INTRODUCTORY BIOCHEMISTRY

- almost all molecules inside cells (other than water) are carbon based
- **organic chemistry** = the study of carbon based compounds
- concentrations of C, H, O. N, S, & P are quite constant from organism to organism
  ⇒ the huge diversity of organic molecules is made possible by the versatility of carbon atoms as building blocks
- C atoms have 4 e- in their outer shell ⇒ forms 4 covalent bonds
  ⇒ C atoms act as intersections; allowing formation of rings, branches, and double bonds

C structures can be represented by **simplified diagrams** where: **Fig 2.14**
(i) C and H atoms are not written in
(ii) each bend = a C atom
(iii) each C is assumed to be bound to enough H's to complete C's outer shell (i.e. to make 4 bonds)

There are 4 major classes of organic compounds found in the human body: carbohydrates, lipids, proteins and nucleic acids
- all 4 classes consist of sub-units that can be: **Figs 2.15, 2.17, 2.21**
  (i) covalently bound together by the chemical **removal of a water** molecule (**dehydration** synthesis)
  (i) broken off from larger molecules by chemical addition of a water molecule (hydro**lysis**)

I. CARBOHYDRATES = sugars, starch, glycogen, & cellulose

A. monosaccharides = "simple" sugars

- made up of C, H, and O; typically in the ratio of 1:2:1 (CH_2O)
- contain **3 to 7 C** atoms and usually **form ring** in solution e.g. glucose **Fig 2.14**
- **glucose, fructose, galactose and manose** are all $C_6H_{12}O_6$ in different arrangements
- sugars are found in relatively small amounts in natural foods:
  glucose and fructose – found in fruits and honey
  galactose – found in grapes and figs
  manose – found in pineapples, olives and carrots
- processed foods contain large amounts of glucose and high fructose corn syrup:
  - corn syrup now accounts for 20% of all carbs consumed in USA
  - rose from 225 gm/person/yr in 1970 to 28 kg/person/yr in 1997 = 225 X
  ⇒ may be a significant contributer to epidemic obesity and insolent resistant diabetes

Metabolic Importance:
- **glucose** (from digestion of larger carbohydrates) is the **main energy supplying molecule** for the body (for cellular respiration)
- all other monosac. are easily converted to glucose
- monosac. (mostly glucose) are **used to make all the larger carbohydrates** (see below)
- **DNA** subunits, **RNA** subunits, **and ATP all contain a 5C sugar** (ribose or deoxyribose)

- combine with lipids and proteins to make glycolipids and glycoproteins (important in cell membranes where they **function in cell to cell recognition**)

Absorption: Figs 24.18 and 24.20 in 11th ed. OR 24.23 and 24.25 in 10th ed.
- carbohydrates from food are digested to **monosach. units** and are then **absorbed into epithelial cells lining the villi of the small intestine**
- glucose and galactose are **actively** absorbed by one membrane transport protein that uses **cotransport with sodium** ions as an energy source
- manose uses active transport by another sodium dependent transport protein
- fructose is absorbed by **facilitated diffusion** (passive)

Transport: Figs 24.20b & 21.28 in 11th ed. OR 24.25b & 21.29 in 10th ed.
- sugars are water soluble
- once absorbed, sugars enter veins via capillary networks
- **veins** from the stomach & intestines **join to form the <u>hepatic portal vein</u>**
  ⇒ **takes nutrients** absorbed from food **to the liver for modification/storage**
- after modification, blood enters **2 hepatic veins** which lead to the **inferior vena cava**
  ⇒ **takes nutrients to heart** for circulation

note: the liver receives most of its blood from the hepatic portal system, but also receives some blood via the hepatic artery

B. <u>disaccharides</u> = 2 monosaccharides covalently joined by dehydration synthesis
e.g. (i) sucrose (cane sugar or table sugar) is made from glucose + fructose **Fig 2.15**
(ii) lactose (milk sugar) = glucose + galactose
(iii) maltose = glucose + glucose
- disaccharides function primarily to **supply energy**

