Lipids

Lipids are large molecules that are not soluble in water. They are soluble in nonpolar solvents. The most common lipid is fat. But steroids and fat soluble vitamins are also classed with lipids.

Function of lipids

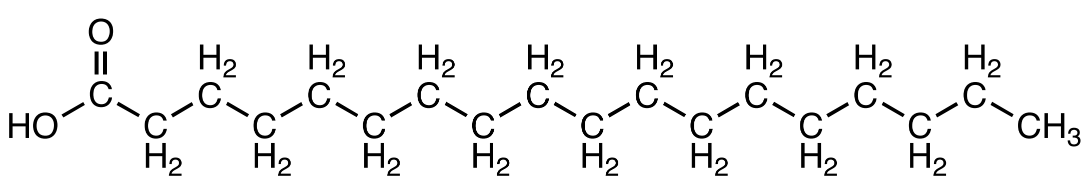
Important part of almost all cells
Found in cell membranes and brain and nervous tissue
Long-term energy storage in the body
Serve as insulation of body's organs against temperature change and shock
Fats and oils generally provide 9 Cal/g of energy in our diet. These can be converted to glucose.

Classes of Lipids

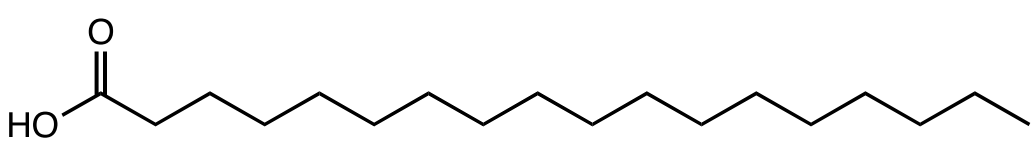
- Triglycerides
- Phosphoglycerides
- Sphingolipids
- Glycolipids
- Steroids
- Fat Soluble Vitamins

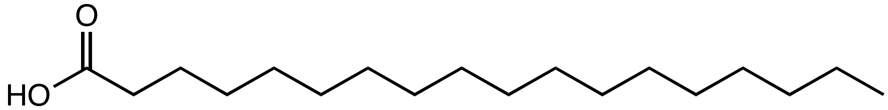
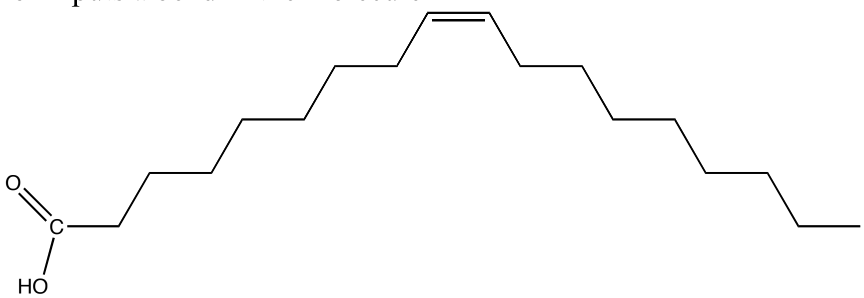
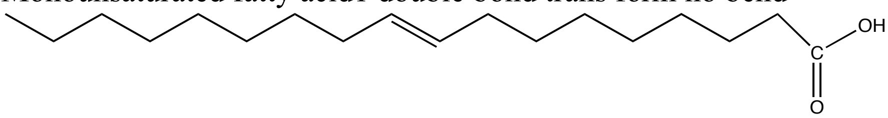
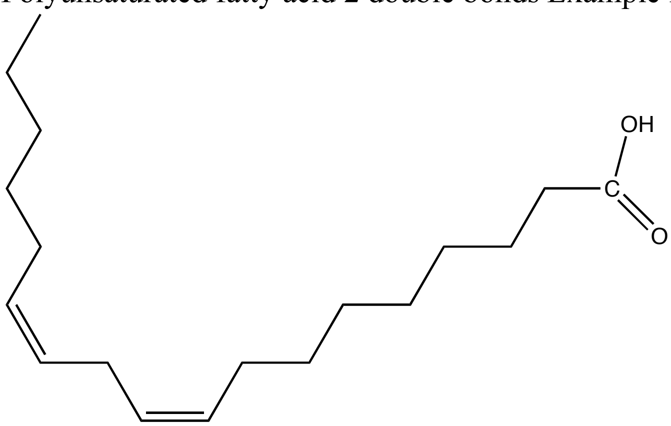
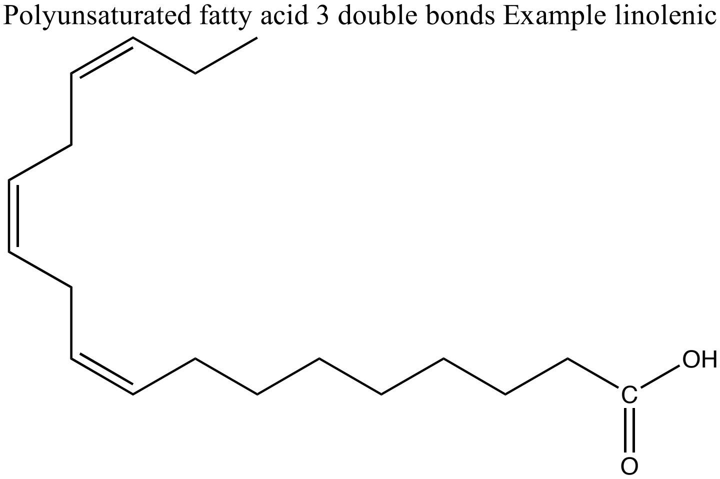
The first four classes of lipids have at least one fatty acid

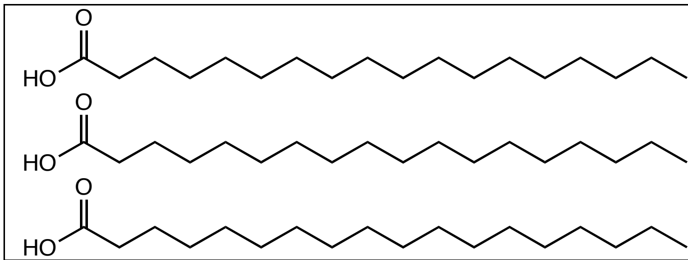
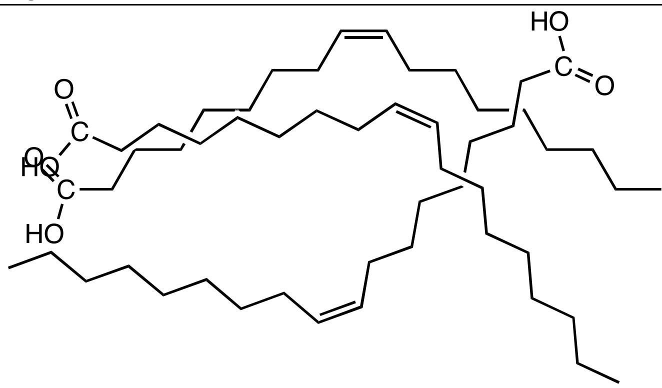
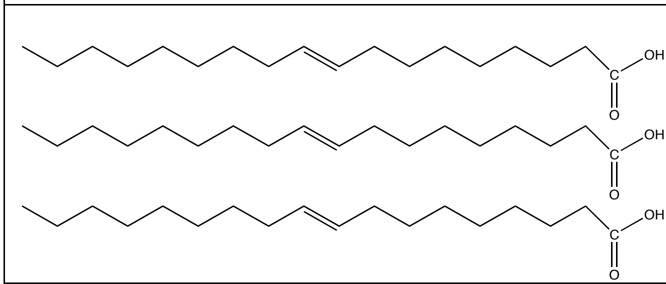
Fatty Acids



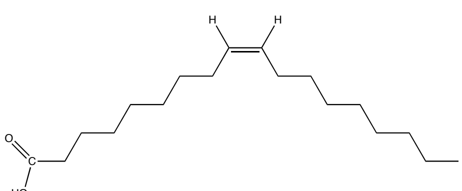
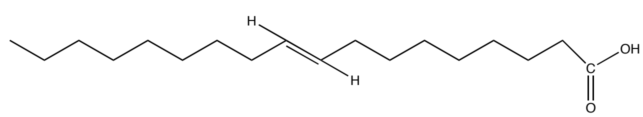
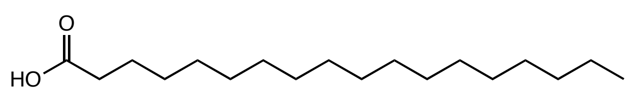
Will be simplified to:



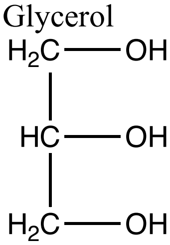
Fatty Acid	Melting point	Source	
Saturated Fatty Acid Example: Stearic acid No double bonds 	69^{o}C solid @RT	pig fat	
Monounsaturated fatty acid Example: oleic acid 1 double bond cis form puts a bend in the molecule 	14 ^{o}C Liquid @ RT	from olive oil	
Monounsaturated fatty acid1 double bond trans form no bend 	43 ^{o}C		
Polyunsaturated fatty acid 2 double bonds Example linoleic acid 	-5 ^{o}C liquid @ RT		
Polyunsaturated fatty acid 3 double bonds Example linolenic acid 	-11 ^{o}C liquid @ RT		

