

1 ☐ Matter & Energy: Chemistry of Life

EVPP 110 Lecture

GMU

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Fall 2003

2 ☐ Molecules are the building blocks of life

✓ Molecules

- building blocks of life
 - four major types of biological macromolecules
 - carbohydrates
 - lipids
 - proteins
 - nucleic acids
 - we'll return to these later

3 ☐ Molecules are the building blocks of life

✓ Molecules

- consist of 2 or more atoms bound together
- all small in comparison to what we can see
- some are “small”
- others are “gigantic”
 - thousands of atoms
 - organized into hundreds of smaller molecules linked into long chains
 - almost always synthesized by living things

4 ☐ Molecules are the building blocks of life

✓ organic molecules

- compounds that are synthesized by cells **and** contain carbon

5 ☐ Molecules are the building blocks of life

✓ carbon

- plays central role in **organic molecules**
- involved in almost all molecules made by cells
 -
- unparalleled in its ability to form large, diverse molecules
- containing compounds most common substances in living organisms, other than water

6 ☐ Carbon plays central role in organic molecules

✓ carbon


- forms **4 covalent bonds**
- **single, double, or triple** covalent bonds w/ other carbon atoms
- forms **variety of molecular shapes**
- combines with hydrogen to form **hydrocarbons**

- **bonds with H, N, O, S**
- forms **isomers**

7 Molecules - life's building blocks

✓Chemistry of carbon

- forms **4 covalent bonds**
 - outer electron shell can hold 8 electrons
 - contains only 4 electrons in its outer shell
 - can form up to 4 covalent bonds ($8-4=4$, or $4+4=8$)

8  Figure 4.3 Valences for the major elements of organic molecules (*Biology*, 6th Ed., Campbell & Reece)


9 

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11 Molecules - life's building blocks

✓Chemistry of carbon


- can form **single, double, or triple** covalent bonds with other carbon atoms
 -
 - can readily form chains of carbon atoms


12  Figure 4.2 The shapes of three simple organic molecules (*Biology*, 6th Ed., Campbell & Reece)

13 Molecules - life's building blocks

✓Chemistry of carbon

- forms **variety of molecular shapes**
 - carbon chains, can be
 - straight
 - branched
 - closed into rings
 - can form greater variety of molecules than any other element


14  Figure 4.4 Variations in carbon skeletons (*Biology*, 6th Ed., Campbell & Reece)

15  Figure 4.4x Hydrocarbons: molecular models (*Biology*, 6th Ed., Campbell & Reece)

16 Molecules - life's building blocks

✓Chemistry of carbon

- combines w/hydrogen, forms **hydrocarbons**
 - organic molecules consisting only of C and H
 - C - H covalent bonds store a lot of energy
 - hydrocarbons make good fuels
 - »
 - »
 - most biologically important molecules are not hydrocarbons

17  Figure 4.2 The shapes of three simple organic molecules (*Biology*, 6th Ed., Campbell & Reece)

18 Molecules - life's building blocks

✓Chemistry of carbon

- carbon forms **bonds with H, N, O, S**

- forming many other biologically significant molecules
 -
 - including biologically important functional groups

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20  **Web/CD Activity 4A:
Diversity of Carbon-Based Molecules**

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21  **Molecules - life's building blocks**

✓ Chemistry of carbon

– forms **isomers**

- alternative forms of a molecule which have same empirical formula but atoms are arranged in different way
- **types of isomers**
 - **structural isomers**
 - **stereoisomers (geometric)**
 - **enantiomers**
- we'll return to this later

22  **The construction of biologically important organic molecules**

✓ any organic molecule can be thought of as a carbon-based core to which specific groups of atoms with specific chemical properties are attached

✓ **carbon skeleton or core**

✓ **functional groups**

23  **The construction of biologically important organic molecules**

✓ **carbon skeleton or core**

- repeating carbons to which specific groups of atoms with definite chemical properties are attached
- represented in diagrams by $R =$, "remainder"

