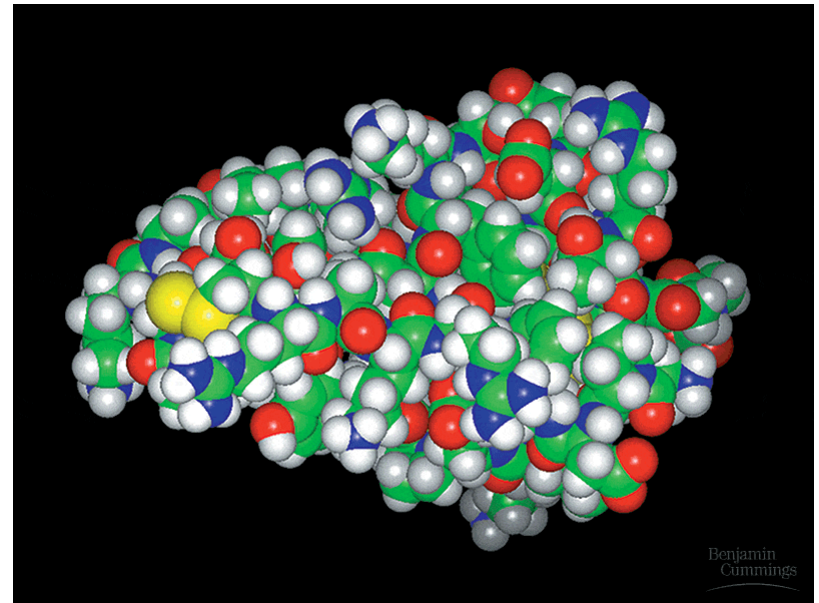


BI107 CHAP 4

Carbon and Molecular Diversity of Life

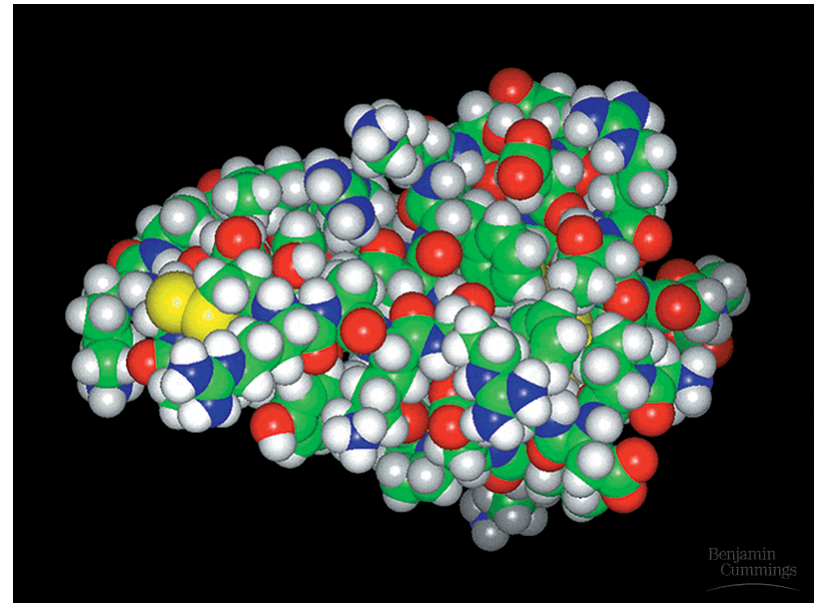
CARBON

- Carbon – great ability to form large complex and diverse molecules
- Molecular diversity leads to diversity of organisms
- Cell is 70-95% water and rest consists mostly of carbon-based compounds