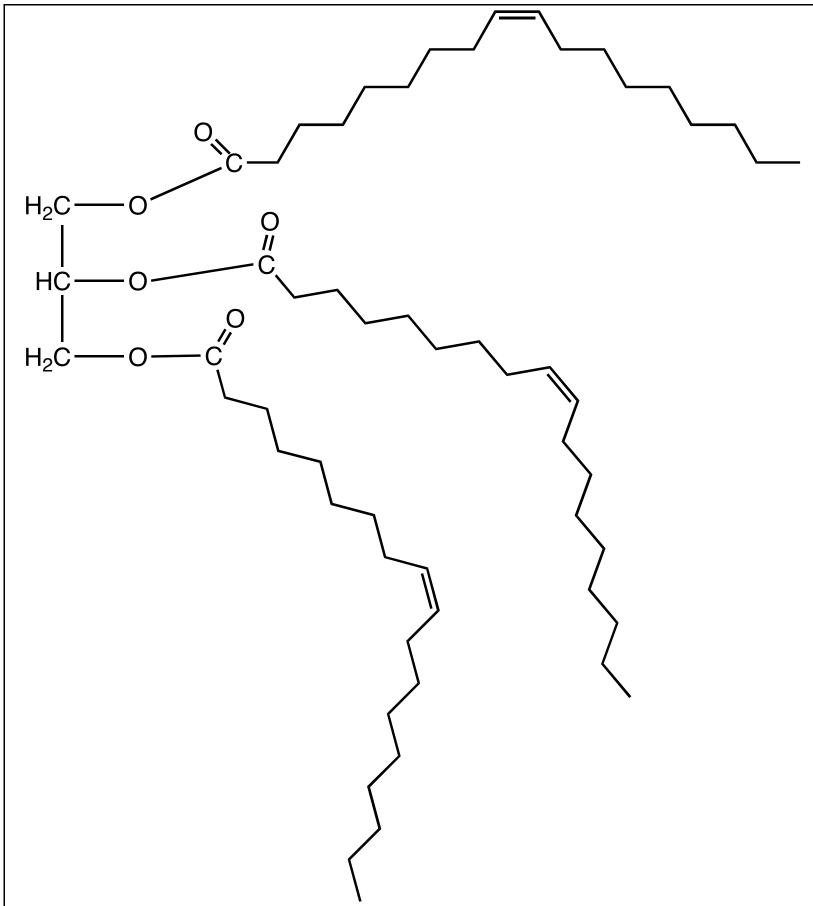
	Saturated fatty acids stack together very easily so it is easy to form a solid so they are solid at room temperature. Saturated fatty acids raise the cholesterol in your blood.
	Cis Unsaturated fatty acids do not stack together well at all so they tend to be liquids at room temperature. Vegatable oils contain cis fatty acids. The double bond tends to oxidize and the oil becomes rancid. The oil can be “hydrogenated” and then become more saturated and resist oxidation.
	Trans fatty acids stack together well like unsaturated fatty acids. When cis fatty acids are hydrogenated some of the cis double bonds become trans. Trans fatty acids raise the levels of low density lipoproteins (LDL) in the blood LDL contain cholesterol which accumulates in the arteries leading to heart disease. These fatty acids are found in milk, fried foods, butter, cookies, crackers and vegetable shortening. Many restaurants are using less trans fatty acids. You should limit these fatty acids in your diet

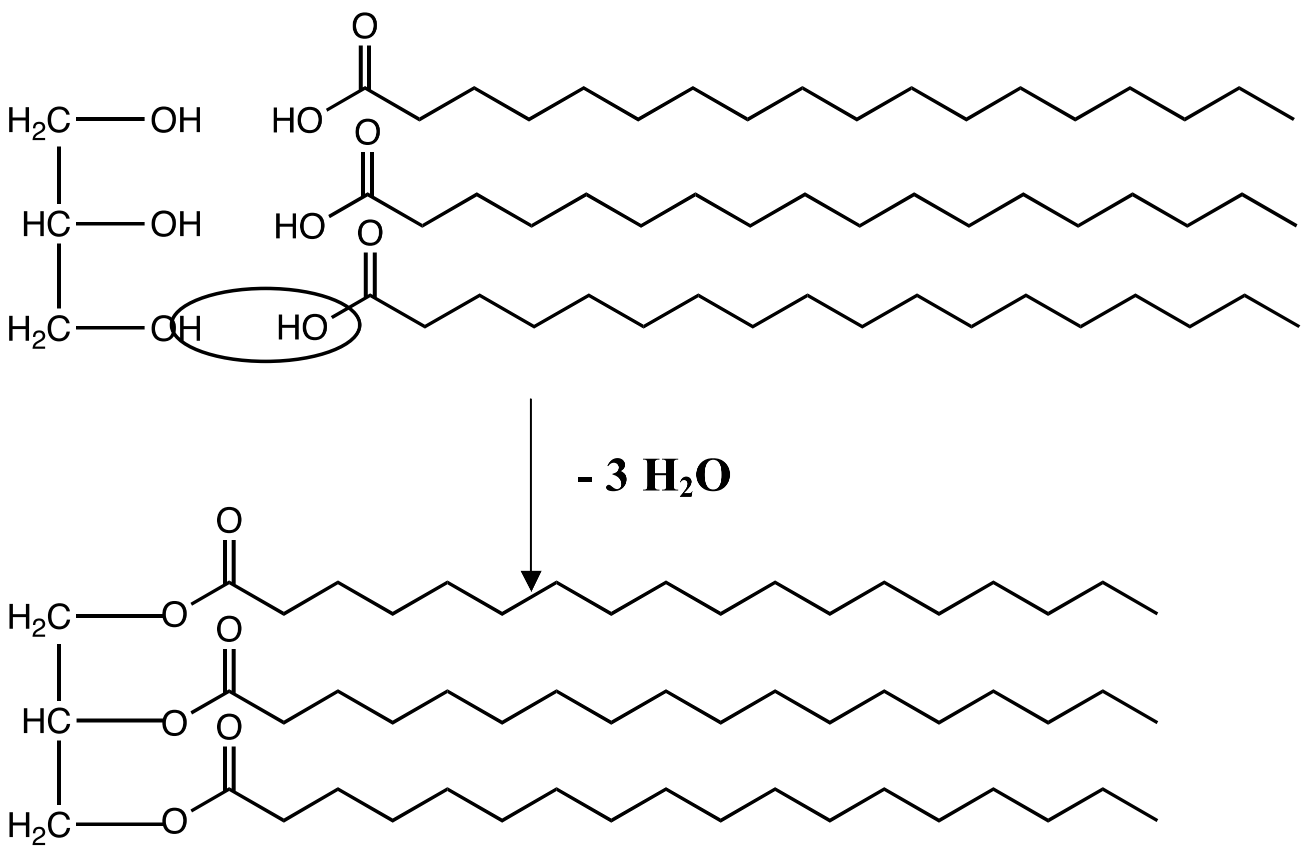
Hydrogenation

	+ H2 Catalyst →	 +  Both the saturated fatty acid and the trans isomer are produced

Glycerol

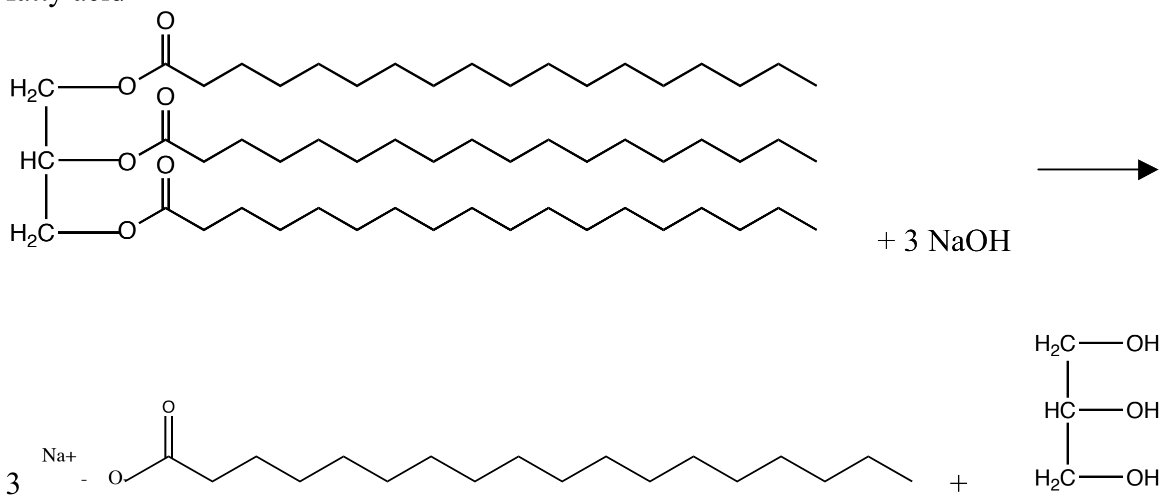


	This is a triglyceride with three **unsaturated** fatty acids that are cis. The bend in the molecules make it difficult for them to stack together and form a solid



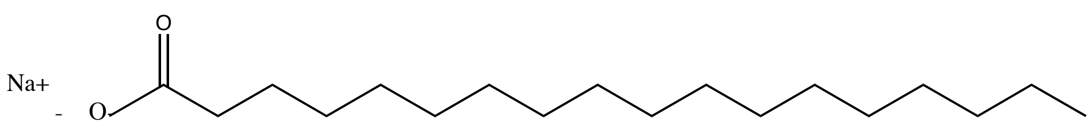
Saponification

The hydrolysis of a triglyceride with a strong base produces a molecule of glycerol and 3 salts of a fatty acid

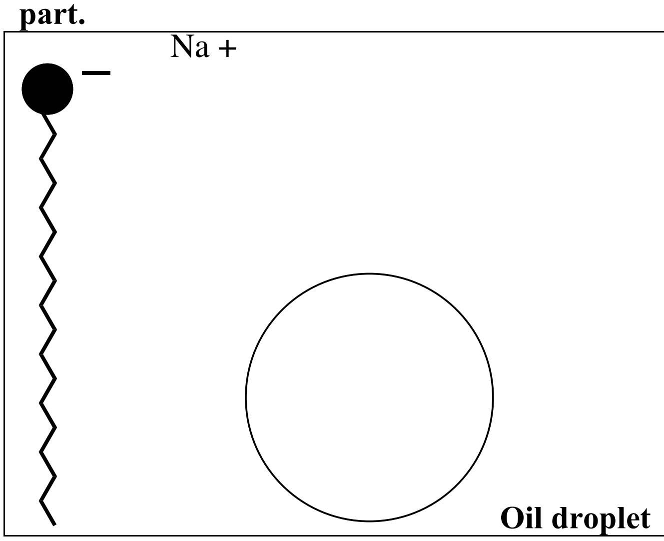
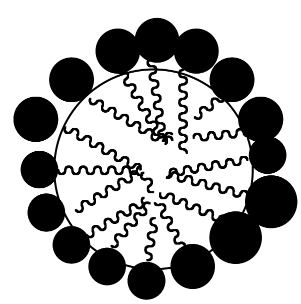