24  **The construction of biologically important organic molecules**

✓ **functional groups**

- groups of atoms w/specific chemical properties attached to C core
- retain their chemical properties no matter where they occur
- most compounds in cells contain two or more different functional groups
- every amino acid contains at least two functional groups
 - an amino group
 - a carboxyl group

25  **The construction of biologically important organic molecules**

✓ **functional groups**

- there are several biologically important functional groups
 - hydroxyl (R-OH)
 - carbonyl (R-[C=O]-H, or (R-[C=O]-R)
 - carboxyl (R-[C=O]-OH, R-COOH)

- amino (R-NH₂)
- phosphate (R-O-P[=O]-OH)-OH)
- sulfhydryl (R-SH)
- methyl (R-CH₃)

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27  Figure 4.8 A comparison of functional groups of female (estradiol) and male (testosterone) sex hormones (*Biology*, 6th Ed., Campbell & Reece)

28  **Web/CD Activity 4C:**
Functional Groups

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29  **Making & Breaking Macromolecules**

✓ **Biological macromolecules**

- polymers
 - made up of repeating subunits (monomers)
- four categories
 - each category contains different subunits
 - assembled in the same way
 - **dehydration synthesis**
 - disassembled in the same way
 - **hydrolysis**

30  **Making & Breaking Macromolecules**

✓ **dehydration synthesis (condensation reaction)**

- macromolecule is assembled by removing an –OH group from one subunit and an H from other subunit
 - constitutes removal of molecule of H₂O
 - also called “water-losing” reaction
 - energy is required to break chemical bonds when water is extracted
 - cells must supply energy to assemble macromolecules

31  **Making & Breaking Macromolecules**

✓ **dehydration synthesis**

– **anabolic reactions**

- reactions in which macromolecules are built from smaller subunits, requires
 - energy
 - **catalysis**
 - » process of positioning (reacting substances must be held close together)
 - » process of stressing bonds (correct chemical bonds be stressed and broken)
 - » these processes carried out by a special class of proteins known as **enzymes**

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34  **Making & Breaking Macromolecules**

- ✓ Cells also disassemble macromolecules into their constituent subunits by performing
 - **catabolic reactions**
 - reactions in which macromolecules are synthesized by disassembling other macromolecules into their constituent parts
 - energy released
 - are essentially the reverse of dehydration synthesis, called
 - **hydrolysis (digestion)**


35  **Making & Breaking Macromolecules**

✓ **hydrolysis (digestion)**


- macromolecules created by disassembling other macromolecules into their constituent parts
 - by adding an –OH group to form one subunit and an H to form other subunit
 - constitutes addition a molecule of water (H₂O) for every macromolecule that is disassembled
 - energy is released when energy-storing bonds are broken

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38  **Web/CD Activity 5A:
Making and Breaking Polymers**

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39  **The 4 major classes of biological macromolecules**

✓ **carbohydrates**

- monosaccharides

✓ **lipids**


- glycerol
- fatty acids

✓ **proteins**

- amino acids

✓ **nucleic acids (DNA, RNA)**

- nucleotide

40  **The 4 major classes of biological macromolecules**

✓ **carbohydrates**

- monosaccharides

✓ **lipids**

- glycerol
- fatty acids

✓ **proteins**

- amino acids

✓ **nucleic acids** (DNA, RNA)

- nucleotide

41  Polymers are large molecules consisting of long chains of repeating subunits

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43  Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- loosely defined group
- molecules that contain C, H, and O in molecular ratio of 1:2:1, with empirical formula of $(\text{CH}_2\text{O})_n$
- functions
 - energy storage molecules
 -
 - structural elements

44  Biological macromolecules have certain functions in organisms

✓ **Carbohydrates**

- named based on number of sugar units they contain
 - **monosaccharides**
 - one sugar unit (mono-)
 - **disaccharides**
 - two sugar units (di-)
 - **polysaccharides**
 - many sugar units (poly-)

