# Respiratory Quotient

When food is oxidized, whether in an open system or closed biological system, oxygen is consumed and $CO_2$ produced.

# The Respiratory Quotient (RQ)

The Respiratory Quotient or RQ value is a measure of the ratio of carbon dioxide produced and oxygen consumed by an organism per unit time

The respiratory quotient is a ratio and therefore has NO UNITS

$$RQ = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen consumed}} \text{ per unit time}$$

The respiratory quotient is a valuable measurement as it provides us with information regarding the nature of the substrate being used by an organism for respiration

The simplified equation for the aerobic respiration of glucose is:

$$C_6H_{12}0_6 \;+\; 6O_2 \;=\; 6CO_2 \;+\; 6H_2O$$

In this reaction, SIX CARBON DIOXIDE MOLECULES are produced and SIX OXYGEN MOLECULES are consumed

**The RQ for this reaction is $6\ CO_2/6\ O_2 = 1$**

NEXT

# The Respiratory Quotient (RQ)

**The RQ value varies with the nature of the substrate being used for respiration**

**The following equation represents the complete oxidation of the fatty acid, OLEIC ACID, when used as the substrate for respiration**

**The simplified equation for the aerobic respiration of oleic acid is:**

$$2C_{18}H_{34}0_2 \;+\; 51\,O_2 \;=\; 36\,CO_2 \;+\; 34\,H_2O$$

**In this reaction, THIRTY SIX CARBON DIOXIDE MOLECULES are produced and FIFTY ONE OXYGEN MOLECULES are consumed**

**The RQ for this reaction is $36\,CO_2/51\,O_2 = 0.7$**

NEXT

- **Proteins**

RQ of proteins is a little complex to determine as it contain N & S in addition to C, H, O.

Using specialized technique the RQ is found to be 0.82

- **Alcohols**

$$C_2O_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$RQ = 2/3 = 0.67$$

# The Respiratory Quotient (RQ)

**The following table shows the RQ values for different classes of respiratory substrate when they are used for aerobic respiration**

| Respiratory Substrate | RQ Value |
| --- | --- |
| glucose | 1.0 |
| fatty acid | 0.7 |
| protein | 0.9 |

**If any degree of anaerobic respiration occurs RQ values significantly above a value of 1.0 are obtained**

NEXT

# Methods for determination of RQ of Man

**Two method**

1. Open Circuit
2. Closed Circuit

# Open Circuit

- Made to breath in a specially designed bag called Douglas Bag for few minutes
- Volume of Breathed air is measured in a gasometer
- Subjected to gas analyzer
- Where $CO_2$ is absorbed by KOH
- Original volume of gas is reduced

