"THE BIG 4" MACROMOLECULES

There are four classes of biological macromolecules: Proteins, lipids, carbohydrates and nucleic acids

Before you can understand the topics in this unit there are some key vocabulary terms you need to know.

Macromolecule

Polymer

Monomer

Carbon

What is a

MACROMOLECULE

What do these words mean?

Micro 

MACRO

So What Is A Macromolecule?

A very large molecule, such as a polymer or protein, consisting of many smaller structural units linked together. Also called *supermolecule*.

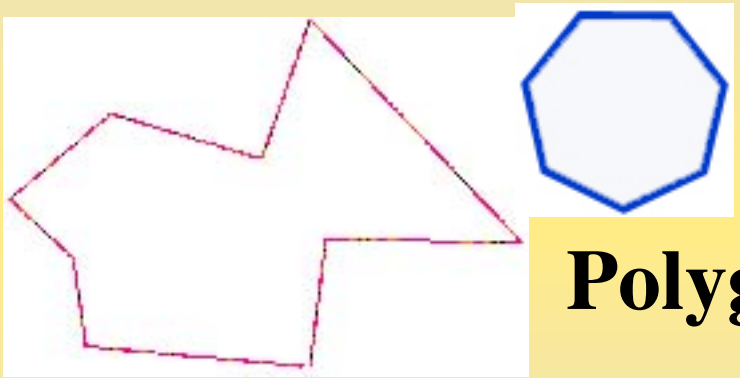
Biological Macromolecule

All biological macro-molecule are made up of a small number of elements: Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus and Sulfur

Next Word…..

Polymer

"Poly"



Polygons

Polyester

Polygamy

Means...

POLY means

MANY

What does “**Mono**” mean?

A Polymer

Here are some analogies to better understand what polymers and monomers are….

EXAMPLE of POLYMER	MONOMER
A TRAIN	?
A NECKLACE	?

If the train is the whole polymer, what would be the small groups that make up the train? If the necklace is the polymer, what are the monomers that make up the necklace?

A Polymer

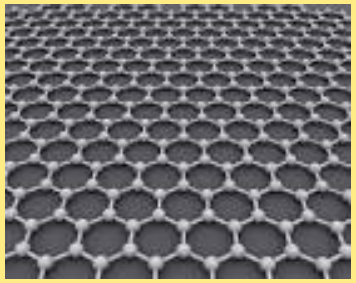
Here are some analogies to better understand what polymers and monomers are….

EXAMPLE of POLYMER	MONOMER
A TRAIN	THE CARS
A NECKLACE	EACH PEARL

If the train is the whole polymer, what would be the small groups that make up the train? If the necklace is the polymer, what are the monomers that make up the necklace?

Now you and a buddy

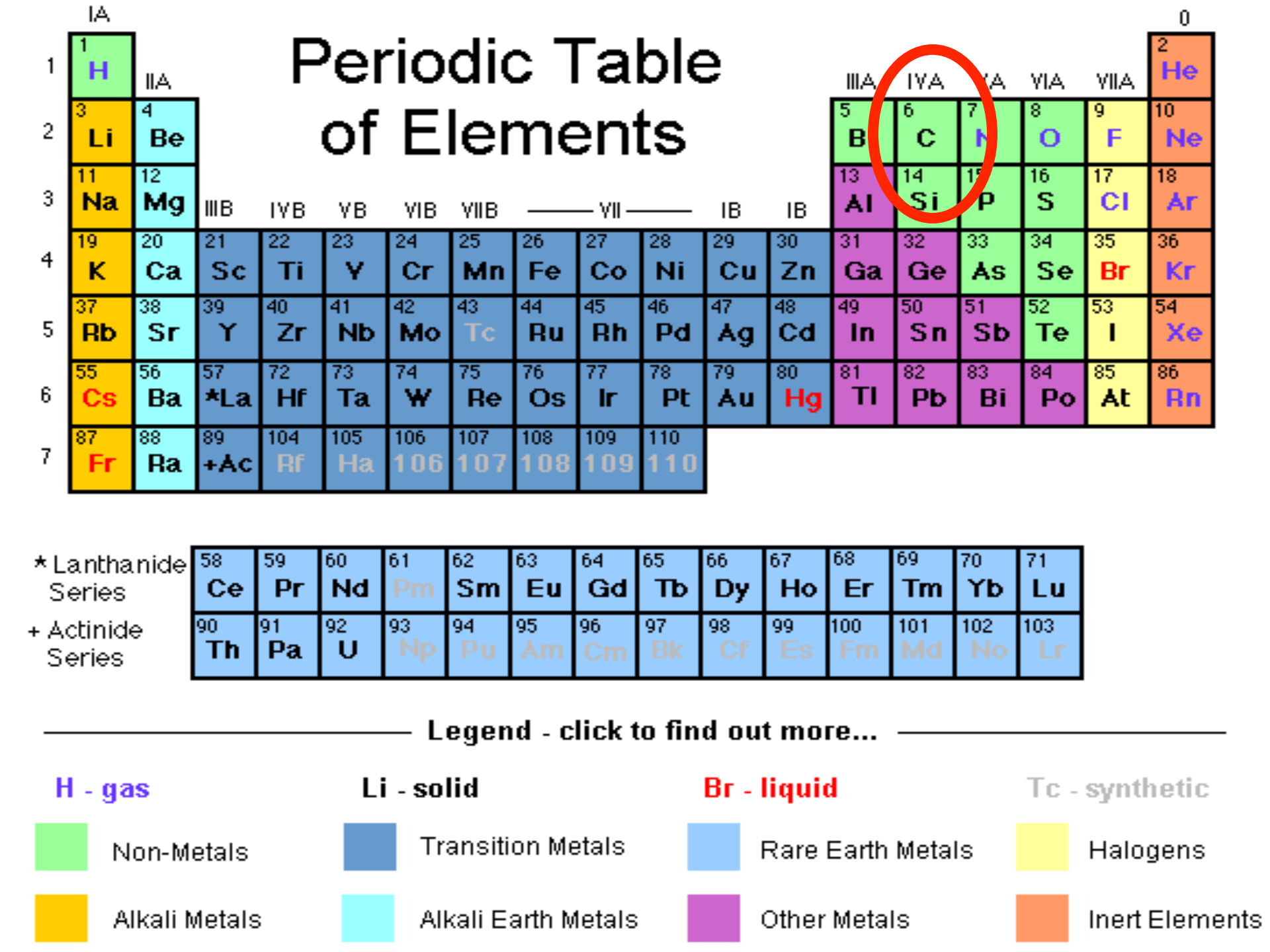
need to think of at least 2 other analogies for a polymer and its monomers.



Carbon

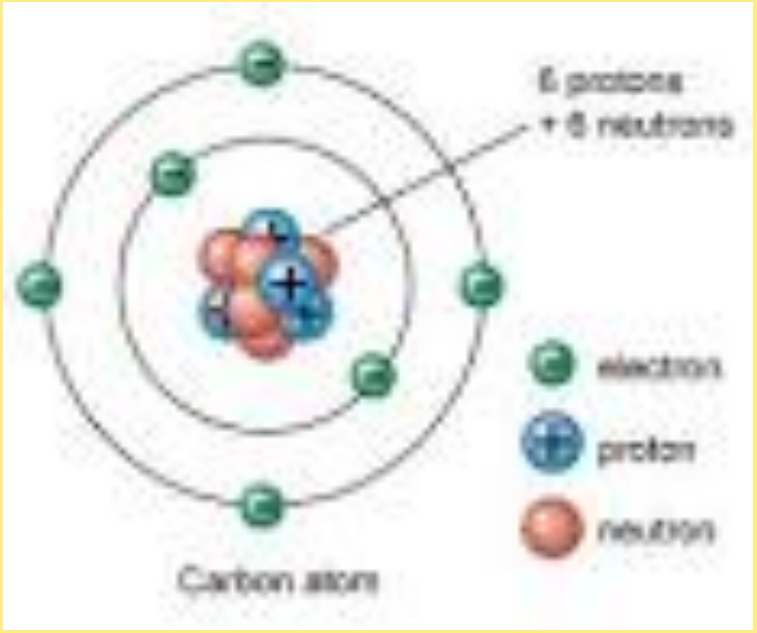
- Carbon atoms form the backbone of the macromolecules essential for life.

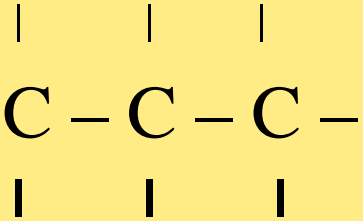
- The carbon atom has 4 unpaired electrons which means it can form **covalent bonds** with up to 4 other atoms.

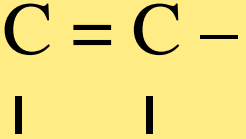

Periodic Table of Elements
IA
IIA
IIIB
IVB
VB
VIB
VIIB
VII
IB
IB
IIIA
IVA
VA
VIA
VIIA
0
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
57 *La
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
87 Fr
88 Ra
89 +Ac
104 Rf
105 Ha
106 106
107 107
108 108
109 109
110 110
* Lanthanide Series
+ Actinide Series
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
71 Lu
90 Th
91 Pa
92 U
93 Np
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No
103 Lr
Legend - click to find out more...
H - gas
Li - solid
Br - liquid
Tc - synthetic
Non-Metals
Transition Metals
Rare Earth Metals
Halogens
Alkali Metals
Alkali Earth Metals
Other Metals
Inert Elements

Carbon

- Carbon atoms can form bonds with other carbon atoms.



