Energy, Work and Power of the Body

First

Energy

Energy

Sun is main source of energy on the earth

The Sun is the ultimate source of energy for life on earth

(Earth's core is the source of energy for the movement of tectonic plates)

The sun is 1 million times bigger than the earth, but the earth only gets 1 billionth of it energy

The sun is 93 million miles away (about 8 light minutes)

Of all of the radiation that reaches earth, only a small amount reaches the surface:

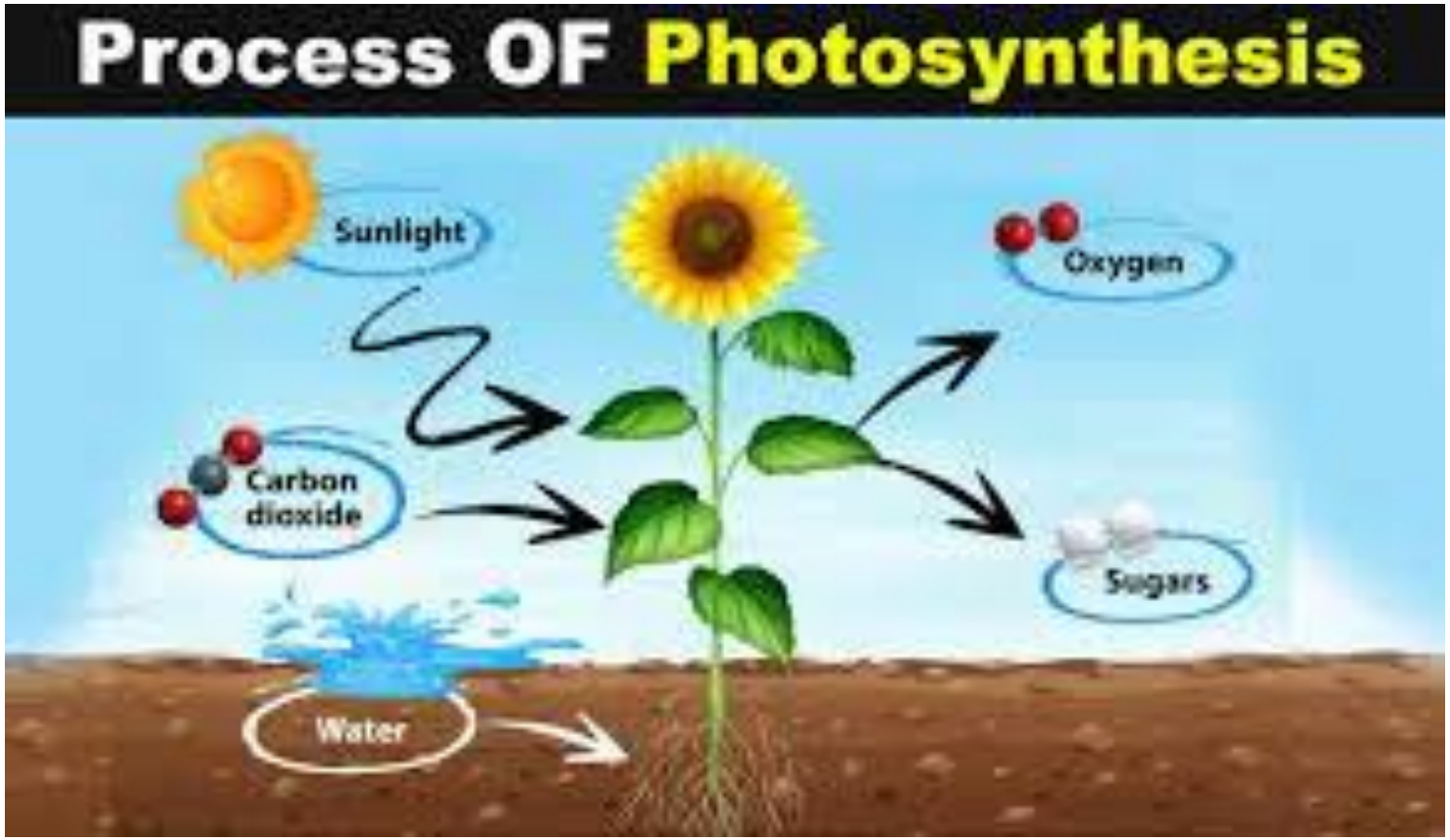
Some is radiated back into space by clouds

