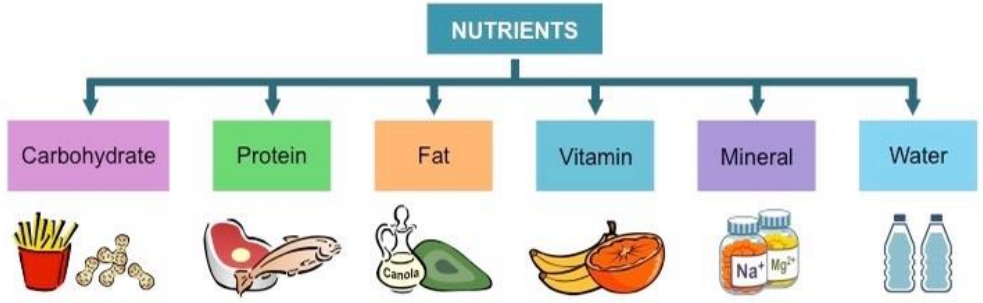
9.1
Why we Need to Eat

P. 394 - 399

Food for Growth & Maintenance

Nutrients are the chemicals that an organism needs in order to grow, to build and repair tissues, and to produce energy.



The nutrients that are important for keeping our bodies healthy are carbohydrates, proteins, lipids (fats), water, minerals, and vitamins.

Energy Transfer and Use

- The **chemical energy** produced by plants (in the form of carbohydrates) is **transferred** to herbivores and omnivores.
- Cells use the energy to fuel biological processes and physical activities such as growth and movement.
- In **endothermic** (warm-blooded) animals, some of this chemical energy is used to **maintain** a fairly constant **body temperature**.
  - Because the body temperature of endotherms is normally higher than the surrounding, some **thermal energy is lost** to the environment.

Factors that Affect Energy Requirements

Exothermic

This frog can survive for weeks on one good meal.

Endothermic

This shrew must consume a large amount of food every day.

- **Endotherms** require **more energy** to regulate their body temperature.

Factors that Affect Energy Requirements

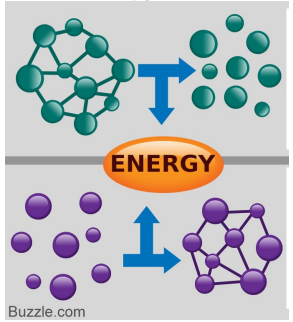
Body Size:

- **Larger animals** generally eat more than **smaller** ones. However, **small** endothermic animals need to **eat more for their size** than large endothermic animals.
  - For example, a 5000 kg elephant might eat 250 kg of food a day - 5 % of its body mass. A 5 g shrew might have to eat 4 g of food a day - 80 % of its body mass!

Factors that Affect Energy Requirements

Metabolic Rate

- **Metabolic rate:** the rate at which the body converts stored energy into working energy
- **Metabolism:** the set of chemical reactions that occur in living organisms necessary to maintain life



Catabolism -
the metabolic reactions that break down larger molecules into smaller subunits (e.g.breakdown of nutrients during digestion)

Anabolism -
the metabolic reactions that use energy to produce larger molecules from smaller subunits (e.g.growth and repair)

Factors Affecting Metabolic Rate

Trends (not rules)...

- **Body size** → a larger body requires more energy
- **Physical activity** →muscles burn more energy than fat
- **Sex** →males require more energy
  (due to larger size and greater muscle mass)
- **Age**→decreases with age
  (since they tend to be larger and have more muscle mass)
- **Hereditary factors**→due to genetics

Measuring Energy & BMR

- Energy is measured using an SI unit: the **joule (J)**.
  - Joules are small, so we use the **kilojoule (kJ)** to refer to the energy requirements of people or the energy stored in foods (1 kJ = 1000 J).
- Another unit is also used - a **calorie (small c)** is the amount of energy required to raise the temperature of 1 g of water by 1 °C.
  - When referring to **food energy, Calorie** (big C) is used.
  - **One Calorie** equals **1000 calories**, or **4180 J**. **or 4.18kJ**

Basal Metabolic Rate

The **rate** at which energy is used by an organism when it is **at rest**.
The **minimum** amount of energy required to keep you alive.

