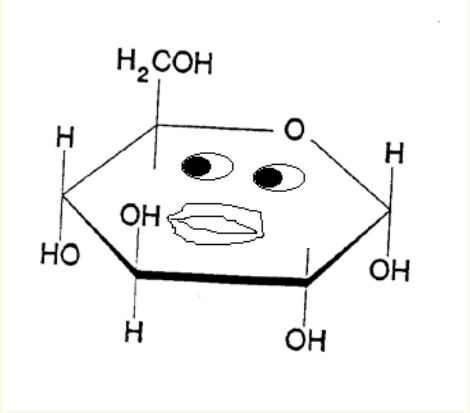
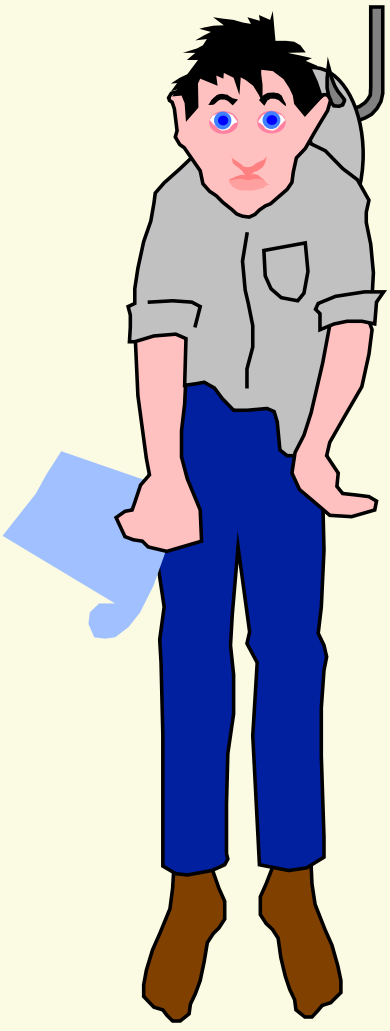
THE IMPORTANCE OF FUNCTIONAL GROUPS IN BIOLOGY



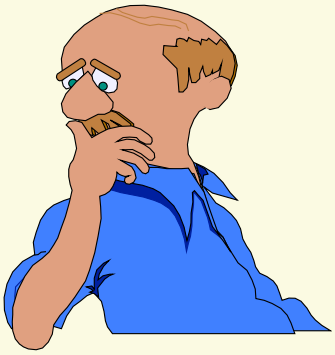
"No alcohol for me bartender. As you could see, I'm already loaded!"

“The Hook”



Background Information:

You should have already acquired these basic knowledge concepts from Grade 11 chemistry:



- ✓ Ionization energy
- ✓ Electron affinity
- ✓ Electronegativity
- ✓ Types of chemical reactions
- ✓ Reactivity of certain elements because of their placement on the periodic table
- ✓ Sources of organic compounds
- ✓ Physical and chemical properties of hydrocarbons
- ✓ Energy changes observed when chemical bonds are formed and when they are broken
- ✓ Exothermic vs. endothermic reaction

Common Misconceptions in Biochemistry

- ✓ Chemical Reactions as Steps – reactants to products
- ✓ Two-Dimensional World
- ✓ High-Energy Bond
- ✓ "Not all functional groups are created equal"

Make the Connection!

- ✓ when going from reactants to products, chemical bonds are broken and new ones are created

- ✓ when going from reactants to products, bonds are broken and new ones are created so as to modify the functional groups in the reactants, and form new ones in the products

Make the Connection!

- if the chemical potential energy of the reactants is higher than the chemical potential energy of the products, then the reaction is spontaneous and will release energy in the process

- if a specific functional group in the product makes it more chemically stable than any other functional group would in the reactant, then the reaction is a favorable one. The result is "free" energy (heat) available to do work – the work could be to activate a previously unreactive molecule, or to change the shape of an enzyme, thus making it "operable"

Make the Connection!

- ✓ if the concentration of the reactants increases, the reaction will proceed at a faster rate to completion

- ✓ if the functional group within a biological molecule is physically “accessible” and is geometrically oriented, in three-dimensional space, the “right” way, then there is a greater chance of it being modified into a new functional group, resulting in a chemical reaction

Make the Connection!