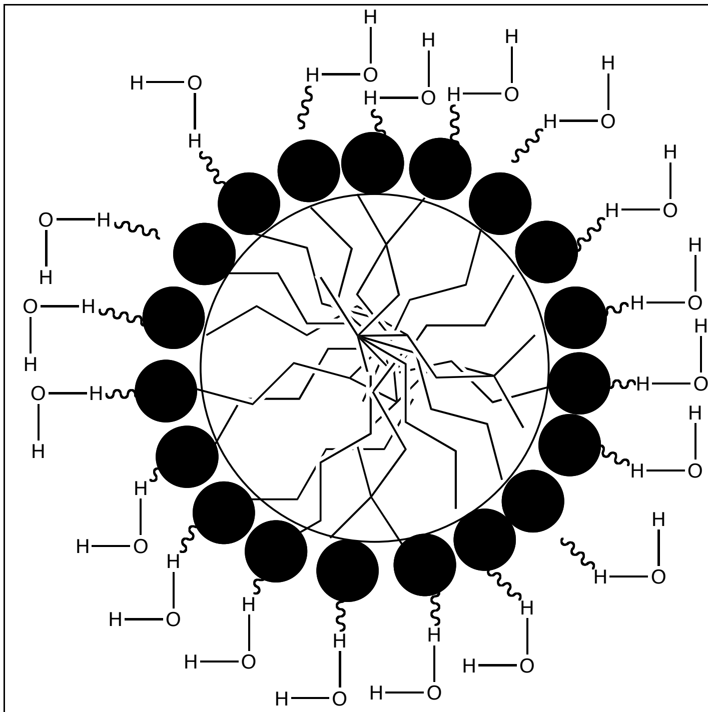
In this reaction glyceryl tristearate is hydrolyzed by sodium hydroxide to form sodium stearate

Soap

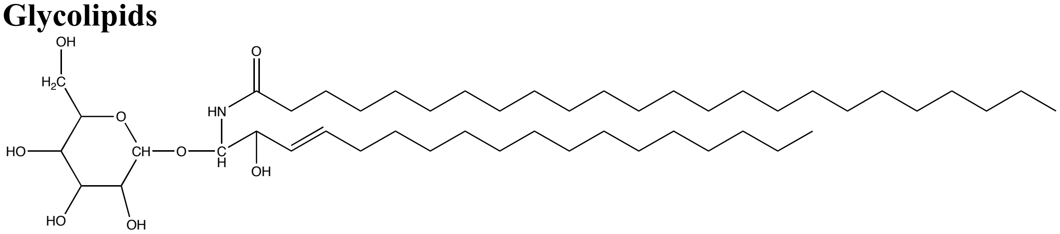


Soap is the salt of a fatty acid. It is unique because it has an ionic end and a long tail that is nonpolar. So it has both a water loving (hydrophilic) part and a water hating (hydrophobic) part.

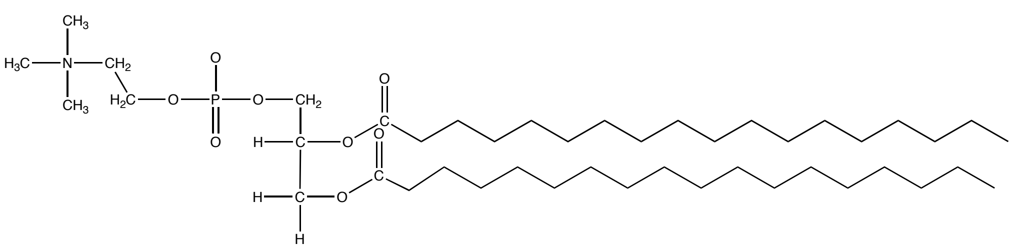
	**The polar "head" will be attracted to water. The nonpolar "tail" will be attracted to oil. This is how soap is able to wash away oil from skin or dishes.** 

 A soap Micelle	**Non polar ends of molecules at the center are attracted to the circular nonpolar material. The negativiely charged groups on the surface are attracted to the water molecules**

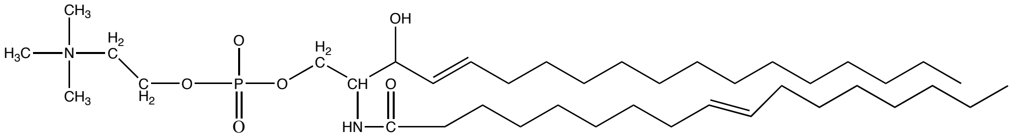
Glycolipids



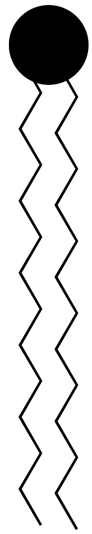
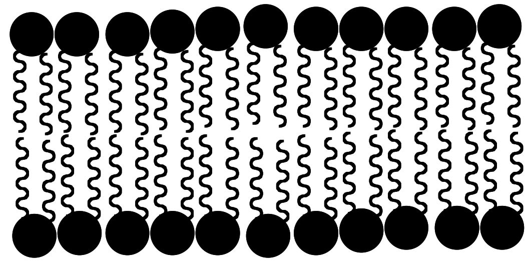
Phosphoglycerides

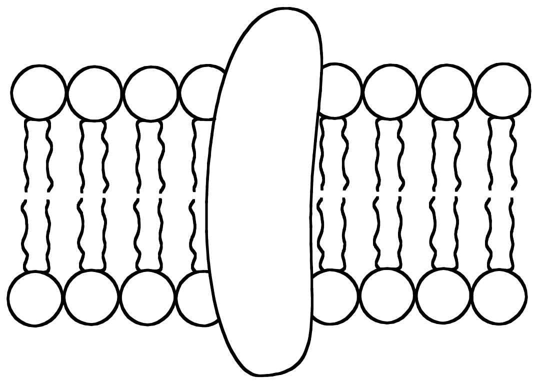


Sphingolipids

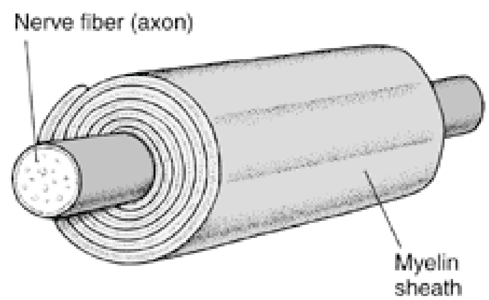


Glycolipids Sphingolipids and phosphoglycerides have two hydrophobic “tails” and a hydrophilic head.
One of the major functions of Sphingolipids and phosphoglycerides is forming the “lipid bilayer” of cell membranes. Glycolipids are found in brain and nervous tissue.

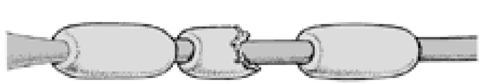
	**Hydrophilic head** **Hydrophobic tail**	 Several of these molecules line up with each other so that on the inside is a hydrophobic region, and on the outside are hydrophilic regions.

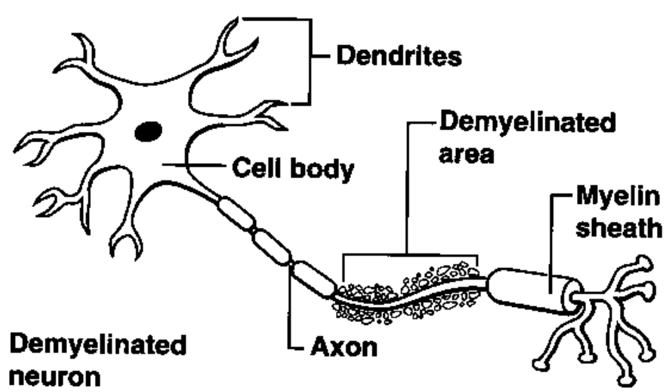
These two layers of lipids form a "lipid bilayer" of the cell membrane. Water can be on either side of the membrane but not on the inner part of the membrane. The parts that stick through are proteins that only let certain molecules through.	

Another major function of sphingolipids is in forming the <u>myelin sheath</u> which protects or insulates nerve tissue.

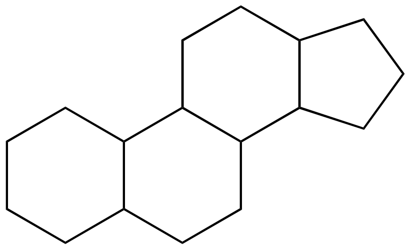


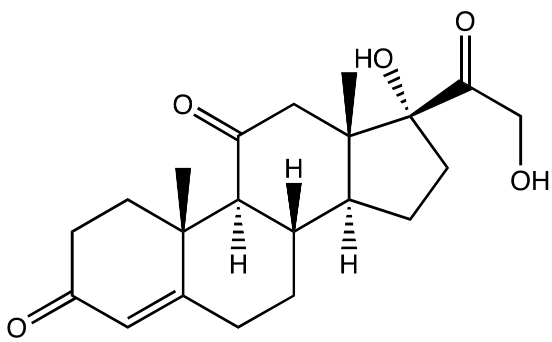

Normal Myelin Sheath


Damaged Myelin Sheath

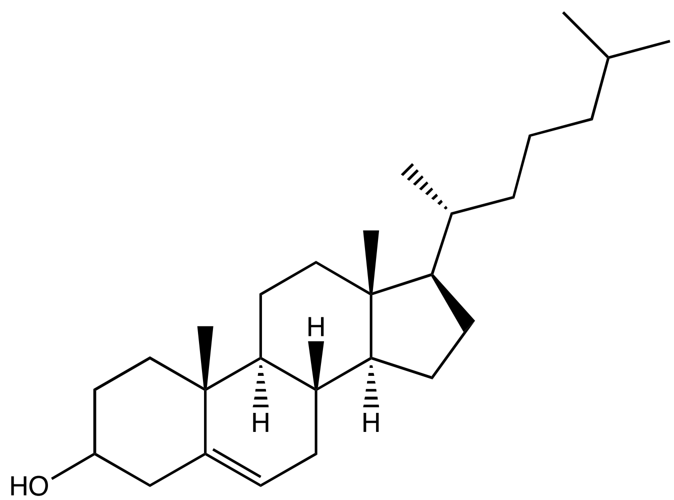


Steroids

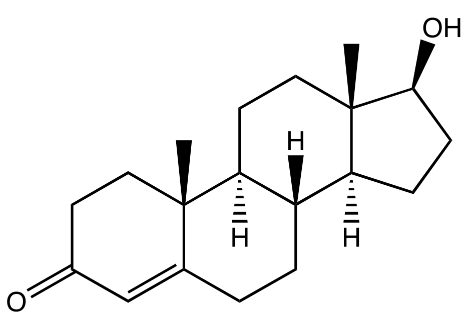




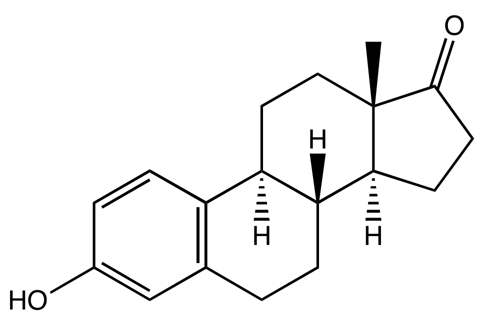
cortisone



cholesterol



testosterone



estrone

Carbohydrates

Carbohydrates make up ______% of our diet. They represent a major part of all of the matter on earth that is organic.