Calculating BMR

Actual BMR Calculation:

- based on the consumption of **oxygen**
- a complex process and **not practical** for everyday use

Estimated BMR:

- BMR is generally **estimated**
- calculation takes into account **four variables**: height, weight, age, and sex
- **males** tend to have a **higher** BMR than females by about 10 %.
- energy requirements also depend on your **activity** level.
- *Note: estimated BMR does not take into account the ratio of muscle to fat*

How much energy do you need?

Try it yourself!

Mini Investigation

How Much Energy Do You Need?

Skills: Observing, Analyzing

SKILLS HANDBOOK A2.1, A6.2

In 1918, J. Arthur Harris and Francis G. Benedict, nutrition researchers at the Nutrition Laboratory of the Carnegie Institute of Washington, published a paper based on their study of basal metabolism. The data from their research allowed them to derive a formula that is still the most commonly used method of estimating basal metabolic rate and energy expenditure.

Your BMR is unique to you. It depends on your sex, size (height and mass), and age. The Harris–Benedict formulas for estimating your BMR are as follows:

female

$$\text{BMR} = [655 + (9.6 \times \text{mass in kilograms}) + (1.8 \times \text{height in centimetres}) - (4.7 \times \text{age in years})] \times 4.18$$

male

$$\text{BMR} = [66 + (13.7 \times \text{mass in kilograms}) + (5.0 \times \text{height in centimetres}) - (6.8 \times \text{age in years})] \times 4.18$$

Example:

Tom is a 16-year-old student who is 175 cm tall with a mass of 75 kg. Estimate his BMR.

Solution:

Use the formula for males and substitute the values as follows:

$$\text{BMR} = [66 + (13.7 \times 75) + (5.0 \times 175) - (6.8 \times 16)] \times 4.18$$

$$\text{BMR} = 7773.5 \text{ rounded to } 7800 \text{ kJ}$$

The Harris–Benedict formula uses the following activity factors in conjunction with the BMR to estimate the average individual daily energy requirement.

- little or no exercise — BMR × 1.2
- light exercise or sports 1–3 days/week — BMR × 1.375
- moderate exercise or sports 3–5 days/week — BMR × 1.55
- vigorous exercise or sports 6–7 days/week — BMR × 1.725
- very hard exercise daily or sports & physical job or 2 × training daily — BMR × 1.9

For example, Tom is a fairly active student who plays sports most weekdays. Therefore his average daily energy requirement will be 7800 kJ × 1.55 = 12 090 kJ rounded to 12 000 kJ.

1. Use the appropriate formula to estimate your BMR.

A. Analyze your lifestyle in terms of your level of activity. Multiply your BMR by the appropriate activity factor to estimate your daily energy requirement. T/I A

Average Energy Requirements for Various Activities

Type of activity	Energy required (kJ/kg/h)	Type of activity	Energy required (kJ/kg/h)
sleeping	4.1	walking (6.4 km/h)	20.6
sitting	5.2	badminton	21.5
writing	6.0	mowing lawn	23.0
standing	6.3	cycling (15.3 km/h)	25.8
singing	7.1	hiking, fast dancing	27.0
using a computer keyboard, playing cards	9.0	tennis, downhill skiing	36.2
washing the car, cooking	10.5	climbing stairs, running (8.8 km/h)	37.5
playing the piano	11.2	cycling (20.9 km/h)	40.5
walking (3.2 km/h)	11.6	cross-country skiing	42.0
cycling (13 km/h)	15.8	running (12.9 km/h)	62.0
walking (4.8 km/h)	16.2	competitive cross-country skiing	73.6

Summary

9.1 Summary

- All animals must eat to obtain materials for growth and repair and to obtain energy for all life processes.
- All of the chemical reactions that occur in an organism are referred to as the organism's metabolism. These reactions include the breakdown of materials to provide energy and the construction of materials for growth and repair.
- The basal metabolic rate (BMR) is the minimum amount of energy required to keep an organism alive. It can be estimated using a formula that takes into account the individual's sex, age, height, and mass.
- Your daily energy requirement depends on your BMR and level of physical activity.

