Nutrition

- Nutrient – a substance that promotes normal growth, maintenance, and repair
- Major nutrients – carbohydrates, lipids, and proteins
- Other nutrients – vitamins and minerals (and technically speaking, water)

Food Pyramid System Message: Physical Activity

- In the Dietary Guidelines:
  - Engage in regular physical activity and reduce sedentary activities to promote health, psychological well-being, and a healthy body weight
- In MyPyramid graphic:
  - Steps and person on them symbolize physical activity should be a part of everyday healthy living

Food Pyramid System Message: Proportionality

- In the Dietary Guidelines:
  - Adopt a balanced eating pattern
    - Sufficient amount of fruits and vegetables
    - 3 or more ounce equivalents of whole-grain products per day
    - 3 cup equivalents per day of fat-free or low-fat milk or milk product
• In MyPyramid graphic:
  o Differing widths of the color bands suggest about how much food should be eaten from each group

Food Pyramid System Message: Moderation
• In the Dietary Guidelines:
  o Limit intake of saturated and *trans* fats, and choose products low in these fats
  o Make choices of meat, poultry, dry beans, and milk products that are lean, low fat, or fat free
  o Choose and prepare foods and beverages with little added sugars or calorie sweeteners
• In MyPyramid graphic:
  o Food group bands narrow from bottom to top suggesting to eat nutrient-dense forms of foods

![MyPyramid Graphic](https://choosemyplate.gov)

**Carbohydrates**
• Complex carbohydrates (starches) are found in bread, cereal, flour, pasta, nuts, and potatoes
• Simple carbohydrates (sugars) are found in soft drinks, candy, fruit, and ice cream
• Glucose is the molecule ultimately used by body cells to make ATP
• Neurons and RBCs rely almost entirely upon glucose to supply their energy needs
• Excess glucose is converted to glycogen or fat and stored
• The minimum amount of carbohydrates needed to maintain adequate blood glucose levels is 100 grams per day
• Starchy foods and milk have nutrients such as vitamins and minerals in addition to complex carbohydrates
• Refined carbohydrate foods (candy and soft drinks) provide energy sources only and are referred to as “empty calories”
Lipids
- Fatty deposits in adipose tissue provide:
  - A protective cushion around body organs
  - An insulating layer beneath the skin
  - An easy-to-store concentrated source of energy
- The most abundant dietary lipids, triglycerides, are found in both animal and plant foods
- Essential fatty acids – found in most vegetables, must be ingested
- Dietary fats:
  - Help the body to absorb vitamins
  - Are a component of myelin sheaths and all cell membranes
- Lipids: Dietary Requirements
  - Higher for infants and children than for adults
  - The American Heart Association suggests that:
    - Fats should represent less than 30% of one’s total caloric intake
    - Saturated fats should be limited to 10% or less of one’s total fat intake
    - Daily cholesterol intake should not exceed 200 mg

Proteins
- Complete proteins that meet all the body’s amino acid needs are found in eggs, milk, milk products, meat, and fish
- Incomplete proteins are found in legumes, nuts, seeds, grains, and vegetables
- Proteins supply:
  - Essential amino acids, the building blocks for nonessential amino acids
  - Daily intake should be approximately 0.8g/kg of body weight

Vitamins
- Organic compounds needed for growth and good health
- They are crucial in helping the body use nutrients and often function as coenzymes
- Only vitamins D, K, and B are synthesized in the body; all others must be ingested
- Water-soluble vitamins (B-complex and C) are absorbed in the gastrointestinal tract
- Fat-soluble vitamins (A, D, E, and K) bind to ingested lipids and are absorbed with their digestion products
- Vitamins A, C, and E also act in an antioxidant

Minerals
- Seven minerals are required in moderate amounts
  - Calcium, phosphorus, potassium, sulfur, sodium, chloride, and magnesium
- Dozens are required in trace amounts
- Minerals work with nutrients to ensure proper body functioning
- Calcium, phosphorus, and magnesium salts harden bone
Metabolism
- Metabolism – all chemical reactions necessary to maintain life
- Cellular respiration – food fuels are broken down within cells and some of the energy is captured to produce ATP
  - Anabolic reactions – synthesis of larger molecules from smaller ones
  - Catabolic reactions – hydrolysis of complex structures into simpler ones
- Stages of Metabolism
  - Energy-containing nutrients are processed in three major stages
    - Digestion – breakdown of food; nutrients are transported to tissues
    - Anabolism and formation of catabolic intermediates
    - Oxidative breakdown – nutrients are catabolized to carbon dioxide, water, and ATP

Gluconeogenesis
- The process of forming sugar from non-carbohydrate molecules
- Takes place mainly in the liver
- Protects the body, especially the brain, from the damaging effects of hypoglycemia by ensuring ATP synthesis can continue

