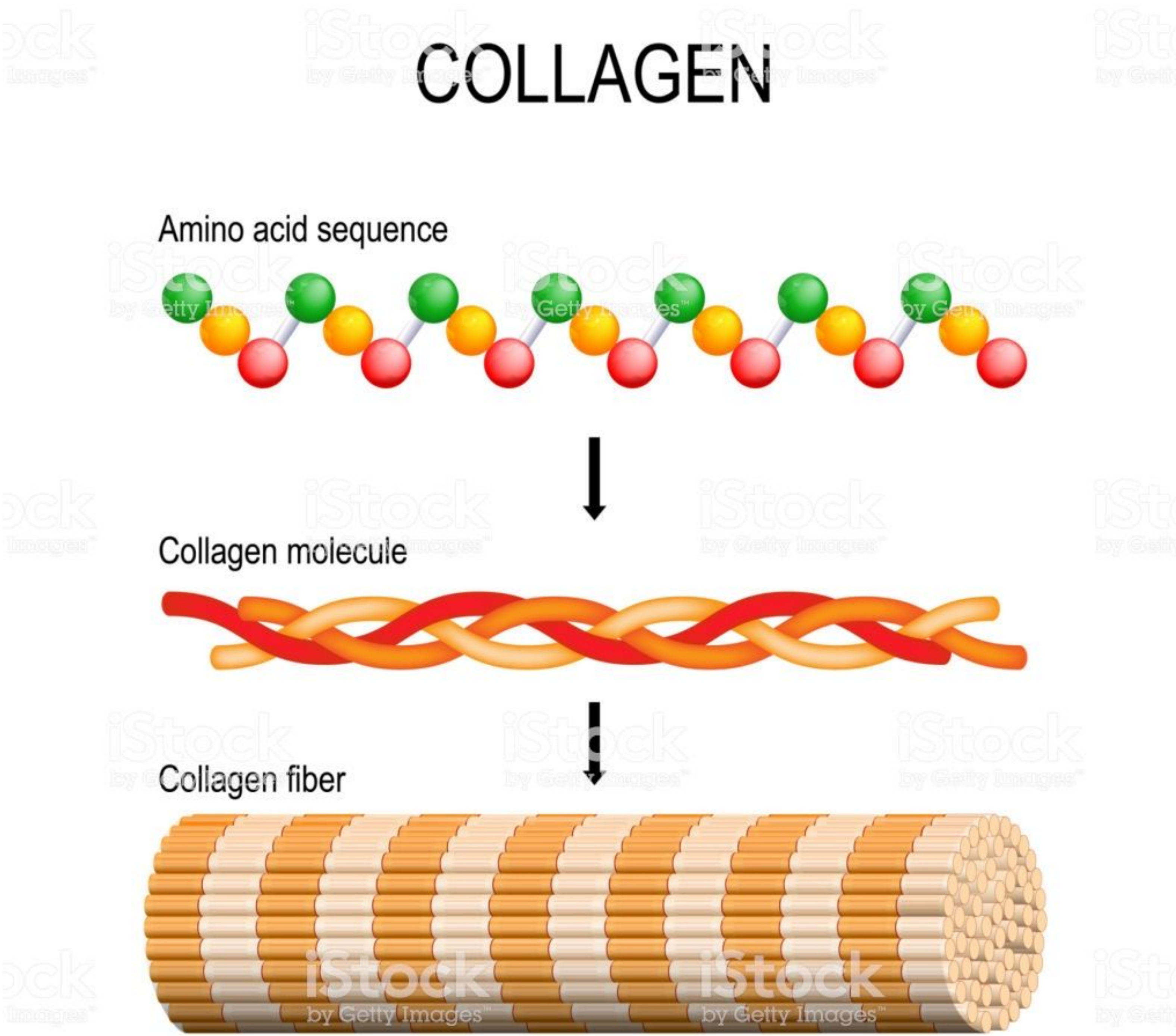


II. COLLAGEN

- Collagen is the most abundant protein in the human body.
- A typical collagen molecule is a long, rigid structure in which three polypeptides (referred to as α chains) are wound around one another in a rope-like triple helix (Figure 4.1).