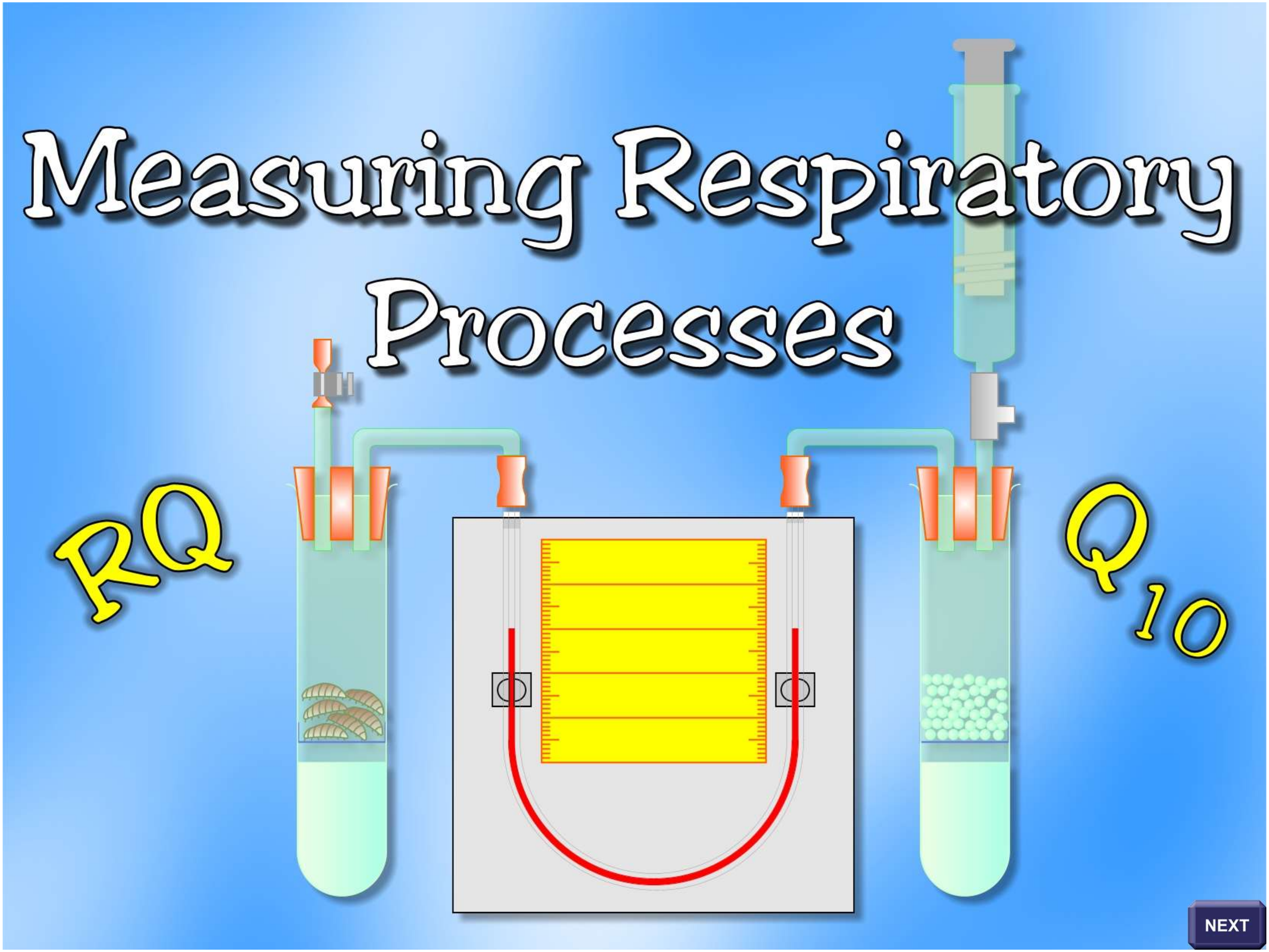
# Open Circuit

- Concentration of $CO_2$ is calculated

- Remaining gas is allowed to react with alkaline pyrogalate which absorb $O_2$

- $O_2$ in the expired is found out

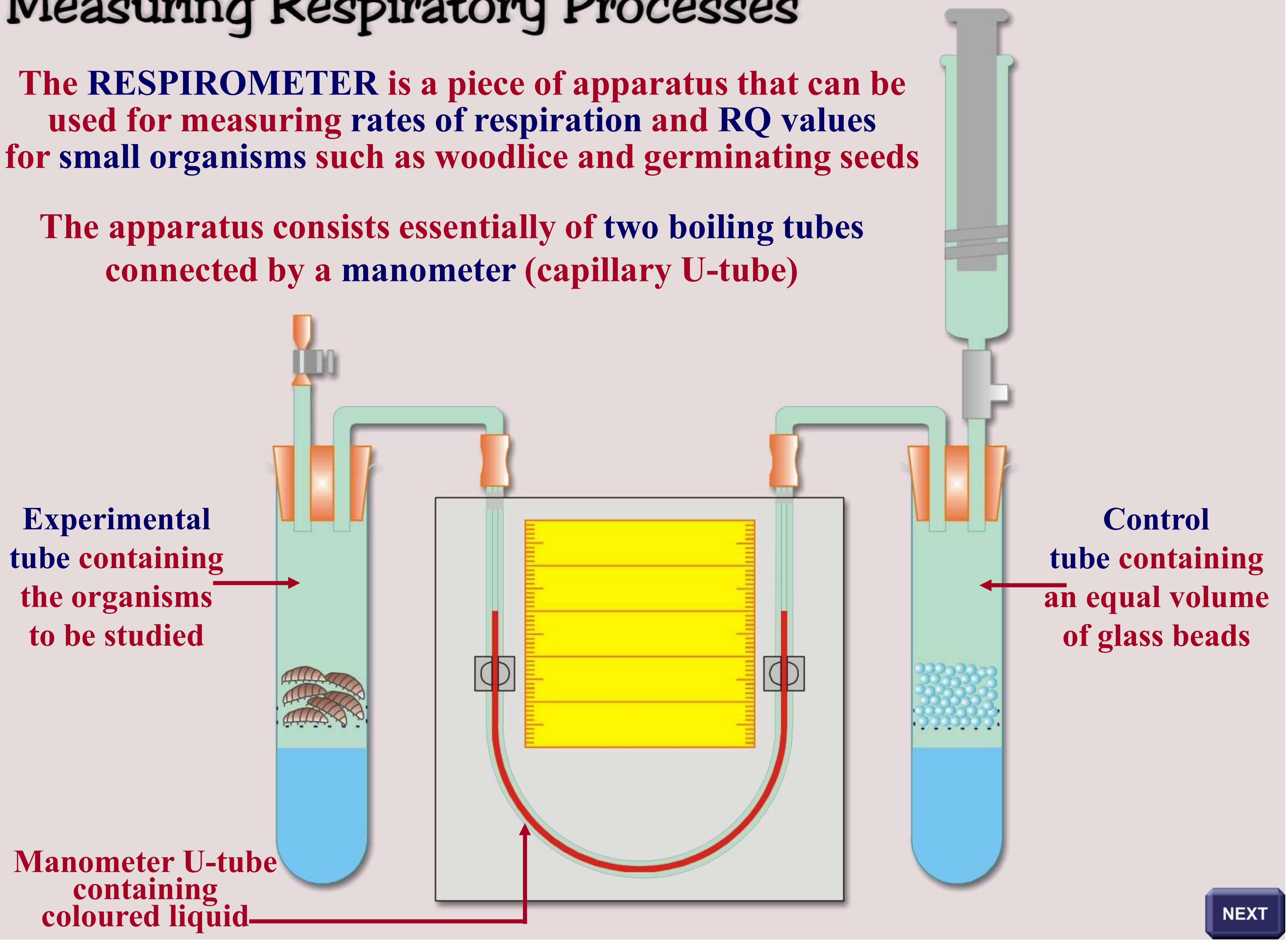
- RQ is calculated $\dfrac{\text{volume of } CO_2}{\text{volume of } O_2}$


Measuring Respiratory Processes
RQ
$Q_{10}$
NEXT

# Measuring Respiratory Processes

The RESPIROMETER is a piece of apparatus that can be used for measuring rates of respiration and RQ values for small organisms such as woodlice and germinating seeds

The apparatus consists essentially of two boiling tubes connected by a manometer (capillary U-tube)



# Measuring Respiratory Processes

Equal volumes of potassium hydroxide (KOH) or SODA LIME are placed into each of the boiling tubes