Lipid Metabolism
- Most products of fat metabolism are transported in lymph
- Lipids are hydrolyzed by plasma enzymes and absorbed by cells
- Only neutral fats are routinely oxidized for energy
- Catabolism of fats involves two separate pathways
  - Glycerol pathway
  - Fatty acids pathway

Protein Metabolism
- Excess dietary protein results in amino acids being:
  - Oxidized for energy
  - Converted into fat for storage
- Synthesis of Proteins
  - Amino acids are the most important anabolic nutrients, and they form:
    - All protein structures
    - The bulk of the body’s functional molecules
  - Amounts and types of proteins:
    - Are hormonally controlled
    - Reflect each life cycle stage
  - A complete set of amino acids is necessary for protein synthesis
    - All essential amino acids must be provided in the diet
### Table 24.4

**Carbohydrates**

<table>
<thead>
<tr>
<th>Reaction</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>

**Lipids**

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta oxidation</td>
<td>Conversion of fatty acids to acetyl CoA</td>
</tr>
<tr>
<td>Lipolysis</td>
<td>Breakdown of lipids to fatty acids and glycerol</td>
</tr>
<tr>
<td>Lipogenesis</td>
<td>Formation of lipids from acetyl CoA and glyceraldehyde phosphate</td>
</tr>
</tbody>
</table>

**Proteins**

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transamination</td>
<td>Transfer of an amine group from an amino acid to α-ketoglutaric acid, thereby transforming α-ketoglutaric acid to glutamic acid</td>
</tr>
<tr>
<td>Oxidative deamination</td>
<td>Removal of an amine group from glutamic acid as ammonia and regenerating α-ketoglutaric acid (NH₃ is converted to urea by the liver)</td>
</tr>
</tbody>
</table>
State of the Body
- The body exists in a dynamic catabolic-anabolic state
- Organic molecules (except DNA) are continuously broken down and rebuilt
- The body’s total supply of nutrients constitutes its nutrient pool

Absoprtive and Postabsorptive States
- Metabolic controls equalize blood concentrations of nutrients between two states
- Absorptive
  - The time during and shortly after nutrient intake
- Postabsorptive
  - The time when the GI tract is empty
  - Energy sources are supplied by the breakdown of body reserves

Insulin Effects on Metabolism
- Insulin controls the absorptive state and its secretion is stimulated by:
  - Increased blood glucose
  - Elevated amino acid levels in the blood
  - Gastrin, CCK, and secretin
- Insulin enhances:
  - Active transport of amino acids into tissue cells
  - Facilitated diffusion of glucose into tissue

Diabetes Mellitus
- A consequence of inadequate insulin production or abnormal insulin receptors
- Glucose becomes unavailable to most body cells
- Metabolic acidosis, protein wasting, and weight loss result as fats and tissue proteins are used for energy

Cholesterol
- Is the structural basis of bile salts, steroid hormones, and vitamin D
- Is transported to and from tissues via lipoproteins
- Lipoproteins are classified as:
  - HDLs – high-density lipoproteins have more protein content
  - LDLs – low-density lipoproteins have a considerable cholesterol component
  - VLDLs – very low density lipoproteins are mostly triglycerides
- Cholesterol Transport
  - Because triglycerides and cholesterol are insoluble in water, they do not circulate freely in the blood
  - Instead, they are transported to and from tissue cells bound to small lipid-protein complexes called lipoproteins
  - High levels of HDL are thought to protect against heart attack
  - High levels of LDL increase the risk of heart attack
    - Scavenge cholesterol from the bloodstream, from the arterial walls and transports it back to the liver for breakdown
    - Think of HDL as the garbage trucks of the circulatory system
Liver Metabolism
- A brief summary of liver functions
  - Packages fatty acids to be stored and transported
  - Synthesizes plasma proteins
  - Forms nonessential amino acids
  - Converts ammonia to urea
  - Stores glucose as glycogen, and regulates blood glucose homeostasis
  - Stores vitamins, conserves iron, degrades hormones, and detoxifies substances
  - Hepatocytes carry out over 500 intricate metabolic functions

Plasma Cholesterol Levels
- The liver produces cholesterol:
  - At a basal level of cholesterol regardless of dietary intake
  - Via a negative feedback loop involving serum cholesterol levels
  - In response to saturated fatty acids
- Non-Dietary Factors Affecting Cholesterol
  - Stress, cigarette smoking, and coffee drinking increase LDL levels
  - Aerobic exercise increases HDL levels
  - Body shape is correlated with cholesterol levels
    - Fat carried on the upper body is correlated with high cholesterol levels
    - Fat carried on the hips and thighs is correlated with lower levels