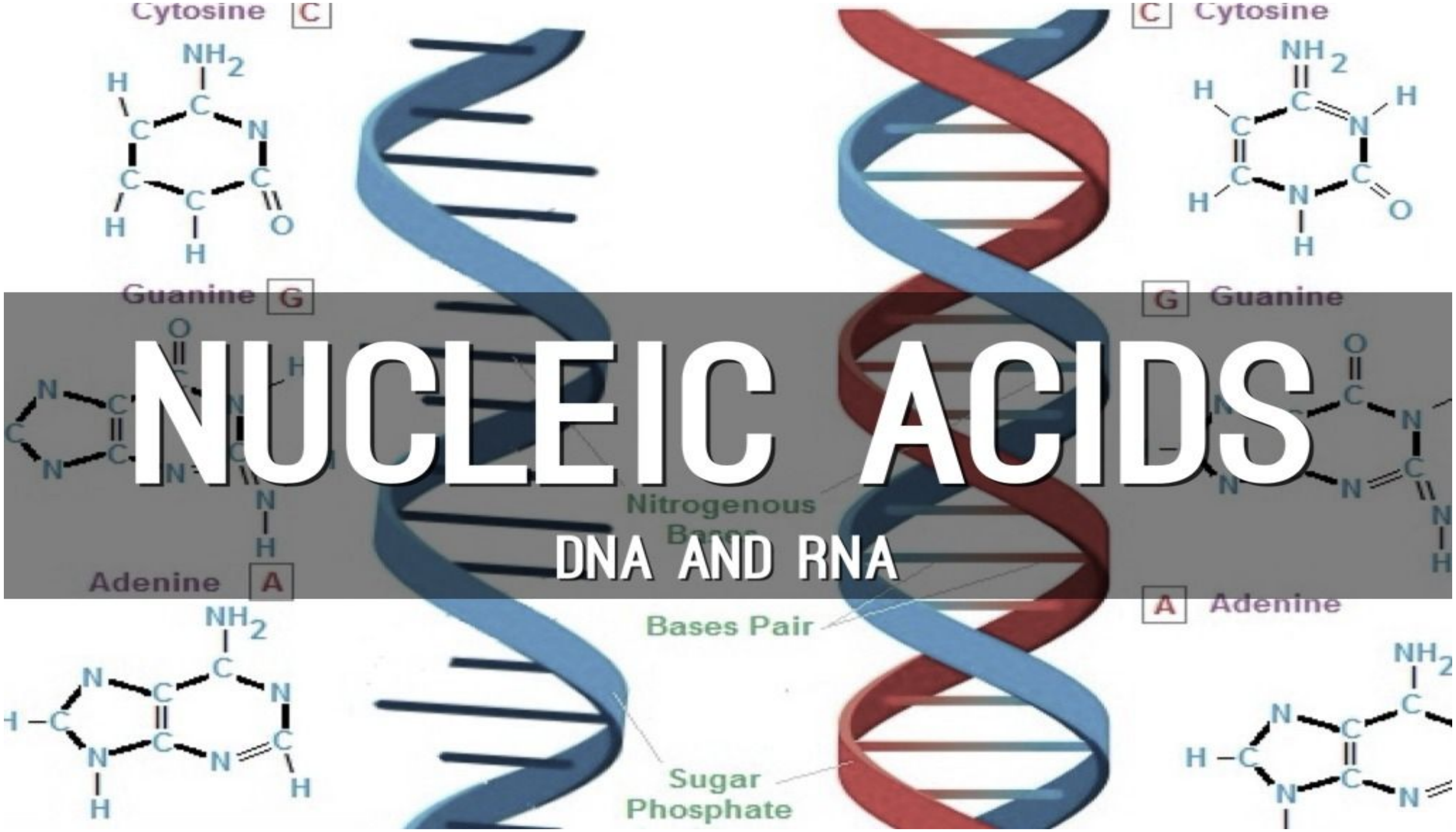


It is mostly found in fibrous tissues such as tendons, ligaments, and skin.



COLLAGEN
Amino acid sequence
Collagen molecule
Collagen fiber

Nucleic acids



Biomolecules: Nucleic acids (DNA and RNA)

- DNA carries the genetic code (genetic material)

