Before talking about organic chemicals essential to our lives, we need to understand another concept that we haven’t discussed so far; isomerism. Isomers are 2 or more compounds with the same molecular formula but different structures or shapes. The most common are what are called structural isomers. There are 2 structural isomers of C₄H₁₀:

\[
\begin{align*}
\text{CH}_3\text{CH}-\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CH}-\text{CH}_3
\end{align*}
\]

There are also isomers that are called stereoisomers, an isomer because of the position or orientation in space of the atoms in the molecule. The specific type of stereoisomers that I want to discuss now can be understood by looking at your hands. They look the same, but try to put one on top of the other so that they are identically oriented (this is called superimposing one on the other). You can’t. But if you put one facing the other, like looking in a mirror, they match. They are mirror images of each other.

In chemistry, if you have 2 molecules that are identical in all respects, including many physical and chemical properties, molecular formulas, bonding and one is the mirror image of the other, but not superimposable, they are called enantiomers or mirror image isomers.

In order to have enantiomers, there must be at least one C atom in the molecule that is bonded to 4 different atoms or groups (for this test a CH₃ group is different than a CH₃-CH₂ group. One example:

\[
\begin{align*}
\text{OH} \quad \text{O} \\
\text{CH}_3\text{CH}-\text{C}-\text{OH}
\end{align*}
\]

Look at the second C from the left. It has 4 different groups bonded to it (CH₃, OH, H, and COOH). This is called an asymmetrical or chiral C atom. Mirror images of compounds with one or more chiral C atoms are not superimposable and are therefore enantiomers.

Sometimes (rarely, however) both forms of an enantiomer are naturally found in nature. The above is an example (lactic acid). One form is produced when milk sours (The odor of sour milk is caused by this) and the other form is produced in our bodies when muscles contract.

Most biochemical molecules are enantiomers and almost always only one form is produced. Frequently, if the other form is introduced into the body, it will...
have no effect or a completely different and perhaps dangerous effect. Also, many
drugs and nutrients or food additives are enantiomers, but only one form has the
effect we want.

Nutrasweet (chemically named aspartame) is sweet in one form and bitter in
the other form. A drug introduced in the early 60’s, thalidomide, to offset morning
sickness in pregnant women, had disastrous results. When made in the lab, both
enantiomers were produced in equal amounts (because of their nearly identical
chemical properties, except when reacting with other enantiomers). This is called a
racemic mixture. One form harmlessly aided morning sickness, but the
(discovered after the fact and too late) other form caused major birth defects, most
commonly being born with missing limbs or appendages).

There are 3 main food types that we will discuss:

1. **Carbohydrates** - Naturally occurring substances that are sugar molecules or
   polymers of sugar molecules. They all contain several C-OH bonds plus one C=O
   bond, hence we say they all polyhydroxide aldehydes or ketones. The most
   important carbohydrate is glucose. We further classify carbohydrates as:
a) **Monosaccharide** – Simple sugar that cannot be decomposed into a smaller carbohydrate.

b) **Disaccharide** – Carbohydrate composed of 2 monosaccharide molecules bonded together.

c) **Polysaccharide** – Carbohydrate composed of more than 3 monosaccharides bonded together, usually hundreds or thousands.

All carbohydrates have enantiomeric forms, only one of which is biochemically active. Besides glucose, the other important simple sugars are galactose and fructose. Both of these are structural isomers of glucose, all with the formula C$_6$H$_{12}$O$_6$. The different structures are shown on page 435. Glucose is also called dextrose, blood sugar and sometimes grape sugar. It is commonly found in fruit and is an absolutely essential chemical in all living cells. The “burning” of glucose in the cells provides energy needed by living organisms to survive.

The most common disaccharides are:

**Sucrose** – From glucose and fructose – Also known as ordinary table sugar.

**Maltose** – From 2 glucose molecules – Found in grains and used as a sweetener in many prepared foods.

**Lactose** – From galactose and glucose – Found in milk

All of these are structural isomers with the formula C$_{12}$H$_{22}$O$_{11}$. All are decomposed in living animals and converted to glucose in living animals, during digestion. The breakdown is called **hydrolysis** and is aided by catalysts called **enzymes**.

The most common polysaccharides are all formed from glucose. The most common are:

**Starches** – Giant molecules used to store glucose in plants.

**Glycogen** – Very large molecules used to store glucose in animals, most prevalently in muscles and the liver. In muscles to provide energy in quick response to need or in the liver to replace glucose that has been removed from the blood since all blood passes through the liver.

In starches and glycogen the glucose molecules are bonded in a way we call alpha-bonding (or simply, using $\alpha$-glucose)

**Cellulose** – The structural material of cell walls in plants. Formed from a different way of bonding glucose together, called beta-bonding (or simply, using $\beta$-glucose).
In order for animals to use polysaccharides, they must decompose them into glucose. Some animals, humans being one, can only decompose starch or glucose, because they can only react with $\alpha$-glucose. Other animals, cows for example, can decompose (digest) cellulose. Grasses are primarily cellulose, hence the grazing animals.

**The primary purpose of carbohydrates in animal diets is to provide energy for all the other biochemical processes.**

2. Fats & Oils are the 2nd type of food for animals. They belong to a larger class of compounds called Lipids, which also include steroids & waxes. All lipids are insoluble in water and soluble in organic solvents.

Fats & Oils are basically the same type of chemical. They are all esters formed by the reaction of the tri-alcohol, glycerol (or more commonly, glycerin) with long chained carboxylic acids, called fatty acids. All fatty acids found in nature have an even # of C atoms, ranging between 8 and 20. Some have one or more C=C double bonds.

\[
\begin{align*}
H_2C & \quad OH \\
HC & \quad OH \\
H_2C & \quad OH
\end{align*}
\]

(glycerol)

\[
\begin{align*}
H_2C & \quad O \quad C \quad R \\
HC & \quad O \quad C \quad R' \\
H_2C & \quad O \quad C \quad R'' \\
(\text{tri-ester of glycerol})
\end{align*}
\]

(FAT)

The difference between fats and oils is that fats are solid at room temperature and oils are liquid at room temperature. In most cases, fats are found in animals while oils are found in plants. All fats and oils are mixtures containing different fat molecules. Also, each fat molecule is composed of different combinations of fatty acids. In most cases, fats have a high concentration of saturated fatty acids (no C=C double bonds), while oils have a high concentration of unsaturated fatty acids. There are exceptions.
Oils can be artificially saturated by adding hydrogen chemically, thus producing a solid fat (vegetable shortenings and margarine).

Fats and oils are converted to human fat in our bodies and provide insulation, cushioning and when necessary can be metabolized (burned) to produce energy.

Fats are also called **triglycerides**.