Chapter 34: Nutrition and Digestion

Nutrition: Process of acquiring / processing nutrients into usable form

Function of Nutrients:
1) Fuel cellular metabolism
   - Measured in calories (energy required to raise 1 g of water 1°C)
     - Calorie = 1000 calories (kilo calorie)
     - Human at rest = 1550 calories burned/day
2) Building blocks to construct complex molecules
3) Molecules to assist in metabolic reactions

Nutrient Classifications:

1) Carbohydrates:
   - Energy source (~ 46% for humans)
     - Body cells burn glucose (some exclusively)
   - Energy storage (short-term): Glycogen (liver / muscles)
   - Obtained via animal products (e.g. muscle) and plants (starch)

2) Lipids:
   - Energy source (~ 38% for humans)
   - Energy storage (long-term): Fats
     - 1 pound = 3600 Calories (Carbs = 1600 Calories / pound)
     - Hydrophobic; no excess water storage
   - Provide building materials (e.g. phospholipids, cholesterol)

3) Proteins:
   - Energy source (~ 16% for humans)
     - Urea: Byproduct of protein breakdown
   - Provide building materials (amino acids)
     - Essential amino acids: Can not be synthesized by body (9 / 20 amino acids)

4) Minerals (Elements / Inorganic molecules - Table 34.3):
   - Structural material (e.g. calcium, iron, iodine)
   - Assist in physiological functions (e.g. sodium, potassium, calcium)
     - Sodium, potassium, calcium, magnesium, etc are also called electrolytes

5) Vitamins (Organic compounds - diverse group):
   - Water-soluble: Cleared from body (urine)
     - Vitamin C = Maintenance of connective tissues
     - B-vitamin complex = Coenzymes
   - Water-insoluble: Stored in body (fat)
     - Vitamin A = Produces visual pigments
     - Vitamin D = Promotes bone growth
     - Vitamin E = antioxidant
     - Vitamin K = Regulates blood clotting

Electrolytes

- Required to maintain certain functions
  - Muscles, neurons, etc.
- Imbalance causes death
- Excess water drinking leads to fatal electrolyte imbalance
- Sport drinks contain electrolytes to prevent water intoxication
Vitamin deficiencies
• Vitamin A: blindness
  We consume beta carotene, which is converted to Vitamin A in our bodies.
  Beta Carotene is found in red/orange vegetables.

Vitamin deficiencies
• Vitamin B complex
  Several different vitamin B
  Thiamin (Vitamin B1)
  Niacin (Vitamin B2)
  Pantothenic acid (Vitamin B6)
  Vitamin B12
  Biotin
  Choline
  Deficiencies lead to diseases beriberi, pellagra, anemia, & mental disorders.
  Sources: grains, legumes, animal products

Vitamin deficiencies
• Vitamin C
  Ascorbic acid
  Deficiencies lead to Scurvy
    Especially affected sailors
    Professional sailors always carried limes or other citrus fruits to ward off scurvy

Vitamin deficiencies
• Vitamin D: Rickets
  Caused by lack of calcium absorption in bones.
  Sources: sunlight, eggs, cod liver oil, dairy products

Vitamin deficiencies
• Vitamin E
  Anemia, neurological problems
  Deficiencies are very rare
    Mainly due to genetic disorders the prevent the absorption of fat.
  Seeds, green leafy vegetables, oils

Vitamin deficiencies
• Vitamin K
  Bleeding, hemorrhages
  Deficiencies rare due to production of vitamin K with the help of intestinal bacteria (E. coli).
  Excessive use of broad spectrum antibiotics can result in deficiencies.
Fat soluble vitamins can lead to overdoses

- Fat soluble vitamins are stored in the fatty tissues in the body
  - The reason why deficiencies are rare with modern diets.
  - Overdoses are becoming more common due to supplements, retinol, etc.
- Vitamin A: 15,000 IU per day or more can be toxic
  - Especially toxic to developing fetuses = birth defects
  - Liver damage

- More than 15,000 IU of Vitamin D per day can lead to overdoses
  - Most deaths are due to children eating sugar coated vitamins.

- More than 1,500 IU of Vitamin E per day can lead to overdoses
  - Excess leads to anticoagulation in blood.