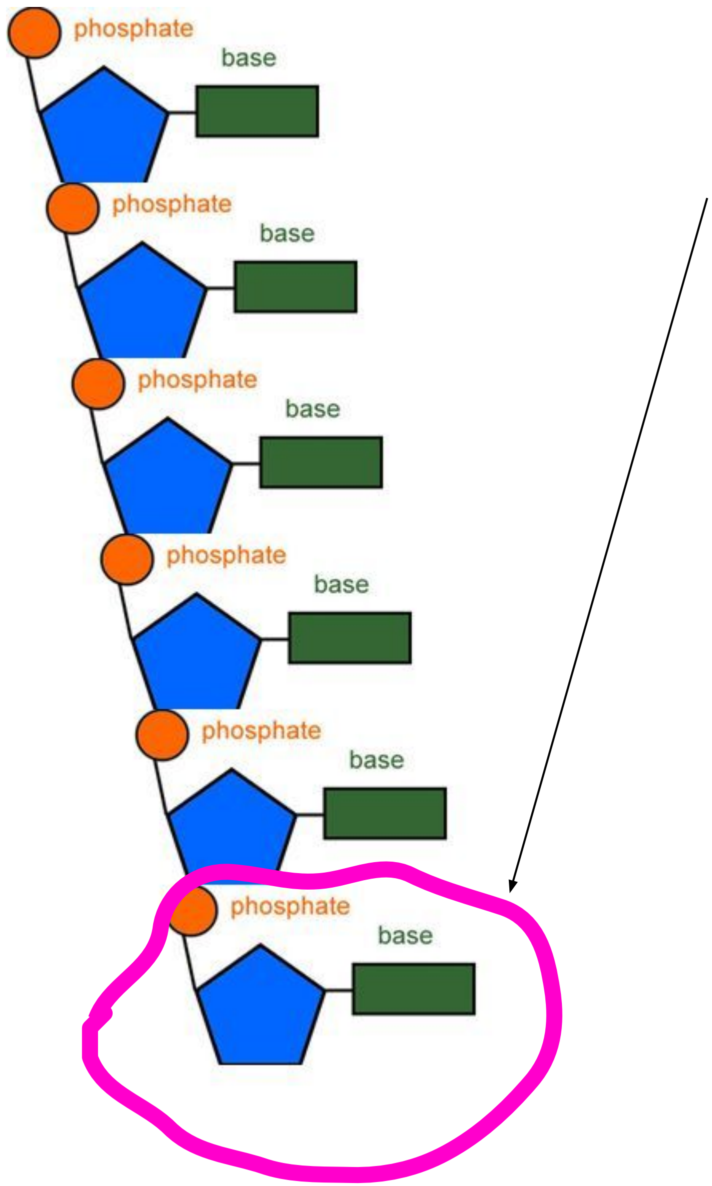
- DNA can replicate and pass on genetic information (hereditary material)

- The sequence of the bases in our DNA provides a code that is used to determine all the kinds of proteins in our body.

- Proteins are required to build an organism and catalyzing all of its biochemical reactions

Biomolecules: Nucleic acids

Nucleic acids are polymers of nucleotides



Monomers link to make polymers!