Some is reflected by light colored surface (snow)

Enough remains to warm the earth and provide energy for nearly all of its life forms

The atmosphere also prevents heat from escaping back into space too quickly (Greenhouse Effect)

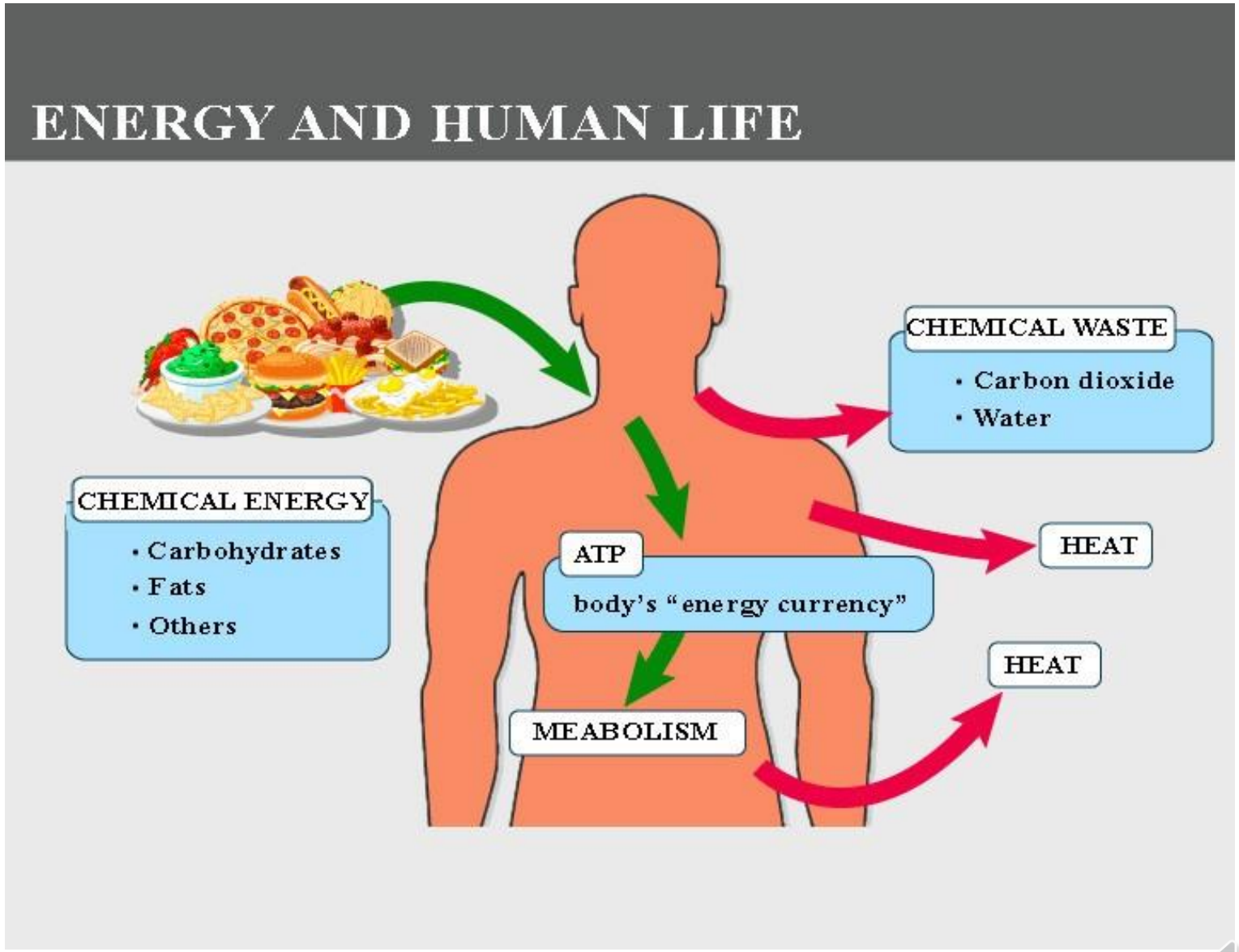
Photosynthesis



- the **process** by which green plants and certain other organisms transform light energy into chemical energy. During **photosynthesis** in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds

Food

Food is the main source of energy for human

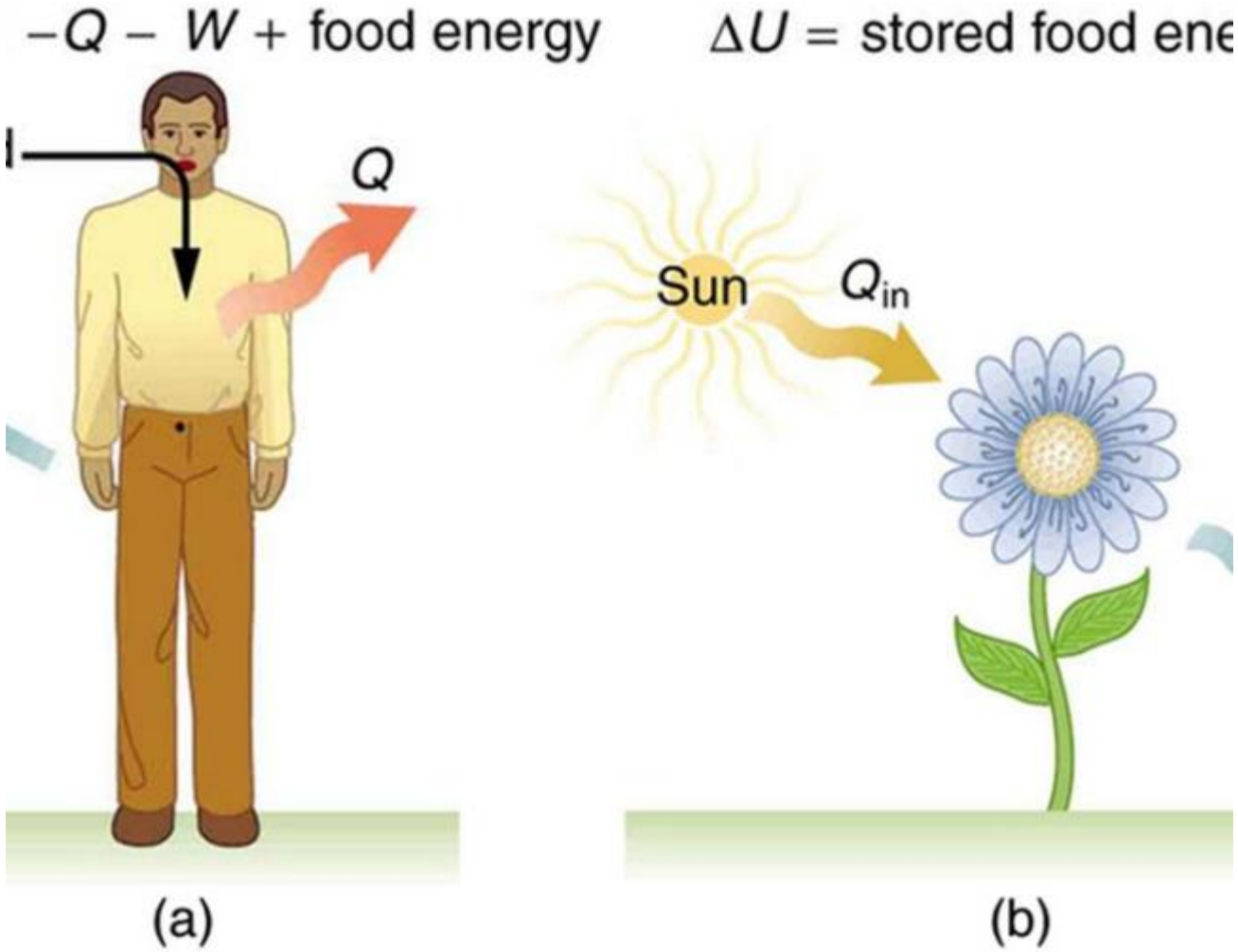


1. Conservation of Energy in the Body:

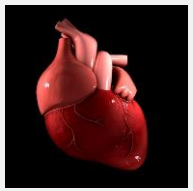
From a physics point of view, we can consider the body to be an energy converter that is subjected to the law of conservation of energy

First law of thermodynamics

Change in stored energy in the body (i.e. food energy, body fat, and body heat) = Heat lost from the body + Work done



The body uses the food energy to



1-operate its various organs

2-maintain a constant body temperature

3- do external work

The energy value

- The energy value of food referred to by
- nutritionists as a Calorie (cal) is an actually kilocalorie (kcal).
- Physicists as joule

Energy, Changes in the Body:

In the oxidation process within the body heat is released as energy of metabolism.

