PowerLecture:
Chapter 3
Molecules of Life
Section 3.0: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.0: Geology of the Delphic Oracle

- Section 3.0: EPA—Methane

- Section 3.0: The Delphic Oracle: A Multidisciplinary Defense of the Gaseous Vent Theory. Henry Spiller et al. *Journal of Toxicology: Clinical Toxicology,* Mar. 2002.

How Would You Vote?

The following is the question for this chapter. See national results below.

- Should we work toward developing the vast undersea methane deposits as an energy source, given that the environmental costs and risks to life are unknown?

Impacts, Issues: Science or the Supernatural?

- Greece, 2000 BCE, the oracle of Delphi made cryptic prophecies

- Her temple was perched on intersecting earthquake faults where hydrocarbon gases seep out of the ground – a possible scientific explanation for the oracle's hallucinations

Impacts, Issues: Science or the Supernatural?

- There may be a thousand billion tons of frozen methane hydrate on the seafloor
- The world's largest reservoir of natural gas

Section 3.1: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.1: Library of 3-D Molecular Structures

- Section 3.1: World Index of Molecular Visualization Resources

- Section 3.1: Synthesizing Chemicals by Computer (from simple hydrocarbons). James Hendrickson. *Technology Review,* April 1984.

Organic Compounds
Hydrogen and other elements
covalently bonded to carbon

- Carbohydrates

- Lipids
- Proteins
- Nucleic Acids

Carbon's Bonding Behavior

- Outer shell of carbon has 4 electrons; can hold 8

- Each carbon atom can form covalent bonds with up to four atoms

Bonding Arrangements

- Carbon atoms can form chains or rings

- Other atoms project from the carbon backbone

Section 3.2: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.2: *Biochemistry* Online

- Section 3.2: Basic Chemistry of Biomolecules

- Section 3.2: Biomolecules and Nanotechnology. David Goodsell. *American Scientist,* May 2000.

Functional Groups

- Atoms or clusters of atoms that are covalently bonded to carbon backbone

- Give organic compounds their different properties

Examples of Functional Groups

Hydroxyl group	- OH
Amino group	- NH_3^+
Carboxyl group	- COOH
Phosphate group	- PO_3^-
Sulfhydryl group	- SH

Types of Reactions

- Functional group transfer

- Electron transfer

- Rearrangement
- Condensation
- Cleavage

Common Functional Groups in Biological Molecules

Functional Groups in Hormones

- Estrogen and testosterone are hormones responsible for observable differences in traits between male and female wood ducks
- Differences in position of functional groups attached to ring structure (pg 36)

Condensation Reactions

- Form polymers from subunits
- Enzymes remove -OH from one molecule, H from another, form bond between two molecules
- Discarded atoms can join to form water

Hydrolysis

- A type of cleavage reaction
- Breaks polymers into smaller units
- Enzymes split molecules into two or more parts
- An -OH group and an H atom derived from water are attached at exposed sites

Consider Methane

- Methane, a "lifeless" hydrocarbon, is present in vast methane hydrate deposits beneath the ocean floor
- Methane hydrate disintegration can be explosive, causing a chain reaction that depletes oxygen
- Evidence points to such an event ending the Permian period 250 million years ago

Methane

Section 3.3: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.3: *Essentials of Glycobiology* Online
- Section 3.3: Complex Carbohydrates

- Section 3.3: Carbohydrates: The Next Generation (from various sources). Kitty Kevin. *Food Processing,* Feb. 1996.

- Section 3.3: Chitin Craze. Elizabeth Pennisi. *Science News,* July 31, 1993.

Carbohydrates
Monosaccharides
(simple sugars)

Oligosaccharides
(short-chain carbohydrates)

Polysaccharides
(complex carbohydrates)

Monosaccharides

- Simplest carbohydrates
- Most are sweet tasting, water soluble
- Most have 5- or 6-carbon backbone

Glucose (6 C) Fructose (6 C)
Ribose (5 C) Deoxyribose (5 C)

Two Monosaccharides
Disaccharides

- Type of oligosaccharide
- Two monosaccharides covalently bonded
- Formed by condensation reaction

Polysaccharides

- Straight or branched chains of many sugar monomers
- Most common are composed entirely of glucose
  - Cellulose
  - Starch (such as amylose)
  - Glycogen

Cellulose & Starch

- Differ in bonding patterns between monomers

- Cellulose - tough, indigestible, structural material in plants

- Starch - easily digested, storage form in plants

Cellulose and Starch
Glycogen

- Sugar storage form in animals

- Large stores in muscle and liver cells

- When blood sugar decreases, liver cells degrade glycogen, release glucose

Chitin

- Polysaccharide
- Nitrogen-containing groups attached to glucose monomers
- Structural material for hard parts of invertebrates, cell walls of many fungi

Chitin

- Chitin occurs in protective body coverings of many animals, including ticks

Section 3.4: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.4: The Structures and Functions of Lipids in Biological Systems
- Section 3.4: Biochemistry of Lipids
- Section 3.4: How Fats Work
- Section 3.4: Cholesterol: The Good, the Bad, and the Ugly. Terri D'Arrigo. *Diabetes Forecast,* Aug. 1999.
- Section 3.4: Fatty Acids: The Dangerous and the Not So Dangerous. Michael Laposata. *Medical Laboratory Observer,* Nov. 1997.
- Section 3.4: The Next Generation of Fat Replacers. Kitty Kevin. *Food Processing,* July 1995.