C. <u>polysaccharides</u> = "many" sugars joined together by dehydration synthesis **Fig 2.16**
e.g. starch, glycogen & cellulose are all made from glucose bound together in different ways
- glycogen and starch function in **long term energy storage** in animals & plants respectively, and both can be digested by humans
- cellulose is a **structural molecule** found in plants; we cannot digest it = "fiber"

II. <u>LIPIDS</u> - a widely divergent class of organic molecules that are grouped together because
(i) they are all **made primarily of C and H** atoms (very little O)
(ii) they are all **hydrophobic** ("water hating")
There are 3 major groups of lipids important to humans:

A. <u>Fats or triglycerides</u>: Figs 2.17
- are made from 2 types of subunits: 1 glycerol + 3 fatty acids
- provide **protection, insulation, highly concentrated source of energy**
- may be **(i) saturated** ⇒ all C atom's in the fatty acid chains are "full" of H (**no double bonds**)
  - occur mostly in **animal** foods and tend to be solid at room temperature
    e.g. lard (from meat), butter, eggs

(ii) unsaturated ⇒ **1 or more double covalent bonds** between C's in fatty acid chains
- occur mostly in **plant** foods and are liquid at room temp.
e.g. olive & peanut oil

(iii) polyunsaturated ⇒ many double covalent bonds e.g. corn & sunflower oil

B. <u>Phospholipids</u>: - made from glycerol + 2 fatty acids + a phosphate group **Fig 2.18**
- fatty acids "tails" are hydrophobic and PO_4 head is hydrophillic (water loving)
⇒ naturally form a bilipid layer (the basic structure of **cell membranes**) **Fig 3.2**

C. <u>Steroids</u> - complex molecules with 4 interlocking rings **Fig 2.19**
- include **(i) hormones** ⇒ regulate cell activities
(ii) cholesterol ⇒ used to make bile and other steroids; part of cell membranes
(iii) Vitamin D ⇒ needed for bone growth, development and repair

<u>Absorption, Transport and Storage of Lipids</u>: Fig 24.20b in 11th ed. OR 24.25b in 10th ed.
- fats are digested to monoglycerides and fatty acids and then absorbed by diffusion into epithelial cells around the small intestine
- in the Golgi of epithelial cells, the final fatty acids are removed from monoglycerides, but the resulting glycerol and fatty acids are the made back into fats
- fats, phospholipids and cholesterol are combined and coated with soluble proteins = **chylomicrons**
- chylomicrons then leave the cells by exocytosis, enter lacteals (small ducts of lymphatic system), and are carried by lymphatic ducts to the left subclavian vein → stored in liver and adipose cells

III. <u>Proteins</u>

- very complex molecules that contain C, H, O, **N** and usually Sulphur (S)
- are structurally diverse and perform **MANY functions;** used minimally for energy **Table 2.8**
- are made from **20 sub-units called amino acids** **Fig 2.20**
- 10 of the amino acids cannot be made in sufficient quantities by the body so they must be obtained in the diet = "**essential** amino acids"
- each amino acid consists of a central C atom covalently bound to:
(i) an NH_2 (**<u>amino</u>**) group (iii) an H atom
(ii) a COOH (carboxylic **<u>acid</u>**) group (iv) one of 20 different "R groups"
- amino acids are joined end to end by dehydration synthesis = a **polypeptide** **Fig 2.22**
- 1 or more polypeptides folded and chemically bonded together = a **protein**
- amino acids are absorbed and transported much like monosacharrides

Note: make sure you study the last two objectives from the Biochemistry unit (I have not covered them)

<u>TORTORA Chapter 2 Textbook Questions to try</u>

- Self Quiz 3, 4, 5, 7, 8, & 13 in 11-12th ed. OR 1, 2, 5, 6, 8, 10, 11 in 10th ed.
- Figure Questions 2.1, 2.2, 2.4, 2.5, 2.15, 2.18, 2.20 and 2.21 (10th to 12th ed.)

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