Nutrient acquisition

- Herbivore
  - Eat plants
- Carnivore
  - Eat animals
- Omnivore
  - Eat plants & animals

Digestion: Mechanical and chemical breakdown of food
- Required to absorb nutrients (complex → simple)

Tasks of Digestive System:
1) Ingestion = Food enters system (mouth)
2) Mechanical Breakdown = Food physically broken down
3) Chemical Breakdown = Food broken down via enzymes
  - Increased surface area (enzyme attack)
4) Absorption = Nutrients from digestive cavity into body
5) Elimination = Indigestible material cleared

Animal Digestive Systems:
1) Intracellular Digestion (e.g., protists, sponges)
   - Cells engulf microscopic particles (no specialized system)
     1) Enclosed in food vacuole
     2) Lysosomes (organelle w/ enzymes) breakdown food
     3) Waste expelled (exocytosis)
Animal Digestive Systems:

2) Sac Digestion (e.g., jellyfish)
   - Chamber present (gastrovascular cavity); single opening
     - Extracellular Digestion (enzymes released into chamber)
   - Food enters / waste exits same opening

Animal Digestive Systems:

3) Tube Digestion (e.g., worms, arthropods, vertebrates)
   - Tube present; two openings (mouth, anus)
   - Efficient digestion of food (one-way system):
     - Crop / Stomach #1 = Food storage
     - Stomach #2 / Gizzard = Mechanical digestion
     - Intestines = Chemical digestion / Absorption

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**gizzard**

- Many toothless animals (i.e., birds) will swallow stones to aid digestion.
  - Stones help grind food inside the gizzard

**Crop**

- Pigeons, doves and flamingoes produce crop milk
  - A secretion produced by the crop that is used to feed the young.

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**Highly Specialized Tube Digestion:**

Ruminants Digest Cellulose...

- Mixes food with cellulase
  - Cellulase produced by bacteria in the rumen

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Human Digestive System:
Process of Human Digestion:

1) Breakdown of Food begins in Mouth
   - Mechanical breakdown = Teeth
     - Incisors: Snip food
     - Canines: Tear food
     - Premolars/Molars: Grind food
   - Chemical Digestion = Salivary Glands
     - Amylase: Enzyme → Carbohydrates

2) Esophagus conveys food to stomach
   - Peristalsis: Rhythmic contraction of smooth muscle; propels food
   - Bolus: Compacted food

3) Stomach:
   - Stores food (2 - 4 liters = 0.5 - 1 gallon)
   - Mechanically breaks down food (smooth muscle → churns)
   - Chemically breaks down food
     - Acidic environment (pH 1 - 3 → HCl secretion)
     - Pepsin: Enzyme → Proteins
       - Bleeding Ulcers
   - Chyme = Thick, acidic liquid
   - Water, Alcohol, Drugs (e.g. aspirin) absorbed through stomach wall

4) Small Intestine = Chemical digestion & absorption:
   - Longest portion of digestive system (~ 3.5 m)
   - Chemical Digestion:
     - Pancreas (pancreatic juice)
       - Bicarbonate ion = neutralizes chyme
     - Amylase = Enzyme → carbohydrates
     - Lipase = Enzyme → lipids
     - Proteases = Enzymes → proteins
     - Liver (bile)
       - Bile stored / concentrated in gallbladder
         - Bile salts = Assist in breakdown of fats
         - Emulsify fats (separate into small droplets)
   - Absorption:
     - Large surface area (2200 square feet)
     - Villi: Finger-like projections tube surface
     - Microvilli: Projections of cell membrane
     - Blood / lymph vessels (lacteals) run up villi (nutrient absorption)
     - Requires energy (ATP)
   - Movements:
     - Segmentation (mixing)
     - Peristalsis (propulsion)
Process of Human Digestion:
5) Large Intestine = absorption & elimination:
   • ~ 1.5 m long (colon & rectum):
     - Contain bacteria:
       - Produce Vitamin B complexes and Vitamin K
     - Absorbs water, vitamins, salts
     - Movement via peristalsis & defecation
       - Feces = Indigestible waste (semi-solid)

Control of Digestion:
1) Nervous System:
   • Food stimuli activates digestive system (e.g. smell, taste, stretch)
     - Secretes saliva (mouth), HCl (stomach)

2) Endocrine System:
   • Gastrin: Stimulates HCl secretion (stomach)
   • Secretin: Stimulates bicarbonate release (pancreas)
   • Cholecystokinin: Stimulates bile release (gallbladder)