Carbohydrates contain _______ functional groups

Carbohydrates are produced in the process called _________:

__________ + ____________ + energy $\rightleftharpoons$ $(CH_2O)n$ + ________

n is usually 3, 4, 5, or 6.

Function of Carbohydrates

In animals and humans

1.

2.

3. Generally carbohydrates provide _____Cal/g of energy

In Plants

1.

2.

3.

3 Types of Carbohydrates

Monosaccharides

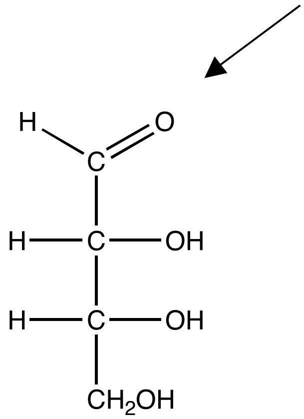
Disaccharides

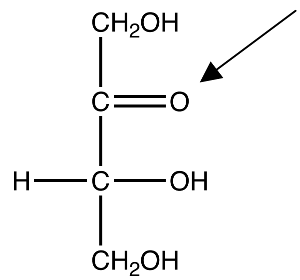
Polysaccharides

Structures

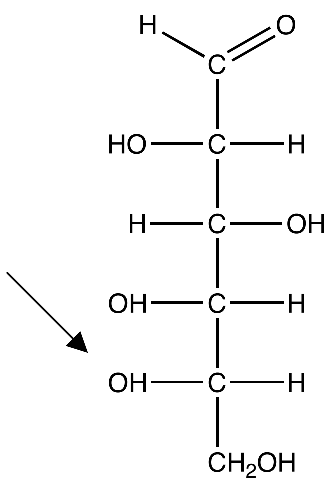
Monosaccharides _______________

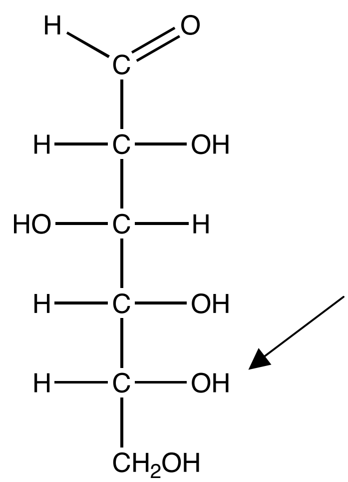
2 Types:



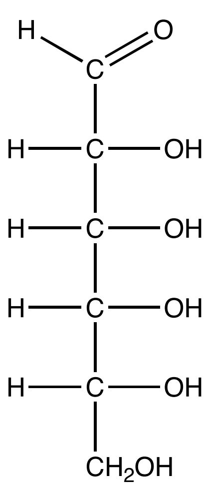


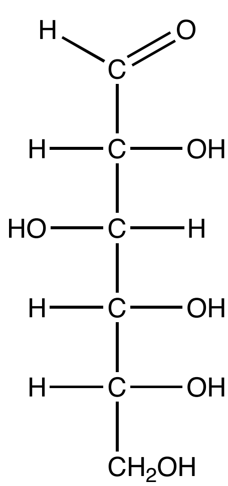
2 significant isomers:

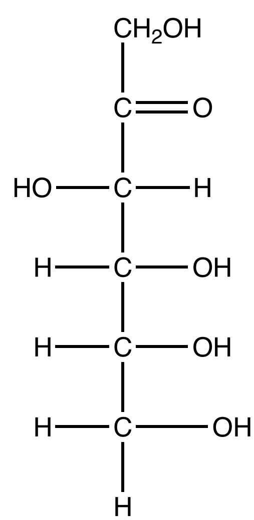




3 important monosaccharides:

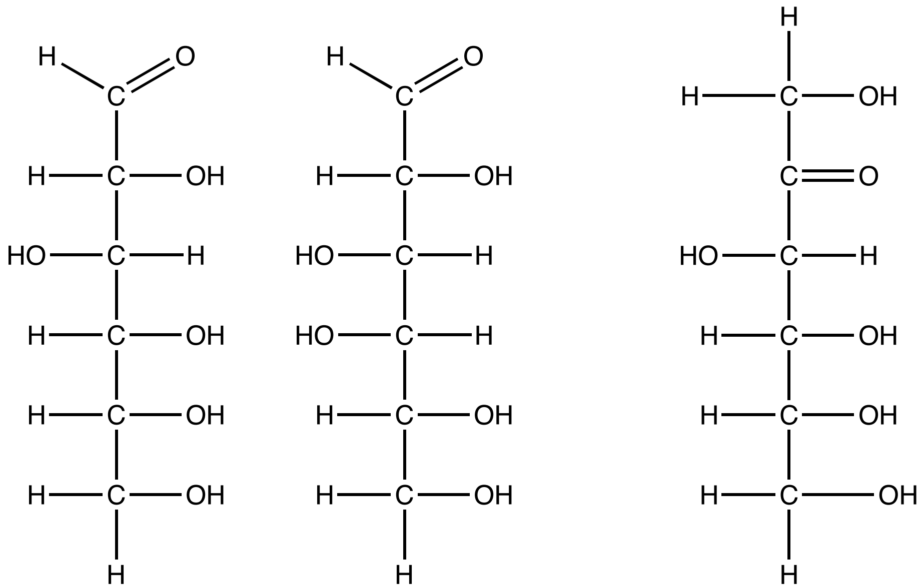




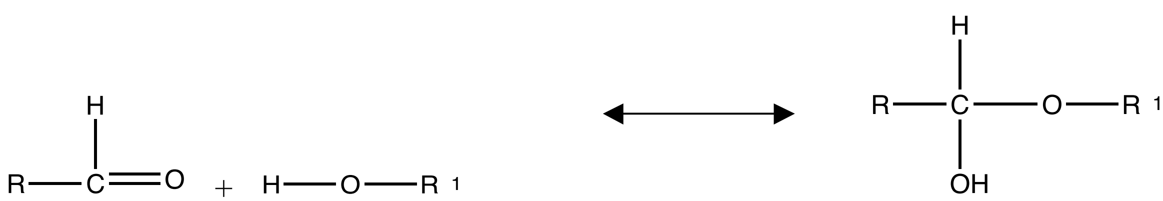


Glycosidic Linkage

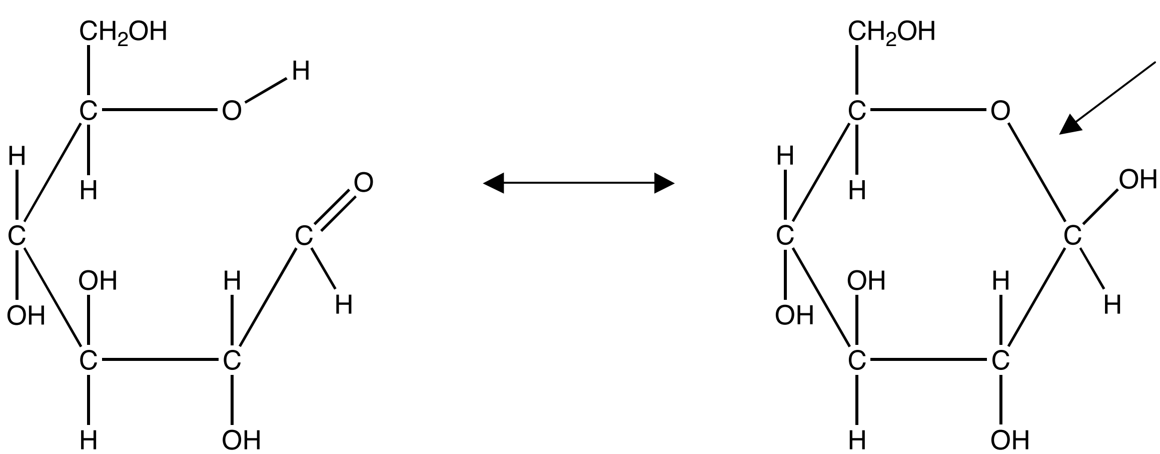
Hemiacetal bond



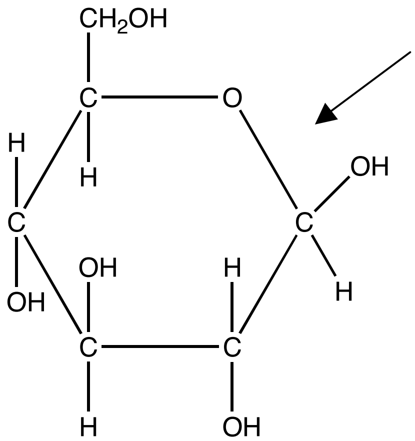
The Hemiacetal bond

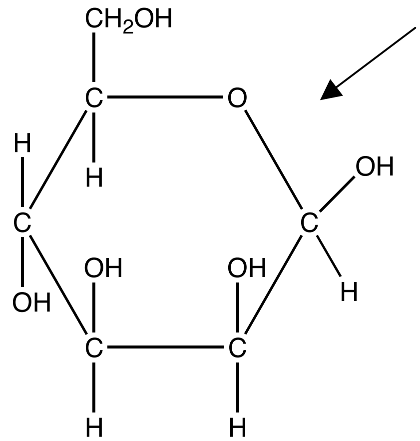


Ring Structures



α and β forms of glucose



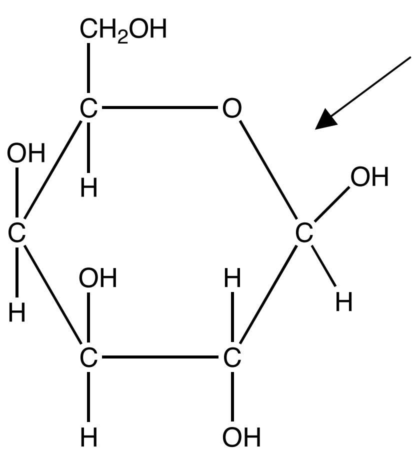


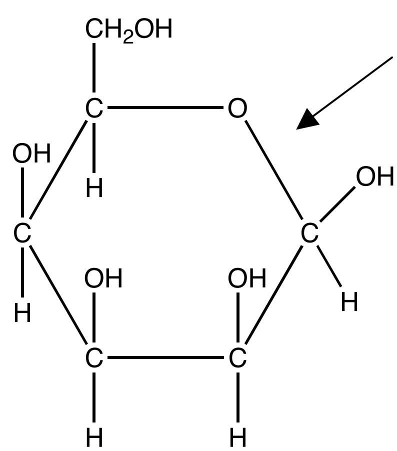
__________________________   _________________________

Glucose is a __________________sugar

These differ only in the position of one hydroxyl group. But starch foods like pasta, bread, and rice contain the ______form. We can digest these foods. The _______form is found in wood and cellulose which we cannot digest. We have an enzyme that can digest the ____form but not the ____form.