- 

- 

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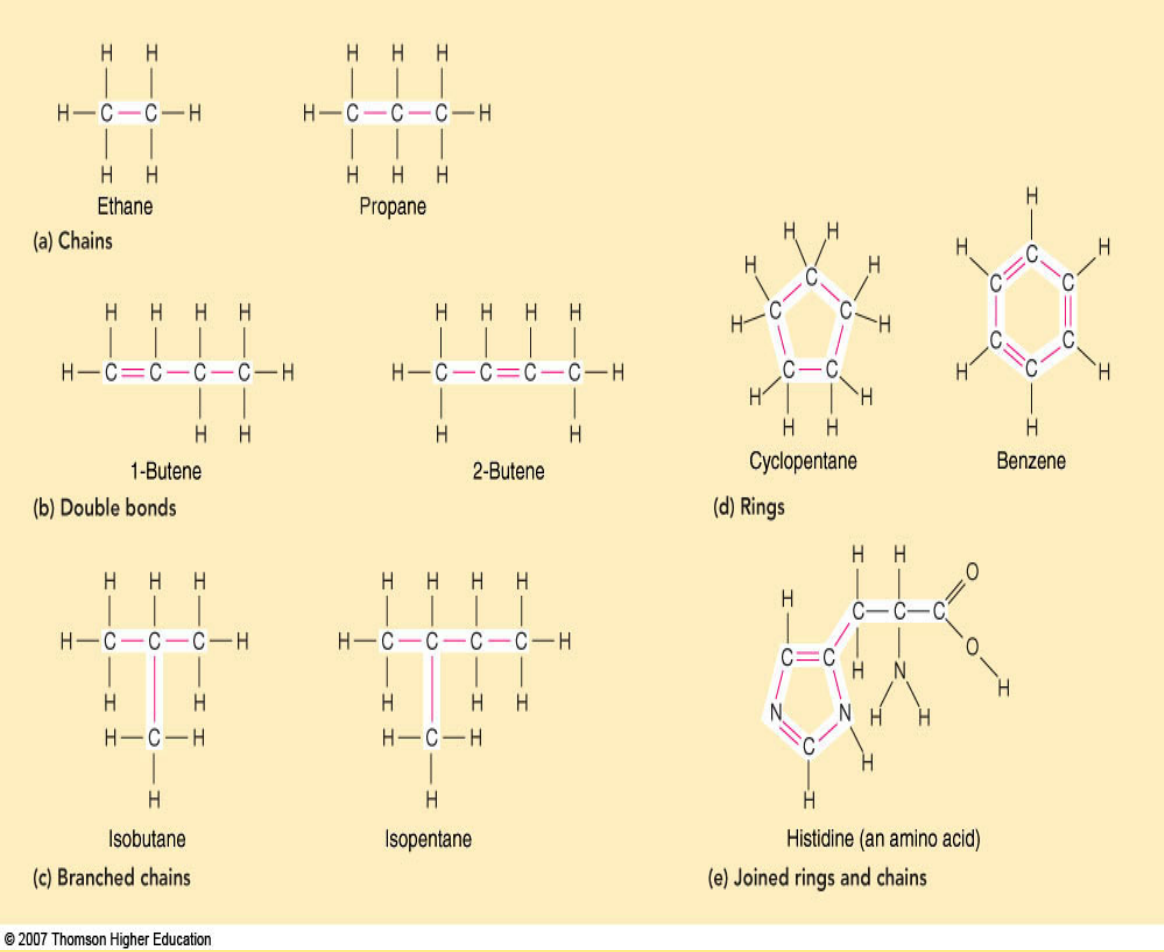
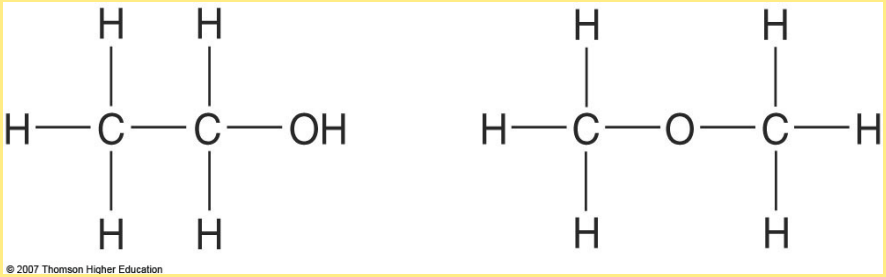
Carbon

- Carbon backbones can form:



Isomers

- Same mocleular formula but different structure.
  - Structural – many are biologically active.



  - Geometric isomers & enantiomers – usually only one form is biologically active.

Now we are ready to begin our study of...

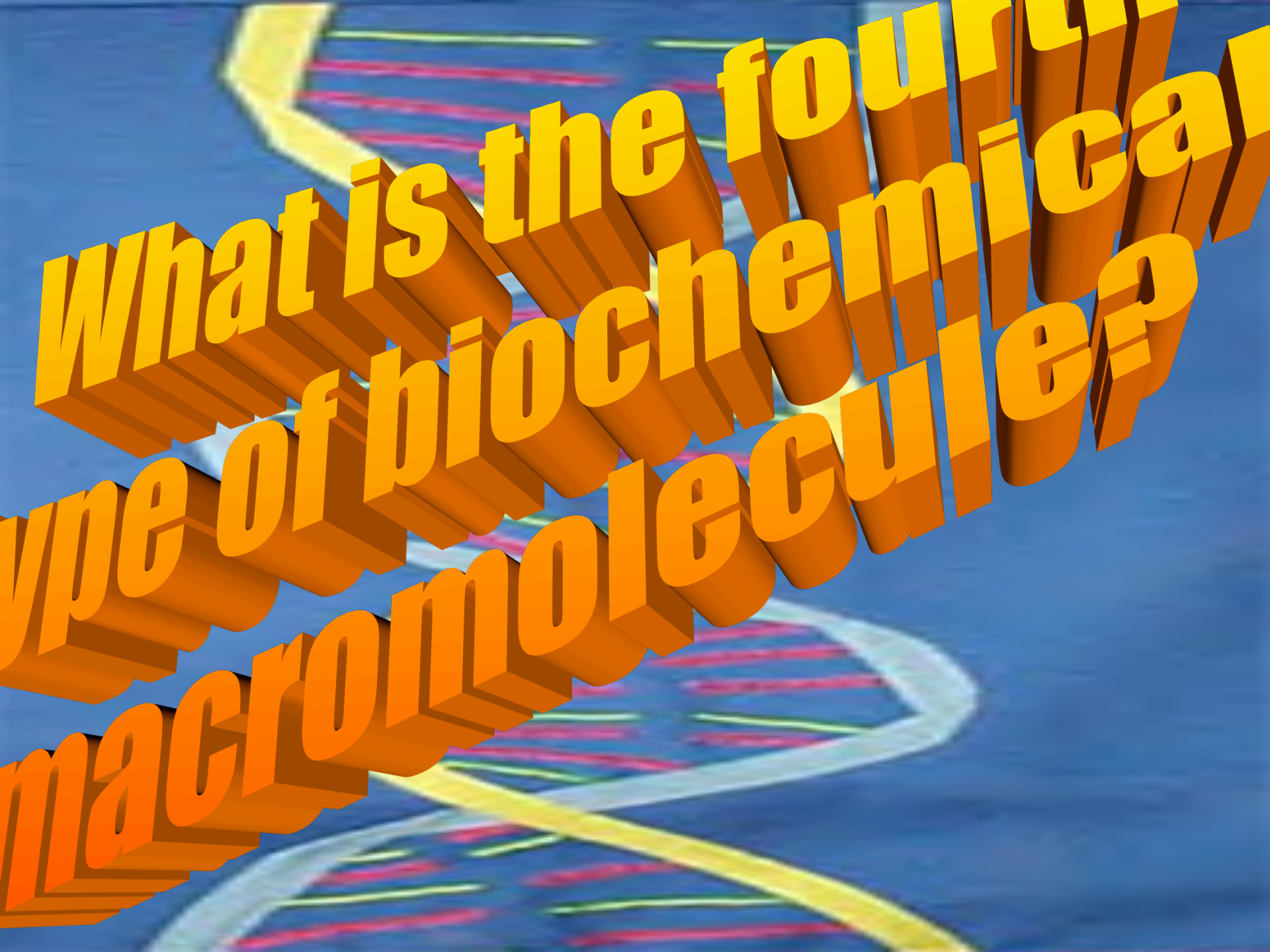
The Big Four

Three out of the 4 types of biochemical macromolecules can be found on food nutrition labels…

Look at the label to the left. 3 of the 4 macromolecules can be found in foods.

The 3 biochemical molecules found on a nutrition label are:

1. FAT (0 grams in this product)
2. Carbohydrates (13 grams in this product)
3. Protein (9 grams in this product)


what is the fourth
ype of biochemical
macromolecule?

The 4th type of biochemical macromolecules are the **NUCLEIC ACIDS**

The types of Nucleic Acids

–DNA (DeoxyriboNucleic Acid)

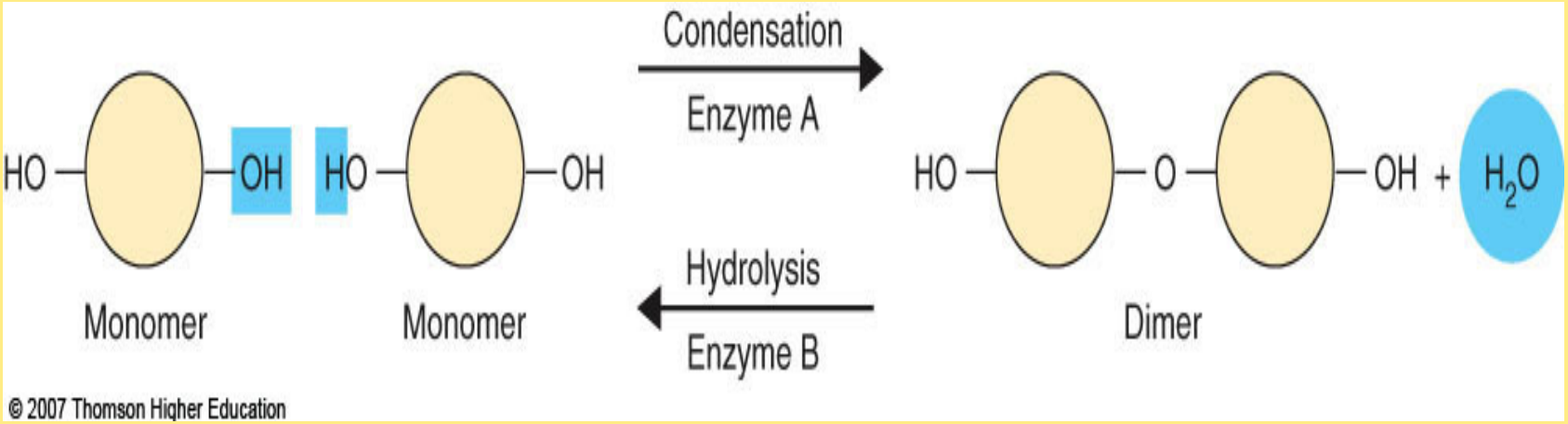
–RNA (RiboNucleic Acid)

DNA

"DNA" is short for
Deoxyribo***N***ucleic ***A***cid

- Now you know why they just call it DNA!