Homework

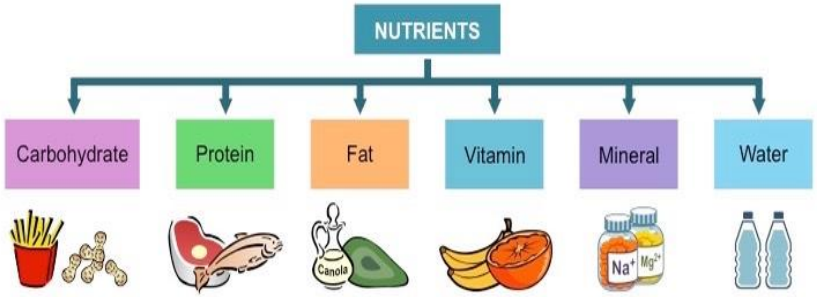
p. 399 # 1, 2, 4 & 5

9.2
What and How Much do we Need to Eat?

P. 400 - 405

Required Nutrients

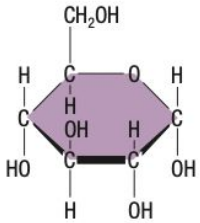
- Your body needs **six essential nutrients** in order to stay healthy:



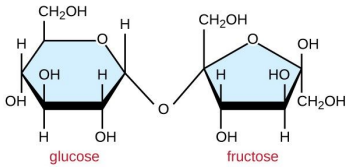
- These are the building blocks of life.
  - if any are absent from your diet for too long, your cells will stop working properly.

Carbohydrates

- Main source of energy for the body
- Composed of C, H, O atoms
- Three main types:
  - **Monosaccharides:**
    one sugar (e.g. glucose and fructose)
  - **Disaccharides:**
    two sugars joined (e.g. sucrose)
  - **Polysaccharides:**
    many sugars joined (e.g. cellulose)



glucose



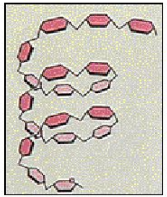
sucrose

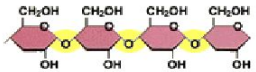
Polysaccharides

Starch (amylose):

- made by plants for energy storage
- made of branched glucose molecules

amylose
(a starch)

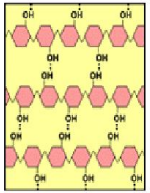


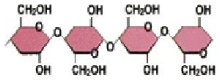


Cellulose

- made and stored in plants, found in cell walls
- structural molecules, straight rigid shape
- we cannot digest cellulose, but it provides bulk (fiber) in our diet

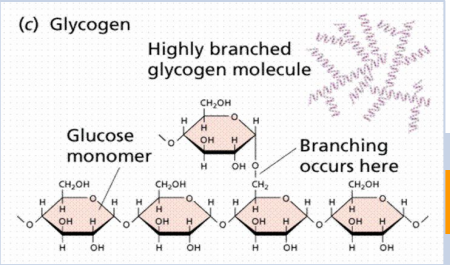
cellulose





Glycogen

- made in animal cells (stored in the liver and muscles) for energy
- in glycogen, glucose subunits are more highly branched compared to starch molecules
- when energy is needed in the body, glycogen is broken down into usable glucose



Carbs in our Diet

Proteins

- key **building blocks** of cells
- important **structural** molecules
- involved in all **metabolic activities**, and are used to generate **motion**.
- some proteins serve as **hormones** – chemical messengers released by cells in the body that influence cellular activity in another part of the body.