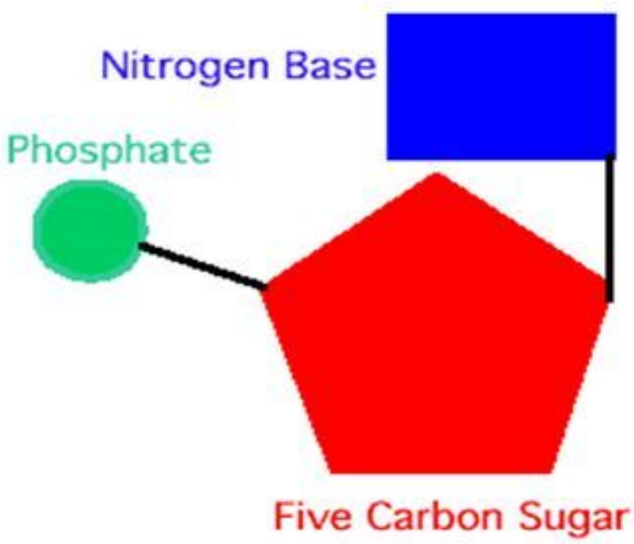
<u>Nucleic Acids</u>

Monomer = Nucleotide

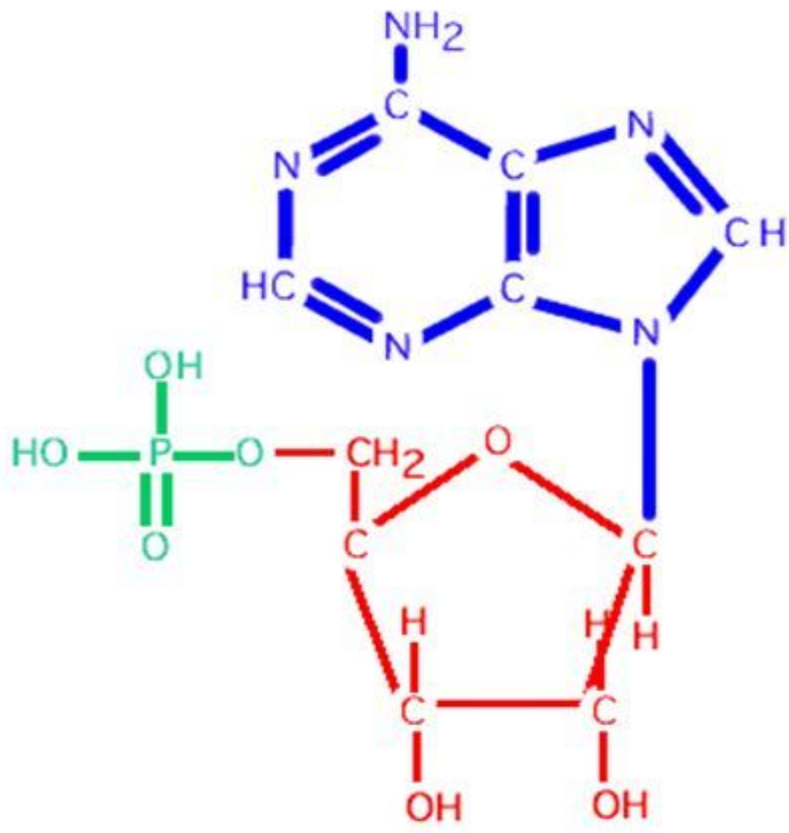
Polymer = Nucleic acid

The monomers of nucleic acids are called nucleotides

Basic Nucleotide Structure



Example