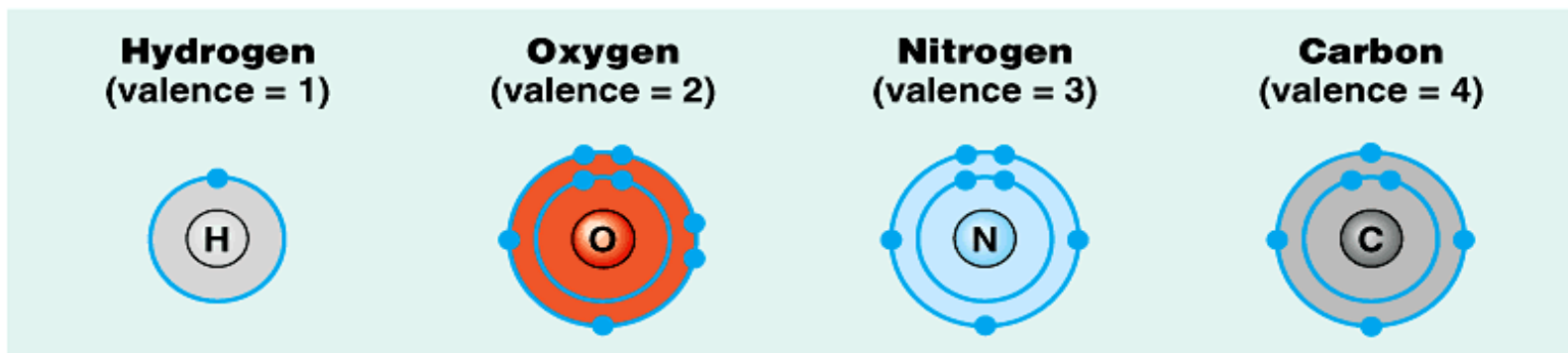
Carbon cont.

- Carbon based molecules – proteins, DNA, RNA, carbohydrates, etc. where carbon atoms bonded to other elements – hydrogen, oxygen, nitrogen, sulfur, phosphorus



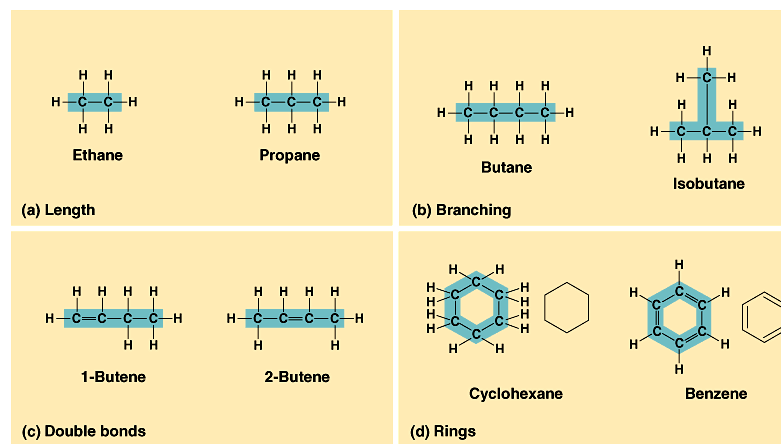
Carbon cont.

- Carbon has 6 electrons – 2 filling the 1st shell and 4 in the outer or valence shell which can hold 8 electrons shell is half full or half empty so has no tendency to form ionic bonds and completes outer shell by sharing electrons- forming covalent bonds as can share 4 pairs of electrons



Carbon cont.

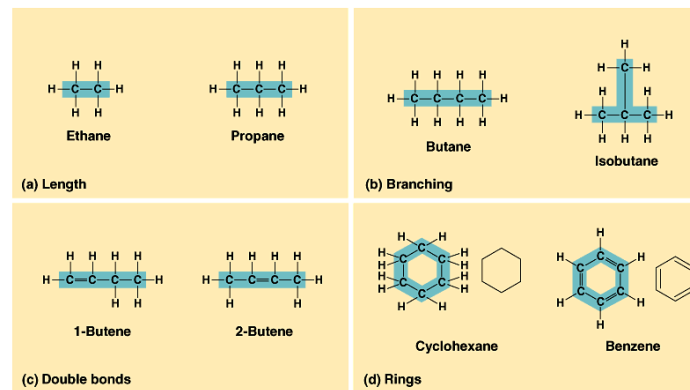
- Carbon acts as a crossroads like a + sign to make large organic molecules
- Carbon chains form skeleton of most organic molecules where skeletons can be straight, branched, or ring structures