Main protein **functions** →

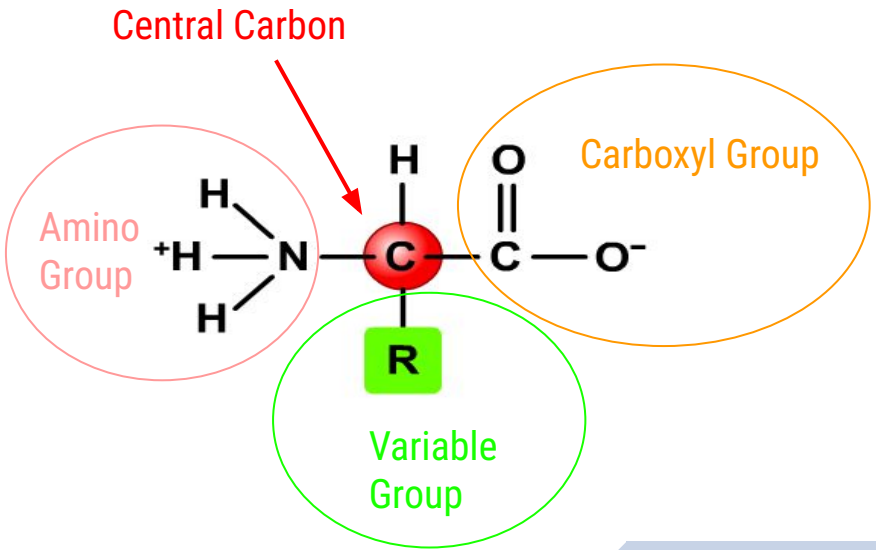
Function	Example
control of chemical reactions	digestive chemicals
movement	myosin in muscle cells
transporting oxygen	hemoglobin in red blood cells
structure	collagen in muscles and connective tissue; keratin in hair and nails
hormones (chemical messengers)	human growth hormone
defence	antibodies produced by the immune system
source of energy	excess proteins from diet

Protein Structure

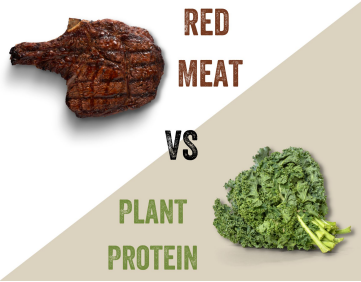
Proteins are the **most complex** of all nutrients and are made up of long chains of smaller molecules called **amino acids** and are highly **variable** in size and shape.

- There are **20 different amino acids** that organisms use to build proteins.

Structure of Amino Acid:



Protein Sources - Animal vs Plant



- **Animal proteins** contain **all eight** essential amino acids
- Most **plant proteins lack at least one** essential amino acid.
  - People who do not eat animal products must eat plant foods in combination to obtain all the amino acids they need.
- Animal muscle has a **higher concentration** of protein than plant material
  - You have to eat a greater mass of plant material to obtain an equivalent amount of protein

Protein Sources in our Diet

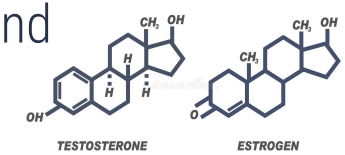
Animal sources high in protein: meat, eggs, fish and cheese

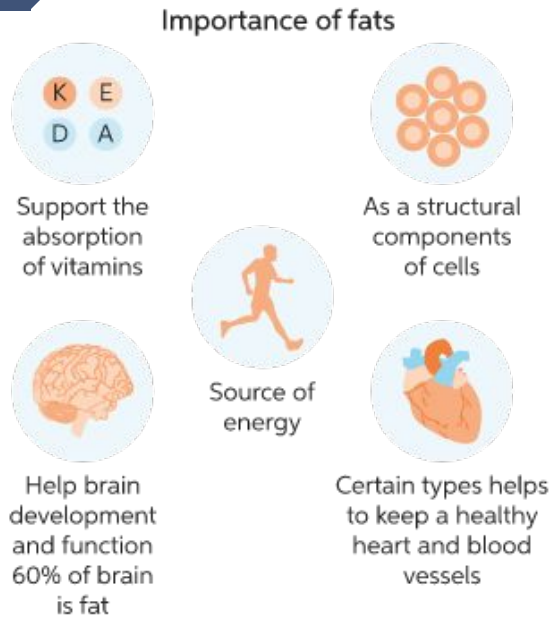
Plant sources high in protein: beans, lentils, seeds and nuts

Your body **separates the proteins** you consume into **individual amino acids** so they can be **rearranged** and used as building blocks for **human proteins**

Lipids

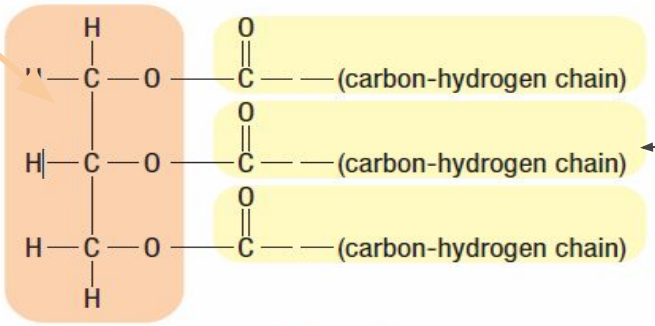
- Provide a concentrated source of energy for the body
- They help **absorb** fat soluble **vitamins**, are a main component of **cell membranes**, and serve as **insulation** for the body
- Certain hormones, including sex hormones (e.g. estrogen and testosterone), are lipids