- Formation = Synthesis chemical reactions: <u>condensation</u> or dehydration reactions.
- Breakdown = decomposition chemical reactions: <u>hydrolysis</u>.



LET'S BEGIN WITH CARBOHYDRATES

WHAT DO THEY DO?

✓**They are the <u>main source</u> for the body <u>to gain energy</u>. They are our fuel!**

✓**They <u>make up the cell wall in plants</u> which allow them to grow tall, without this carbohydrate, a plant would be a mushy mess! This type of carbohydrate is called <u>*Cellulose*</u>.**

<u>THINK: CARBS= ENERGY and CELL WALLS</u>

CARBOHYDRATES

WHERE ARE THEY FOUND?

- **In plant foods- in the cell walls of plants --- in fruits, vegetables, peas, beans, SUGAR comes from a plant and so does FLOUR! (pasta, potatoes, bread, candy, cookies)**

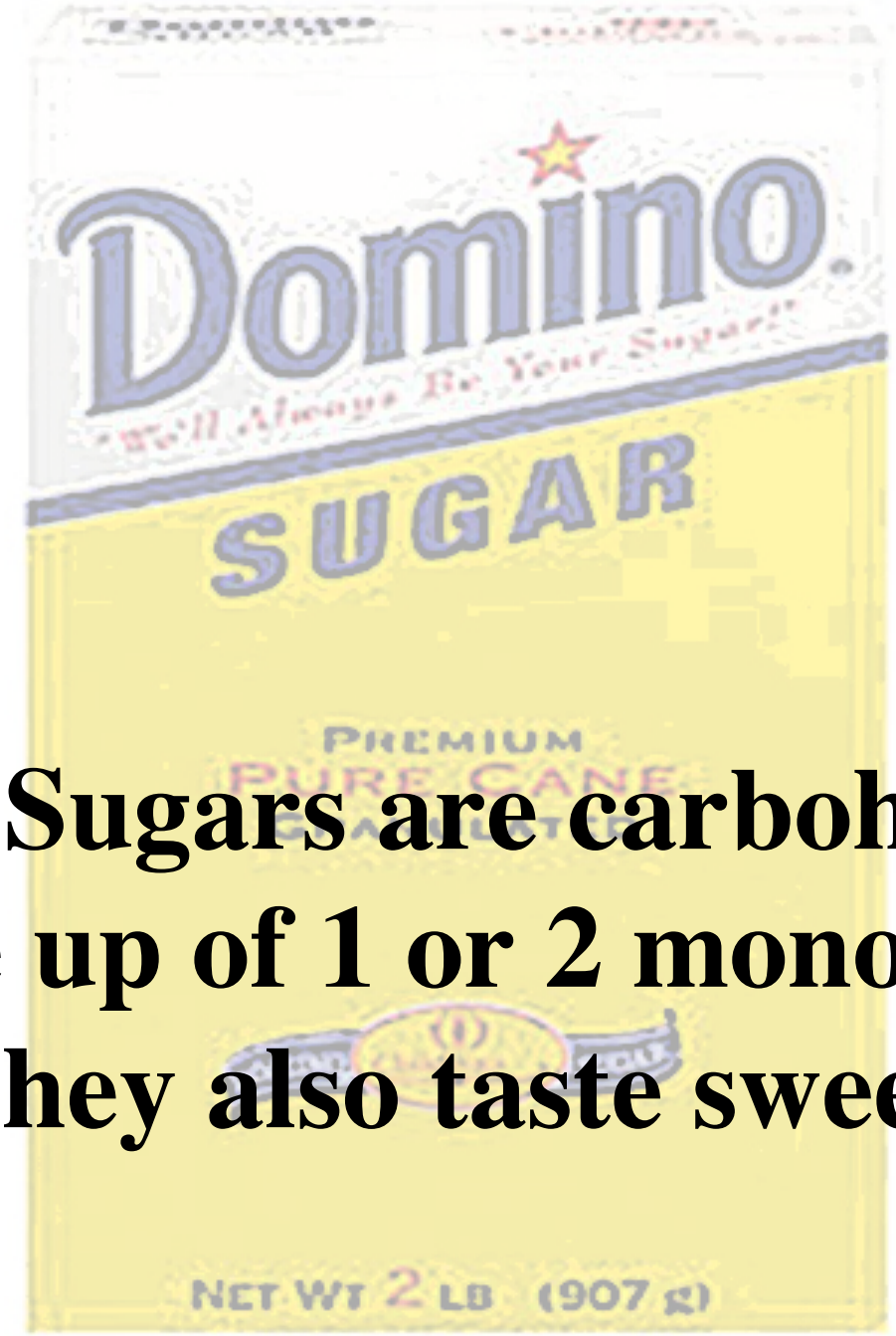
- **In animal products- in MILK**

CARBOHYDRATES

TYPES

THERE ARE 2 TYPES OF CARBOHYDRATES

	Complex



Simple Sugars are carbohydrates made up of 1 or 2 monomers. They also taste sweet.

Simple Sugars

Complex Carbohydrates… What are they?

Complex Cabohydrates are polymers made up of many monomers. Most also taste starchy.

Complex Carbohydrates

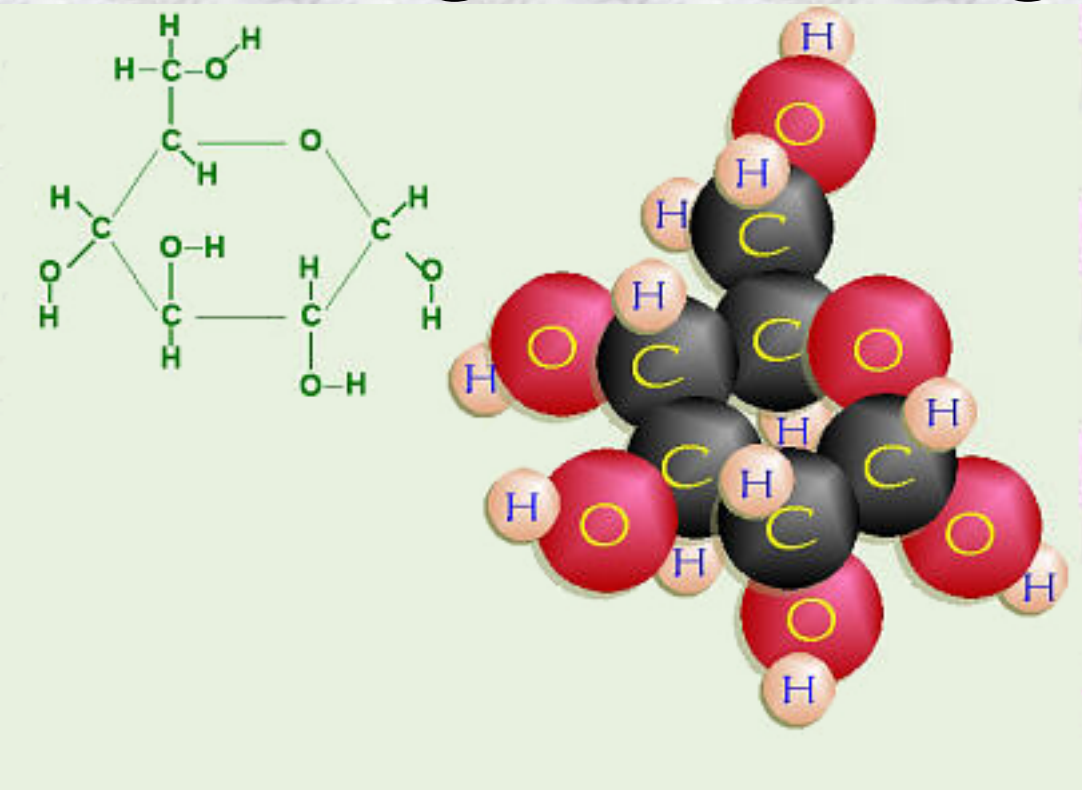
CARBOHYDRATES

MADE UP OF...

Carbohydrates are chains (polymers) made of monomers. The most common monomer of carbohydrates is…

GLUCOSE

The shape of Glucose is a hexagonal ring



CARBOHYDRATES

AT THE ATOM LEVEL

Each carbohydrate is made up of…

Carbon, Hydrogen, and Oxygen

THINK: “CHO”

Carbohydrate Structure

- General formula: $(CH_2O)_n$.
  i.e. "carbon –water".

- Carbon chains or rings with H's, OH groups and a C=O or carbonyl group. Depending on the placement of the carbonyl group they may be aldoses or ketoses.