The rate of oxidation is called the metabolic rate

Let us consider the oxidation of glucose, a common form of sugar used for intravenous feeding.

The oxidation equation for 1 mole of glucose ($C_6H_{12}O_6$) is:

$C_6H_{12}O_6 + O_2 \rightarrow H_2O + CO_2 + \text{energy}$

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ H_2O + 6\ CO_2 + 686\ \text{kcal}$

1 mole of glucose + 6 moles of O_2 →6 moles H_2O + 6 moles CO_2 + 686 kcal of heat energy

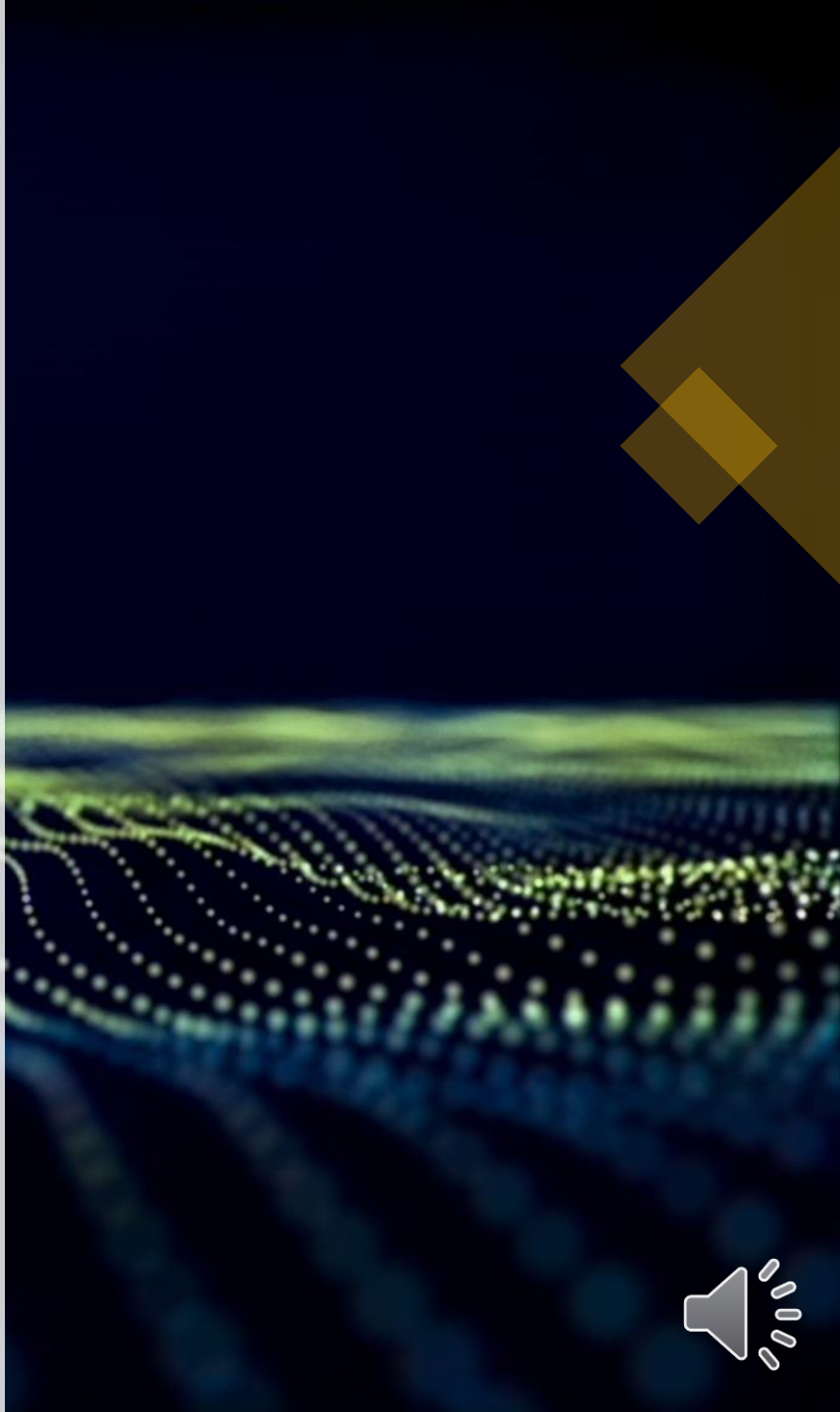
$6x12+12x1+6X16 + 6\ (16x2) \rightarrow 6\ (1x2+16) + 6\ (12+16x2) + 686\ \text{kcal}$

