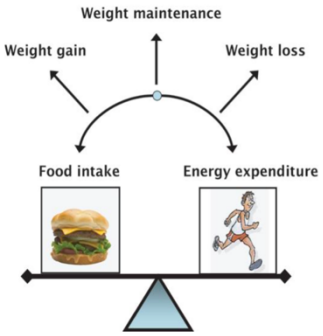
Energy Balance

Learning Objectives:

- Describe energy balance and the components of daily energy expenditure
- Identify some of the factors that affect our individual energy expenditure
- State the nutrients that yield energy and how much energy they yield per gram
- Calculate the macronutrient content of a food as percentage total energy
- Explain the concept of energy density and its effect on food intake
- Calculate energy density in certain foods
- Differentiate high and low energy density diets

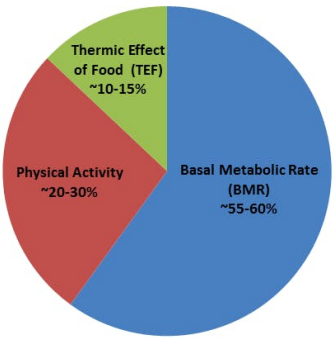
Energy balance is the relationship between "energy in" (food calories taken into the body through food and drink) and "energy out" (calories being used in the body for our daily energy requirements). This relationship determines whether weight is lost, gained or remains the same.



- Energy expenditure = weight stable/maintenance
- Positive energy balance = weight gain
- Negative energy balance = weight loss

Energy Expenditure

Energy expenditure is the amount of energy/calories that a person needs to carry out physical activities. The total daily energy expenditure is the total number of calories that is burned each day. Daily energy expenditure is broken up into three distinct parts:



- Physical activities (30-50%)

  Energy expenditure is variable, depending on the duration, frequency and intensity of the physical activity. This may be slightly lower for older people who are not able to move very much

- Thermic effect of food (10%)

  Thermic effect of food (TEF), or dietary induced thermogenesis, is the amount of energy expenditure to process and metabolise (digestion and absorption) the food consumed. The primary determinants of daily TEF are the quantity and composition of the food ingested. For example: raw celery and grapefruit have a negative calorie balance as the thermic effect is greater than the calorie balance due to the high fibre content which must be unravelled to access the carbohydrates. Insulin sensitivity is another factor that can influence TEF, where there is a significant effect in more insulin resistant individual. In contrast, there is negligible to zero effect in individuals with high insulin resistance.

  It is usually about 10% of energy intake, but varies substantially for different food components.

	Processing	**Thermic effect**
Dietary fat	Very easy	Very little
Protein	Hard	Much larger

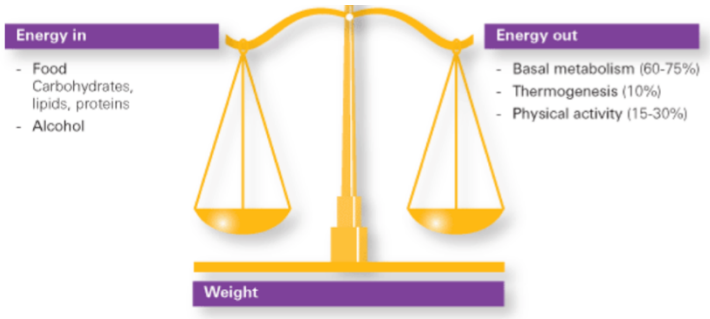
- Basal metabolism (50-65%)

  Basal metabolism is the basic processes of life to maintain the normal function in the body → basal metabolic rate (BMR)

	Average expenditure for reference body weight	
	Adult male (76kg)	**Adult female (61kg)**
19-30 years	10.8 MJ for sedentary activity 13.8 MJ for moderate activity	8.1 MJ for sedentary activity 10.5 MJ for moderate activity
31-50 years	11-16.1 MJ	7.9-9.6 MJ
51-70 years	9.5-12.1 MJ	7.6-9.6 MJ
70 and older	7.4-13.6 MJ	7.1-9.1 MJ

Factors Affecting Energy Requirements

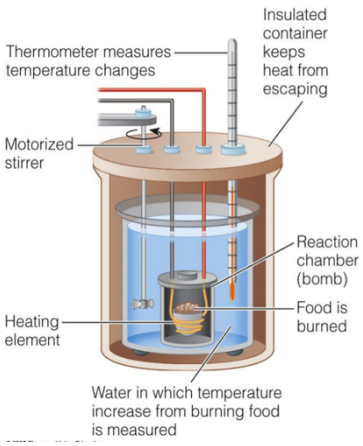
- Age
- Sleep
- Smoking and Caffeine
- Height
- Fever
- Stress
- Growth
- Malnutrition
- Hormones (gender)
- Body Composition
- Fasting/Starvation
- Environmental temperature



Bomb Calorimeter

A bomb calorimeter is a type of constant-volume calorimeter used to measure the heat of combustion of a particular reaction. It can also be used to measure energy in food, by burning the food with oxygen to mimic oxidation in the body. The amount of heat released in the reaction is calculated by the temperature rise and represents the amount of energy in that food sample.

$$Q = m \times C \times \Delta T$$



Units of Energy

There are two different kinds of units of energy which allow us to talk about how much energy a food contains and how much energy can be burned during exercise.