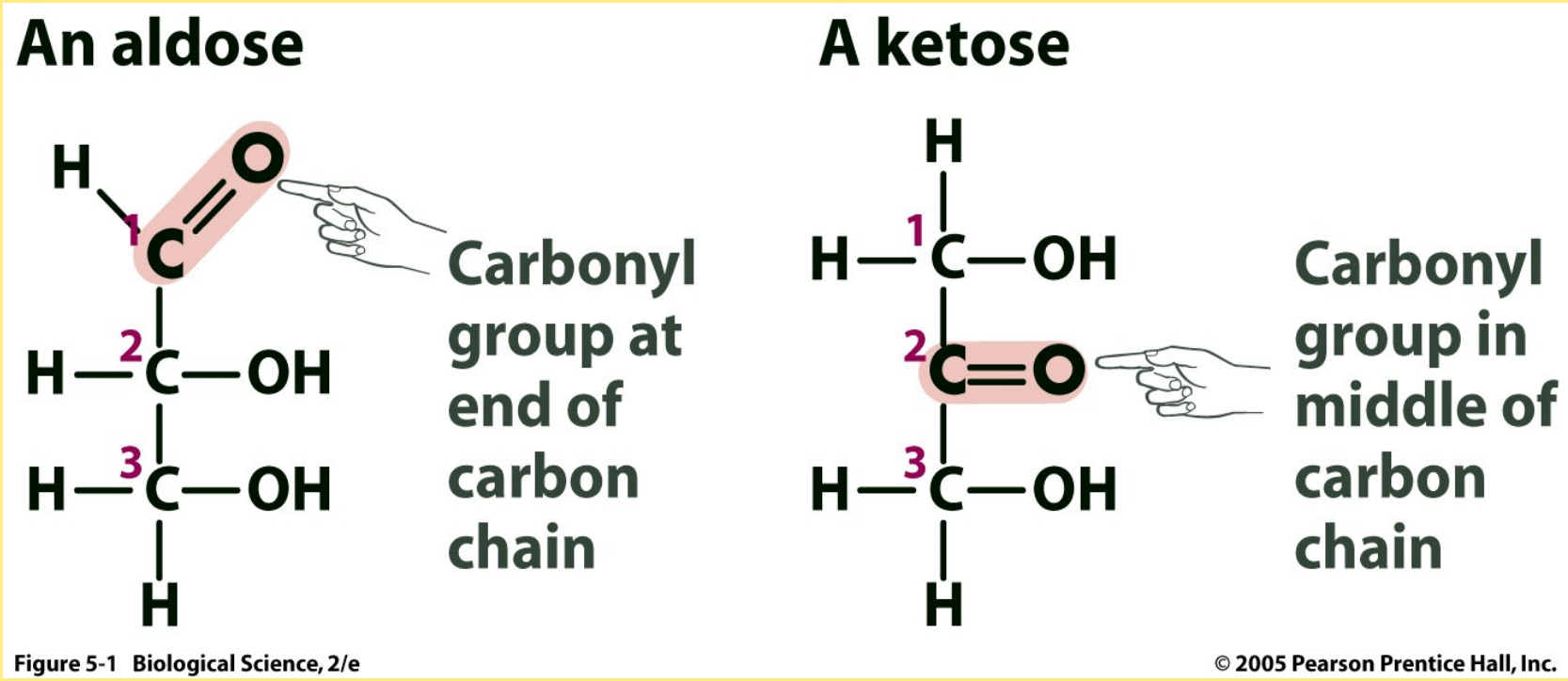
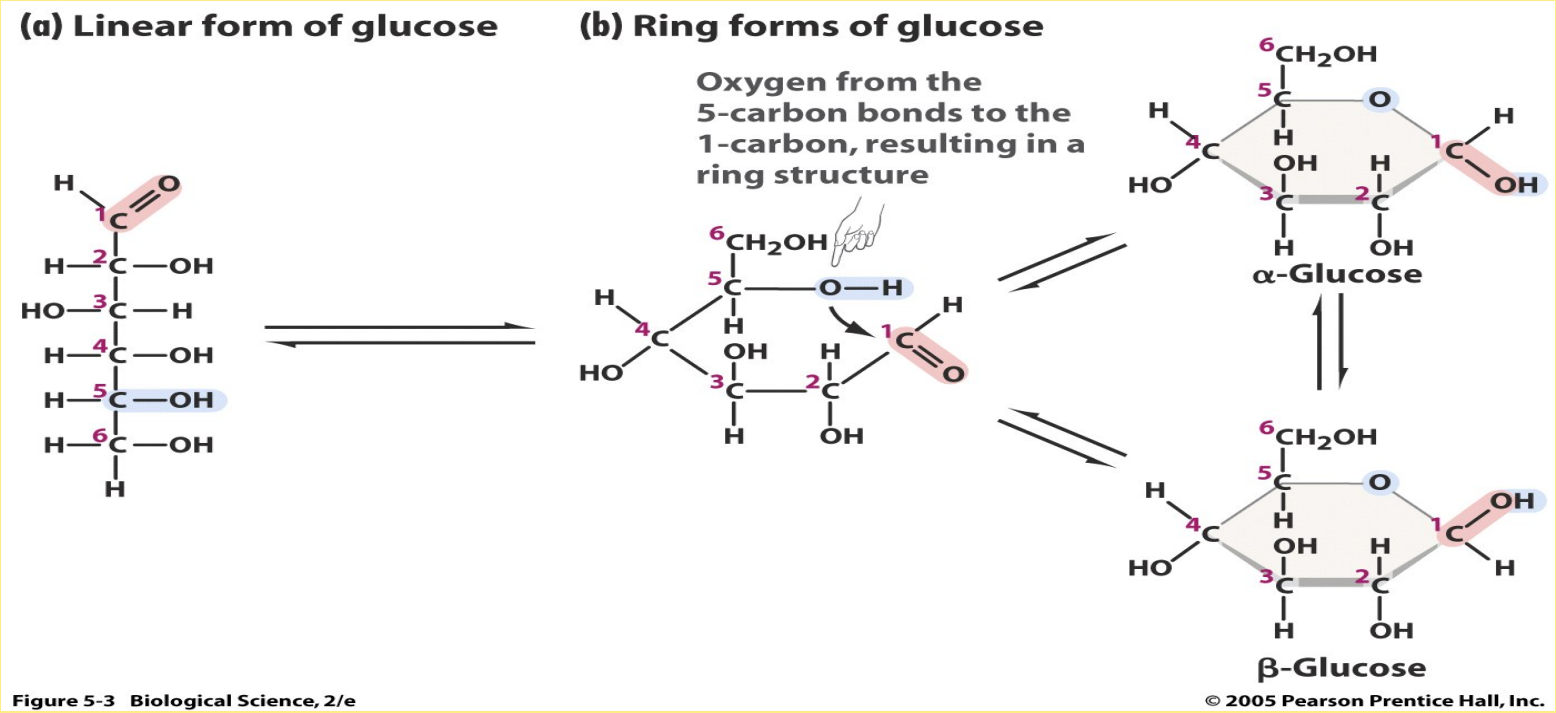


Figure 5-1 Biological Science, 2/e

Carbohydrate Structure

- Often monosaccharides form a carbon ring creating a new OH group.
- The OH group may be above or below the plane of the ring.

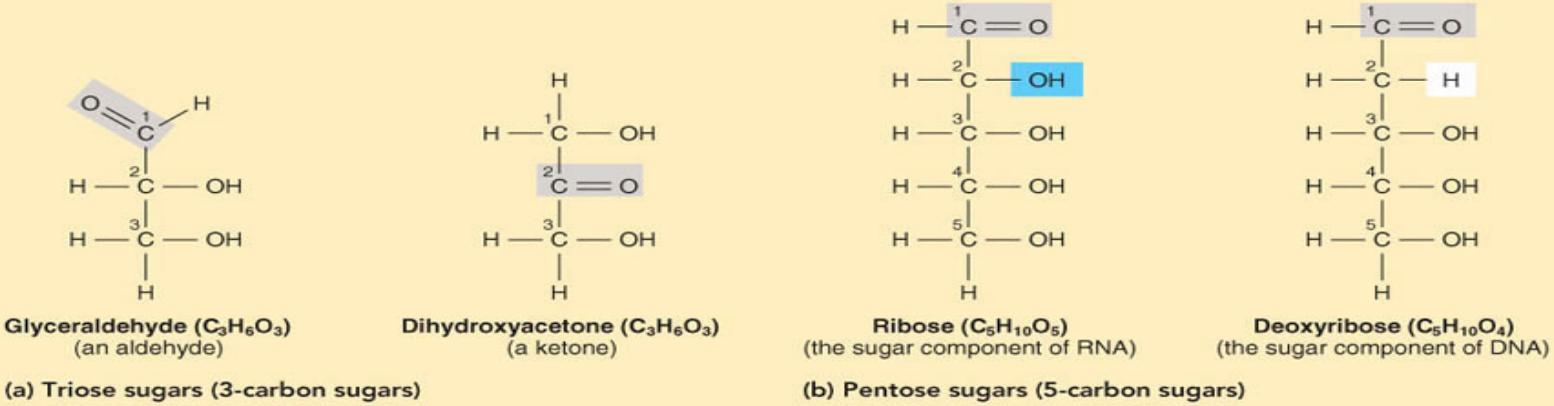


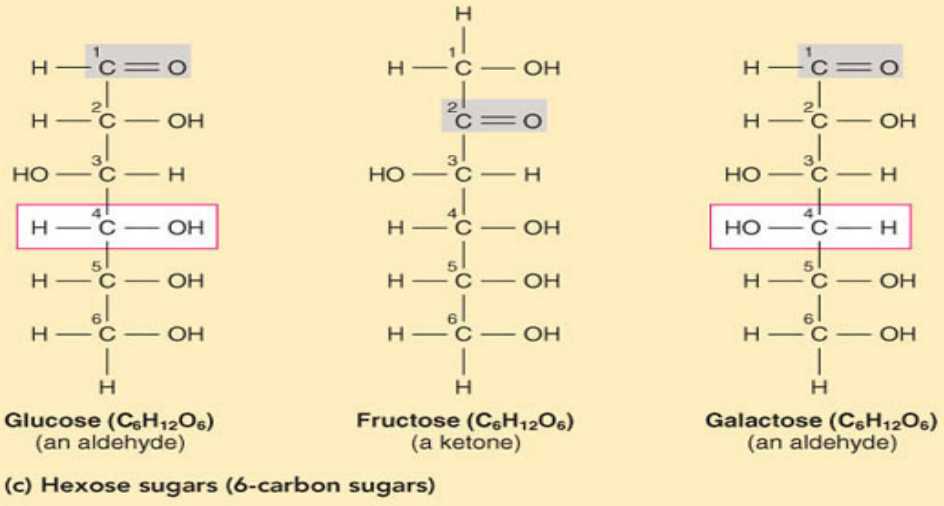
Monosaccharides

- Most common:
  - 3-C sugars (trioses) –
  - 5-C sugars (?) –

  - 6-C sugars (?) - 3 are structural isomers:
    - Glucose –
    - Fructose –
    - Galactose –