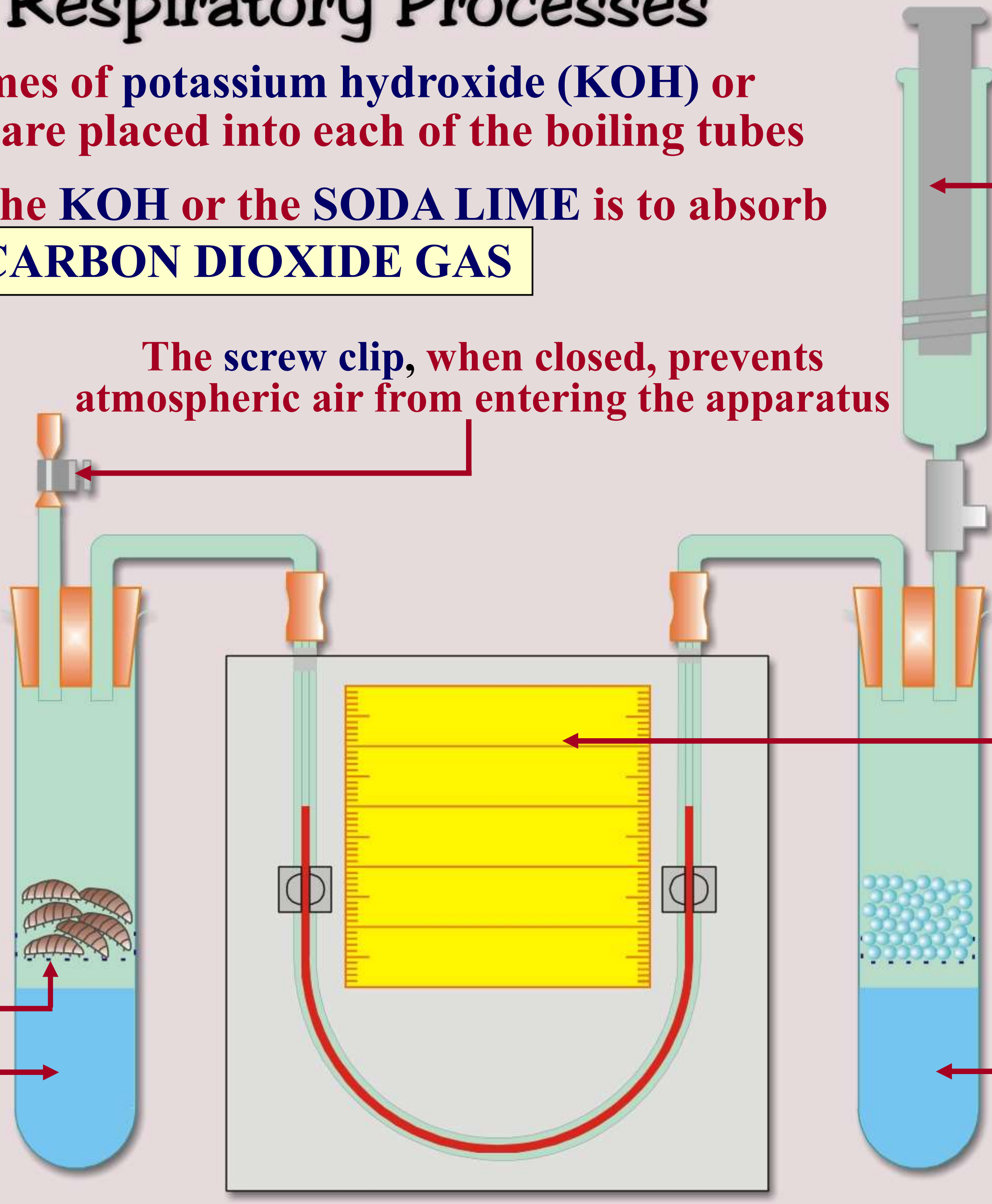
The function of the KOH or the SODA LIME is to absorb

**CARBON DIOXIDE GAS**

A 1 $cm^3$ syringe is inserted into the control tube and is used to force air through the apparatus before the experiment and to equalise the manometer levels between experiments

The animal or plant material in the experimental tube is protected from the KOH or SODA LIME by a barrier consisting of a zinc-gauze platform

The screw clip, when closed, prevents atmospheric air from entering the apparatus