Adenosine 5' phosphoric acid

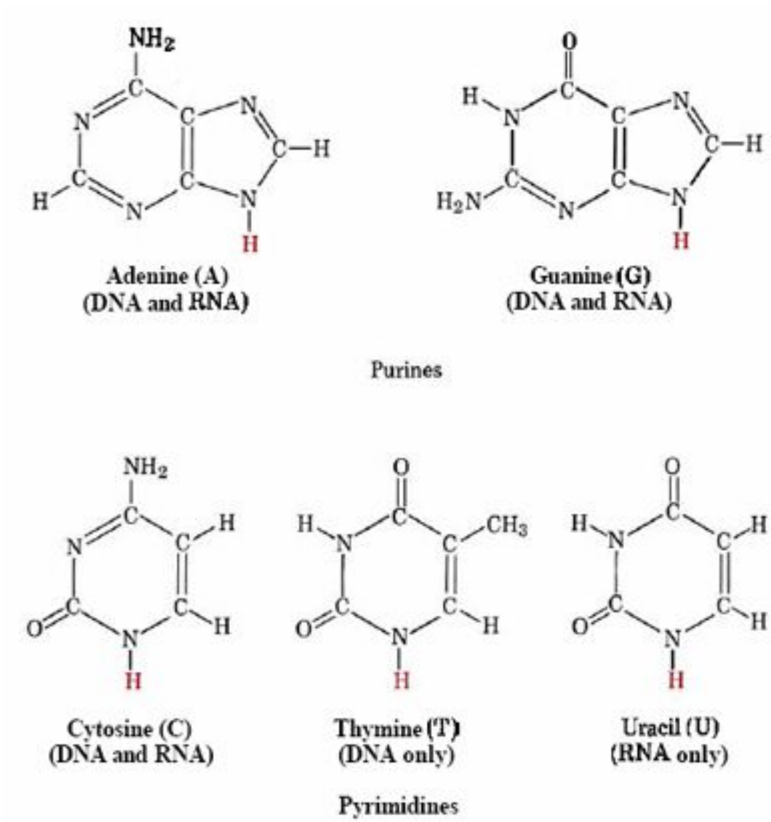
Biomolecules: Nucleic acids

Nitrogenous base are

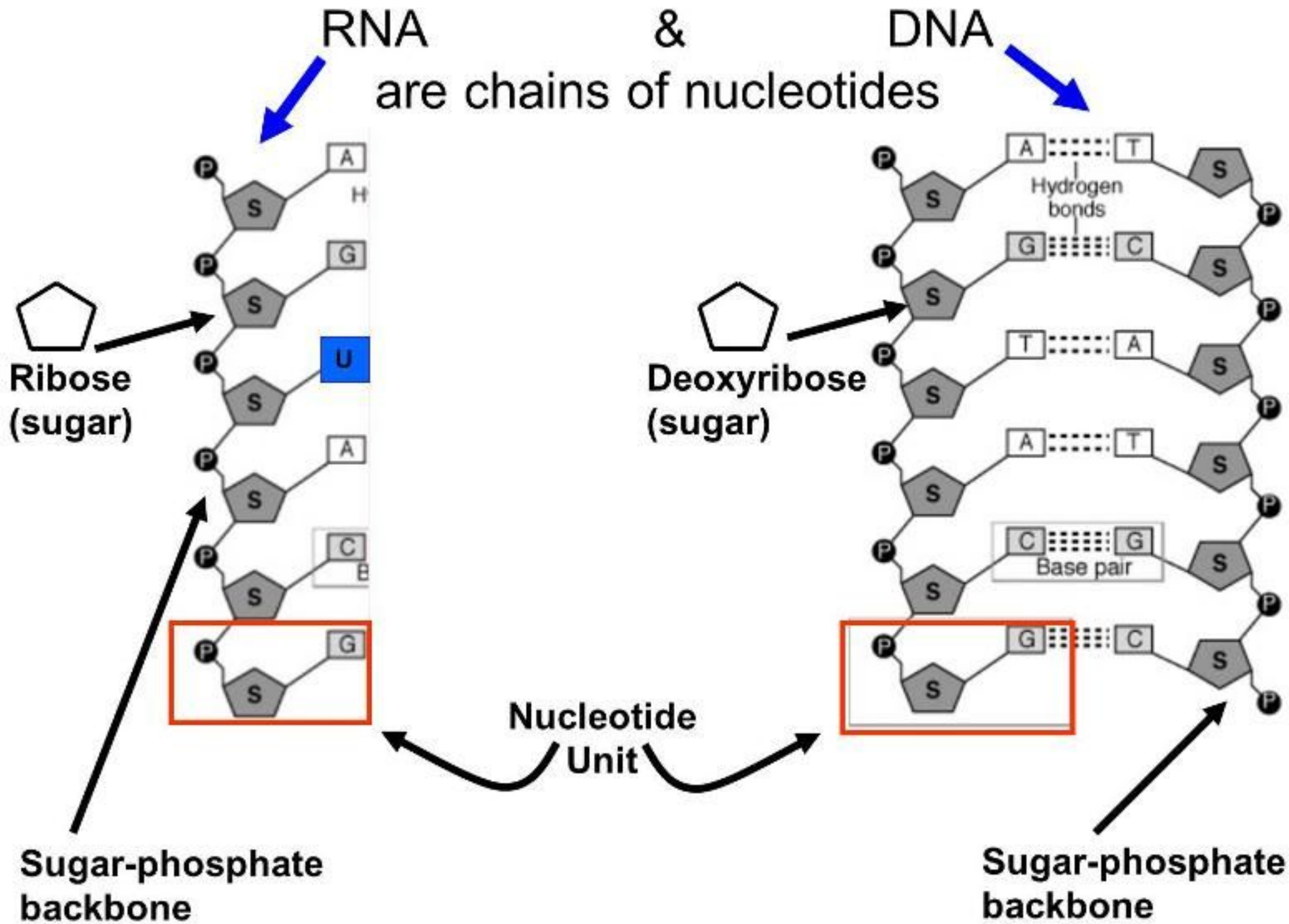
- Purine — **Adenine (A) and Guanine (G)**
- Pirimidine — **Cytosine (C), Thymine (T) and Uracil (U)**