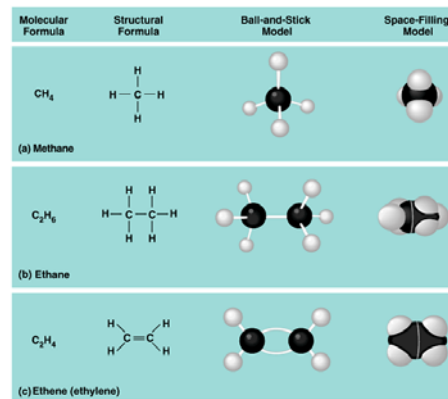
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Carbon cont.

- Carbon skeletons can have single or double bonds
- Carbon compounds with addition of only hydrogen are called hydrocarbons – in petroleum products



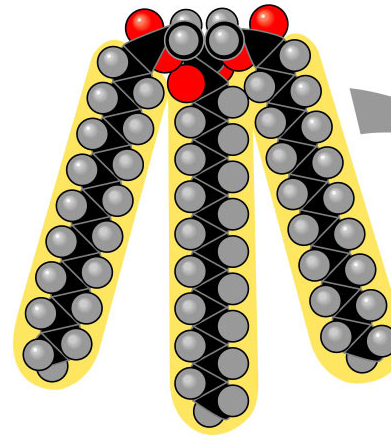
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Carbon cont.

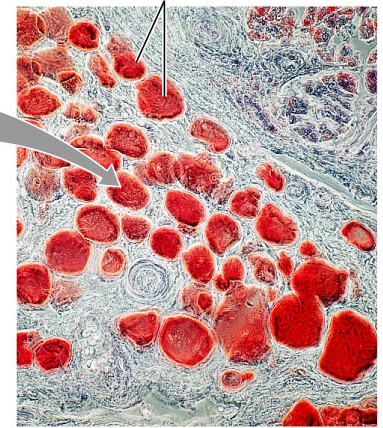
- In cells many molecules have hydrocarbon parts – fat molecules have long hydrocarbon tails
- Hydrocarbon molecules are nonpolar and so are hydrophobic (water avoiding) and they store large amounts of energy



(a) A fat molecule

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Fat droplets (stained red)