α and β forms of galactose

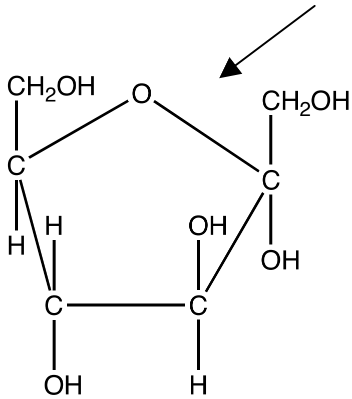


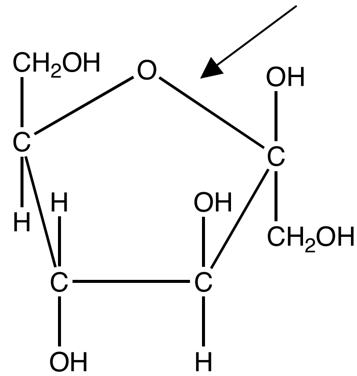


__________________________   ________________________________

Galactose is a ____________________sugar.

α and β forms of fructose





__________________________ __________________________

Fructose is a ____________________sugar.

Reducing Sugars:

These are sugars that contain a free carbonyl group are known as reducing sugars. The oxygen in the carbonyl can react with certain reagents that give a positive test for reducing sugars. Benedict's solution is one of those reagents. The three monosaccharides are reducing sugars. Lactose and maltose are reducing sugars. Sucrose and the polysaccharides are not. But if those non reducing sugars are hydrolyzed into monoscaccharides, then the product is a reducing surgar. This reaction is also responsible for the browning of certain foods during the cooking process.

Function of the monosaccharides glucose, galactose, and fructose.

1. **Fructose**
   Found in fruits and honey
   Sweeter than sucrose or glucose and other carbohydrates
   Converted to glucose in the liver

2. **Galactose**
   Obtained from the disaccharide lactose found in milk
   Found on surfaces of cell membranes
3. **Glucose**
   Main carbohydrate in our blood
   Found in honey and fruit
   It is the major building block of polysaccharides
   The brain uses only glucose for fuel, but the brain does not store glucose so the blood glucose level must be maintained. Below 25% of normal, coma can occur. This could be caused by an overdose of insulin

Disaccharides

The three important disaccharides are maltose, lactose and sucrose.

Function

Maltose

Obtained by hydrolyzing starch
Used in cereals, candy, and brewing beverages

Lactose

Found in milk (human milk 6-8% , cow milk 4-5%)
Some people do not have the enzyme needed to hydrolyze lactose and are considered lactose intolerant.
Lactose is the least sweet sugar

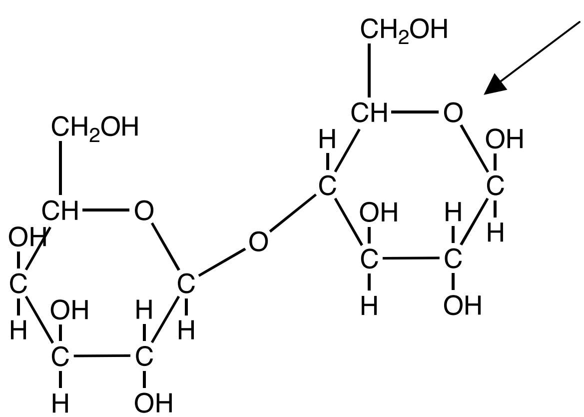
Sucrose

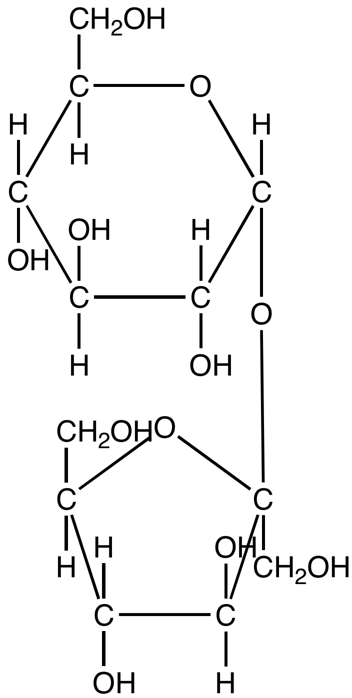
Mostly obtained from sugar cane (20% sucrose) and sugar beets (15% sucrose)
Commonly referred to as "table sugar".
In the year 1700 Americans consumed _____lbs of sugar per person per year. In 1780 it was______lbs. In 1960 it was_______. By 2005 Americans consumed ________lbs per person pear year of sugar and other sweeteners!

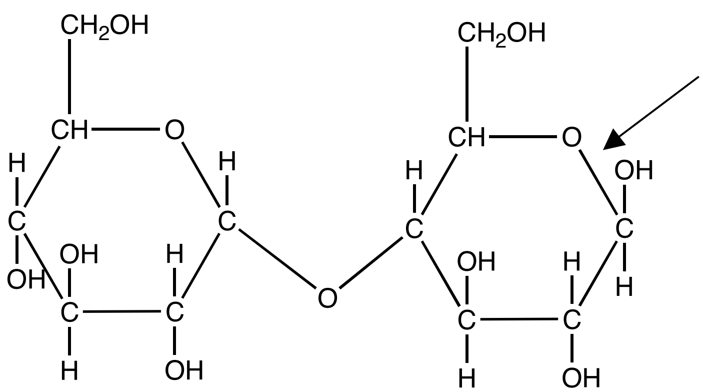
Structure

Each of these disaccharides are made of 2 monosaccharides held together by a glycosidic or ether bond.

glucose + glucose → maltose
glucose + galactose → lactose
glucose + fructose → sucrose







Polysaccharides

Starch

Cellulose

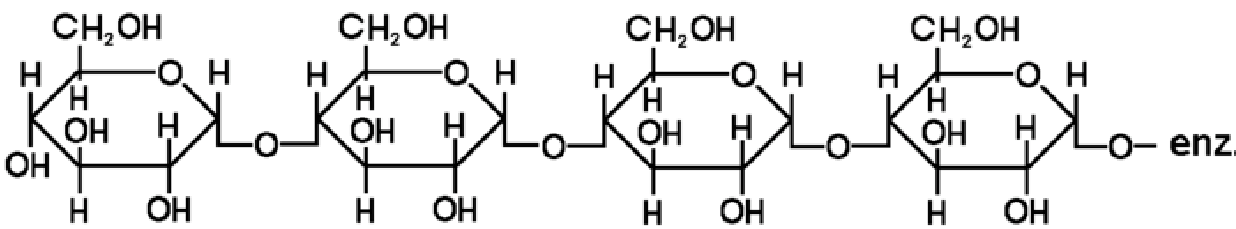
Glycogen

Starch
Function

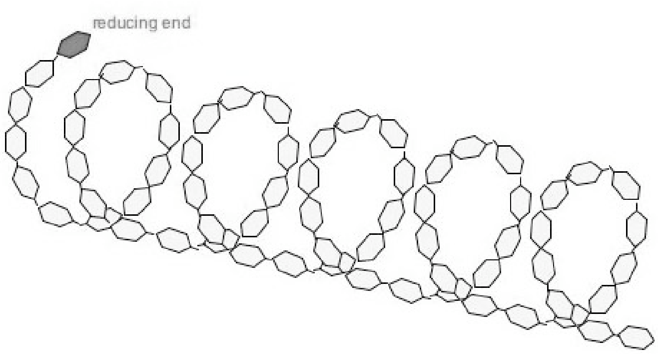
1. **Storage of carbohydrates in plants**
2. **Provides about 50% of the glucose in our diet**
    a. **Found in rice, wheat, beans, breads, cereals, and potatoes.**

Structure

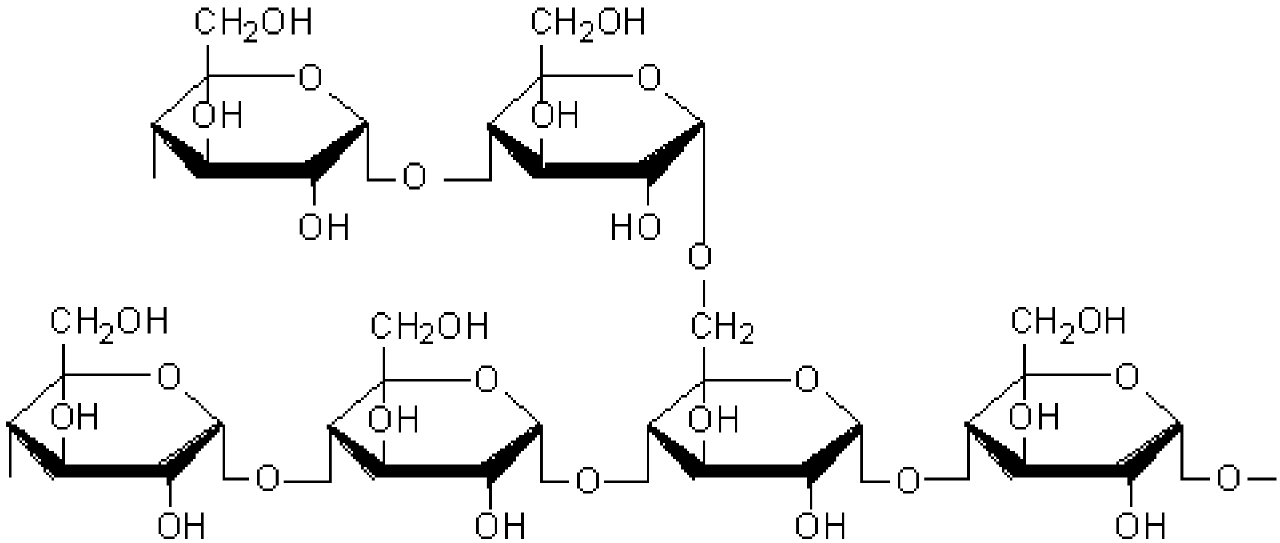
Starch is made of 80% amylopectin and 20% amylose



__________________ a straight chain that coils up. It tends to be unbranched chains of 200-4000 α-D-glucose units. Molecules are connected by α-1,4gylcosidic bonds.



