Nutrition, Metabolism & Temperature Regulation

“You are what you eat!”
All seasons are beautiful for the person who carries happiness within.

Roland Walter Haase
1920–2006
Nutrition

• Nutrient
• a substance (chemical or compound) found in food that is used by the body to ________________

______________________________

______________________________
Nutrition

• There are 6 categories of nutrients, subdivided into 2 groups:

• Major nutrients
• Minor nutrients
• Essential nutrients
• Non-Essential Nutrients
Nutrient

• **Major nutrients:**
  – Carbohydrates
  – Lipids
  – Proteins

• **Minor nutrients**
  – Vitamins
  – Minerals
Nutrient

• **Essential nutrients**
  – cannot be made by the body
  – Must be obtained through ________

• **Non-Essential Nutrients**
  – converted by __________________ from one type of molecule into another through chemical reactions
Carbohydrates

• Except for milk sugar (lactose) & small amounts of glycogen found in meats, all the carbohydrates we ingest are derived from plants.

• **Monosaccharides & Disaccharides**
  – Sugars that come from fruits, sugar cane, milk & honey.

• **Starch** (a polysaccharide) is found in grains, legumes & root vegetables.

• **Cellulose** is a plant polysaccharide that is not digestible by humans but provides roughage or fiber that increases stool bulk & facilitates defecation.
Carbohydrates continued…

- Glucose is the carbohydrate molecule ultimately used by the body as fuel to make ______
- The digestion of carbohydrates results in the formation of monosaccharides such as fructose, galactose & glucose, but all are converted into glucose by the liver before entering the general circulation
- (**Recall & Review the hepatic portal system)
Carbohydrates continued…

• Many body cells can use **fats** as energy sources, but other cells such as neurons & RBCs can only use **glucose**

• Blood glucose levels are **carefully monitored** by the body since even temporary shortages can lead to neuron death

• Excess glucose that cannot be stored as glycogen is converted to fat
Carbohydrates continued...

- Current recommendation is $125 \text{–} 175$ grams of carbohydrates daily with the emphasis on ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______

  -(whole grains & vegetables)

- The minimum amount needed to maintain blood glucose levels is believed to be $100$ grams per day
Carbohydrates continued…

- Starches & other "Complex Carbohydrates" contain valuable nutrients such as vitamins & minerals
- Candy & soft drinks that contain only sugars provide energy, but no vitamins & minerals & the term "____________________ ____________________ ____________________ ____________________" is used to describe them
Lipids

• The most common dietary lipids are the neutral fats, triglycerides or triacylglycerols (occur as Saturated & Unsaturated fats)

• ________________ fats
  found in meats & dairy products

• ________________ fats
  found in seeds, nuts & most vegetable oils
Lipids continued…

• The liver can convert many fatty acids into other types when needed, but there are 2 essential fatty acids that must be ingested in the diet:

  • Linoleic Acid (Omega 6- Sunflower Oil)
  • Linolenic Acid (Omega 3- Fish, Flax, Hemp & Canola Oil)
  • Oleic Acid (Omega 9- Olive Oil)- non essential

• These are necessary for the production of other types of lipids in the body
Omega 3 Fatty Acids

- Essential Fatty Acids
- Fish Oil
  - EPA (Eicosapentaenoic Acid)
  - DHA (Docosahexaenoic Acid)
- NIH states that Omega 3’s have tremendous health benefits including anti-inflammation
- Highest grade fish oil is molecularly distilled
- Greatest concern is heavy metals
- Canadian Research Labs claim 2–5 g/day is Safe
Lipids continued…

• Dietary fats are essential for several reasons, they are:
  • major source of fuel for Hepatocytes & Skeletal Muscle
  • necessary for absorption of fat-soluble vitamins such as A, D, E & K
  • components of the myelin sheaths & cellular membranes of the body
Lipids continued…

• **Cholesterol**
  another dietary lipid that is found in egg yolk, meats & milk products

• **important cell membranes stabilizer & building block of** __________________ __________________ (testosterone & estrogens)

• **Fatty deposits in adipose tissue provide insulation & a protective cushion around some body organs**
Lipids continued…

- **Dietary requirements & recommendations:**
  - **30%** or less of caloric intake
  - Saturated fats should be 10% or less of total fat intake
  - Daily cholesterol should be no more than 200 mg (one egg yolk!)
Proteins