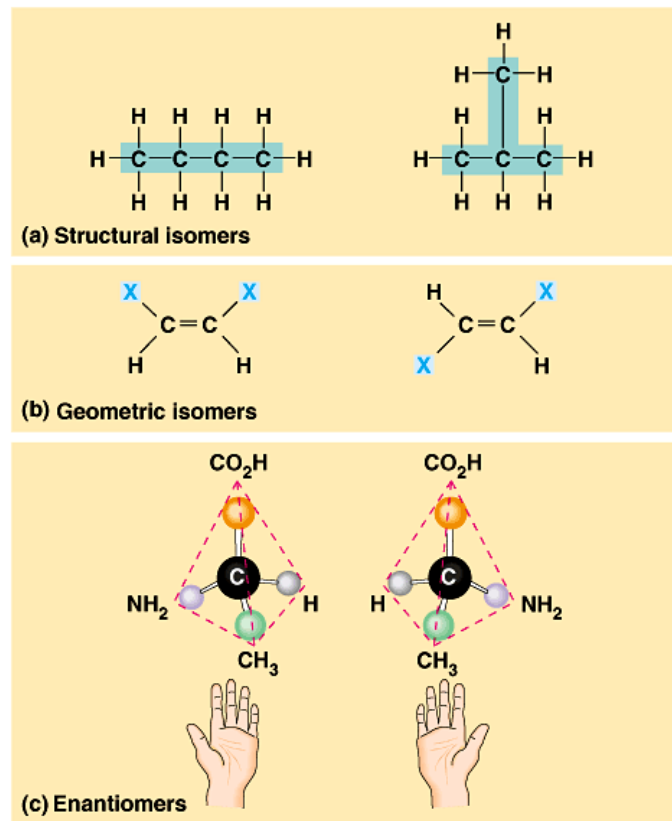


100 μm

(b) Mammalian adipose cells

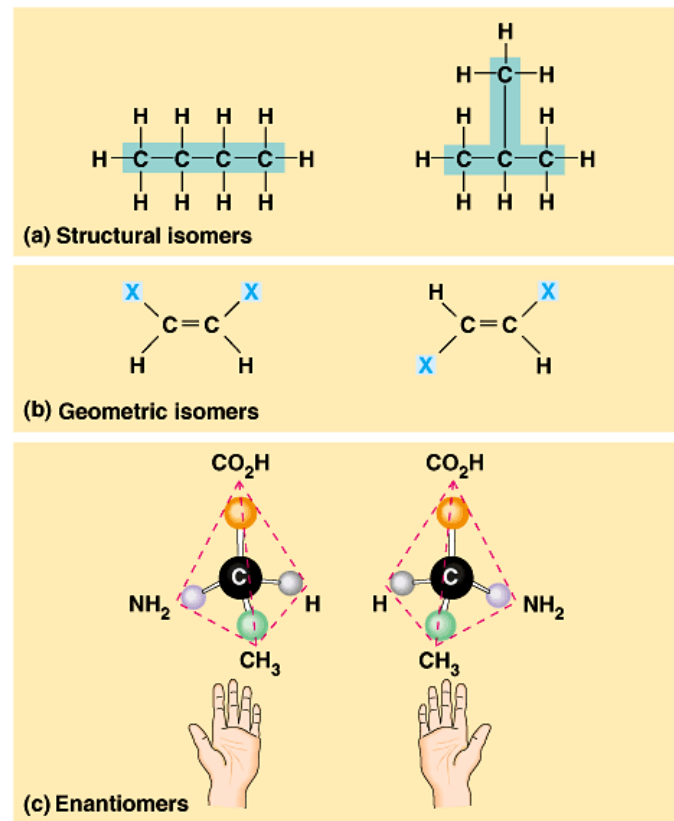
Isomers of Organic Molecules

- Isomers – compounds with same molecular formula but different structures leading to different properties
- 3 types of isomers – 1) structural, 2) geometric, 3) enantiomers



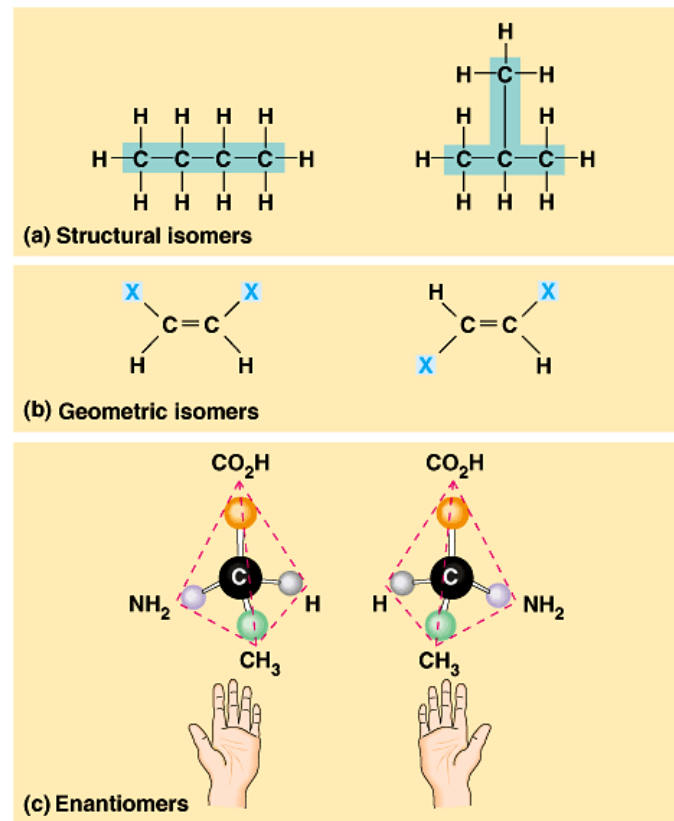
Isomers cont.