- some elements (within molecules) are more reactive than others because of their highly metallic, or highly non-metallic, character, and because of their placement on the periodic table

- any biological molecule's reactivity is largely based on the degree to which its functional group(s) make(s) it chemically unstable. The less "stress" a functional group causes a molecule to have (i.e., the less that it contributes to the instability of the molecule), the less likely it will be modified

Make the Connection!

- all chemical reactions must follow the Law of Conservation of Mass and Matter – the chemical equations must balance – the same number of elements on the reactant side of an equation must equal the same number of elements on the product side of an equation

- in all biochemical reactions, functional groups in the reactants are rearranged, or modified, into new ones, making products. Essentially, it is like taking apart a puzzle, and putting it back together in a different arrangement. All the pieces would be accounted for after the process is done, however, the picture is now different. The “pieces” that come together to make the puzzle are analogous to the functional groups in a molecule. As well, all the pieces that do not contribute to the main theme of the puzzle, could represent the hydrocarbon component of a biological molecule, or the “spectator” portion of the molecule

Complete List of Functional Groups

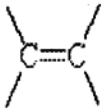
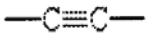
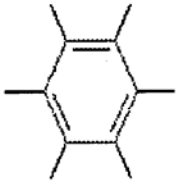
http://www.cem.msu.edu/~reusch/OrgPage/functab.html

Functional Groups

Functional groups are atoms or small groups of atoms (two to four) that exhibit a characteristic reactivity when treated with certain reagents. A particular functional group will almost always display its characteristic chemical behavior when it is present in a compound. Because of their importance in understanding organic chemistry, functional groups have characteristic names that often carry over in the naming of individual compounds incorporating specific groups. In the following table the atoms of each functional group are colored red and the characteristic IUPAC nomenclature suffix that denotes some (but not all) functional groups is also colored.

Functional Group Tables

Exclusively Carbon Functional Groups

Group Formula	Class Name	Specific Example	IUPAC Name	Common Name
	Alkene	$H_2C{=}CH_2$	Ethene	Ethylene
	Alkyne	$HC{\cong}CH$	Ethyne	Acetylene
	Arene	C_6H_6	Benzene	

Complete List of Functional Groups

http://www.cem.msu.edu/~reusch/OrgPage/functab.html

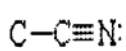
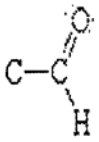
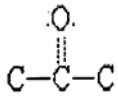
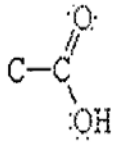
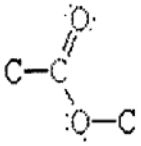
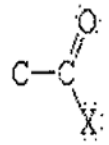
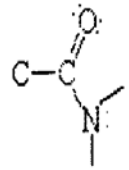
Functional Groups with Single Bonds to Heteroatoms

Group Formula	Class Name	Specific Example	IUPAC Name	Common Name
C–X:	Halide	H_3C-I	Iodomethane	Methyl iodide
C–OH	Alcohol	CH_3CH_2OH	Ethanol	Ethyl alcohol
C–O–C	Ether	$CH_3CH_2OCH_2CH_3$	Diethyl ether	Ether
C–N	Amine	H_3C-NH_2	Aminomethane	Methylamine
C–N(⊕)(O)–O(⊖)	Nitro Compound	H_3C-NO_2	Nitromethane	
C–SH	Thiol	H_3C-SH	Methanethiol	Methyl mercaptan
C–S–C	Sulfide	H_3C-S-CH_3	Dimethyl sulfide	

Complete List of Functional Groups

http://www.cem.msu.edu/~reusch/OrgPage/functab.html

Functional Groups with Multiple Bonds to Heteroatoms

Group Formula	Class Name	Specific Example	IUPAC Name	Common Na
	Nitrile	H_3C-CN	Ethanenitrile	Acetonitril
	Aldehyde	H_3CCHO	Ethanal	Acetaldehyd
	Ketone	H_3CCOCH_3	Propanone	Acetone
	Carboxylic Acid	H_3CCO_2H	Ethanoic Acid	Acetic acid
	Ester	$H_3CCO_2CH_2CH_3$	Ethyl ethanoate	Ethyl acetat
	Acid Halide	H_3CCOCl	Ethanoyl chloride	Acetyl chlori
	Amide	$H_3CCON(CH_3)_2$	N,N-Dimethylethanamide	N,N-Dimethylaceta