• Recall that proteins are composed of combinations of Amino Acids
• Amino Acids can be divided into 2 categories:
  • Nonessential – Amino Acids synthesized in the __________
  • Essential – Amino Acids obtained through ______________
Proteins continued…

- Animal products contain the highest-quality proteins, those with the greatest amount & best ratio of **Essential Amino Acids**
- Proteins in eggs, milk & meats are considered to be **complete proteins** that meet all the body’s amino acid requirements for tissue maintenance & growth
- Legumes, nuts & cereals are protein-rich, but **not complete**, but when cereal grains & legumes are **ingested together they provide all the Essential Amino Acids**
Proteins continued…

• Proteins are important as structural materials of the body, enzymes & hormones

• All amino acids needed to make a particular protein must be present in a cell at the same time & in sufficient amounts for the protein to be made (the “all-or-none” rule of protein synthesis)
Proteins continued...

• For optimal protein synthesis the diet needs sufficient carbohydrate or fat calories for ATP production

• The body is in **nitrogen balance** when the amount of nitrogen ingested in proteins is equal to the amount lost in urine & feces

• Anabolic hormones accelerate protein synthesis & growth
Proteins continued…

• The amount of protein a person needs reflects his or her age, size, metabolic rate & current state of nitrogen balance

• As a general rule, a daily intake of 0.8 g of protein per kg body weight is recommended

• (**Note - to convert lbs. into kilograms, divide lbs. by 2.2)**
Vitamins

- See Vitamin Table
- Potent organic compounds needed in small amounts for growth & good health, most of which function as coenzymes
  - (non-protein parts of enzymes that are necessary for the proper functioning of the enzymes)
Vitamins continued…

• Most vitamins are not made in the body & must be taken via foods or vitamin supplements
  – The exceptions are vitamin___ made in the skin & vitamin___ made by intestinal bacteria
  – The body can also convert the pigment beta carotene from carrots into vitamin___

• Fat-soluble vitamins
• Water-soluble vitamins
Water-soluble vitamins

• **B complex vitamins & vitamin C**
• Absorbed along with __________ from the gastrointestinal tract, & excess amounts are excreted from the body in __________
• One exception is Vitamin ____, which must bind to gastric intrinsic factor in order to be absorbed (recall “Pernicious Anemia” from Chapter 17)
• Since only very small amounts of the water-soluble vitamins are stored, problems resulting from overdose are rare
Fat-soluble vitamins

- **Vitamin A, D, E & K**
- Bind to ingested lipids & are absorbed along with their digestion products
- Anything that interferes with fat absorption also interferes with the absorption of fat-soluble vitamins
- Because fat-soluble vitamins can be stored (with the exception of vitamin K), excess intake or "hypervitaminosis" can lead to various health problems, depending on the specific vitamin
Vitamins

- Vitamins A, C, and E are **Antioxidants** that disarm tissue-damaging **free radicals**
- A “______________” is a very reactive molecule that has unpaired electrons
- They are produced as by-products of certain chemical reactions in cells
  - One example is the “**superoxide**”, which is an oxygen molecule that has odd numbers of electrons in its outer energy levels
Vitamins continued…

• One theory of aging is that damage caused by **free radicals** accumulates over time because cells are less & less able to keep up with repairs.

• Thus, the flood of vitamins & creams that promise to decrease the signs of aging because they contain the “complete antioxidant group!”
Minerals

- See Mineral Table
- The body requires moderate amounts of ___________ & trace amounts of about a dozen others that are used by the body to add strength to structures or to act as ions in the blood & cells
Minerals continued…

- Like vitamins, minerals are not used as fuel sources, but work with other nutrients to ensure a smoothly functioning body.

- A fine balance between uptake & excretion is crucial for preventing toxic overload while retaining needed amounts.
Minerals continued…

– The best sources of minerals are vegetables, legumes, milk, some shellfish & some meats

– Fats, sugars & highly refined cereals & grains have little to no minerals
Metabolism

• biochemical modification of chemical compounds through metabolic (chemical) pathways

• Cell Metabolism includes all chemical processes occurring within a cell

• Total Metabolism including all biochemical processes within an organism
Metabolism

• **Consist of sequences of enzymatic steps** of which there are 2 processes:
  – **Catabolism** (catabolic chemical pathways)
  – **Anabolism** (anabolic chemical pathways)