- Structural isomers differ in covalent arrangement of atoms & number of possible isomers increases as length of carbon skeleton increases and location of double bonds can vary



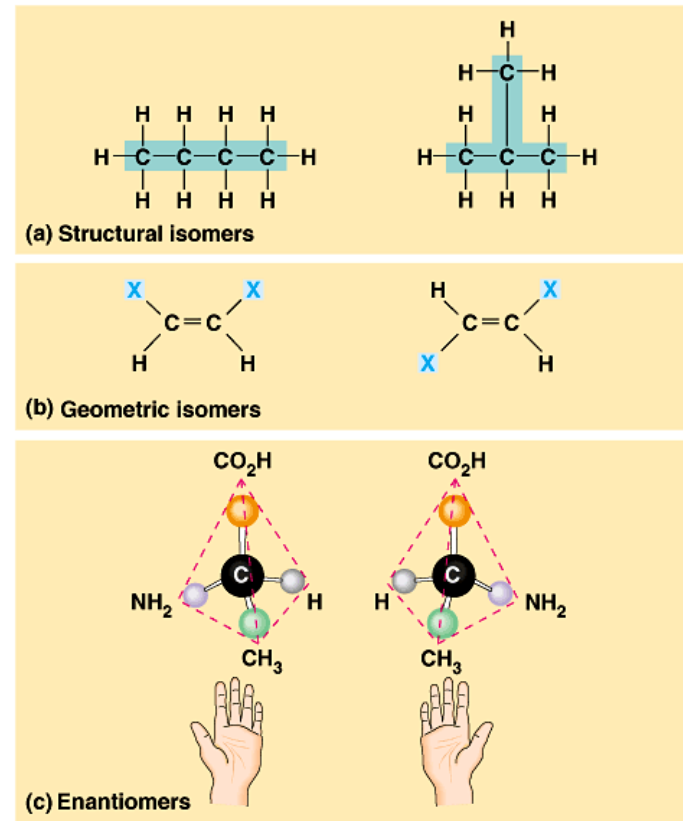
Isomers cont.

- Geometric isomers have the same covalent partners but differ in spatial arrangement indicating that small differences in shape can be very important





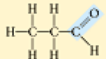

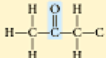





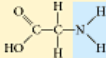


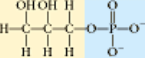
Isomers cont.

- Enantiomers are mirror image molecules built around an asymmetric carbon or middle carbon
- Carbon is attached to 4 different atoms or groups of atoms like right and left hand molecules which have different shapes which cells can detect so only 1 enantiomer is active



Functional Groups



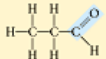

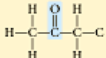





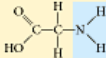


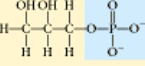
- Molecular components attached to carbon skeletons giving distinctive properties to organic molecules
- Most commonly involved in chemical reactions and functional groups behave the same on different organic molecules

Table 4.1 Functional Groups of Organic Compounds			
Functional Group	Formula	Name of Compounds	Example
Hydroxyl	—OH	Alcohols	 <p>Ethanol (the drug of alcoholic beverages)</p>
Carbonyl		Aldehydes	 <p>Propanal</p>
		Ketones	 <p>Acetone</p>
Carboxyl	 (non-ionized)  (ionized)	Carboxylic acids	 <p>Acetic acid* (the acid of vinegar)</p>
Amino	 (non-ionized)  (ionized)	Amines	 <p>Glycine* (an amino acid)</p>
Sulfhydryl	—SH	Thiols	 <p>Ethanethiol</p>
Phosphate		Organic phosphates	 <p>Glycerol phosphate</p>

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups cont.