45  Biological macromolecules have certain functions in organisms

✓ **Carbohydrates**


- **monosaccharides**
 - structure
 - simplest carbohydrate
 - is a single sugar unit
 - contain 3 to 7 carbons (typically 6-7)
 - empirical formula, $\text{C}_6\text{H}_{12}\text{O}_6$ or $(\text{CH}_2\text{O})_6$
 - exist in straight chain form or in rings
 - in water solutions they almost always form rings


46  Biological macromolecules have certain functions in organisms


✓ **carbohydrates**

- **monosaccharides**
 - function
 - play central role in energy storage
 - » glucose most important
 - examples
 - glucose

- fructose
- glyceraldehyde phosphate


47  Figure 5.3 The structure and classification of some monosaccharides (*Biology*, 6th Ed., Campbell & Reece)

48  Figure 5.4 Linear and ring forms of the monosaccharide glucose (*Biology*, 6th Ed., Campbell & Reece)

49  Figure 5.3x Hexose sugars (*Biology*, 6th Ed., Campbell & Reece)

50  **Web/CD Activity 5B:**
Models of Glucose

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51  Biological macromolecules have certain functions in organisms

✓ **Carbohydrates**

– **disaccharides**

- structure
 - “double sugars”
 - two monosaccharides joined by a covalent bond

52  Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

– **disaccharides**


- function
 - play a role in the transport of sugars
 - »
 - »


53  Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

– **disaccharides**

- examples
 - » sucrose
 - » lactose

54  Figure 5.5 Examples of disaccharide synthesis (*Biology*, 6th Ed., Campbell & Reece)

55  Figure 5.5x Glucose monomer and disaccharides (*Biology*, 6th Ed., Campbell & Reece)

56  Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

– **polysaccharides**

- structure
 - many monosaccharides put together
 - »
 - precise number of sugar units varies
 - »
 - chains can be single or branched

57  Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- **polysaccharides**
 - function
 - storage of energy
 - structural

58 ☐ Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- **polysaccharides**
 - functions
 - storage of energy
 - » **starch** = formed in plants, consists of glucose units
 - » **glycogen** = formed in animals, consists of glucose units

59 ☐ Figure 5.6 Storage polysaccharides (*Biology*, 6th Ed., Campbell & Reece)

60 ☐ Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- **polysaccharides**
 - functions
 - structural
 - » **cellulose** = formed in plants, consists of glucose units, component of plant cell walls
 - » **chitin** = formed in insects, fungi and certain other organisms, consists of glucosamine units (contains N)

61 ☐ Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- **polysaccharides**
 - functions
 - structural
 - » **glycocalyx** = coating or layer of oligosaccharides on outside of an animal cell
 - » **glycoproteins** = protein with covalently attached carbohydrates

62 ☐ Biological macromolecules have certain functions in organisms

✓ **carbohydrates**

- **polysaccharides**
 - functions
 - structural
 - » **glycolipids** = lipid with polysaccharide attached
 - » **peptidoglycan** = modified protein or peptide possessing an attached carbohydrate, bacterial cell walls

63 ☐ Biological macromolecules have certain functions in organisms


✓ **carbohydrates**

- **polysaccharides**
 - examples

- starch = amylose, amylopectin
- glycogen
- cellulose
- chitin

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65 

66  Figure 5.8 The arrangement of cellulose in plant cell walls (*Biology, 6th Ed., Campbell & Reece*)

67  **Biological macromolecules have certain functions in organisms**

✓ **Carbohydrates**

– **sugar isomers**

- more than one sugar can have same empirical formula but different arrangement of their atoms
 - these structural differences can account for functional differences between isomers
- two types of isomers
 - **structural isomers**
 - **stereoisomers (geometric isomers)**

68  **Biological macromolecules have certain functions in organisms**

✓ **Carbohydrates**

– **sugar isomers**

- **structural isomers**
 - identical chemical groups bonded to different carbon atoms
 - example: glucose and fructose
- **stereoisomers (geometric isomers)**
 - identical chemical groups bonded to same carbon atoms but in different orientations
 - example: glucose and galactose