Common Functional Groups in Biology

http://esg-www.mit.edu:8001/esgbio/chem/functgroups.htm

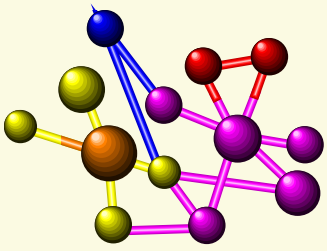
Functional Groups	Class of Molecules	Formula	Example
Hydroxyl —OH	Alcohols	R—OH	Ethanol
Carbonyl —CHO	Aldehydes		Acetaldehyde
CO	Ketones		Acetone
Carboxyl —COOH	Carboxylic Acids		Acetic Acid
Amino —NH_2	Amines		Methylamine
Phosphate $-OPO_3^{-2}$	Organic Phosphates		

Why should I know all this stuff about functional groups?

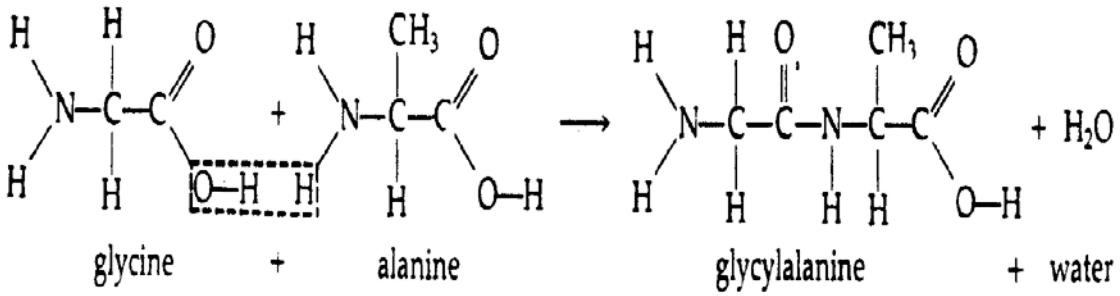
Because you want a good mark!?

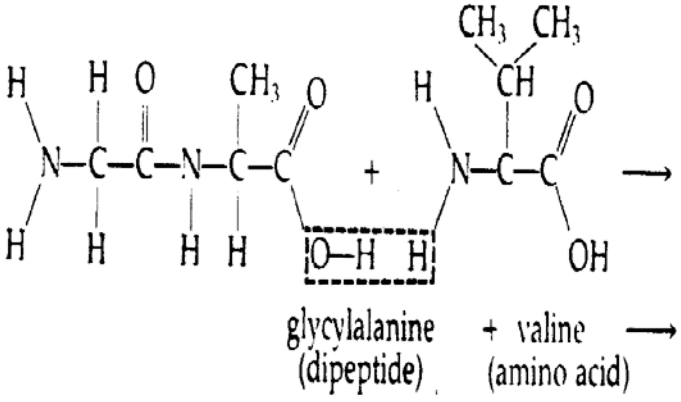
No, seriously folks, you should try to visualize chemical reactions as three-dimensional events occurring in space, where molecules are colliding into one another's "reactive parts" to make a new substance.

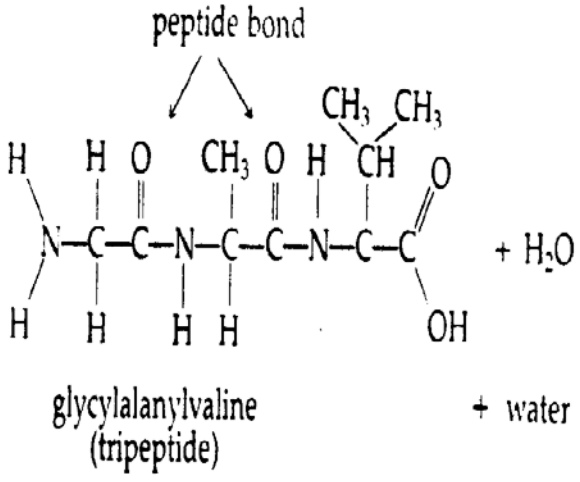
You should also know that the position, or location of functional groups, as well as the individual nature of the functional groups themselves, have a great influence in contributing to the chemical properties of a substance. As well, they play an important role in physical interactions -- intermolecular and intramolecular. The following examples demonstrate this