The scale attached to the manometer allows changes in the levels of the manometer fluid to be measured

gauze platform

KOH solution

KOH solution

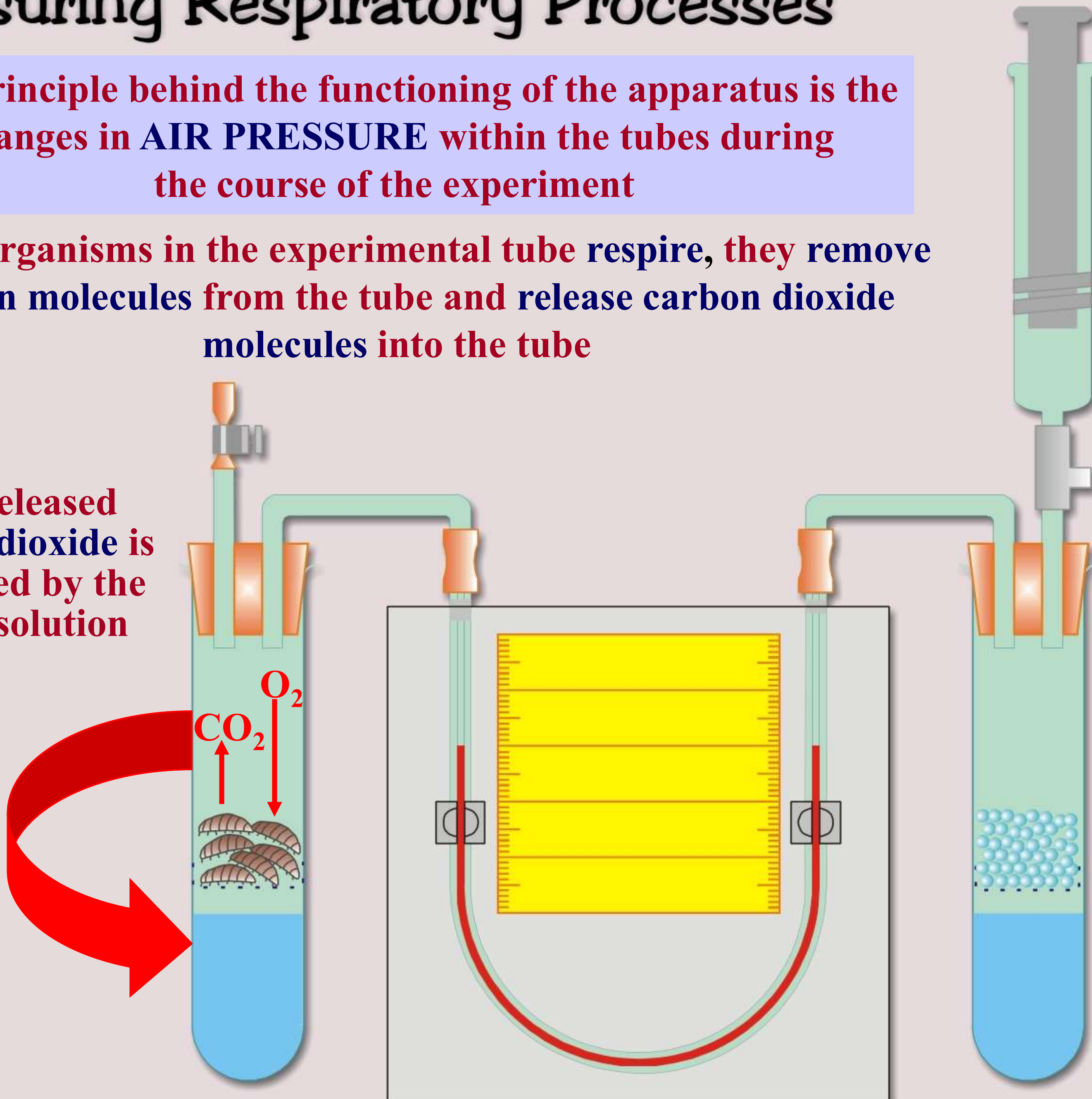
NEXT

# Measuring Respiratory Processes

The principle behind the functioning of the apparatus is the changes in AIR PRESSURE within the tubes during the course of the experiment

As the organisms in the experimental tube respire, they remove oxygen molecules from the tube and release carbon dioxide molecules into the tube