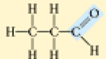

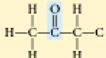





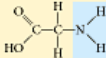


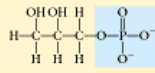
- Number and arrangement of functional groups in organic molecules give each molecule unique properties
- Main types are hydroxyl, carbonyl, amino, carboxyl, sulfhydryl, phosphate

Table 4.1 Functional Groups of Organic Compounds			
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Carbonyl		Aldehydes	 Propanal
		Ketones	 Acetone
Carboxyl	 (non-ionized)  (ionized)	Carboxylic acids	 Acetic acid* (the acid of vinegar)
Amino	 (non-ionized)  (ionized)	Amines	 Glycine* (an amino acid)
Sulfhydryl	$-\text{SH}$	Thiols	 Ethanethiol
Phosphate		Organic phosphates	 Glycerol phosphate

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups cont.



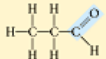

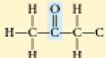





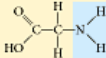


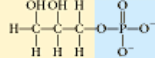
- Organic compounds with hydroxyl groups are called alcohols
- Functional group designated by (-OH or HO-) (not by OH⁻ the hydroxide ion)
- Electronegative oxygen atom makes hydroxyl group polar so it attracts H₂O so compounds are H₂O soluble

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Sulfhydryl	-SH	Thiols	 Ethanethiol
Phosphate		Organic phosphates	 Glycerol phosphate

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups cont.

- Carbonyl group – carbon atom joined to oxygen atom by double bond
- If carbonyl group is on the end of an organic molecule called an aldehyde (propanal) & if not on the end called a ketone (acetone) – structural isomers but have different properties (=CO)



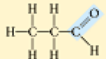

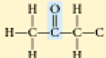





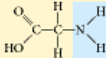


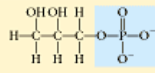
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Amino	 (non ionized)  (ionized)	Amines	 Glycine* (an amino acid)
Sulphydryl	—SH	Thiols	 Ethanethiol
Phosphate		Organic phosphates	 Glycerol phosphate

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups cont.

- Carboxyl group – oxygen atom double-bonded to a carbon atom which is also bonded to a hydroxyl group together called a carboxyl group giving molecule acidic properties since bond between hydrogen and oxygen of hydroxyl group is very electronegative and hydrogen ion dissociates reversibly to form H^+ (-COOH)

Table 4.1 Functional Groups of Organic Compounds



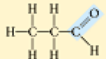

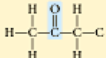





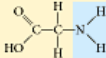


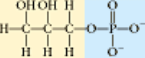
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Sulphydryl	-SH	Thiols	 Ethanethiol
Phosphate		Organic phosphates	 Glycerol phosphate

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups cont.

- Amino group – nitrogen atom bonded to 2 hydrogen atoms and to the carbon skeleton
- Organic compounds with an amino group are called amines
- Amino group acts as a base picking up an extra H^+ and giving the group a charge of +1 designated by $(-NH_2)$

Table 4.1 Functional Groups of Organic Compounds



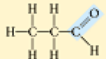

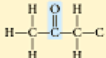





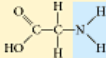


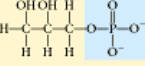
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Functional Groups cont.

- Sulfhydryl group – designated by (-SH)
- Sulfur atom bonded to hydrogen atom
- Organic compounds with sulfhydryl groups are called thiols
- Mainly used to stabilize protein structure



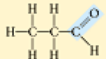

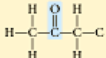





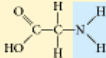


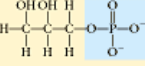
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Functional Groups cont.

- Phosphate group – anion formed by dissociation of inorganic acid called phosphoric acid (H_3PO_4) loss of hydrogens by dissociation gives the group 2 negative charges phosphate group ($-\text{OPO}_3^{2-}$) is attached to the carbon skeleton used in the cell for energy transfer

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