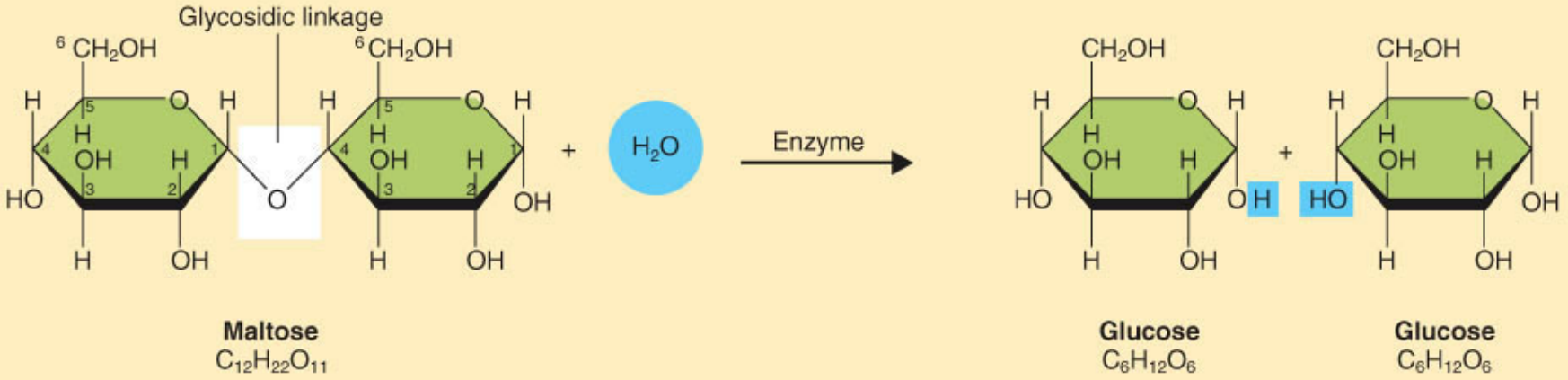
Monosaccharides



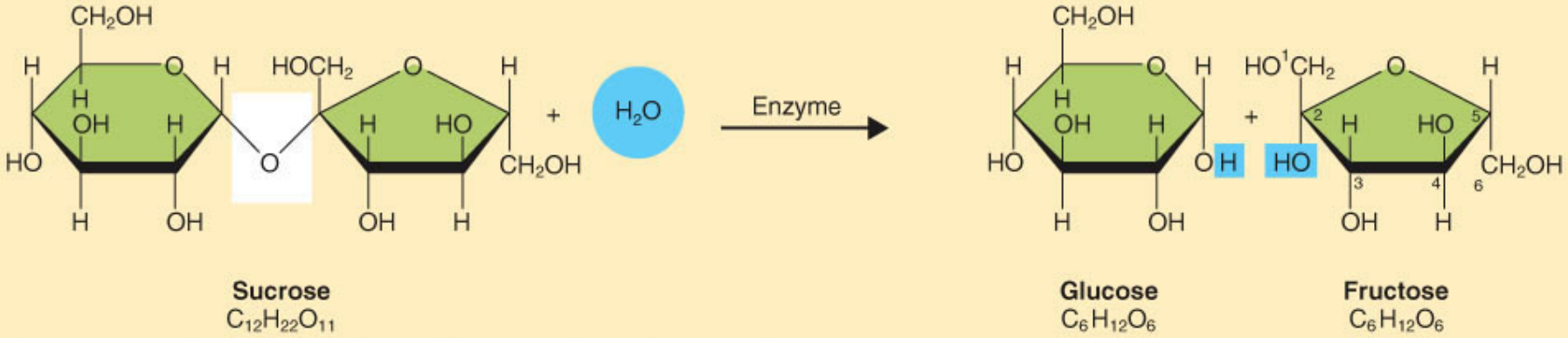


Disaccharides

- 2 monosaccharides joined by a condensation reaction. The resulting bond is called a glycosidic linkage.
- Disaccharides are hydrolyzed to 2 monosaccharides.
- Common disaccharides:



(a) Maltose may be broken down (as during digestion) to form two molecules of glucose. The glycosidic linkage is broken in a hydrolysis reaction, which requires the addition of water.



(b) Sucrose can be hydrolyzed to yield a molecule of glucose and a molecule of fructose.

Polysaccharides

- Polysaccharides consist of many monosaccharides joined together by glycosidic bonds.
- Common polysaccharides:
  - Starch
  - Glycogen
  - Cellulose
  - Chitin
  - Peptidoglycans

NOW ONTO PROTEINS

WHAT DO THEY DO?

✓**They are the major structural molecules in living things for growth and repair : muscles, ligaments, tendons, bones, hair, skin, nails…IN FACT ALL CELL MEMBRANES have protein in them**

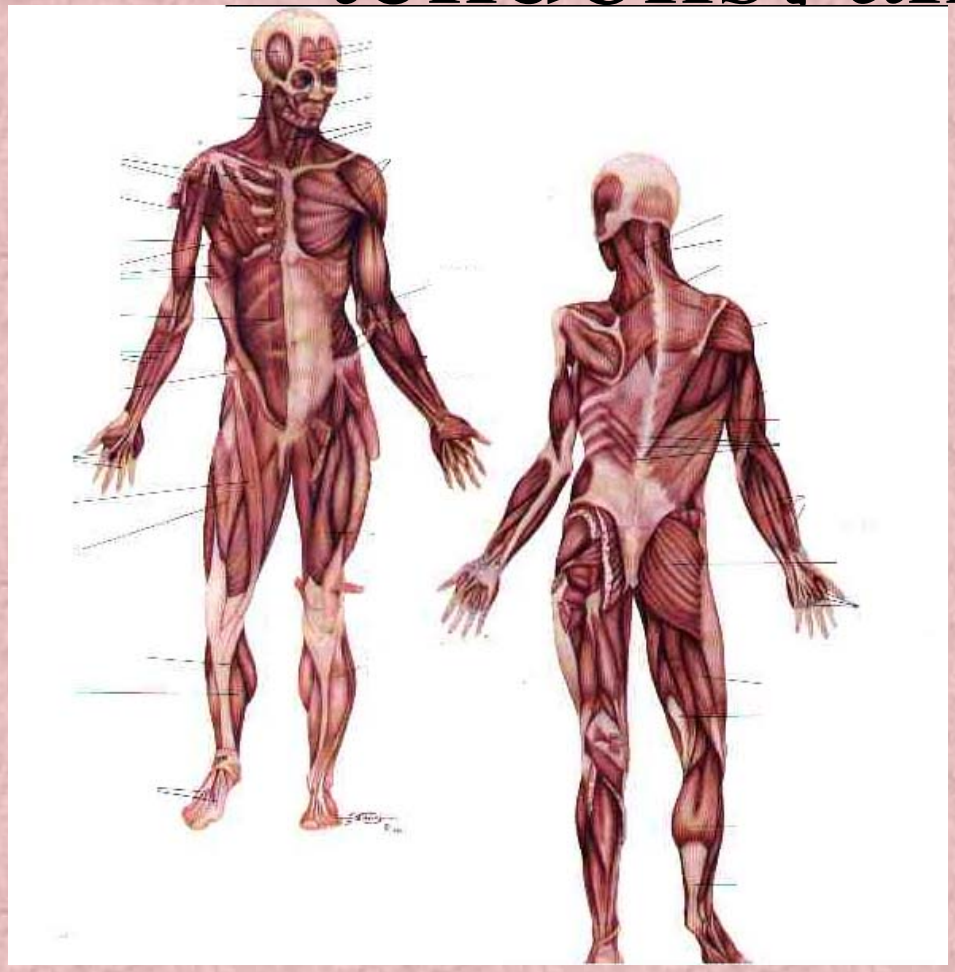
✓**They make up antibodies in the immune system**

✓**They make up enzymes for helping chemical reactions**

✓**They makeup non-steriod hormones which**

THINK: Proteins= membranes, enzymes, antibodies, hormones, structural molecules

Muscles, ligaments, tendons, and bones



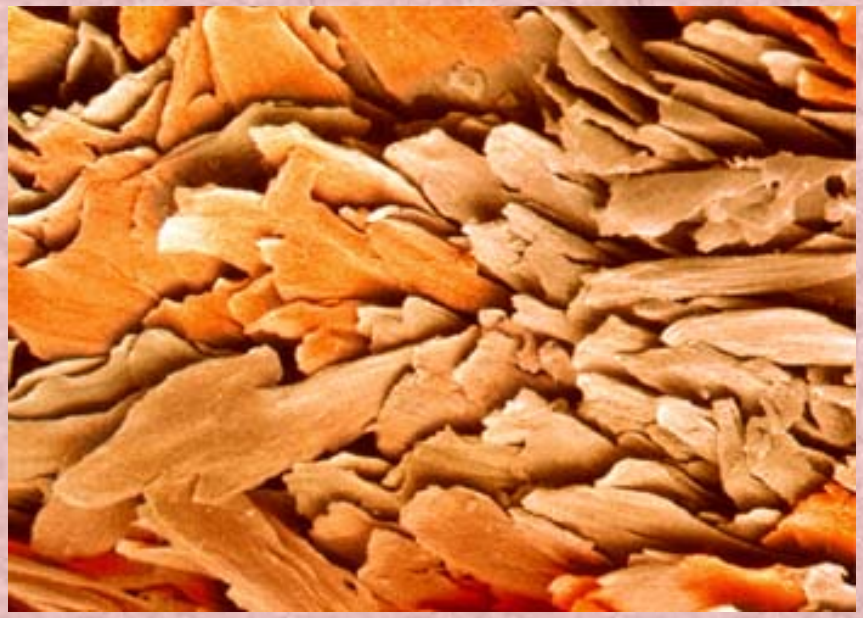
Without these particular structural proteins, we would look more like this….

Well, maybe not exactly…

Hair, Skin, and Nails

Microscope View of Skin and Nails

This is skin



This is a nail

Cell Membrane

The cell membrane surrounds everything in a cell so it doesn't leak out. It is kind of like the balloon in a water balloon.

The cell membrane is made mostly of <u>protein</u> AND <u>lipids.</u>

Antibodies

Antibodies are part of the immune system. When something enters the body that isn't supposed to be there, like certain bacteria, antibodies find the invader and stick themselves onto it. When a white blood cell finds the invader covered with antibodies, it knows it doesn't belong there and kills it.