The released carbon dioxide is absorbed by the KOH solution




The total number of gas molecules in the experimental tube will therefore be reduced

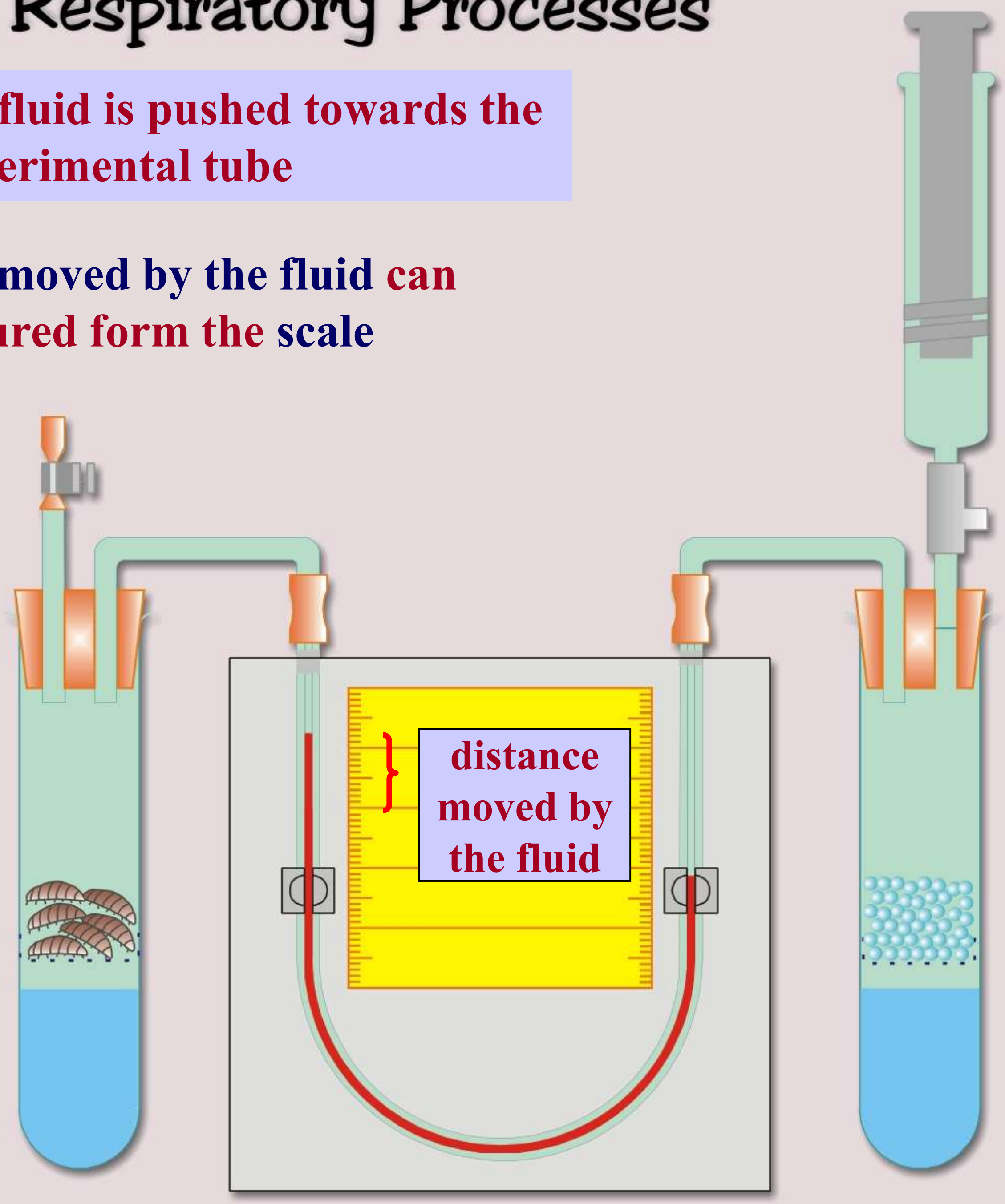
The air pressure in the experimental tube therefore decreases and the manometer fluid will be pushed upwards in the left-hand side of the U-tube