DNA only

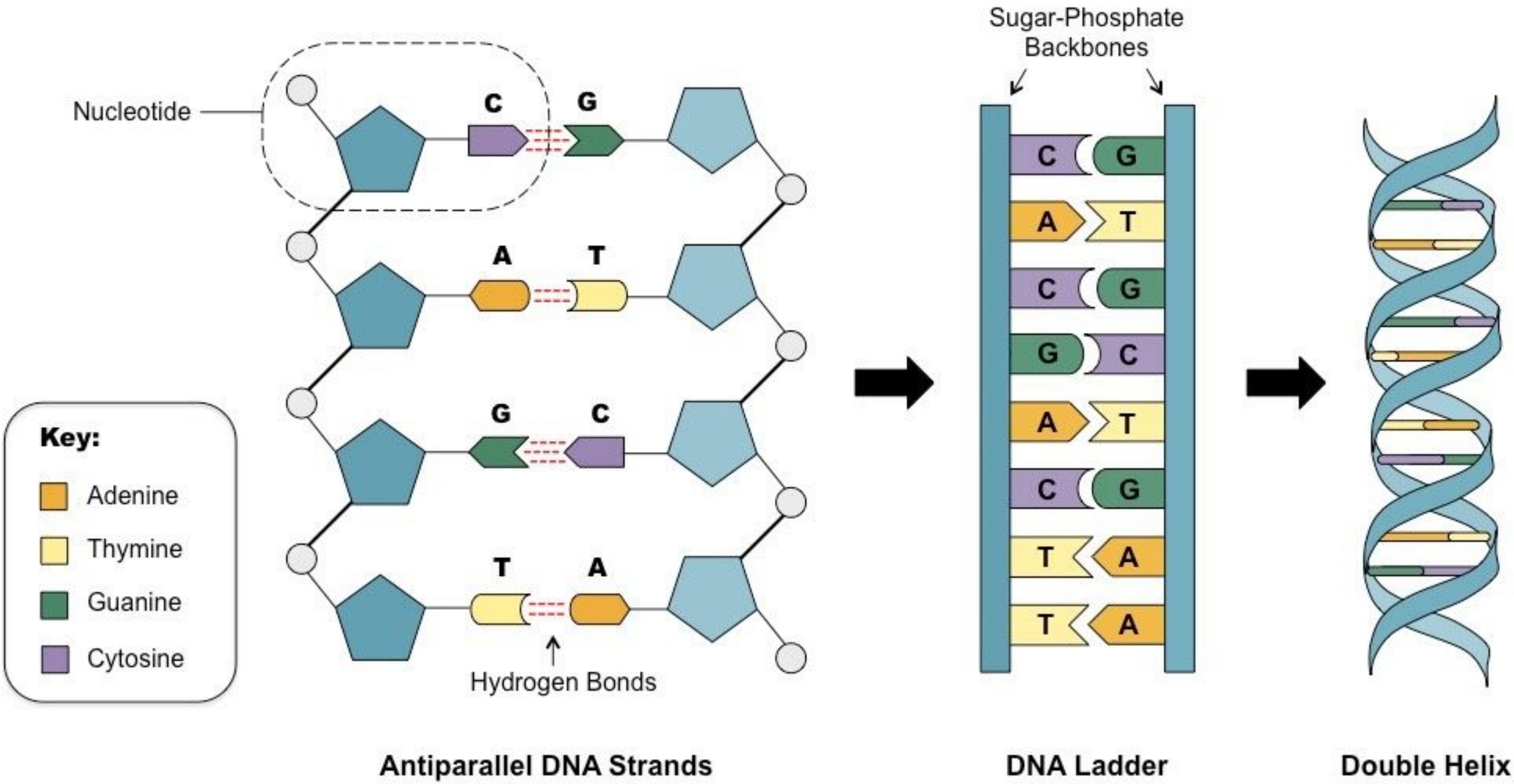
RNA only



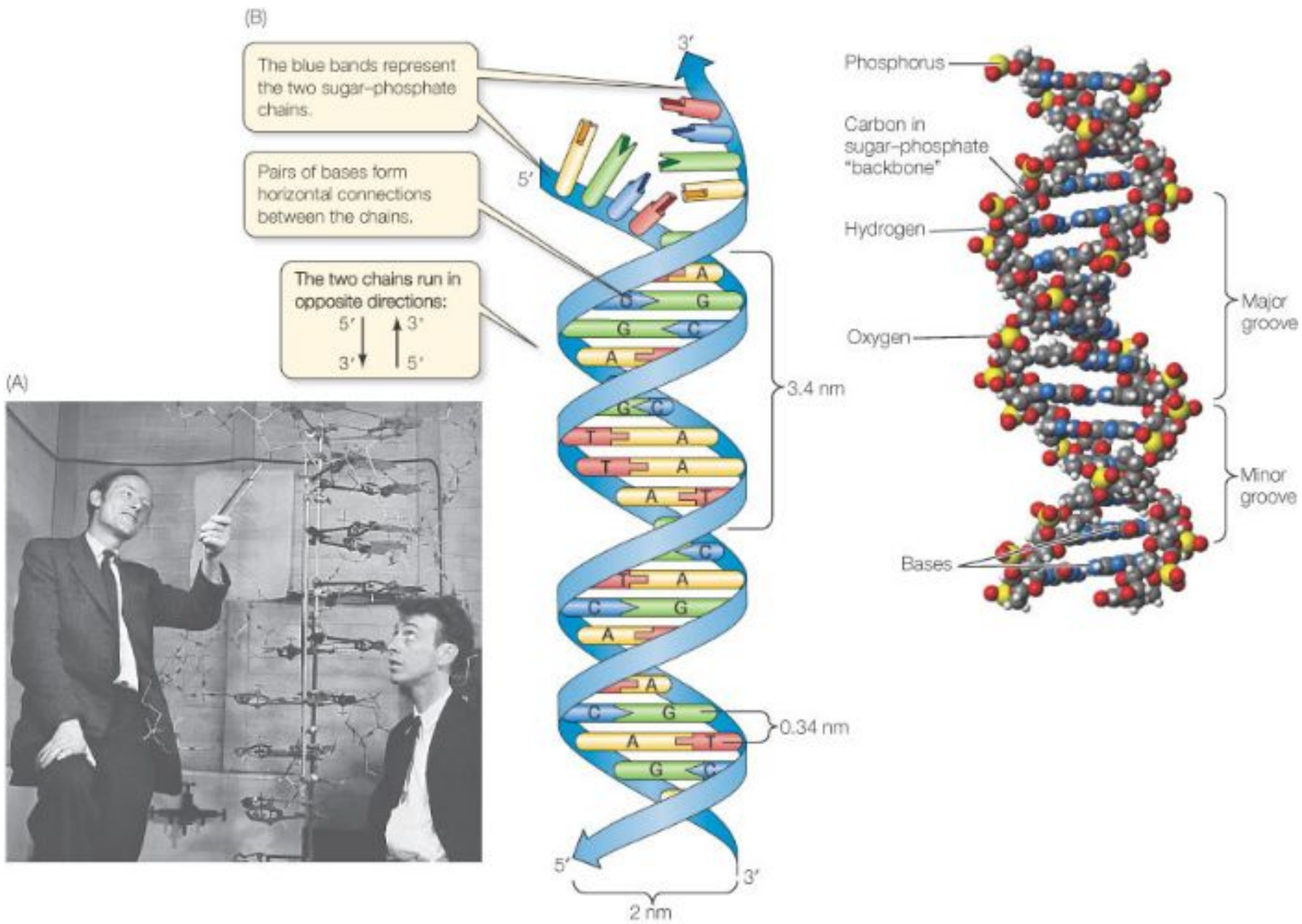
Biomolecules: Nucleic acids



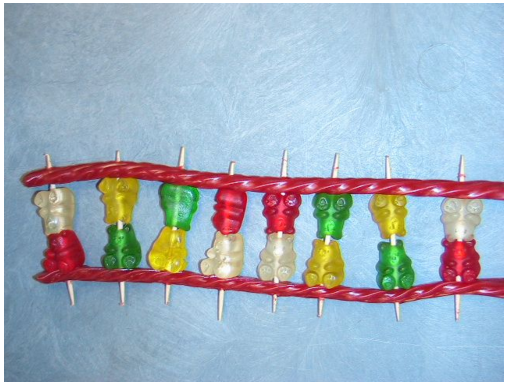
Biomolecules: Nucleic acids
DNA double helix