Body Energy Balance
- Bond energy released from catabolized food must equal the total energy output
- Energy intake – equal to the energy liberated during the oxidation of food
- Energy output includes the energy:
  - Immediately lost as heat (about 60% of the total)
  - Used to do work (driven by ATP)
  - Stored in the form of fat and glycogen
- Nearly all energy derived from food is eventually converted to heat
- Cells cannot use this energy to do work, but the heat:
  - Warms the tissues and blood
  - Helps maintain the homeostatic body temperature
  - Allows metabolic reactions to occur efficiently

Feeding Behaviors
- Feeding behavior and hunger depend on one or more of five factors
  - Neural signals from the digestive tract
  - Bloodborne signals related to the body energy stores
  - Hormones, body temperature, and psychological factors
- When energy intake and energy outflow are balanced, body weight remains stable
- The hypothalamus releases peptides that influence feeding behavior
Hormones, Temperature, Psychological Factors

- Glucagon and epinephrine stimulate hunger
- Insulin and cholecystokinin depress hunger
- Increased body temperature may inhibit eating behavior
- Psychological factors that have little to do with caloric balance can also influence eating behaviors

Metabolic Rate

- Rate of energy output (expressed per hour) equal to the total heat produced by:
  - All the chemical reactions in the body
  - The mechanical work of the body
- Measured directly with a calorimeter or indirectly with a respirometer
- Basal metabolic rate (BMR)
  - Reflects the energy the body needs to perform its most essential activities
- Total metabolic rate (TMR)
  - Total rate of kilocalorie consumption to fuel all ongoing activities
- Factors that Influence BMR
  - Surface area, age, gender, stress, and hormones
  - As the ratio of surface area to volume increases, BMR increases
  - Males have a disproportionately high BMR
  - Stress increases BMR

Regulation of Body Temperature

- Body temperature – balance between heat production and heat loss
- At rest, the liver, heart, brain, and endocrine organs account for most heat production
- During vigorous exercise, heat production from skeletal muscles can increase 30–40 times
- Normal body temperature is 36.2°C (98.2°F); optimal enzyme activity occurs at this temperature
- Temperature spikes above this range denature proteins and depress neurons
Core and Shell Temperature
- Organs in the core (within the skull, thoracic, and abdominal cavities) have the highest temperature
- The shell, essentially the skin, has the lowest temperature
- Blood serves as the major agent of heat transfer between the core and shell
- Core temperature remains relatively constant, while shell temperature fluctuates substantially (20°C–40°C)

Mechanisms of Heat Exchange
- The body uses four mechanisms of heat exchange
  - Radiation – loss of heat in the form of infrared rays
  - Conduction – transfer of heat by direct contact
  - Convection – transfer of heat to the surrounding air
  - Evaporation – heat loss due to the evaporation of water from the lungs, mouth mucosa, and skin (insensible heat loss)
- Evaporative heat loss becomes sensible when body temperature rises and sweating produces increased water for vaporization
Role of the Hypothalamus
- The main thermoregulation center is the hypothalamus
- The heat-loss and heat-promoting centers comprise the thermoregulatory centers
- The hypothalamus:
  - Receives input from thermoreceptors in the skin and core
  - Responds by initiating appropriate heat-loss and heat-promoting activities

Heat-Promoting Mechanisms
- Low external temperature or low temperature of circulating blood activates heat-promoting centers of the hypothalamus to cause:
  - Vasoconstriction of cutaneous blood vessels
  - Increased metabolic rate
  - Shivering

Heat-Loss Mechanisms
- When the core temperature rises, the heat-loss center is activated to cause:
  - Vasodilation of cutaneous blood vessels
  - Enhanced sweating
- Voluntary measures commonly taken to reduce body heat include:
  - Reducing activity and seeking a cooler environment
  - Wearing light-colored and loose-fitting clothing

Hyperthermia
- Normal heat loss processes become ineffective and elevated body temperatures depress the hypothalamus
- This sets up a positive-feedback mechanism, sharply increasing body temperature and metabolic rate
- This condition, called heat stroke, can be fatal if not corrected

Heat Exhaustion
- Heat-associated collapse after vigorous exercise, evidenced by elevated body temperature, mental confusion, and fainting
- Due to dehydration and low blood pressure
- Heat-loss mechanisms are fully functional
- Can progress to heat stroke if the body is not cooled and rehydrated

Fever
- Controlled hyperthermia, often a result of infection, cancer, allergic reactions, or central nervous system injuries
- White blood cells, injured tissue cells, and macrophages release pyrogens that act on the hypothalamus, causing the release of prostaglandins
- Prostaglandins reset the hypothalamic thermostat
- The higher set point is maintained until the natural body defenses reverse the disease process
Developmental Aspects

- Good nutrition is essential \textit{in utero} as well as throughout life
- Lack of proteins needed for fetal growth and in the first three years of life can lead to mental deficits and learning disorders
- With the exception of insulin-dependent diabetes mellitus, children free of genetic disorders rarely exhibit metabolic problems
- In later years, non-insulin-dependent diabetes mellitus becomes a major problem