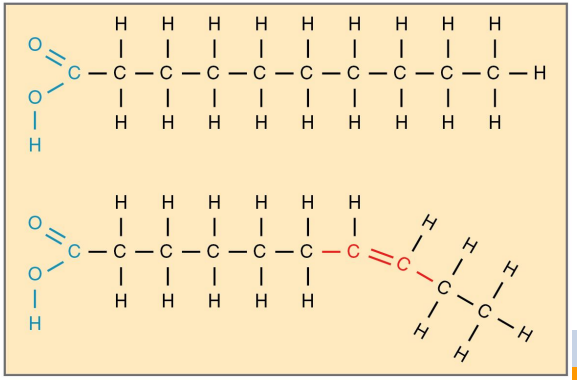


Lipid Structure

- Fats and oils are made up of triglycerides
  - Each **triglyceride** is made up of three fatty acids bonded to a glycerol molecule
  - Triglycerides can be either saturated or unsaturated, depending on the structure of their fatty acid chains.



triglyceride



Only single bonds (tightly packed)

Contains double bond(s)(bent)

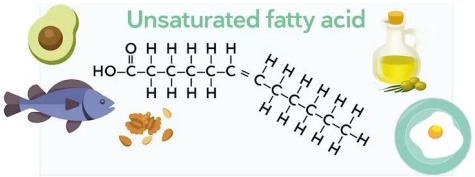
Saturated vs. Unsaturated Lipids

Saturated Fats

- Fatty acids contain **single** bonds only (dense structure)
- Usually **solid** at room temperature
  - E.g. butter
- Considered to be **less healthy**

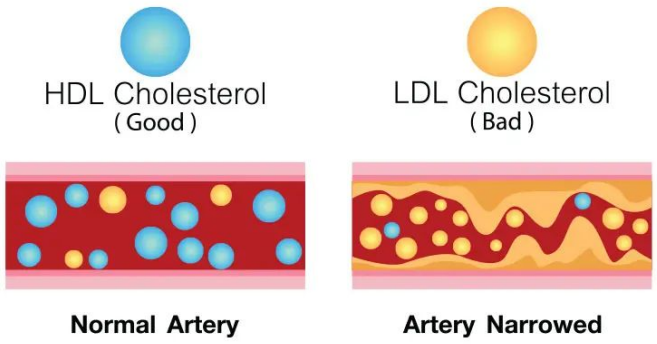
Unsaturated Fats

- Fatty acids contain **double** bond(s) (bent/loose structure)
- Usually **liquid** at room temperature
  - E.g. Vegetable oil
- Considered to be **more healthy**



Steroids

- A **special group** of **lipids** called steroids include:
  - **Sex hormones:** (e.g. testosterone and estrogen) control the development of male and female sex characteristics
  - **Cholesterol** is a key component of all animal cell membranes, cholesterol has “good” and “bad” forms

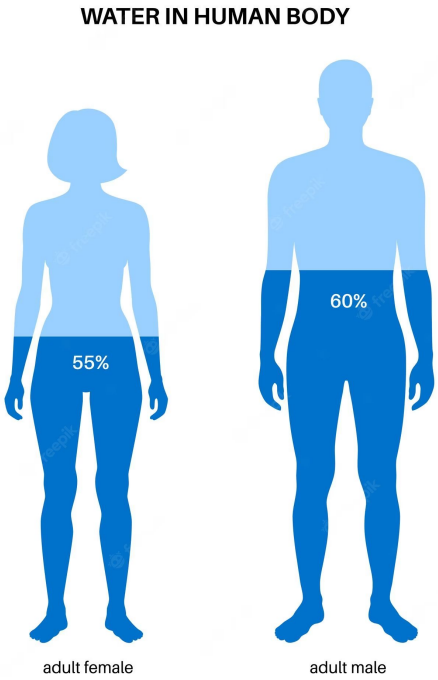


Low-density lipoprotein *(LDL) can build up inside arteries, increasing risk of heart disease and stroke.* ***High-density lipoprotein*** *(HDL) absorbs cholesterol from blood to be eliminated*