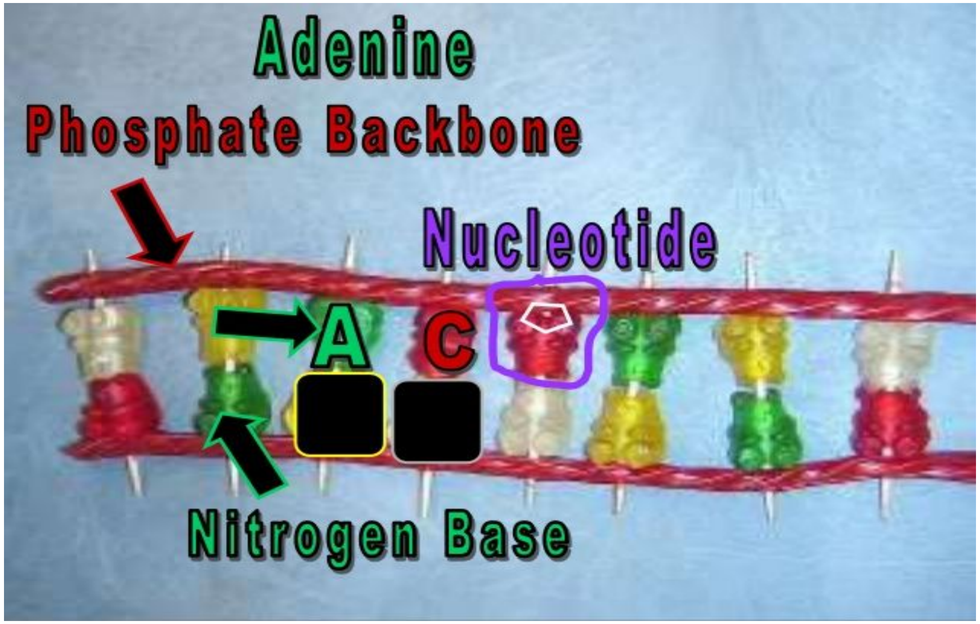


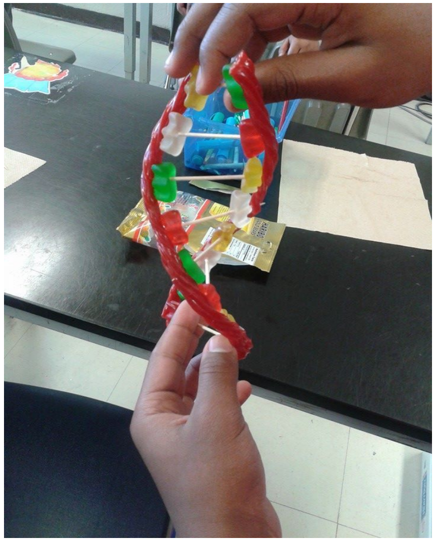
Biomolecules: Nucleic acids
DNA double helix- (1953 Watson and Crick)

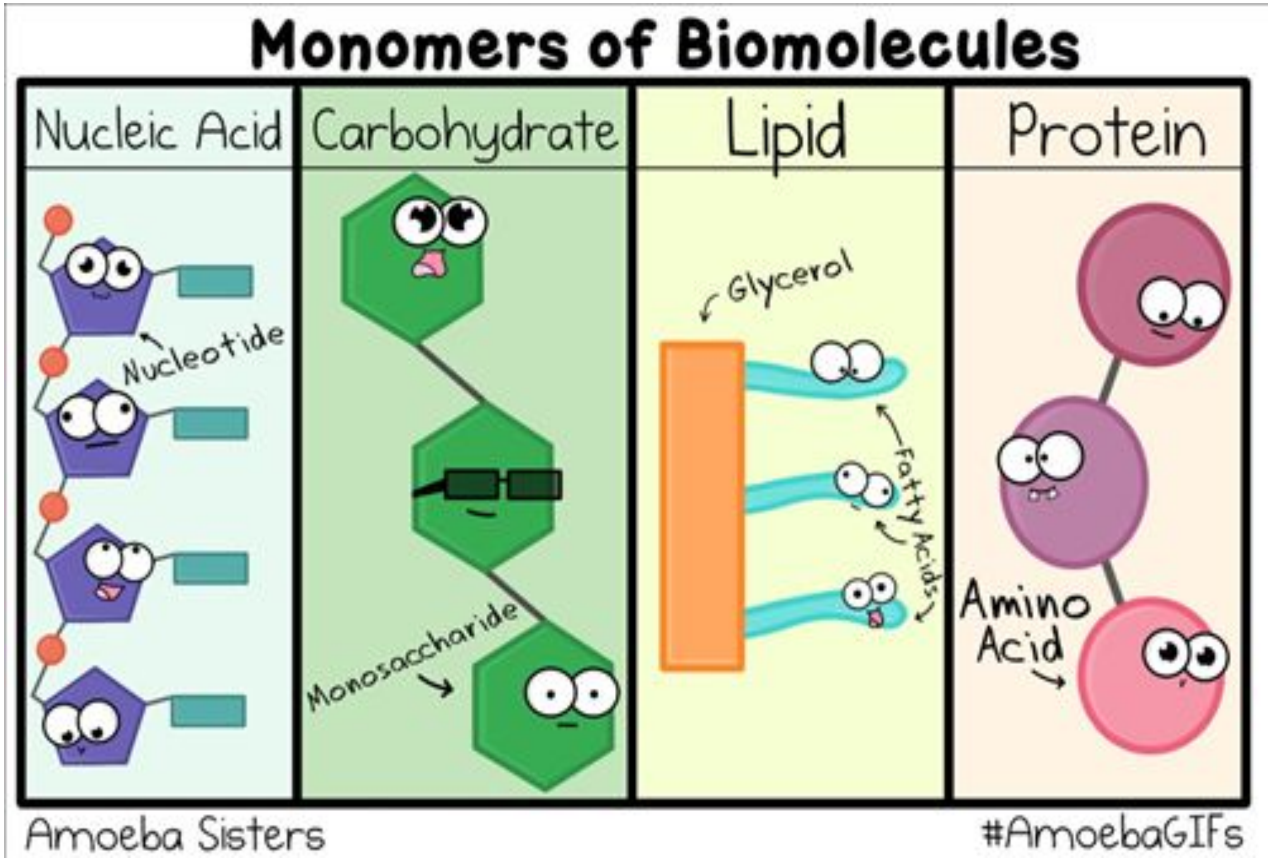


Biomolecules: Nucleic acids
DNA double helix with haribo








Monomers of Biomolecules
Nucleic Acid
Carbohydrate
Lipid
Protein
Nucleotide
Monosaccharide
Glycerol
Fatty Acids
Amino Acid
Amoeba Sisters
#AmoebaGIFs