Amylose, an unbranched starch



____________________ is a branched structure of glucose units. A branch occurs every 25 glucose units or so. **Molecules are connected by α-1,4-gylcosidic bonds. . Branches are connected by α-1,6-gylcosidic bonds.**

Cellulose

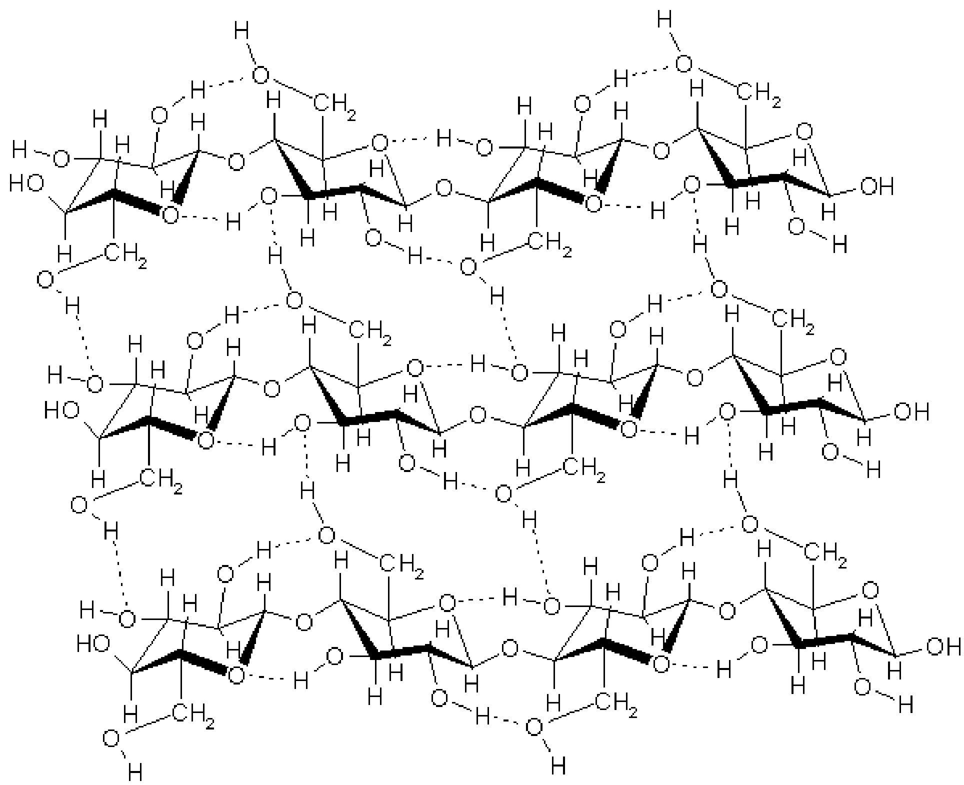
Function

Structural Material in plants. It is found in the cell walls of plants. Cotton is almost all cellulose. Wood and paper contain a great deal of cellulose

It is the fiber in our diet.

Structure

Cellulose does not coil like amylose. It forms in parallel rows.



Cellulose

. Molecules are connected by β-1,4gylcosidic bonds. Our bodies have enzymes that can hydrolyze the α-1,4gylcosidic bonds of starch but we do not have enzymes to hydrolyze the β-1,4gylcosidic bonds found in cellulose . It is still and important part of our diet.

The rows are held together by hydrogen bonds and then bundles of the rows of chains are twisted into fibers. Cellulose is the fiber in our diet

Glycogen

Function

The way carbohydrates are stored in humans and animals
Helps maintain glucose level in blood and muscle tissue
Stored in the liver and in muscles

Structure

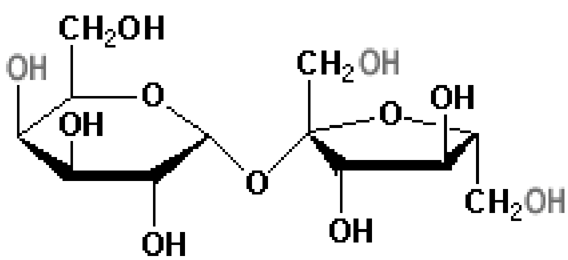
Glucose **molecules are connected by α-1,4-gylcosidic bonds.**

Branching occurs every 10-15 units. So there is much more branching in glycogen than in amlopectin

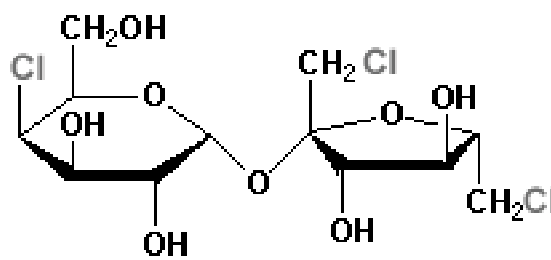
Glycogen **Amylopectin**

Why is branching different?

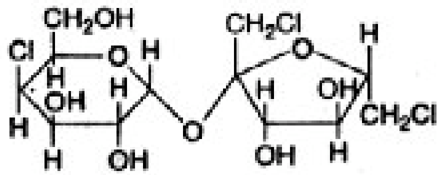
Tasting Sweetness



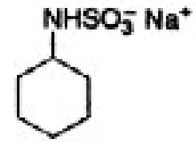
Sucrose
(Sugar)



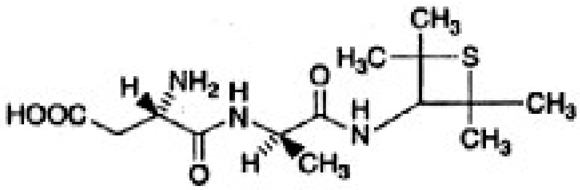
Sucralose
(Splenda)



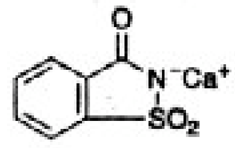
Sucralose



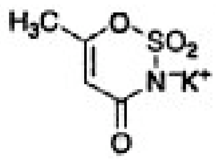
Cyclamate



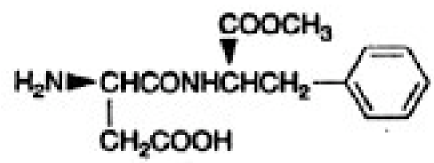
Alitame



Saccharin



Acesulfame-K



Aspartame

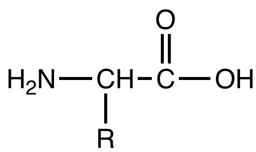
Sweetness scale	Standard (Sucrose = 100)
galactose	30
glucose	75
fructose	175
lactose	16
maltose	33
sucrose	100
sucralose (slpenda)	60,000
Aspartame (nutrasweet)	18,000
Saccharin (sweet'n low)	45,000

Metabolism
Proteins
Enzymes
DNA

Proteins

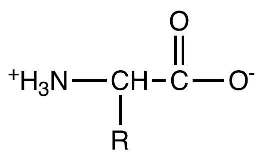
Proteins are polymers of amino acids in a particular arrangement that allows them to perfom a particular biological function.

Amino Acids

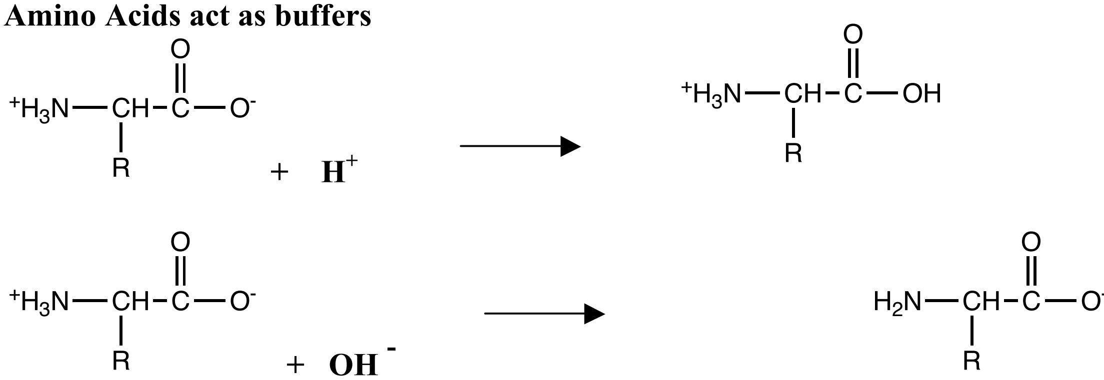


Amino Acids are amphoteric

Amino Acids are Zwitterions:



