Biochemistry

Chem 1020

Ron Robertson

Isomers

When it is possible to have more than one set of atom arrangements for a general formula we say that the different arrangements are isomers. There are two major ways in which this can happen.

1. Constitutional isomers

This means that the isomers have the same general formula but different structural formulas (different atom to atom sequences). This also means they have different Lewis structures.

Example: $C_2H_4Cl_2$

2. Stereoisomers

This type is more tricky. The isomers have the same sequence of atom to atom bonds, but the arrangement of the bonds in space is different. There are two types of stereoisomers.

a. Cis-trans in alkenes

This type occurs when both of the double-bonded carbon atoms have two different groups attached.

Example $CH_3BrC=CClCH_3$

b. Optical

This type occurs with an asymmetric molecule. In such a molecule a carbon atom is bonded to 4 different atoms or groups of atoms - such a carbon atom is said to be chiral.

Asymmetric molecules have isomers that are mirror images but are not superimposable. These mirror images are called optical isomers or enantiomers.

Enzymes in living systems are so specific that they only work on 1 isomer of an enantiomeric pair. Examples of biochemicals that are optically active are amino acids and sugars.

Example: CHClBrI

Protein Background

Uses

- **Synthesis of enzymes, tissues, hormones**
- **Energy**

Composition

C, H, O, N, S ---the presence of N sets proteins apart from carbs and lipids

Definition

Proteins are polymers of amino acids. They are made by the reaction of the carboxyl group of one amino acid with the amino group of another

1. There are 20 common amino acids.

2. The body is incapable of synthesizing 10 of these in sufficient quantities – these are called essential amino acids and must be obtained from food.

3. Complete proteins are those foods that contain all ten. Most animal proteins are complete. Most plant protein is incomplete.

Protein Chemistry

The peptide linkage is made from the reaction of an acid group and an amine group.

We commonly use the term peptide to refer to a sequence of up to 50 amino acids.

With 20 different amino acids there is a tremendous number of different protein combinations.

Structural Levels

Primary Structure – sequence of amino acids

Secondary Structure – the fixed 3-d shape of the protein that results from the interactions between amide linkages that are close to each other. Hydrogen bonding is primarily responsible.

1. alpha helix – hair

2. beta pleated sheet – silk

Tertiary structure – the overall 3-d shape that results from the attractive forces among amino acid side chains that are widely separated.

1. globular – hemoglobin and many enzymes

2. fibrous – keratin in hair and skin, collagen in bones, tendons and cartilage

Hydrolysis

Breakdown by heating in strong acid or base to amino acids. The body uses enzymes to accomplish this and we call the process digestion. Amino acids are not stored - protein must be eaten every day.

Denaturation

The loss of secondary and tertiary structure of a protein. This causes a loss in biological activity. Heat, UV and microwave radiation, violent shaking, strong acids or bases, heavy metals, reducing agents, ethanol can accomplish this.

- **The cooking of food denatures protein and makes it easier to digest. It also kills microorganisms by protein denaturation.**
- **Acids or bases in the eye coagulates protein and causes cloudiness.**
- **Alcohols are used to disinfect by denaturing bacterial protein.**
- **A reversible denaturation is involved in waving hair - getting a "perm". Hair is a fibrous protein with disulfide linkages, which give the tertiary structure of the protein (keratin). The protein is denatured using a reducing agent (thioglycolic acid), then set, and finally "glued" back into disulfide bridges by an oxidizing agent (H_2O_2)**

Lipids

Definition – non water soluble

Types

1. **waxes**
2. **fats and oils**
3. **steroids**
4. **compound lipids**

Waxes

Esters formed from the reaction of a long chain alcohol with a fatty acid (long chain carboxylic acid).

Waxes are usually protective coatings.

Fats and Oils

Mixtures of esters formed from 3 fatty acid molecules and glycerol

Fats are triglyceride mixtures that have a high % of saturated fatty acid components. They are usually solid-like and are produced mainly by animals.

Oils are triglyceride mixtures that have a high % of unsaturated fatty acid components. They are usually liquids and are produced mainly by plants. Exceptions are palm oil and coconut oil which have a high saturated content.

Saturated fats have been implicated with high cholesterol levels in atherosclerosis**, a buildup of plaque on the artery walls. For that reason the use of vegetable oils that are high in unsaturation is advised. [See chart of unsaturated character of oils]**

Margarines are unsaturated vegetable oils that have been treated (hydrogenated) with hydrogen to make a solid-like product. This means that many of the double bonds in the oils have been changed to single bonds, but not all.