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71  Figure 4.6 Three types of isomers (*Biology, 6th Ed., Campbell & Reece*)

72  **Web/CD Activity 4B:
Isomers**

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73  **Web/CD Activity 5C:
Carbohydrates**

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74  **The 4 major classes** of biological macromolecules

✓ **carbohydrates**

- monosaccharides

✓ **lipids**

- glycerol
- fatty acids

✓ **proteins**

- amino acids

✓ **nucleic acids** (DNA, RNA)

- nucleotide

75 ☐ Biological macromolecules have certain functions in organisms

✓ **Lipids**

- loosely defined group
- molecules with one main characteristic
 - insoluble in water
- main type
 - **fats** (triglycerides or triacylglycerols)
- other types
 - **phospholipids**
 - **steroids**
 - **waxes**

76 ☐ Biological macromolecules have certain functions in organisms

✓ **lipids**

- **fats** (triglycerides or triacylglycerols)
 - structure = glycerol + 3 fatty acids
 - **glycerol**
 - » 3-carbon alcohol with each carbon bearing a hydroxyl group
 - **fatty acids**
 - » long hydrocarbon chains ending in a carboxyl group
 - »

77 ☐ Biological macromolecules have certain functions in organisms

✓ **Lipids**

- **fats** (triglycerides or triacylglycerols)
 - functions
 - energy storage
 - » efficient energy storage molecules because of their high concentrations of C-H bonds
 - insulation
 - cushioning

78 ☐

79 ☐ Figure 5.10 The synthesis and structure of a fat, or triacylglycerol (*Biology*, 6th Ed., Campbell & Reece)

80 ☐ Biological macromolecules have certain functions in organisms

✓ **Lipids**

– **saturated** and **unsaturated** fats

- based on absence/ presence of double bonds between carbon atoms and number of hydrogen atoms

81  Biological macromolecules have certain functions in organisms

✓ **Lipids**

– **saturated** fats

- all internal C atoms are bound to at least two other C atoms
- results in maximum number of H atoms
 - said to be **saturated**
- fatty acid chains tend to be straight and fit close together
- most are solid at room temperature
 - such as butter

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84  Biological macromolecules have certain functions in organisms

✓ **Lipids**

– **unsaturated** fats

- double bonds between one pair of C atoms
 - results in less than maximum number of hydrogen atoms
 - because double bonds replace some of hydrogen atoms
 - said to be **unsaturated**
- most are liquid at room temperature
 - such as oil

85  Biological macromolecules have certain functions in organisms

✓ **Lipids**

– **unsaturated** fats

- **polyunsaturated** fats
 - double bonds between 2+ pairs of C atoms
- have low melting points because fatty acid chains can't closely align
 - double bonds cause kinks
 - most are liquid at room temperature
 - » such as corn oil

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87 


88  Biological macromolecules have certain functions in organisms


✓ **lipids**

– **fats** (triglycerides or triacylglycerols)

- **other types** and their function
 - **phospholipids**
 - » modified fats with two fatty acid chains rather than three
 - » one fatty acid chains is replaced by a phosphate group
 - » has hydrophilic head, hydrophobic tail
 - » structure of cell membranes = phospholipid bilayer

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90  Figure 5.12 The structure of a phospholipid (*Biology*, 6th Ed., Campbell & Reece)

91  Figure 5.13 Two structures formed by self-assembly of phospholipids in aqueous environments (*Biology*, 6th Ed., Campbell & Reece)

92  **Biological macromolecules have certain functions in organisms**

✓ **lipids**

- **fats** (triglycerides or triacylglycerols)
 - **other types** and their function
 - **terpenes**
 - » long chain lipids which are components of many biologically important pigments
 - » chlorophyll and other plant pigments
 - » vitamin A (retinol)
 - » retinal – visual pigment of eyes of mollusks, insects, and vertebrates
 - » rubber and other plant products