Water

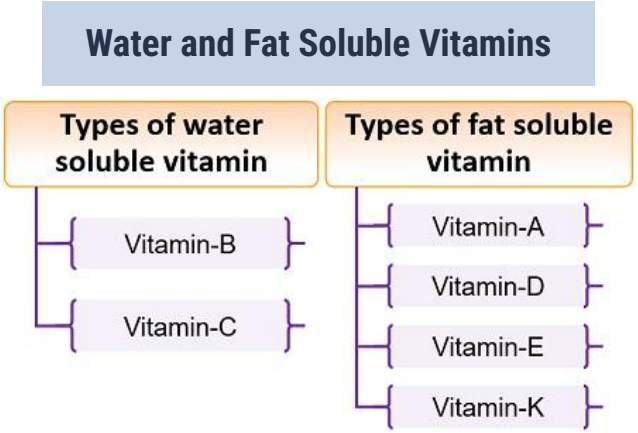
- We need about **2L** of water per day
- Our bodies are **55 – 60 %** water

- Water is needed by our bodies:
  - for chemical **reactions**
  - to **digest** food
  - to **eliminate waste** products
  - to **maintain** your **blood volume**
  - to **regulate body temperature**
  - to keep skin **moist**



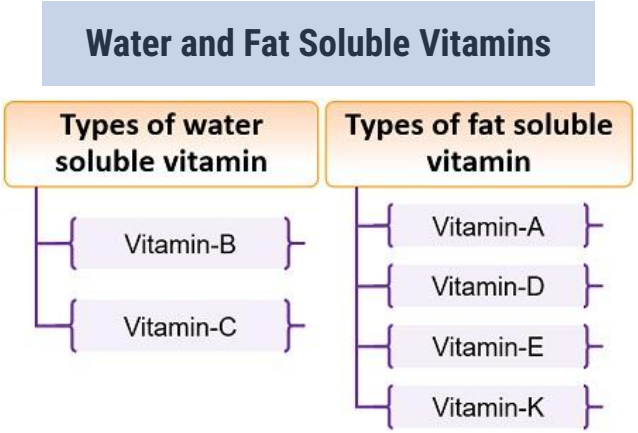
Vitamins

- Organic molecules that the body requires in **small amounts** as essential nutrients
- **Function:** regulate cell functions, growth, and development
- Are either **fat** soluble (will dissolve in fats) or **water** soluble (will dissolve in water)



Vitamins: Storing and Eliminating

- **Fat soluble** vitamins **can be stored** in the body's fatty tissues for future use and are therefore not easy to eliminate from the body if they are in excess (danger of toxicity)
- **Water soluble** vitamins **cannot be stored** in the body, and excess quantities are readily excreted in urine.



Vitamin Sources

- We obtain most of our vitamins from food, but vitamins A, D, and K can also be produced in our bodies.

Vitamin A

The body can convert a chemical called beta-carotene (found in green veggies, carrots, egg yolks, liver) into vitamin A.

Vitamin D

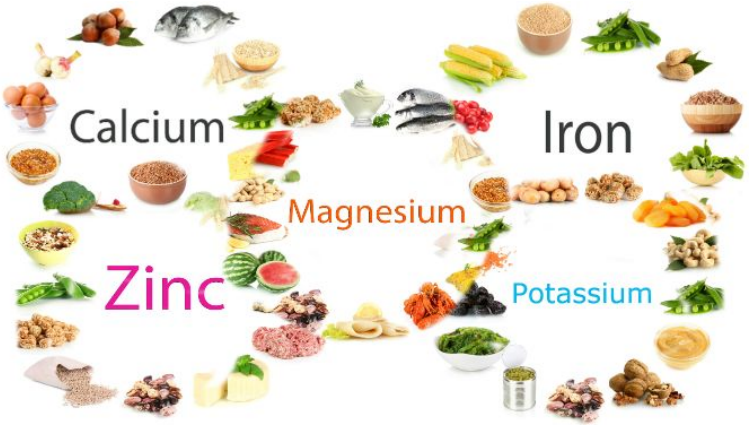
Formed in the skin when the skin is exposed to sunlight. Our bodies can produce enough vitamin D from 10 min to 15 min of sunshine three times a week.