Problems can occur with the use of these partially hydrogenated products because the process of hydrogenation converts the natural cis fatty acids to trans fatty acids.

The trans fatty acids stack like saturated fatty acids and are stored and not metabolized by the body as the natural cis fatty acids are.

Cis fatty acids react with cholesterol and tie it up; trans fatty acids do not and allow the cholesterol to roam the arteries and form blockages.

A majority of cholesterol is carried in the blood by LDL (low density lipoprotein). A smaller amount is carried

by HDL (high density lipoprotein), but the HDL carries the cholesterol to the liver for metabolism and prevents it from forming plaque in the arteries. This shows why we need to raise the HDL to LDL ratio.

Soaps

Fats and Oils are used to make soap by the saponification reaction.

Soaps are "surface active"' (surfactants) and form micelles.

Soaps form precipitates with ions such as calcium, magnesium, and iron.

Detergents are "synthetic soaps" which do not form these precipitates as much.

Steroids

Lipids which have the basic perhydrocyclopentanophenanthrene structure. (know how to sketch this basic structure) Examples are:

- cholesterol – much is synthesized in the body; it is needed as a starting material for many other substances, such as hormones, vitamin D, etc.
- bile salts – these emulsifying agents make dietary lipids soluble in the aqueous digestive tract. They are surface active and form micelles.
- hormones – chemicals produced by the ductless glands that provide communication between tissues.
  1. sex hormones such as testosterone, progesterone, estrogens and progestins
  2. cortisone – an anti-inflammatory (adrenal glands)
  3. anabolic steroids are synthetic steroids that accentuate the muscle building (anabolic) effects of testosterone and minimize (supposedly) the androgenic (masculinizing) effects

Digestion

Carbohydrates

- Mouth - salivary amylase (ptyalin) causes starches to hydrolyze to maltose
- Stomach - no enzymes due to acidity
- Intestinal tract - acidity is neutralized by secretion from pancreas, other pancreatic juices hydrolyze poly and disaccharides to mono saccharides

Fats and Oils

Intestinal tract - bile salts emulsify and allow other enzymes to hydrolyze fat and oil to fatty acids and glycerol

Protein

- Stomach - pepsin begins hydrolysis
- Intestinal tract - the hydrolysis is completed to amino acid fragments

After absorption through the intestinal walls the water soluble products are sent to the liver for storage and conversion. Glycogen is assembled from excess glucose, fatty acids are sent for storage or prepared for metabolism, and amino acids are assembled into enzymes. The liver is the central nutrient bank of the body.

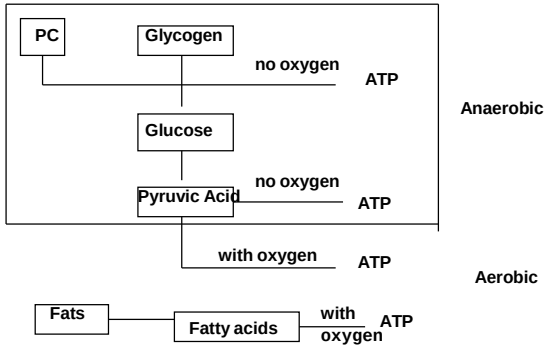
Energy Transfer

Energy to drive muscles comes from

ATP Þ ADP + P + energy
Thus ADP must be replenished
ADP + P + energy Þ ATP

How do we get the energy to make ATP?

Anaerobically (without oxygen)
Aerobically (with oxygen)



The anaerobic series of complex reactions is called the Embden-Meyerhof pathway. The aerobic series is called the Krebs cycle.

Nucleic Acids

A. Definition - polymeric molecules in which the repeating unit is a <u>nucleotide</u>

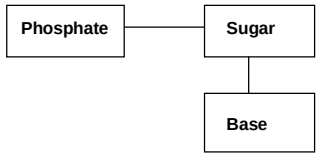
B. Types

DNA (deoxyribonucleic acid) - nucleus
RNA (ribonucleic acid) - nucleus and cytoplasm

C. Functions

Store, transfer, and transmit genetic information
Control and direction of protein synthesis

D. Nucleotide structure



E. Overall structure

1. **Primary - sequence of nucleotides**
   Base changes, phosphate and sugar backbone remain the same

2. **Secondary - 3d structure due to short range interactions (H bonding) of nitrogen bases**

3. **Tertiary - 3d structure due to long range interactions**