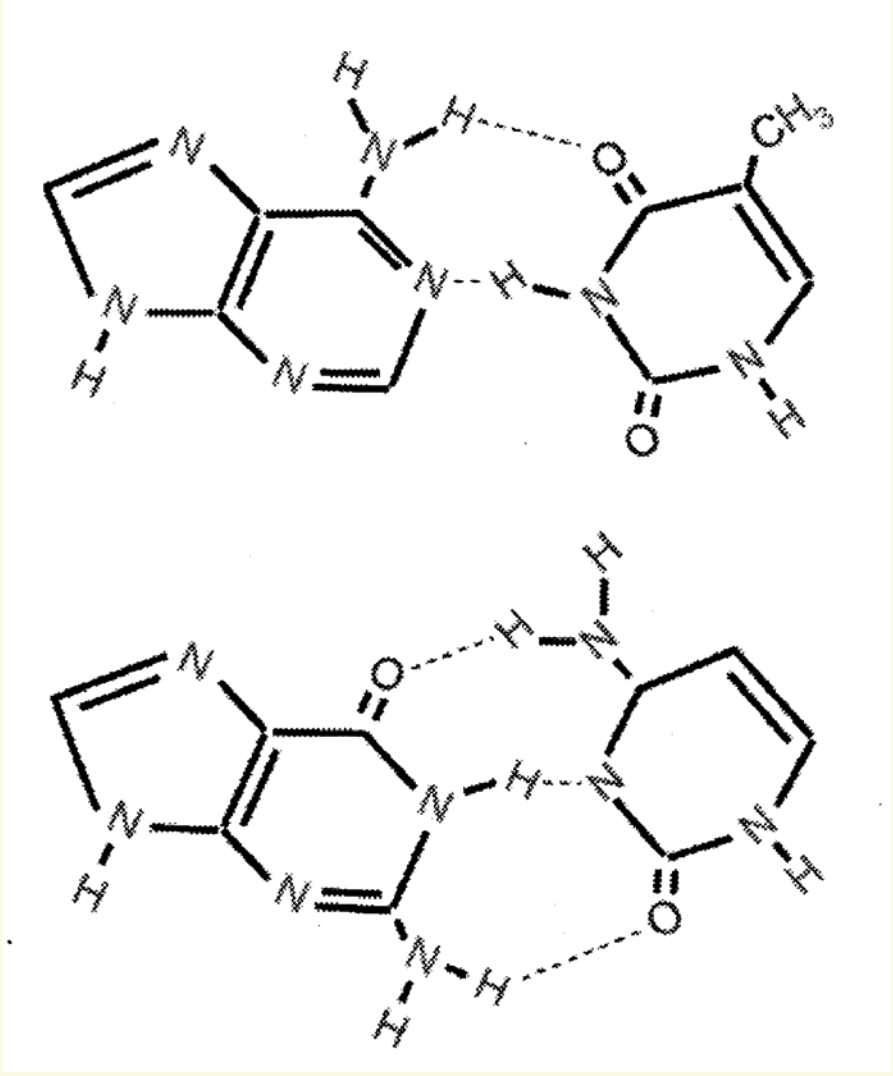
Amino Acids Sequence



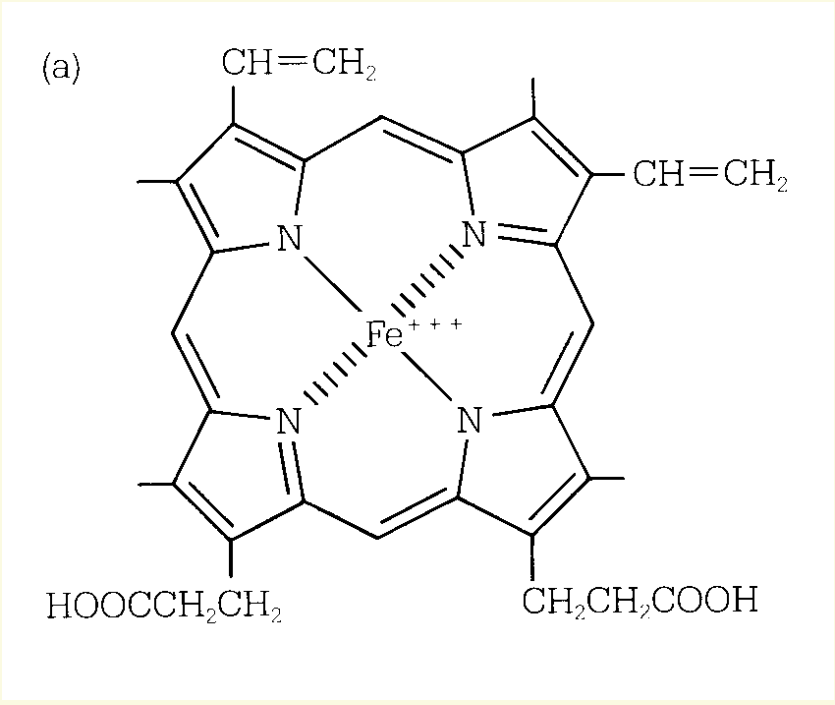


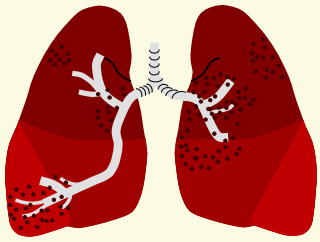


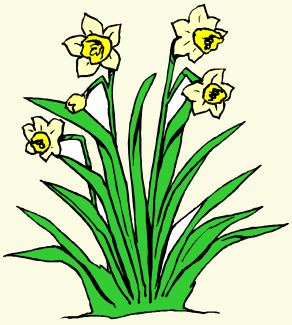
Nitrogenous Base-Pairing in DNA

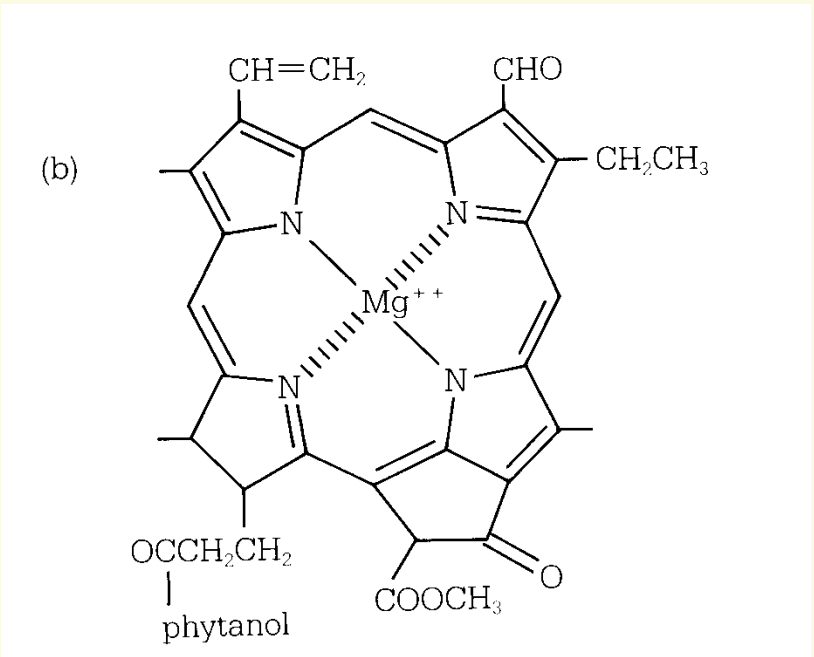


Porphyrin Ring Systems in Animals and Plants