Lipids

- Most include fatty acids
  - Fats
  - Phospholipids
  - Waxes
- Sterols and their derivatives have no fatty acids
- Tend to be insoluble in water

Fats

- Fatty acid(s) attached to glycerol
- Triglycerides are most common

Fatty Acids

- Carboxyl group (-COOH) at one end
- Carbon backbone (up to 36 C atoms)

- Saturated - Single bonds between carbons
- Unsaturated - One or more double bonds

Phospholipids

- Main components of cell membranes

Waxes

- Long-chain fatty acids linked to long chain alcohols or carbon rings
- Firm consistency, repel water
- Important in water-proofing

Waxes

- Bees construct honeycombs from their own waxy secretions

Sterols and Derivatives

- No fatty acids
- Rigid backbone of four fused-together carbon rings
- Cholesterol - most common type in animals

Section 3.5: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.5: The Amino Acid Collection

- Section 3.5: IMB Jena Image Library of Biological Macromolecules

- Section 3.5: Got Silk? Adam Summers. *Natural History,* July 2001.

- Section 3.5: Single-Cell Proteins (bacteria turn hydrocarbons into protein supplements). John Litchfield. *Science,* Feb. 11, 1983.

Amino Acid Structure

Properties of Amino Acids

- Determined by the "R group"
- Amino acids may be:
  - Non-polar
  - Uncharged, polar
  - Positively charged, polar
  - Negatively charged, polar

Protein Synthesis

- Protein is a chain of amino acids linked by peptide bonds
- Peptide bond
  - Type of covalent bond
  - Links amino group of one amino acid with carboxyl group of next
  - Forms through condensation reaction

Primary Structure

- Sequence of amino acids
- Unique for each protein
- Two linked amino acids = dipeptide
- Three or more = polypeptide
- Backbone of polypeptide has N atoms:

-N-C-C-N-C-C-N-C-C-N-

Protein Shapes

- Fibrous proteins
  - Polypeptide chains arranged as strands or sheets
- Globular proteins
  - Polypeptide chains folded into compact, rounded shapes

Primary Structure & Protein Shape

- Primary structure influences shape in two main ways:
  - Allows hydrogen bonds to form between different amino acids along length of chain
  - Puts R groups in positions that allow them to interact

Secondary Structure

- Hydrogen bonds form between different parts of polypeptide chain

- These bonds give rise to coiled or extended pattern

- Helix or pleated sheet

Examples of Secondary Structure

Tertiary Structure

Folding as a result
of interactions between R groups

Quaternary Structure

Some proteins are made up of more than one polypeptide chain

Section 3.6: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.6: The Principles of Protein Structure

- Section 3.6: The Protein Problem

- Section 3.6: Folding@Home

- Section 3.6: Misshapes and Misfits: Protein Misfolding and Disease. Sarah Perrett. *Chemistry and Industry,* May 18, 1998.

Polypeptides with Attached Organic Compounds

- Lipoproteins
  - Proteins combined with cholesterol, triglycerides, phospholipids
- Glycoproteins
  - Proteins combined with oligosaccharides

Denaturation

- Disruption of three-dimensional shape
- Breakage of weak bonds
- Causes of denaturation:
  - pH
  - Temperature
- Destroying protein shape disrupts function

Section 3.7: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 3.7: Zooming into DNA

- Section 3.7: Molecular Biologists: Watson and Crick. Robert Wright. *Time,* Mar. 29, 1999.

Nucleotide Structure

- Sugar
  - Ribose or deoxyribose
- At least one phosphate group
- Base
  - Nitrogen-containing
  - Single or double ring structure

Nucleotide Functions

- Energy carriers

- Coenzymes
- Chemical messengers
- Building blocks for nucleic acids

ATP - A Nucleotide

Nucleic Acids

- Composed of nucleotides
- Single- or double-stranded
- Sugar-phosphate backbone

Bonding Between Bases in Nucleic Acids

DNA

- Double-stranded
- Consists of four types of nucleotides
- A bound to T
- C bound to G

RNA

- Usually single strands
- Four types of nucleotides
- Unlike DNA, contains the base uracil in place of thymine
- Three types are key players in protein synthesis