Enzymes

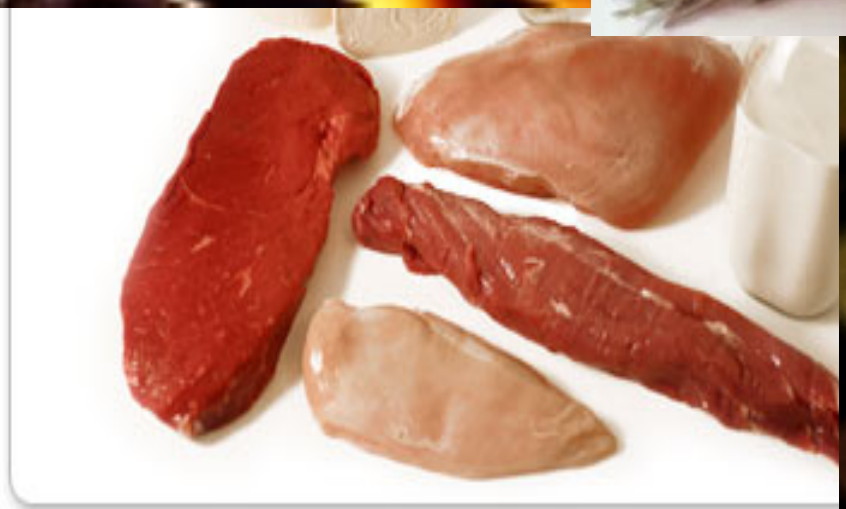
Enzymes are proteins that speed up chemical reactions. If you didn't have enzymes in your stomach to speed up digestion, the food would rot in your stomach because it would take so long!

PROTEINS

WHERE ARE THEY FOUND?

- **In plant foods- in the cell membranes**
- **In animal products- in the cell membranes- in the muscles or living things- cows, chicken, fish…**

Proteins



Proteins

Aside from the protein found in animal sources…protein can also be found in fruits, vegetables, grains, and nuts. (it just does not have as many amino acids)

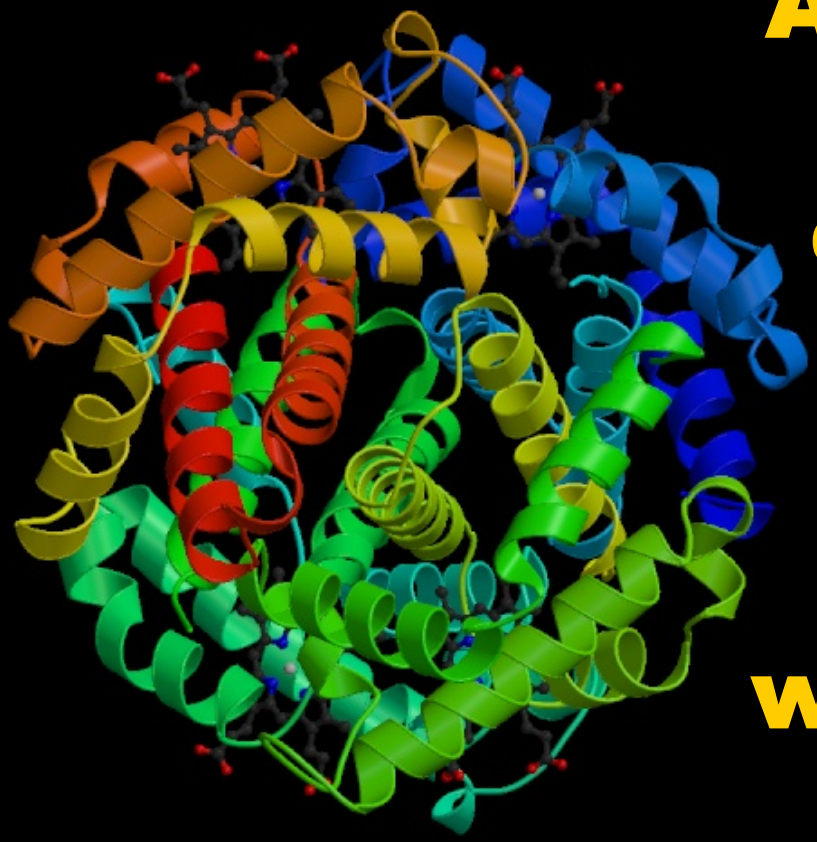
PROTEINS

MADE UP OF...

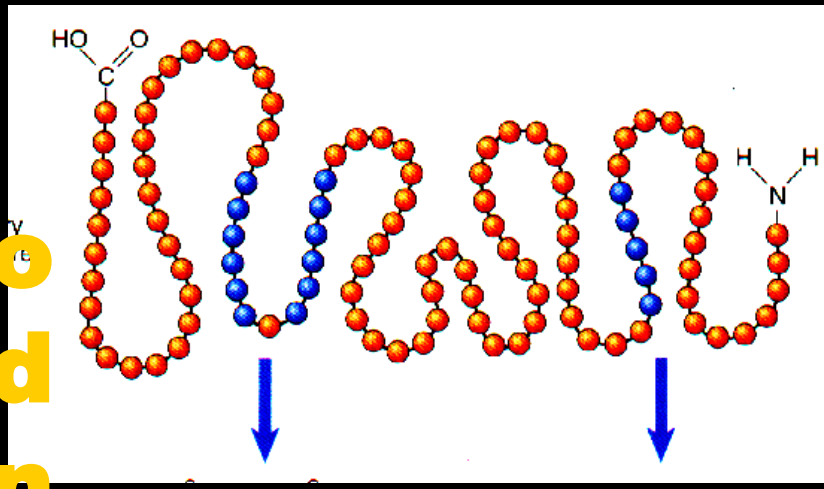
Proteins are made of long chains (polymers) made of monomers. All proteins are made of the monomer…

AMINO ACID

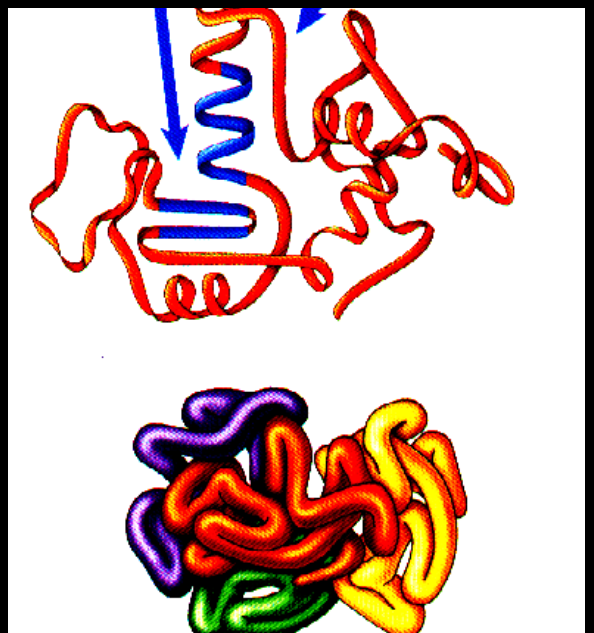
The shapes of proteins are like a balled up piece of string



Amino Acid chain



All wound up



PROTEINS

AT THE ATOM LEVEL

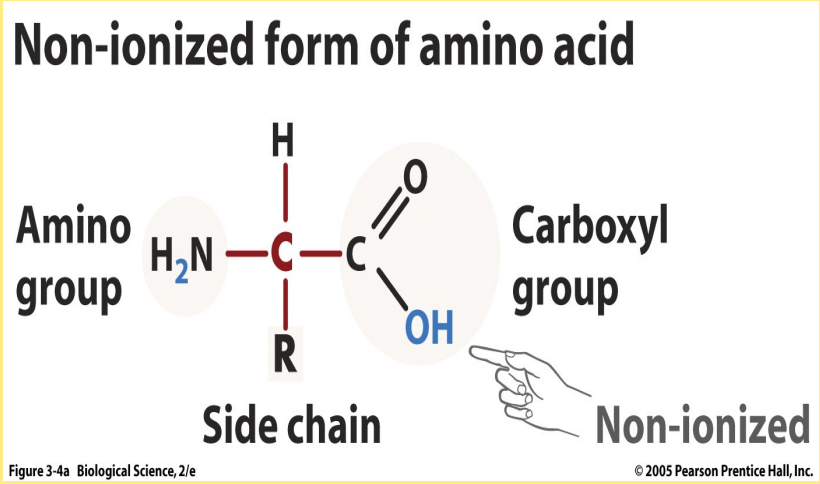
Each protein is made up of…

Carbon, Hydrogen, and Oxygen, Nitrogen and sometimes Sulfur

THINK: “CHONS”

Protein Structure

- Subunits (monomers) are amino acids.
  - There are 20 amino acids in living organisms with an infinite number of combinations.
- General structure:
  - Carbon atom
  - Amino group at one end.
  - Carboxyl group (acid) at the other.
  - Side chain (R).

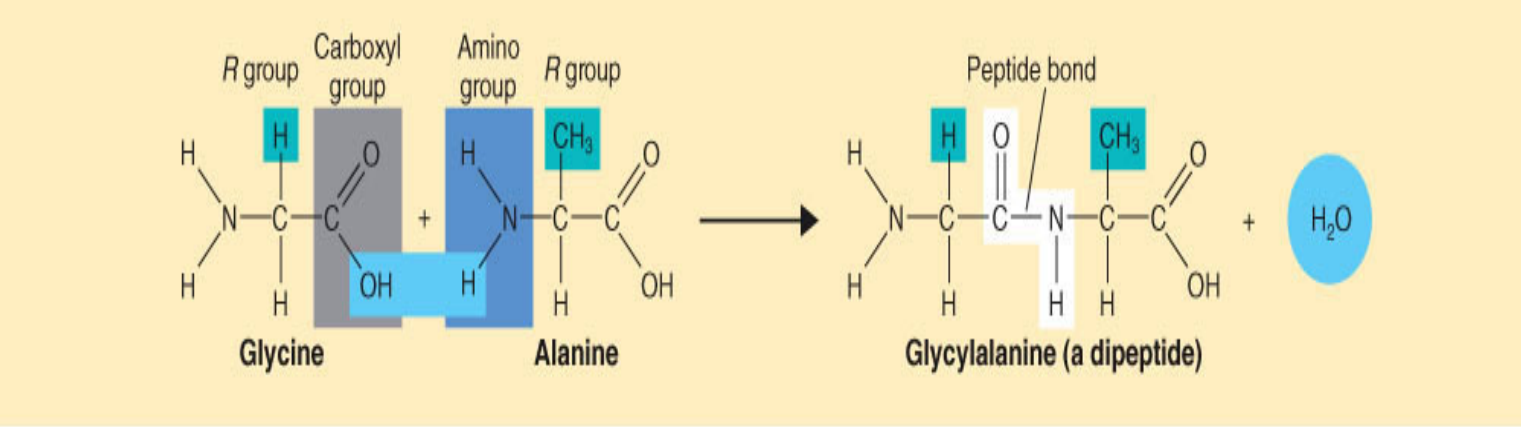


Proteins

- Amino acids
  - Side chains are carbon chains with other atoms attached (S, P, H_2, N_2, O_2), fig 3.3.
  - The side groups give amino acids different chemical properties.
    - Polar groups
    - Non-polar groups
    - Chemical reactivity -