Amino Acids act as buffers

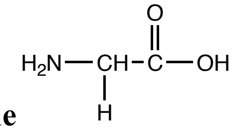
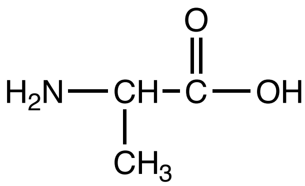
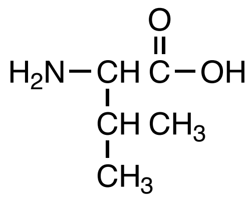
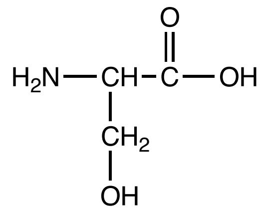
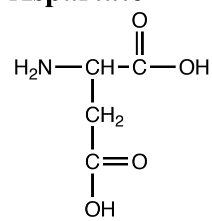
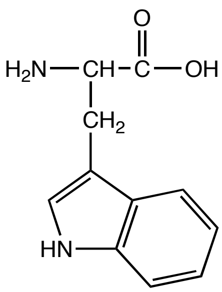
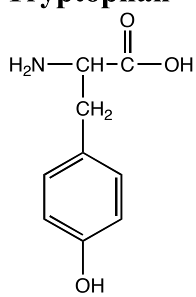
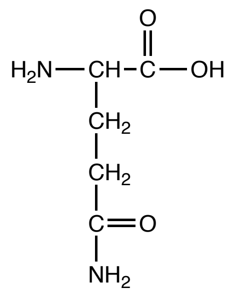
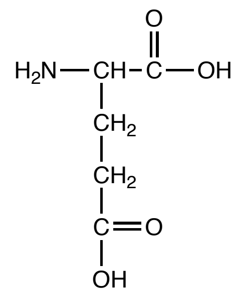
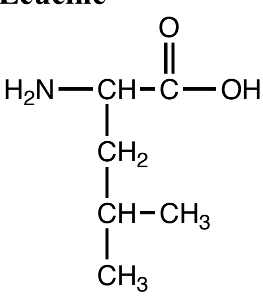
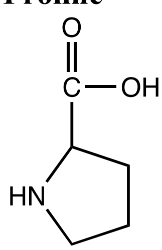
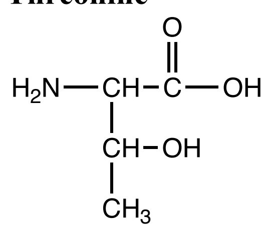
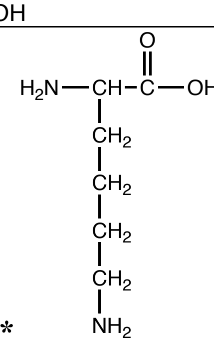
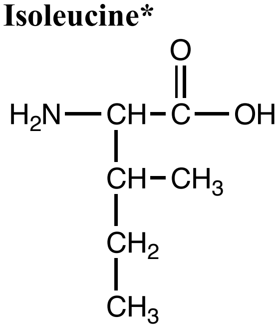
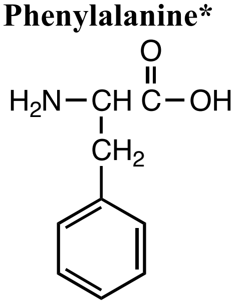
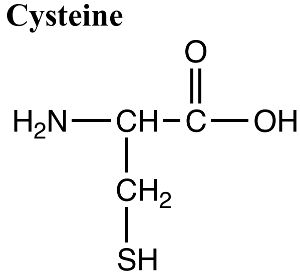
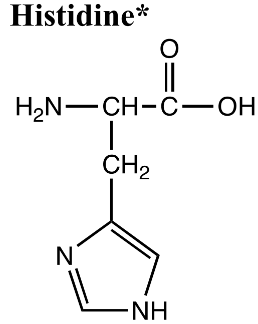
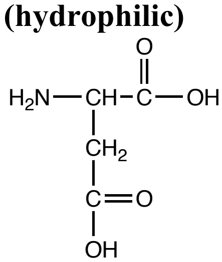
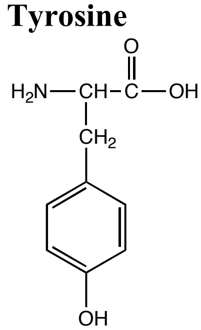
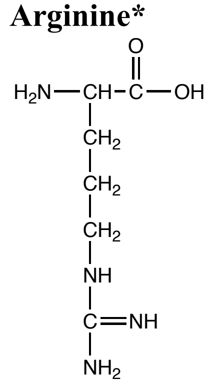


Only the L-isomers of amino acids are found in nature

Amino Acids have a very high molecular weight. Insulin has a weight of 5,700 hemoglobin a weight of 64,000 and some virus proteins have a weight of 40 million

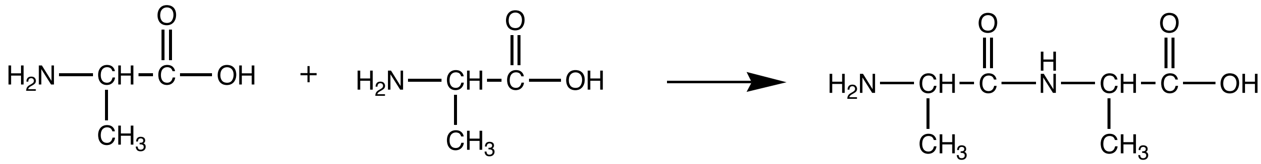
Amino Acid Names and Structures

*denotes essential(must be obtained from your diet)

Amino Acid Hydrophobic (water fearing) nonpolar		**Amino Acid Hydrophilic (water loving) polar**	 **Glycine**
Alanine 	**Valine*** 	**Serine** 	**Aspartate** 
Methionine* 	**Tryptophan*** 	**Glutamine** 	**Glutamate** 
Leucine* 	**Proline** 	**Threonine*** 	 **Lysine***
Isoleucine* 	**Phenylalanine*** 	**Cysteine** 	**Histidine*** 
The 10 amino acids with a *denotes essential(must be obtained from your diet). The other 10 amino acids can be synthesized in the body from lipids or carbohydrates.	**Asparagine (hydrophilic)** 	**Tyrosine** 	**Arginine*** 

Peptide bonds.

The bond that holds amino acids together in a chain which becomes a protein is called the peptide bond or amid linkage. This bond is between the amino group of one amino acid and the carboxyl group of another amino acid



2 amino acids

dipeptide
with amide linkage

If a polypeptide chain is hydrolyzed the products are amino acids

Types of proteins

Fibrous protein

Long, linear, polypeptide chains that are side by side

Insoluble in water

Structural proteins

Examples: hair, muscle

Globular Proteins

Polypeptide chains folded up

Attracted to water

These proteins can be moved from one place to another

Examples: enzymes, hemoglobin, insulin, antibodies

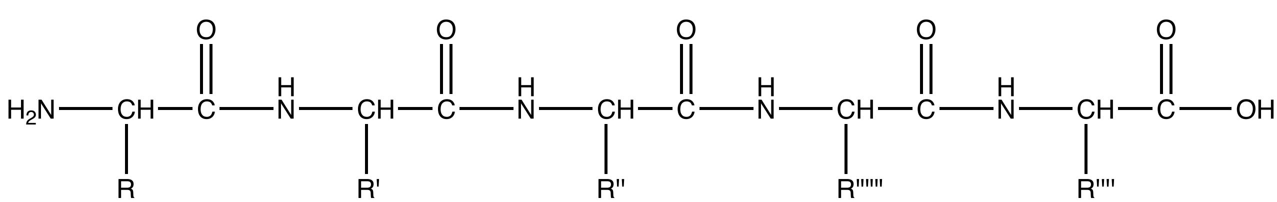
Structure: There are 4 levels of protein structure

Primary structure

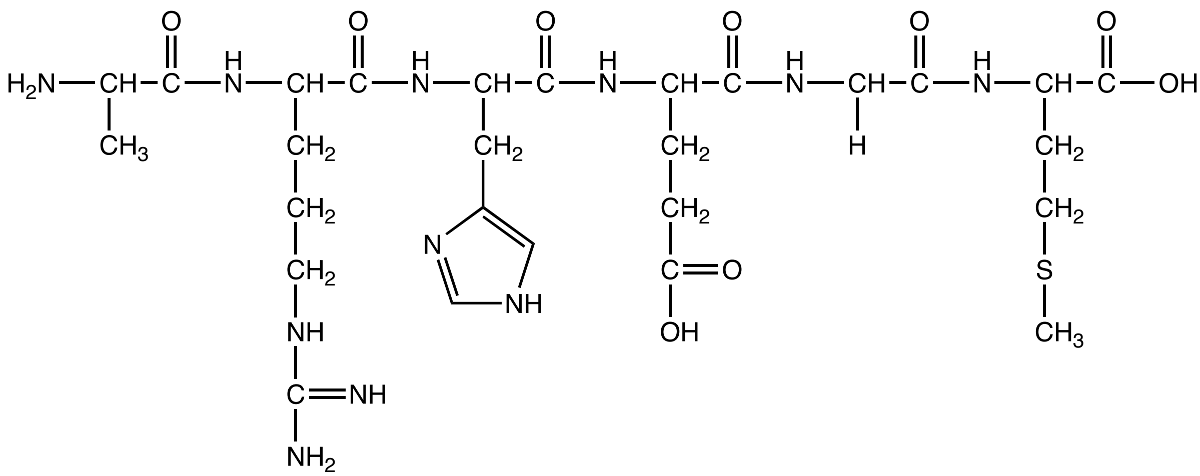
The sequence/order of amino acids

Maintained by peptide bonds

Other levels of structure depend on primary structure



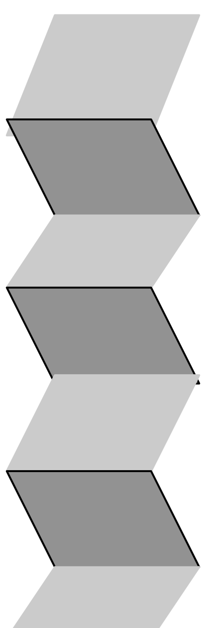
Here is a peptide chain of 6 amino acids