- A calorie (cal): the amount of energy, as heat, required to raise the temperature of 1g water by 1°C
- A joule (J): the amount of energy expended (work done) when 1kg is moved by 1 meter by a force of 1 newton

Other units of energy include:

- A kilocalorie (kcal) or Calorie (C) = one thousand calories
- A kcal = 4.184 kJ
- A megajoule (MJ) = one thousand kilojoules

Energy Distribution

The amount of energy is dependent on the proportion of carbohydrates, proteins and fats available in the food as different macronutrients provide different amounts of energy. Fats and alcohols are energy dense (most energy per gram) and therefore, should be moderately consumed.

Protein	1 gram	17 kJ	4 kcal
Carbohydrates	1 gram	17 kJ	4 kcal
Fat	1 gram	37 kJ	9 kcal
Alcohol	1 gram	29 kJ	7 kcal
Dietary fibre	1 gram	13 kJ	
Water		0 kJ	0 kcal

To calculate the percentage energy provided by each component, the formula:

$$\%\ energy\ from\ that\ nutrient = \frac{kJ\ of\ nutrient\ in\ the\ food}{total\ kJ\ in\ the\ food} \times 100$$

The acceptable proportion of macronutrients recommended for a healthy diet:

Protein	15-25%
Carbohydrate	45-65%
Fat	20-35%
Alcohol	20g/day

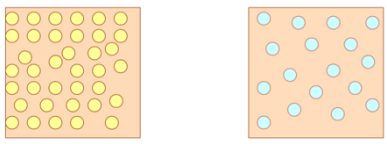
Energy Density

Energy density (kJ/g) is the amount of energy stored in a given system or region of space per unit volume. The higher the energy density of a system or material, the greater the amount of energy stored in its mass. Therefore, it influences total energy intake.

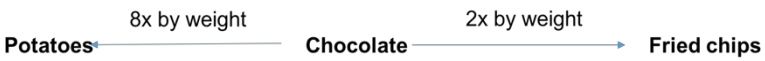
People tend to eat a constant weight of food, in terms of grams, and not influenced by energy density, therefore, not influenced by the proportion of carbohydrates, proteins and fats in the food.

$$Energy\ Density = \frac{Total\ food\ energy}{Total\ food\ weight\ eaten\ per\ day}$$

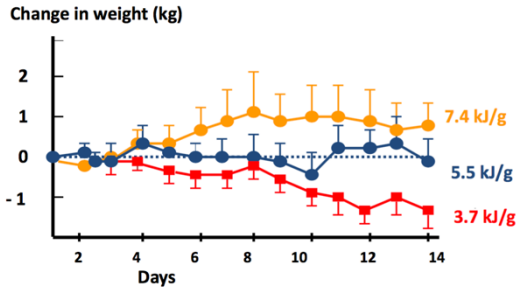
As seen in the diagram below, comparing 1 gram of fat and 1 gram of protein, fat consists of more kilojoules and thus, is more energy dense compared to protein.



If comparing the same energy density, the weight of different components differs drastically.



Energy density is considered quire important as 6-8-year-old kids with the most energy dense diet end up being the heavy weighted kids during their adolescent years. In contrast, those with a low energy dense diet end up losing weight instead.



Fats in food increases energy density, thus there is more energy in food with less weight. Low fat food, however, can also have high energy density if they are high in starch or sugar instead. An example of this is a McDonald's Muffin Lite which is 97% fat-free. Each muffin is 165 grams, consisting of 3.3 grams of fat. The total energy is 1650 kJ, but energy density if 10 kJ/g. In contrast, fibre and water content in food decreases energy density.

To get a low energy density diet, dilute high energy dense foods with low energy dense foods.

- Oil and meat: dilute with vegetables
- Cereals: dilute with skim milk

Food Energy Density		
High	>12 kJ/g or 3 kcal/g	Eat rarely – if at all
Medium	7.5-12 kJ/g or 1.8-3 kcal/g	Eat sparingly
Low	<7.5 kJ/g or 1.8 kcal/g	Eat at will