Proteins – Linking Amino Acids

- Polymerization of amino acids - condensation reaction.
- The bond formed between 2 amino acids is called a peptide bond. *Requires energy

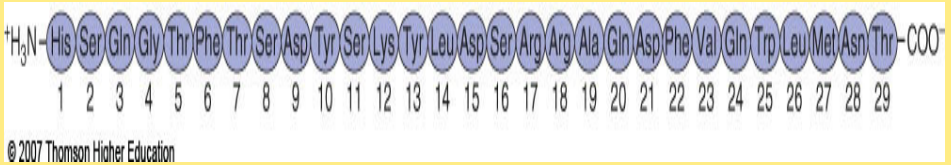


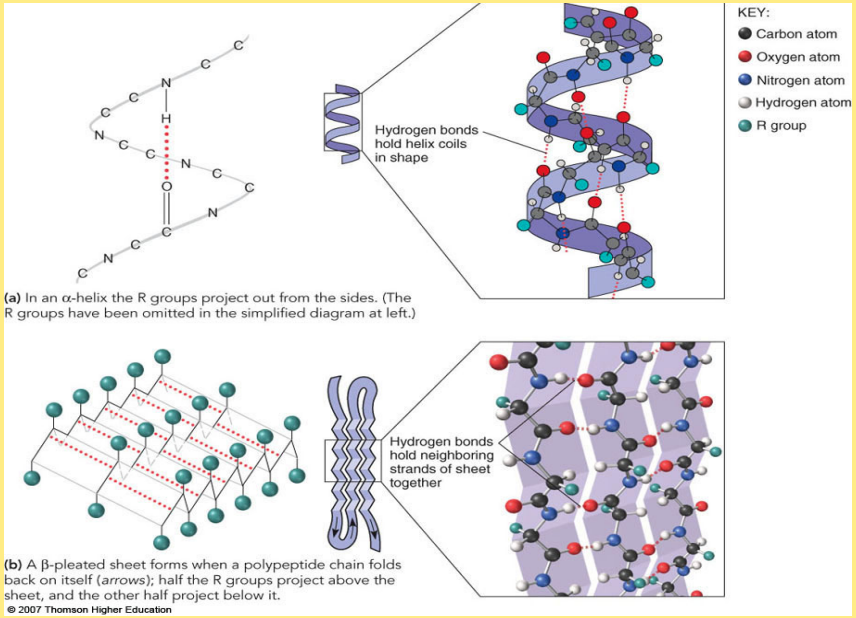
Protein Structure

- As the protein grows it tends to fold back on itself because the side chains interact with one another.
- The proper folding is necessary for proper functioning of the protein.
- 4 levels of structure:
  - Primary
  - Secondary
  - Tertiary

Protein Structure

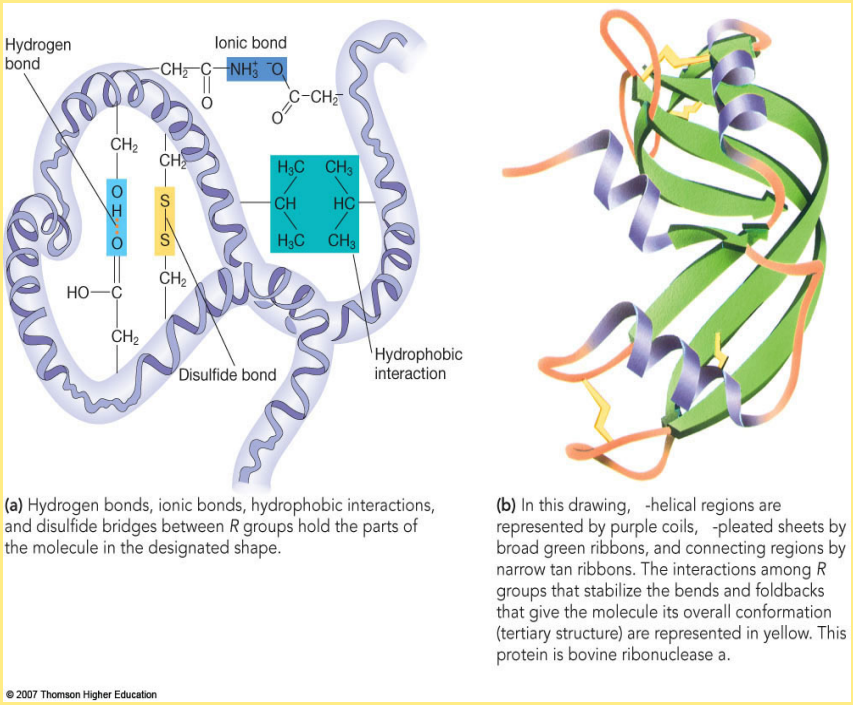
- Primary structure = amino acid sequence.
- Secondary structure:





Protein Structure

- Tertiary structure: hydrogen bonds, ionic bonds, disulfide bonds and van der Waals associations (hydrophobic interactions) form 3-D structures.

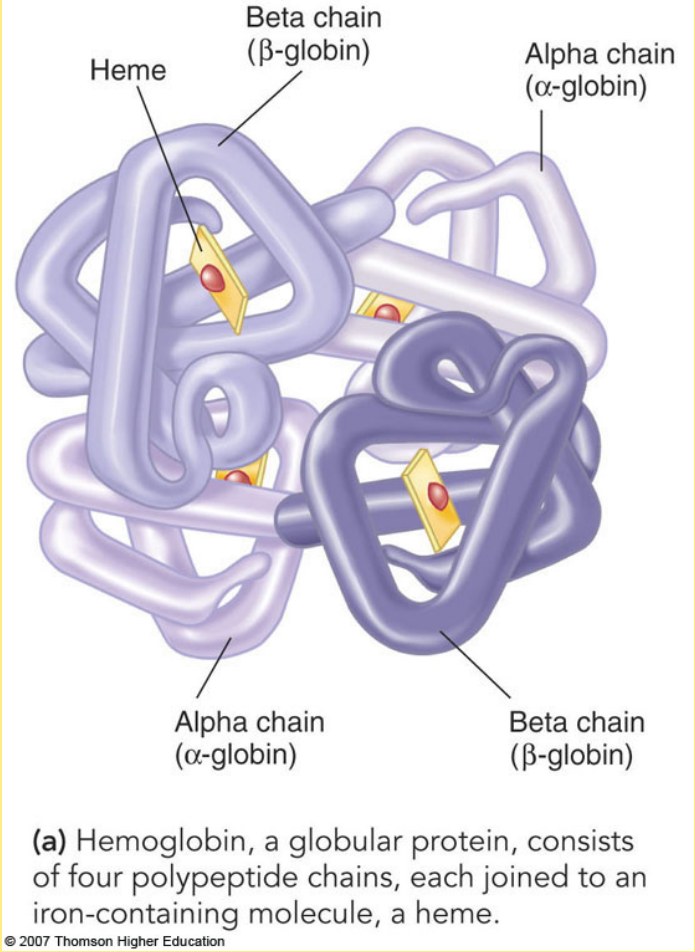


(a) Hydrogen bonds, ionic bonds, hydrophobic interactions, and disulfide bridges between *R* groups hold the parts of the molecule in the designated shape.

(b) In this drawing, -helical regions are represented by purple coils, -pleated sheets by broad green ribbons, and connecting regions by narrow tan ribbons. The interactions among *R* groups that stabilize the bends and foldbacks that give the molecule its overall conformation (tertiary structure) are represented in yellow. This protein is bovine ribonuclease a.

Protein Structure

- Quaternary structure:



(a) Hemoglobin, a globular protein, consists of four polypeptide chains, each joined to an iron-containing molecule, a heme.

LIPIDS ARE NEXT

WHAT DO THEY DO?

✓They are a great source of STORED ENERGY so we have it in the future.

✓They INSULATE the body to maintain normal body temperature and they CUSHION the internal organs for protection.

✓They produce hormones for the body called STERIODS

✓They waterproof surfaces of animals,plants, and fruits- these are waxes!

THINK: Waterproof, insulate, steriods, energy, cushion… "WISE C"

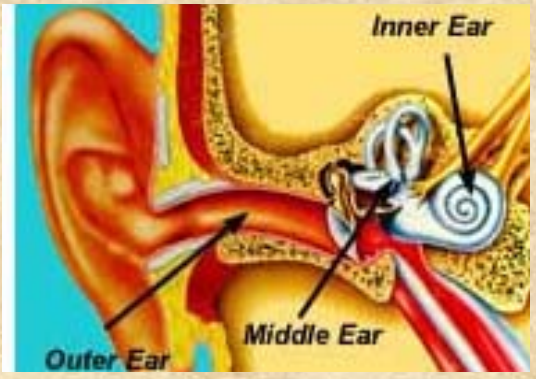
LIPIPS…Some interesting info

Waterproofing…

•Fruits produce a waxy coating to keep from drying out.

• The cells in a tulip make a wax which helps coat the leaves.

•Ear wax traps dust, sand, and other foreign particles from going deeper into the ear and causing damage.



•Beeswax- a structural material to hold honey in the hive

LIPIPS…Some interesting info

Steriods…

There are many different types of steroids. They are all lipids. Their functions vary. Some common steroids are:

SEX STEROIDS **ANABOLIC STERIODS**

CHOLESTEROL

Like testosterone and estrogen

They increase muscle

LIPIPS…Some interesting info

NATURAL STERIODS IN OUR BODY INCREASE MUSCLE GROWTH AND BONE DEVELOPMENT AND ARE GOOD. THE ILLEGAL ONES THAT ARE SYNTHETIC ARE BAD.

very unhealthy

LIPIDS

WHERE ARE THEY FOUND?

- In plants- in the seeds

- In animals- in adipose tissue, connective tissue, in animals

---

- Lipids make up the cell membrane of all cells.