180 g of glucose + 192 g of O_2 → 108 g of H_2O + 264 g of CO_2 + 686 kcal of heat energy in the reaction.

Useful quantities for glucose metabolism

Remember that 1 mole of a gas at normal temp. and pressure (NTP), i.e. 0°C and76 cm Hg, has a volume of 22.4 liters

- **Kilocalories of energy released per gram of fuel = 686/180 = 3.80**
- **Kilocalories of released per liter of O_2 used = 686/(22.4 x 6) = 5.1**
- **Liters of O_2 used per gram of fuel = (6 x 22.4)/180 = 0.75**
- **Liters of CO_2 produced per gram of fuel = (6 x 22.4)/180 = 0.75**
- **The ratio of moles of CO_2 produced to moles of O_2 used is called the respiratory quotient (R) = 1.0**
- **Note: Similar calculations can be done for fats, proteins and other carbohydrates.**



Food Combustion.

Not all the food energy is available to the body because

part is lost in incomplete combustion.

The “unburned” products are released in feces, urine and flatus (intestinal gas).

However, the body is usually moderately **efficient** at extracting energy from food.

Basal metabolic rate (BMR

the basal metabolic rate (BMR), is define as the amount of energy needed to perform minimal body functions (such as breathing and pumping the blood through the arteries) under resting conditions

When the person is completely at rest, he typically consumes energy at a rate of about 92 kcal/h or 107 watt.

The BMR depends primarily upon **thyroid function**. A person with an overactive thyroid has a higher BMR than a person with normal thyroid function.

The energy used for basal metabolism becomes heat which is primarily dissipated from the skin.

The metabolic rate

- The rate of oxidation is called **the metabolic rate**
- The metabolic rate depends to a large extent on the **temperature of the body.**
- Chemical processes are very temperature dependent, and a small change in temperature can produce large change in the rate of chemical reactions.
- If the body temperature changes by **one degree**, there is a change of about **10%** in the metabolic rate.
- For example, if a patient has a temperature of **40 ºC, or 3 ºC** above its normal temperature,
- the metabolic rate is about **30%** greater than that of the normal value,
- similarly, if the body temperature drops 3ºC below normal, the metabolic rate (and oxygen consumption) decreases by about 30%.
- You can see why **hibernating** at a low body temperature is **advantageous** to an animal and why a patient's temperature is sometimes **lowered** during **heart surgery**.

Obviously

in order to keep a constant weight an individual must consume just enough food provide for

1- basal metabolism

2- physical activities.

Eating too little results in weight loss; continued too long it results in starvation

Eating too high results in weight increase; continued too long it results in obese

Eating enough food results normal body weight

Example 1a.

- **Problem**
- Suppose a person wish to loss 4.54 kg through a physical activity