Vitamin K

Synthesized by special bacteria found in the large intestine.

Minerals

- Minerals are elements (e.g. calcium, sodium, oxygen, iron, phosphorus) required by the body in **small amounts**
- Function: play role in **cell processes** and **repair**



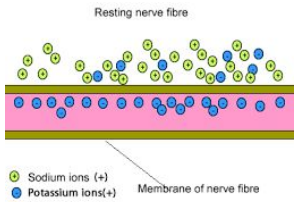
Minerals - some functions

Calcium and phosphorus

- The most abundant minerals
- Critical in formation and maintenance of bones

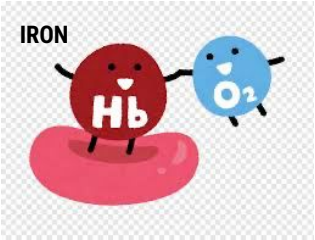
Sodium and potassium

- Involved in nerve impulse transmission and muscle contraction



Iron

- Key component of the blood protein hemoglobin that binds oxygen for transport



Trace minerals include

- Fluorine, zinc, and copper

Body Mass Index

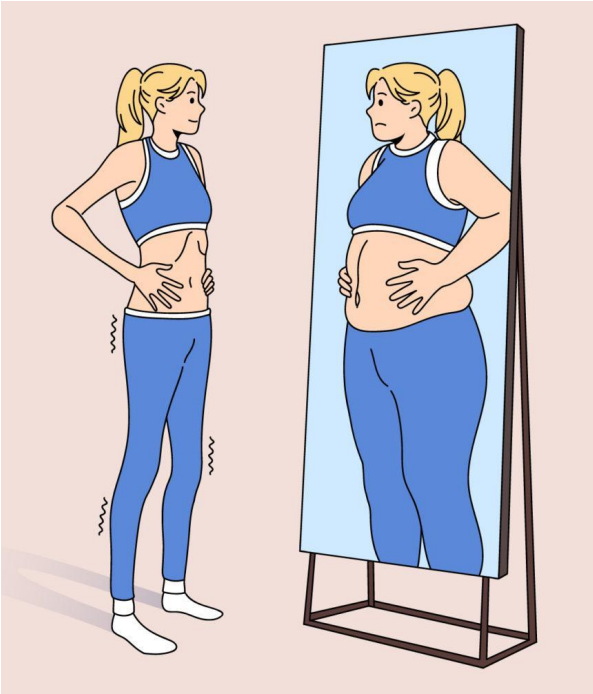
- Ratio of a person's height and weight
- General indicator of whether a person has a healthy body weight for their height
- **BMI = weight(kg) ÷ height(m)²**

Balanced Eating

- There are **three variables** in maintaining a healthy dietary lifestyle: level of physical activity, amount of food consumed, and type of food consumed.
- The key to maintaining a healthy weight is to ensure that the **energy intake is balanced by the energy output.**
- In a large majority of cases, **obesity** is the result of overeating, an unhealthy diet, and inactivity but genetics, emotional factors and medicines, etc. often play a role.
- Eating disorders such as anorexia and bulimia are **psychological disorders** that can lead to serious physical health risks.

Eating Disorders

- In a recent study, 27% of Ontario girls 12-18 years old were reported to be engaged in severely problematic food and weight behaviour.
- Eating disorders are now the third most common chronic illness in adolescent girls.



Summary

9.2 Summary

- The nutrients that we obtain from our food are carbohydrates, proteins, and lipids. Generally, carbohydrates and lipids are energy nutrients. Amino acids from food are used to construct a variety of proteins that have numerous functions in the body.
- Vitamins and minerals are important to maintaining good health, and water is an essential substance for survival.
- The key to maintaining a healthy weight is to ensure that the energy intake is balanced by the energy output. This can be achieved by a combination of a healthy diet and an appropriate level of physical activity.
- In a large majority of cases, obesity is the result of overeating, an unhealthy diet, and inactivity.
- Eating disorders such as anorexia and bulimia are psychological disorders that can lead to serious physical health risks.

Homework

p. 405 # 1, 3(b) & 4