93  **Biological macromolecules have certain functions in organisms**

✓ **lipids**

- **fats** (triglycerides or triacylglycerols)
 - **other types** and their function
 - **prostaglandins** = modified fatty acids w/ 2 nonpolar tails attached to 5 C ring
 - » local chemical messengers in animal tissues
 - **waxes**
 - » waterproof coating on leaves, bird feathers, mammalian skin, arthropod exoskeleton

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95  **Biological macromolecules have certain functions in organisms**

✓ **lipids**


- **fats** (triglycerides or triacylglycerols)
 - **other types** and their function
 - **steroids** = lipids composed of 4 carbon rings
 - » hormones
 - » regulatory
 - » cholesterol
 - » found in eukaryotic cell membrane
 - » bile salts (emulsify fats)

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97  **Web/CD Activity 5D:**

Lipids

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98  **The 4 major classes** of biological macromolecules

✓ **carbohydrates**

- monosaccharides

✓ **lipids**

- glycerol
- fatty acids

✓ **proteins**

- amino acids


✓ **nucleic acids** (DNA, RNA)

- nucleotide

99  **Biological macromolecules have certain functions in organisms**

✓ **proteins**


- perform many functions
- are all polymers of only 20 amino acids
- **structure**
 - **amino acids** joined by peptide bonds
- **levels of structure**
- **functions**
- **types of**

100  **Biological macromolecules have certain functions in organisms**

✓ **proteins**

- structure
 - made up of repeating subunits, **amino acids**
 - joined by peptide bonds
 - molecules containing
 - » an amino group (-NH₂)
 - » a carboxyl group (-COOH)
 - unique chemical properties determined by nature of the side group

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102  **Biological macromolecules have certain functions in organisms**

✓ **proteins**

- structure
 - **amino acids**
 - grouped into 5 chemical classes based on their side groups
 - » nonpolar
 - » polar
 - » ionizable
 - » aromatic (rings)
 - » special function

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104 

105 

106 

107  Biological macromolecules have certain functions in organisms


✓ **proteins**

– structure

- **peptide bonds** join amino acids together
 - covalent
 - »
 - has partial double bond characteristic
 - is stiff
 - » amino acids are not free to rotate around C-N linkage
 - »

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109 

110  Biological macromolecules have certain functions in organisms

✓ **proteins**

– levels of structure


- **primary**
- **secondary**
 - motifs
- **tertiary**
- **domains**
- **quaternary**


111  Biological macromolecules have certain functions in organisms

✓ **proteins**

– levels of structure

- **primary**
 - result from specific amino acid sequence
 - one dimensional

112  Figure 5.18 The primary structure of a protein (*Biology*, 6th Ed., Campbell & Reece)

113  Biological macromolecules have certain functions in organisms


✓ **proteins**

– levels of structure

- **secondary**
 - results from hydrogen bonding between individual amino acids
 - two dimensional
 - two patterns of hydrogen bonding
 - ***b***pleated sheets

→ ***a*** helix

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115  Biological macromolecules have certain functions in organisms

✓ **proteins**


– **levels of structure**

• **tertiary**


- final folded shape of protein
- globular, 3-D
- results from hydrophobic interactions with water

• **domains**

- different sections of a protein fold into a structurally independent globular protein like knots on a rope

116  Figure 5.22 Examples of interactions contributing to the tertiary structure of a protein (*Biology*, 6th Ed., Campbell & Reece)

117 

118  Biological macromolecules have certain functions in organisms


✓ **proteins**


– **levels of structure**


• **quaternary**

- two or more polypeptide chains associate to form a functional protein

119 

120  Figure 5.23 The quaternary structure of proteins (*Biology*, 6th Ed., Campbell & Reece)

121  Figure 5.24 Review: the four levels of protein structure (*Biology*, 6th Ed., Campbell & Reece)

122  Biological macromolecules have certain functions in organisms

✓ **proteins**

– **levels of structure**

• how proteins fold and unfold

– **chaperone proteins**

- » help protein fold correctly

– **denaturation**

- » process by which a protein changes its shape or unfolds

123  Biological macromolecules have certain functions in organisms

✓ **proteins**

– **levels of structure**

• how proteins fold and unfold


– **chaperone proteins**

- » help protein fold correctly

- » rescue proteins caught in a wrongly folded state giving them another chance to fold correctly