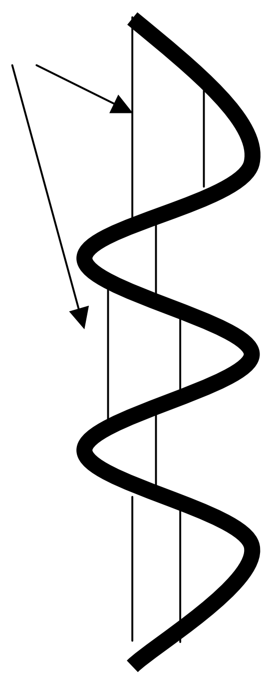
Secondary Structure

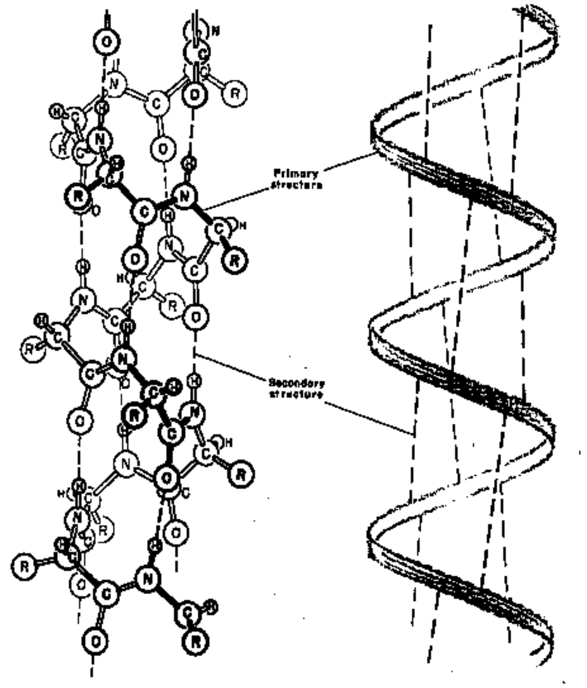
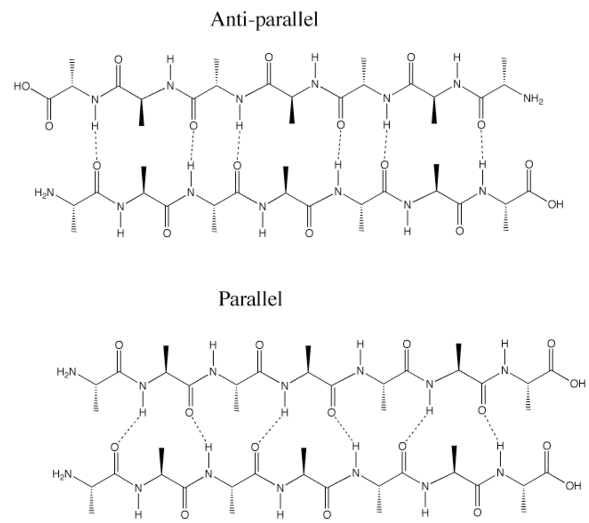
The folding or other repeating pattern of the peptide chain.
Maintained by hydrogen bonds

Beta Pleated Sheet



Alpha Helix



Alpha Helix	Beta Sheet
	
Examples are hair and wool and muscle	Example is silk

Globular proteins

Contain a combination of secondary structures giving rise to their tertiary structure

Fibrous proteins

Contain only one kind of secondary structure and no tertiary structure

Tertiary Structure 3^o

The folding of the peptide chain

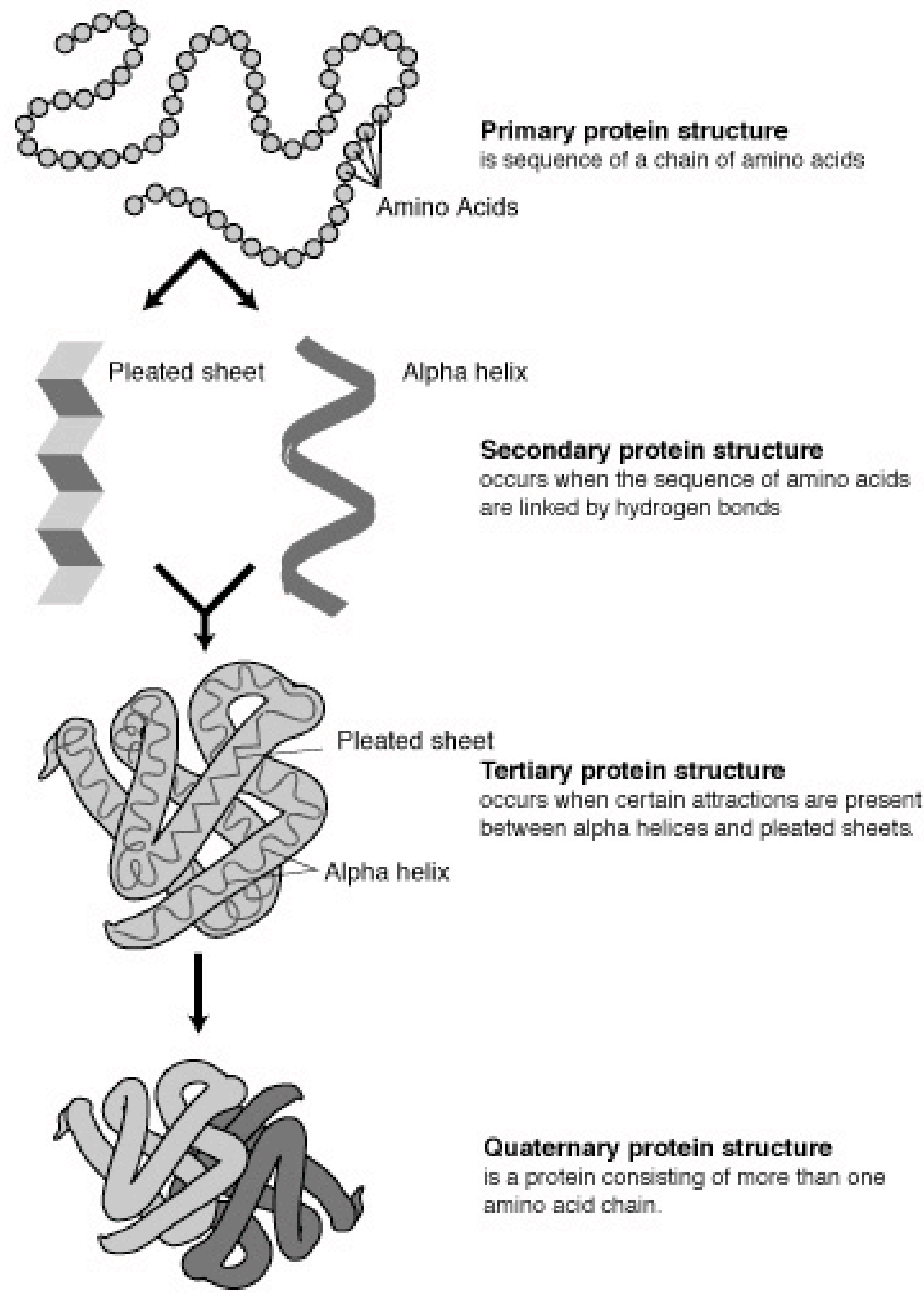
Maintained by hydrogen bonds, disulfide bonds (S-S), ionic interactions, hydrophobic interactions all between different parts of the chain.

Only globular proteins have tertiary structure.

Quaternary Structure 4^o

When different subunits of 3^o structures are part of the same protein

4 Types of Structures of proteins



Denaturing Protein

Breaking down the 3^o, 3^o and 4^o structures but not the amino acid sequence.

Losing structure caused by the hydrogen bonds, disulfide bonds, folding, etc. The shape of the protein is lost.

The peptide bonds are <u>not</u> broken so 1^o structure stays the same.

Effects

Protein is no longer biologically active

No longer soluble

Causes of denaturing

Extreme heat as in cooking

Extreme pH

Presence of certain heavy metal ions Ag^{+}, Pb^{2+}, Hg^{2+}

<u>Examples of Proteins</u>	**<u>Function</u>**
Enzymes	
sucrase	hydrolyzes sucrose
lipase	hydrolyzes lipids
protease	hydrolyzes peptide bond
Storage Proteins	
ovalbumin	egg-white protein
casein	milk protein
ferritin	iron storage protein
Transport Proteins	
hemoglobin	transports oxygen in blood
myoglobin	transports oxygen in muscle
serum albumin	transports fatty acids in blood
Contractile Proteins	
myosin	thick filaments in muscle
actin	thin filaments in muscle
Protective Protein	
antibodies	form complexes with foreign proteins like viruses
fibrinogen	protein used for blood clotting
Hormones	
growth hormone	stimulates growth of bone
insulin	regulates glucose in blood
Structural Protiens	
α-keratin	Skin, hair, feathers, horns, nails, wool, hooves
collagen	Fibrous connective tissue: tendons, bone, cartilage

How Proteins are made

1. Nucleic Acids

Nucleic acids carry the information that is the blueprint needed to make the primary structure of proteins

a. Nucleotides

Sugar + base + phosphate -> nucleotide

Nitrogen containing bases

1. Adenine (A)
2. Thymine (T)
3. Guanine (G)
4. Cytosine (C)
5. Uracil (U)

DNA contains A, G, C, T
RNA contains A, G, C, U

b. Structure of Nucleic acids

Polymers of nucleotides

```
                Base                Base                  Base
                 |                   |                     |
Phosphate—Sugar—Phosphate--Sugar—Phosphate—Sugar--Phosphate
```

c. Double Helix

DNA is a spiral molecule in which to strands of the polymer are hooked together by hydrogen bonds.
Adenine hydrogen bonds with thymine
Guanine hydrogen bonds with cytosine

```
-A—C—G—A—T—C—T-
 :  :  :  :  :  :  :
-T—G—C—T—A—G—A-
```

d. DNA Replication

e. Transcription

DNA→ mRNA

1. **Types of RNA**

   Messenger RNA (mRNA)

   Ribosomal RNA (rRNA)

   Transfer RNA (tRNA)

2. **The genetic code**
   The genetic information carried by the Nucleic acids to make proteins is coded. There are only 4 bases in mRNA and there are 20 amino acids. The genetic code is a system of 3 bases in a particular order that corresponds to an amino acid.

   Code

   Guanine-guanine-cytosine (GGC) is the code for the amino acid gly. GAG is the code for the amino acid glutamic acid.

   There are 64 code words or codons for the 20 amino acids.

f. Translation

Initiation-Elongation-Termination

g. Issues involving Nucleic Acids

1. Recombinant DNA technology

2. Muatations

X rays, UV sunlight,
Mutagens,
Viruses

DNA ————————> alteration of DNA———>defective protein———>genetic disease (germ cells)
Cancer (somatic cells)

	Normal Sequence	Mutation
DNA ↓	ACA—CCC—AGG—TTT	ACA—C**A**C—AGG—TTT
mRNA ↓	UGU—GGG—UCC—AAA	UGU—G**U**G—UCC—AAA
Amino Acid sequence	Cys—Gly—Ser—Lys	Cys—**Val**—Ser—Lys

3. Viruses