NEXT

# Measuring Respiratory Processes

**The manometer fluid is pushed towards the experimental tube**

**The distance moved by the fluid can be measured form the scale**




NEXT

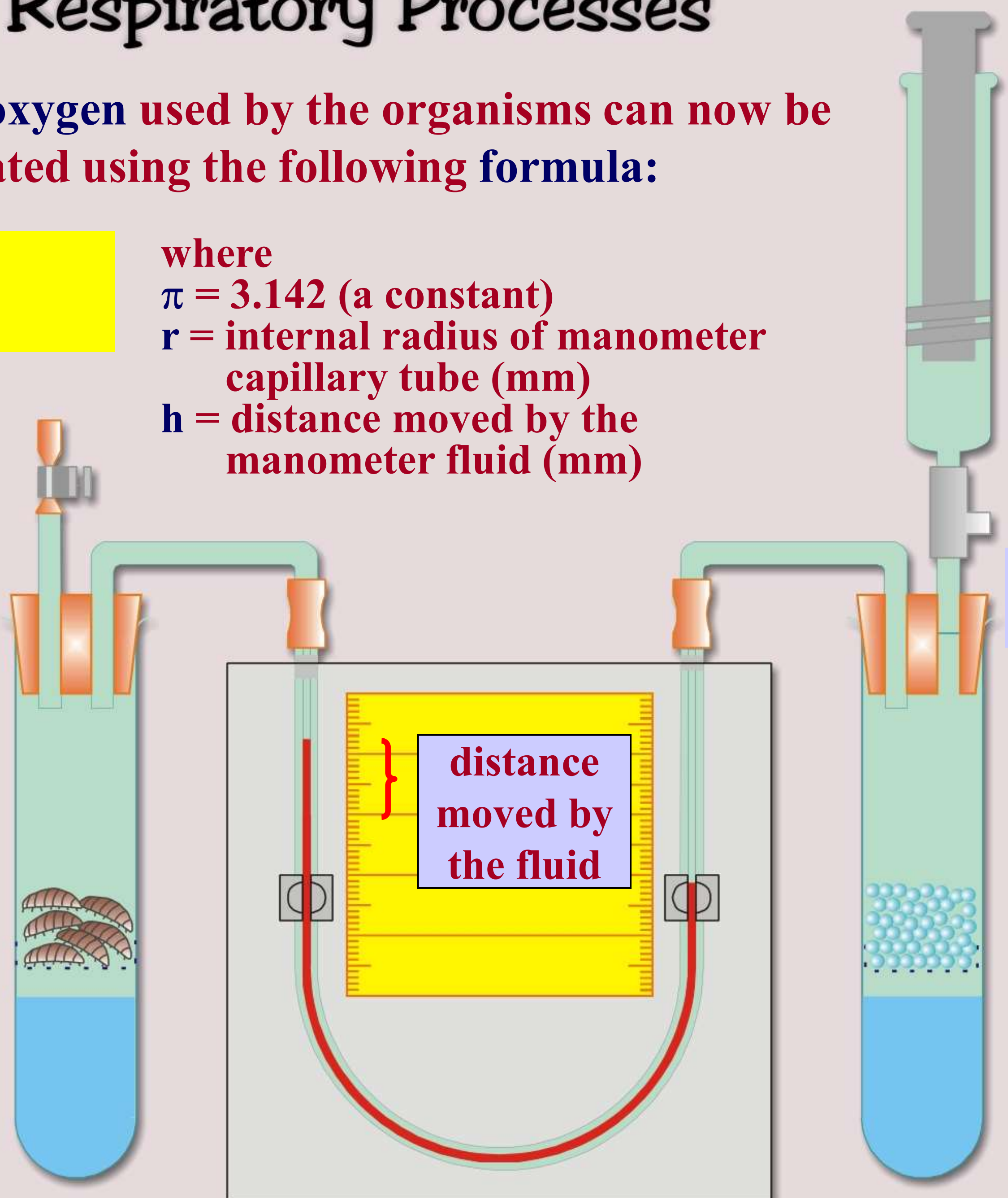
# Measuring Respiratory Processes

The volume of oxygen used by the organisms can now be calculated using the following formula:

$$\pi r^2 h$$

where
$\pi$ = 3.142 (a constant)
r = internal radius of manometer capillary tube (mm)
h = distance moved by the manometer fluid (mm)