» chaperone deficiency may play role in disease

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125  Biological macromolecules have certain functions in organisms


✓ **proteins**

– **levels of structure**

- how proteins fold and unfold

– **denaturation**

- » process by which a protein changes its shape (secondary & + structure) or even unfolds when its “tolerance range” for some factor is exceeded
- » results from breaking hydrogen bonds, disrupting polar - nonpolar interactions

126  Biological macromolecules have certain functions in organisms

✓ **proteins**

– **levels of structure**

- how proteins fold and unfold

– **denaturation** can be caused by

- » heats
- » acids
- » bases
- » salts


127  Figure 5.25 Denaturation and renaturation of a protein (*Biology*, 6th Ed., Campbell & Reece)

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129 

130  Web/CD Activity 5F:
Protein Structure


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131  Biological macromolecules have certain functions in organisms

✓ **proteins**


– functions

- regulation
- structural
- contractile
- transport
- energy storage
- defense
- osmotic regulation

132  Biological macromolecules have certain functions in organisms


✓ **proteins**

- functions
 - **regulation**
 - enzymes catalysts in metabolic pathways
 - hormones
 - in gene expression

133  Biological macromolecules have certain functions in organisms

✓ **proteins**


- functions
 - **structural**
 - cell membranes
 - cell cytoskeleton components
 - collagen
 - elastin
 - keratin

134  Biological macromolecules have certain functions in organisms

✓ **proteins**

- functions
 - **contractile**
 - muscle fibers
 - **transport**
 - hemoglobin
 - myoglobin

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136  Biological macromolecules have certain functions in organisms

✓ **proteins**

- functions
 - **energy storage**
 - egg albumin
 - plant seeds
 - **defense**
 - antibodies
 - **osmotic regulation**
 - globulins

137  Table 5.1 An Overview of Protein Functions (*Biology*, 6th Ed., Campbell & Reece)

138  Web/CD Activity 5E:
Protein Function
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139  Biological macromolecules have certain functions in organisms

✓ **proteins**

- types of
 - dipeptides
 - two amino acids
 - polypeptides
 - many amino acids
 - fibrous
 - globular

140  **The 4 major classes** of biological macromolecules

✓ **carbohydrates**

- monosaccharides

✓ **lipids**


- glycerol
- fatty acids

✓ **proteins**

- amino acids


✓ **nucleic acids** (DNA, RNA)

- nucleotide

141  **Biological macromolecules have certain functions in organisms**


✓ **nucleic acids**

- information storage devices of cells
- long polymers of repeating subunits called **nucleotides**
- two types
 - **DNA**
 - deoxyribonucleic acid
 - **RNA**
 - ribonucleic acid

142  **Biological macromolecules have certain functions in organisms**

✓ **nucleic acids**


- genetic material organisms inherit from their parents consists of DNA
 - within DNA are **genes**
 - specific stretches of that program amino acid sequences of proteins

143  **Biological macromolecules have certain functions in organisms**

✓ **nucleic acids**

- **nucleotides**
 - consist of three components
 - five-carbon sugar
 - phosphate group
 - nitrogenous base
 - » organic nitrogen-containing base

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145  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– **nucleotides**

- consist of three components
 - **five-carbon sugar**
 - » **ribose in RNA**
 - » **deoxyribose in DNA**

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147  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– **nucleotides**

- consist of three components
 - **phosphate group**

148 

149  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– **nucleotides**

- consist of three components
 - **nitrogenous base**
 - » **two types of organic bases occur in nucleotides**
 - » **purines**
 - » **pyrimidines**

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151  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– **nucleotides**

- two types of organic bases occur in nucleotides
 - **purines** = large, double-ringed molecules
 - » **adenine (A)** - found in RNA and DNA
 - » **guanine (G)** - found in RNA and DNA
 - **pyrimidines** = smaller, single-ringed molecules