- How long would the person have to work at an activity of 15 kcal/min to lose 4.54 kg of fat? (Of course, the person could not maintain this activity rate very long). The person can expect a maximum of 9.3 kcal/g of fat.
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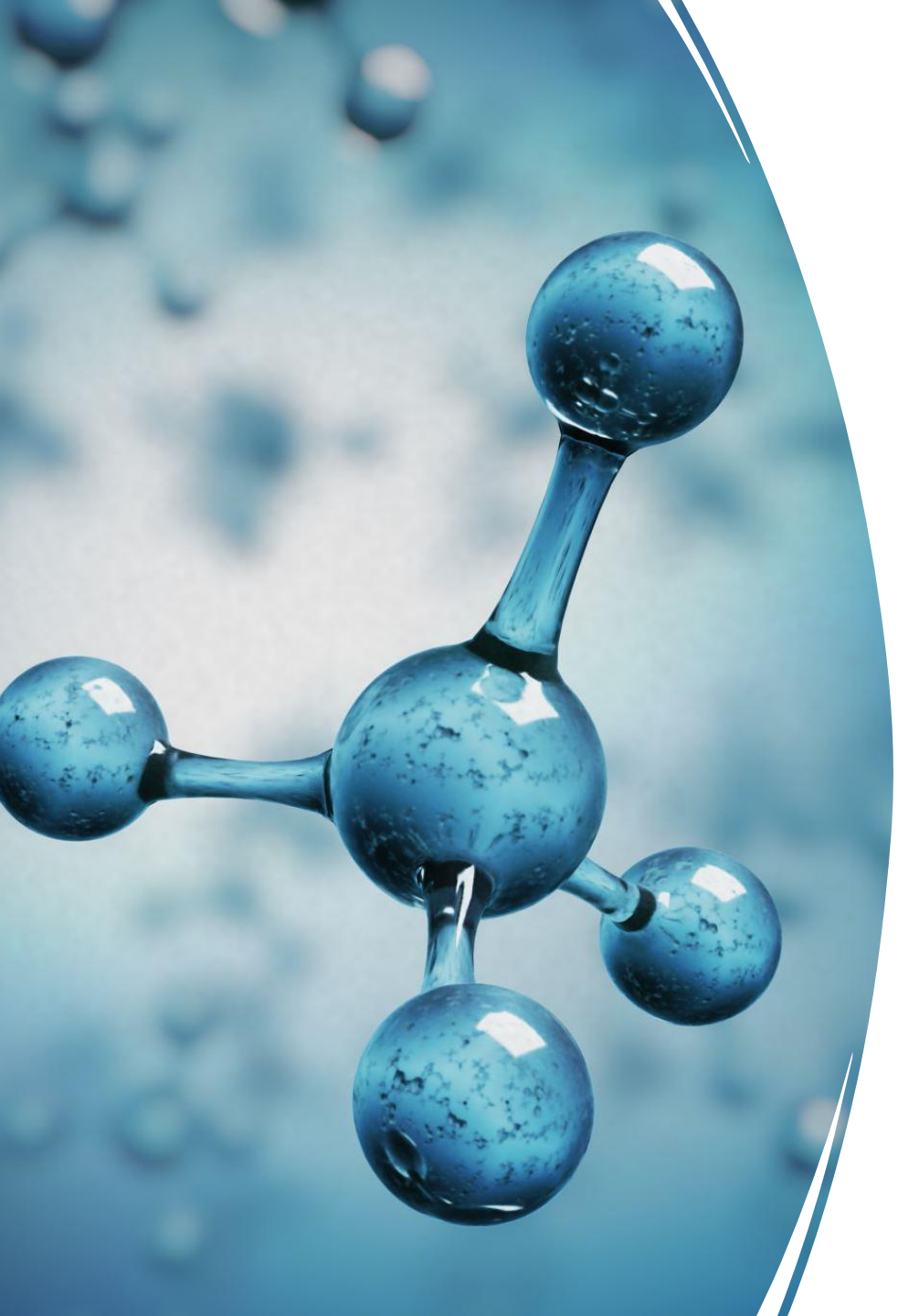
- **Solution:**
- The time of working (T) = [4.54 x 10^3 g)(9.3 kcal/g)]/(15 kcal/min)
- = 2810 min ≈ 47 hours
- **Note that** a great deal of exercise is needed to lose few kg.

Example 1b.

a. Suppose a person wish to loss 4.54 kg through dieting

b. It is usually much easier to loss weight by reducing food intake. If the person normally use 2500 kcal/day, how long must he diet at 2000 kcal/day to lose 4.54 kg of fat?

- **Solution:**
- The time of diet (T) = [4.54 x 10^3 g)(9.3 kcal/g)]/(500 kcal/g)
- = 84 days



BMR Determination

- The BMR is sometimes determined from the oxygen consumption at resting
- The amount of energy used by various organs can be determined from its oxygen consumption.
- They can also estimate the food energy used in various physical activities by measuring the oxygen consumption.

Thank you

Any question?