Throughout the procedure the boiling tubes are immersed in a water bath, usually maintained at 20˚C, to minimise any temperature fluctuations that may occur during the course of the experiment



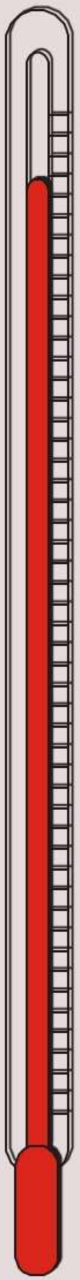

The control tube has two functions

It negates any effects that temperature changes may have on the pressure of the air in the system

It enables us to demonstrate that any changes in the manometer tube are due to living processes

NEXT

# The effect of temperature on the respiratory rate of small organisms can be investigated using the respirometer



**The effect of temperature on the rate of respiration can be investigated by changing the temperature of the water bath**

**A temperature range of 10°C to 40°C is suitable for this investigation**

**As the temperature of the water bath is changed for each rate measurement, it is important to allow a period of around 10 minutes to elapse before timing the experiment**

**This ten minute time period is necessary to allow for equilibration, i.e. to enable gas pressures in the apparatus to adjust and to allow the organisms to be fully adjusted to the new temperature**

**The results of temperature experiments can be used to calculate a $Q_{10}$ value for respiration where:**

$$Q_{10} = \frac{\text{Rate of respiration at } t + 10^{o}\text{C}}{\text{Rate of respiration at } t^{o}\text{C}}$$

NEXT

Remember that when rate of utilization of fat increases in relation to carbohydrates, RQ falls.

Commonly seen in Diabetes mellitus

Utilization of carbohydrates increases RQ

# Energy requirement of a normal person

While calculating we should consider the energy required for

- Maintenance of BMR
- Thermogenic effect of food (SDA)
- Extra energy expenditure for PA

Remember that when rate of utilization of fat increases in relation to carbohydrates, RQ falls.

Commonly seen in Diabetes mellitus

Utilization of carbohydrates increases RQ

# Applications

- RQ is a dimensionless number used in calculations of Basal metabolic rate (BMR)
- A value of 0.7 indicates that lipids are being metabolized, 0.8 for proteins, and 1.0 for carbohydrates. The approximate respiratory quotient of a mixed diet is 0.8. Some of the other factors that may affect the respiratory quotient are energy balance, circulating insulin, and insulin sensitivity.
- Practical applications of the respiratory quotient can be found in severe cases of Chronic obstructive pulmonary disease, in which patients spend a significant amount of energy on respiratory effort. By increasing the proportion of fats in the diet, the respiratory quotient is driven down, causing a relative decrease in the amount of $CO_2$ produced. This reduces the respiratory burden to eliminate $CO_2$, thereby reducing the amount of energy spent on respirations.

# Applications….

- An indicator of over or underfeeding. Underfeeding, which forces the body to utilize fat stores, will lower the respiratory quotient while overfeeding, which causes Lipogenesis, will increase it. Underfeeding is marked by a respiratory quotient below 0.85, while a respiratory quotient greater than 1.0 indicates overfeeding.

- Respiratory quotient can be used in analysis of liver function and diagnosis of liver disease. In patients suffering from Liver cirrhosis, non-protein respiratory quotient (npRQ) values act as good indicators in the prediction of overall survival rate. Patients having a npRQ $< 0.85$ show considerably lower survival rates as compared to patients with a npRQ $> 0.85$. A decrease in npRQ corresponds to a decrease in glycogen storage by the liver.