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153  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– **nucleotides**

- two types of organic bases occur in nucleotides
 - purines
 - **pyrimidines** = smaller, single-ringed molecules
 - » **cytosine (C)** – found in RNA and DNA
 - » **thymine (T)** – found in DNA only
 - » **uracil (U)** – found in RNA only

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155  Biological macromolecules have certain functions in organisms


✓ **nucleic acids**

– **nucleotides**

- nucleotides are linked together with **phosphodiester bonds**
 - result when phosphate group of one nucleotide binds to hydroxyl group of another nucleotide, releasing water
 - creates a “sugar-phosphate” backbone


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157 

158  Figure 5.29 The components of nucleic acids (*Biology*, 6th Ed., Campbell & Reece)


159  **Web/CD Activity 5H:
Nucleic Acid Structure**

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160  Biological macromolecules have certain functions in organisms


✓ **nucleic acids**

- types of and functions
 - **RNA**
 - **DNA**
 - **ATP** and other high energy molecules

161  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **RNA**
 - usually consists of a single polynucleotide strand
 - serves as an intermediary for DNA
 - » DNA’s information is transcribed into RNA

162  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **RNA**
 - interprets genetic blueprint through protein synthesis
 - transcribing DNA message into a chemically different molecule
 - » allows cell to tell which is original information storage molecule and which is


transcript

163  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **RNA**
 - 3 types
 - » mRNA = messenger RNA
 - » tRNA = transfer RNA
 - » rRNA = ribosomal RNA

164  Figure 5.28 DNA → RNA → protein: a diagrammatic overview of information flow in a (*Biology*, 6th Ed., Campbell & Reece) cell


165  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **DNA is a double helix**
 - two polynucleotides wrap around each other
 - nitrogenous bases protrude from two sugar-phosphate backbones into center of helix where they pair
 - » adenine (A) with thymine (T)
 - » cytosine (C) with guanine (G)


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168  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **DNA**
 - forms genetic blueprint in genes or chromosomes
 - organisms encode information specifying amino acid sequences of their proteins as sequences of nucleotides

169  Figure 5.30 The DNA double helix and its replication (*Biology*, 6th Ed., Campbell & Reece)

170  Table 5.2 Polypeptide Sequence as Evidence for Evolutionary Relationships (*Biology*, 6th Ed., Campbell & Reece)


171  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

- types of and functions
 - **ATP and other high energy molecules**
 - nucleotides play critical roles in molecules which serve as the energy currency of the cell
 - **ATP** = adenosine triphosphate
 - **NAD⁺** = nicotinamide adenine dinucleotide
 - **FAD⁺** = flavin adenine dinucleotide

172 


173  Web/CD Activity 5G:
Nucleic Acid Functions
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174  Biological macromolecules have certain functions in organisms


✓ **nucleic acids**

– **discovering the structure of DNA**

- x-ray crystallographer Rosalind Franklin
 - in 1952, made image of DNA that showed a distinctive X-shape
 - » indication that DNA had twisted or helical structure
 - in 1953, estranged co-worker (Wilkins) gave the image to James Watson (of Watson & Crick fame) without her knowledge (more of her data was subsequently passed to them as well)

175  Figure 5.27 X-ray crystallography (*Biology*, 6th Ed., Campbell & Reece)

176  Figure 5.x4 Rosalind Franklin (*Biology*, 6th Ed., Campbell & Reece)

177  Biological macromolecules have certain functions in organisms

✓ **nucleic acids**

– discovering the structure of DNA

- Watson & Crick
 - in March 1953, announced they had solved DNA puzzle, produced model showing helical structure
 - won 1962 Nobel Prize for Physiology and Medicine (along with Wilkins) for discovery of DNA's structure
 - » Franklin was never mentioned
 - » Franklin died in 1958 at age 37 from ovarian cancer

178  Figure 5.x3 James Watson and Francis Crick (*Biology*, 6th Ed., Campbell & Reece)

179  The End.