• Without metabolism we would not be able to survive
Anabolism

• the general term for all reactions in which larger molecules or structures are built from smaller ones

• the ______________ of complex organic molecules from basic building blocks
  – Example – the bonding of amino acids to make a protein
Catabolism

• Refers to all processes that break down complex structures to simpler ones
• The hydrolysis of complex organic molecules into basic building blocks
• Example – the breaking down of glucose by body cells to release the energy needed for ATP production ("cellular respiration") – this will be explored in more detail under Carbohydrate metabolism below
Metabolism

• 3 Stages in the Processing of Energy-containing nutrients in the body
Metabolism Stage 1

- digested nutrients are absorbed into the bloodstream & transported within the blood & delivered to the tissue cells
Metabolism Stage 2

• (Cellular Respiration)

• Newly delivered nutrients are built into lipids, protein, or glycogen by anabolic pathways or broken down by catabolic pathways into pyruvic acid & Acetyl CoA
Metabolism Stage 3

• **Catabolic Processes in the**
  
  ________________________________ of cells
  complete the breakdown of foods in the presence of oxygen, producing CO$_2$, H$_2$O & large amounts of __________ (the ultimate goal!)

• *(cellular respiration)*
Carbohydrate Metabolism

• All food carbohydrates taken in through the diet are eventually transformed into glucose \((C_6H_{12}O_6)\)

• Glucose molecules then enter body cells from the bloodstream through facilitated diffusion (a process that is greatly enhanced by insulin from the pancreas)
# Summary: Carbohydrate Metabolic Reactions

## Table 24.2.1

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular respiration</td>
<td>Reactions that together complete the oxidation of glucose, yielding CO₂, H₂O, and ATP</td>
</tr>
<tr>
<td>Glycolysis</td>
<td>Conversion of glucose to pyruvic acid</td>
</tr>
<tr>
<td>Glycogenesis</td>
<td>Polymerization of glucose to form glycogen</td>
</tr>
<tr>
<td>Glycogenolysis</td>
<td>Hydrolysis of glycogen to glucose monomers</td>
</tr>
<tr>
<td>Gluconeogenesis</td>
<td>Formation of glucose from noncarbohydrate precursors</td>
</tr>
<tr>
<td>Krebs cycle</td>
<td>Complete breakdown of pyruvic acid to CO₂, yielding small amounts of ATP and reduced coenzymes</td>
</tr>
<tr>
<td>Electron transport chain</td>
<td>Energy-yielding reactions that split H removed during oxidations to H⁺ and e⁻ and create a proton gradient used to bond ADP to Pᵢ, forming ATP</td>
</tr>
</tbody>
</table>
Carbohydrate Catabolism

Figure 24.5
Cellular Respiration

- **Oxidation of Glucose**
- nearly all reactions inside a cell involve “Oxidation”, (the loss of electrons from a molecule)
- The addition of O\(_2\) or removal of H\(^+\) atoms
- In the case of glucose, the cells use 3 processes to systematically remove pairs of H\(^+\) atoms (& their electrons) from glucose
- All that remains in the end is CO\(_2\)
Cellular Respiration

- \( \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + 36 \text{ ATP} + \text{Heat} \)
- Oxidized molecules always LOSE energy & the liberated energy from glucose is ultimately used by the cell to make more ATP from ADP
- There are 3 biochemical pathways involved in cellular respiration:
  - ______________________
  - ______________________
  - ______________________
  - ______________________
Glycogenesis

• the formation of glycogen, the animal_________________________, when excess glucose is ingested

• Since there is a limited storage space for Glycogen (mainly skeletal muscle & liver cells), the excess glucose that can’t be converted into glycogen is converted into Fat
Glycogenolysis

- the ______________________________ into individual glucose molecules that occurs when the blood sugar levels drop
- The _____________ in particular releases glucose from its glycogen stores when blood glucose levels drop
Mechanisms of ATP Synthesis:
Substrate-Level Phosphorylation

- High-energy phosphate groups are transferred directly from phosphorylated substrates to ADP.
- ATP is synthesized via substrate-level phosphorylation in glycolysis & the Krebs cycle.
Mechanisms of ATP Synthesis: Oxidative Phosphorylation

Figure 24.4b
Gluconeogenesis

• the process of forming ______________ ____________________________ that occurs in the ________ using glycerol & amino acids

• This protects the body & especially the ________________, from the damaging effects of low blood sugar