LIPIDS

OILS

BUTTER

MARGARINE

LIPIDS

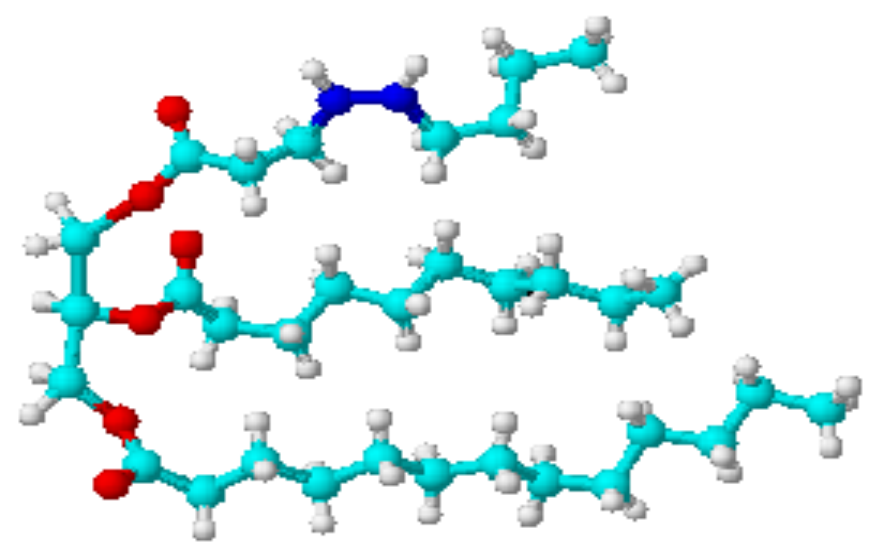
MADE UP OF...

Lipids are chains (polymers) made of monomers. The most common monomer of lipids is…

TRIGLYCERIDES

The Shape of a triglyceride is like the letter

E



This is a triglyceride molecule

LIPIDS

AT THE ATOM LEVEL

Each carbohydrate is made up of…

Carbon, Hydrogen, and Oxygen

THINK: “CHO”

OH NO CHO!
Lipids like Carbs?

You might have noticed that both carbohydrates and lipids have the elements Carbon, Hydrogen, and Oxygen.

"CHO"

A carbohydrate, has twice as many hydrogen atoms as the number of oxygen atoms.

EX: $C_6H_{12}O_6$

(This is a carb= there are double the number of H compared to O)

On the other hand, lipids have a lot more than twice the amount hydrogen atoms as the number of oxygen atoms.

EX: $C_{27}H_{46}O$ cholesterol

Simple tests can detect the presence of proteins, lipids and carbohydrates in given samples (i.e. various food items)

Testing for carbohydrates

- Lugol's reagent (iodine solution)
- Benedict's solution

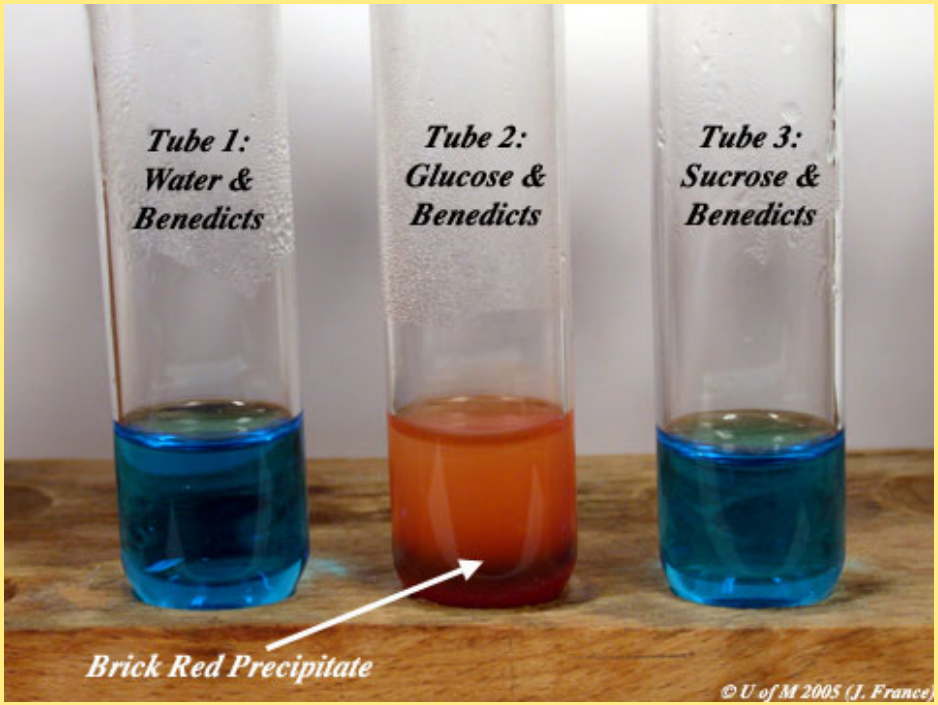
Testing for the presence of starch (complex sugar)

Lugol's reagent (iodine solution) changes from yellowish-brown to dark purple/ black.

Testing for simple carbohydrates

Benedict's solution is used to test for simple carbohydrates.
Benedict's solution is a blue colored liquid that contains copper ions.

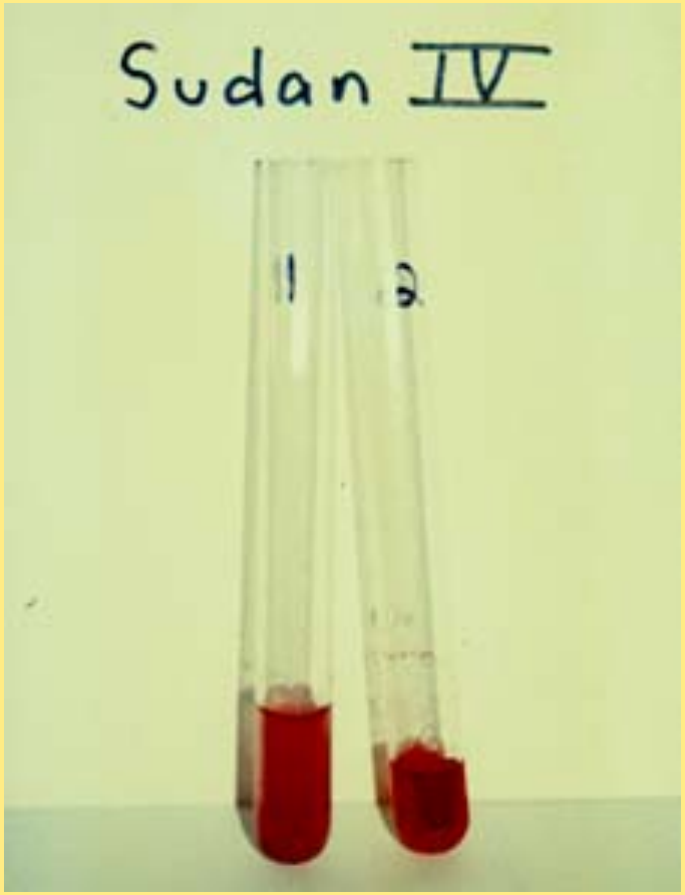
Testing for simple carbohydrates



When Benedict's solution and simple carbohydrates are heated, the solution changes to orange red/ brick red.

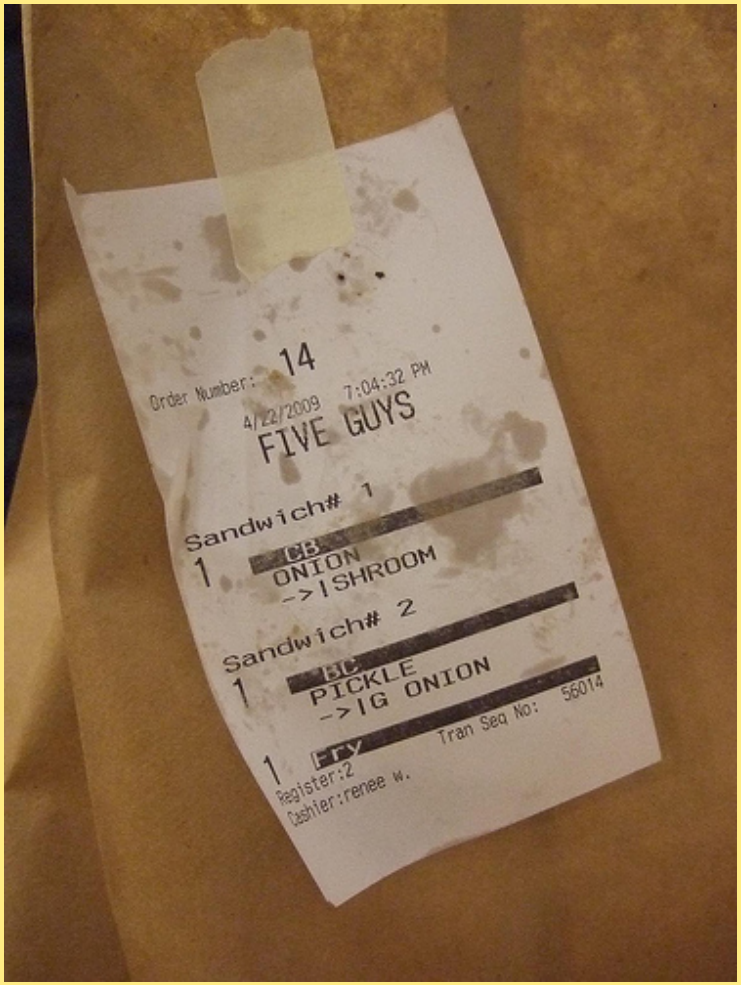
Testing for lipids

- Grease spot test/Brown paper test
- Sudan Red test



Brown paper test for lipids

As we all know from experience, lipids leave translucent spots (grease spots) on unglazed brown paper bags.



Sudan Red test for lipids

Sudan red is a fat-soluble dye that stains lipids red. Using Sudan red can show the amount and the location of lipids.

Testing for proteins – Buiret test

Buiret solution is a blue liquid that changes to purple when proteins are present and to pink in the presence of short chains of polypeptides. The copper atom of the biuret solution reacts with the peptide bonds to cause the color change.

Testing for proteins – Buiret test