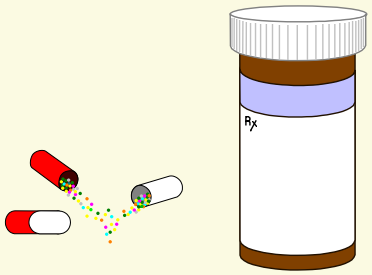


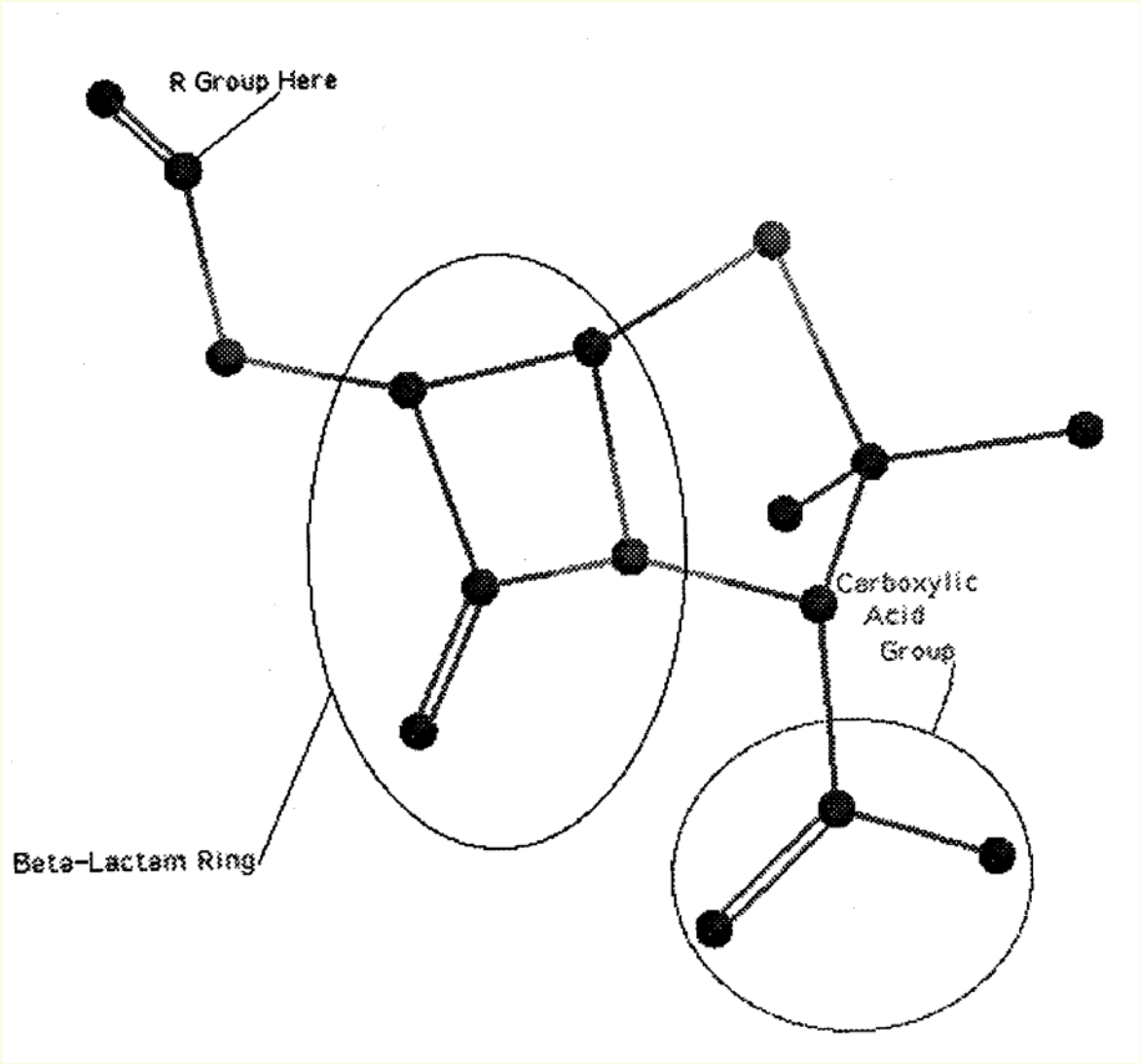




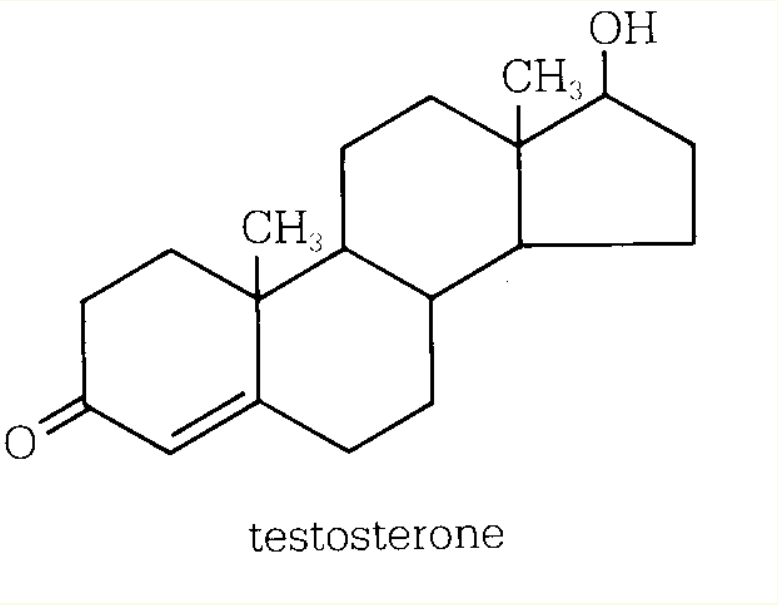


Basic Structure of the Penicillin "Family"

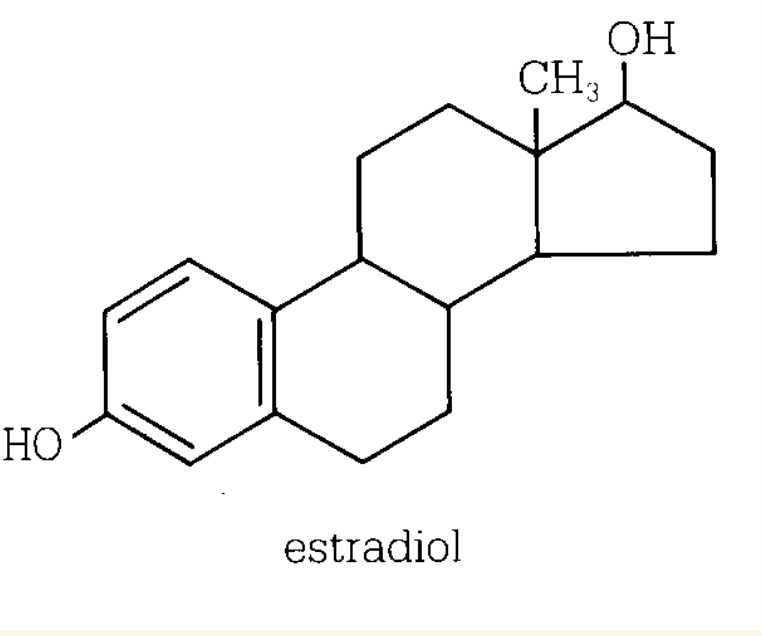




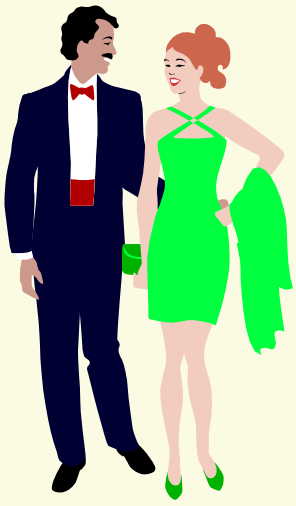
Steroid Hormones: Testosterone and Estradiol



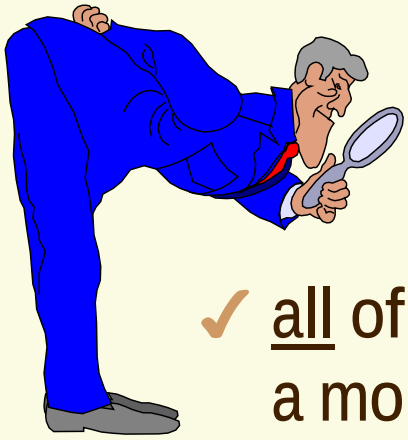
testosterone



estradiol



Let's collect our thoughts, and take one more close look at what we've learned so far…



- ✓ biological molecules are put together in units called functional groups
- ✓ all of the functional groups in a molecule contribute to the molecule's physical and chemical character
- ✓ some functional groups are more involved in chemical activity, some are more involved in physical activity, and some just "watch it all happen"
- ✓ functional groups play a huge role in many of life's biologically important interactions

Questions? Ideas? Suggestions? Comments?

Thank you!