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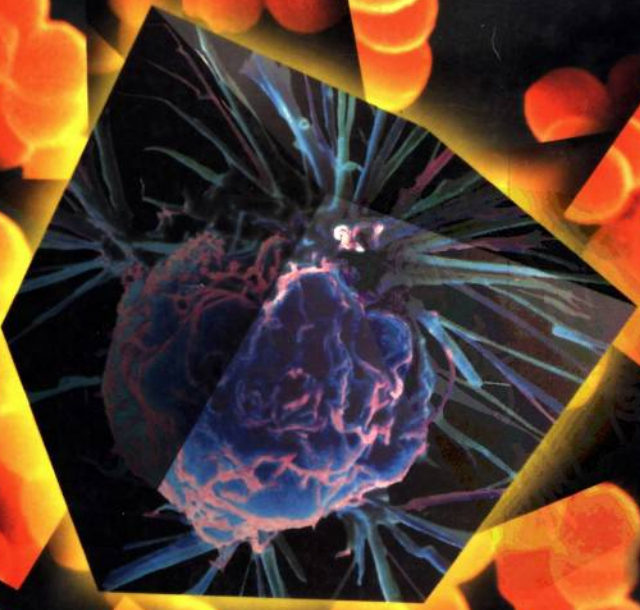
BIOLOGY

Mastering Basic Concepts 2

基础生物学

Second edition



Pang King Chee Cheung Lai Man

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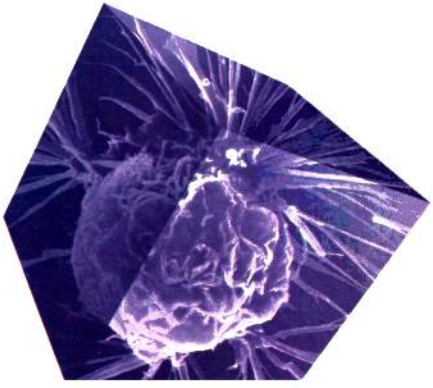
Dr Pang King Chee
Ms Cheung Lai Man

Reviewer: Dr Jeffrey R. Day



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Preface

This course is dedicated to all teachers and students in Hong Kong secondary schools.

It is specially written to promote the use of interactive approaches in teaching biology, as well as learning the subject in an active, stimulating and interesting way. Teachers will find the course useful in enhancing the effectiveness of their teaching; students will find it helpful in studying biology.

The course is written for the latest CDC Biology Syllabus. It consists of three textbooks, three workbooks (plus teacher's edition), three teacher's guides, overhead transparencies and wallcharts.

In the revised edition, those features in the first edition which teachers and students found useful have been kept. In addition, a number of new sections have been added such as ***Do you remember?***, ***Challenge***, ***Integrated Learning*** and ***Puzzle***. Comments and feedback from teachers and students on the first edition have also been incorporated. Further improvements have been made, including simplifying the contents better to suit the needs of teaching, updating the information and enhancing the format for more attractive presentation.

The following are special features of the revised edition of the book.

Emphasis on mastering concepts

- Study targets in question format as ***Do you know?*** are introduced at the beginning of each chapter to focus attention.
- Concepts are highlighted and clearly explained in the text.
- ***Key learning*** is provided at the end of each part to help consolidate key concepts.
- ***Check your concepts*** and ***Wrong concepts*** are included at the end of each chapter to help students evaluate and clarify concepts.
- ***Exercises*** at the end of each chapter provide further chances for students to apply concepts and reinforce learning. Teachers could use these as written homework.

Encourage development of problem-solving skills

- The numerous graphs and tables are useful for class discussion.
- ***Question***, ***Challenge*** and ***Do you remember?*** require different levels of abilities in answering. Many of them are specially designed to develop higher level thinking skills such as analysis, synthesis and evaluation.

Emphasis on developing interest in biology

- ***Additional information*** sections present interesting daily examples with biological facts to arouse interest.
- ***Activity*** sections are suggested to provide relevant biological work for students to do either in school or at home to promote active learning.
- In the ***Integrated learning*** sections which aim to help students integrate concepts and facts from different areas in the syllabus, daily life situations have been incorporated where appropriate.
- ***Puzzle*** sections are included after each section to enhance learning interest through games.

Attractive layout and easy to study

- Colourful photographs, annotated diagrams, cartoons, posters are liberally used to enhance interest in using the textbooks.
- Materials outside the scope of the syllabus have been clearly distinguished to avoid over-learning.
- The content is kept concise and simple English is used.

We should be grateful for any feedback and comments from teachers and students using these books so as to make improvements in future editions.

Pang King Chee
Cheung Lai Man

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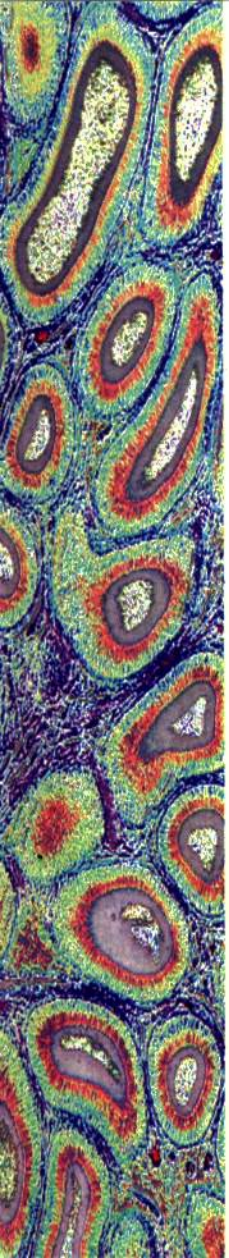

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Chapter 15 Detection of environmental conditions by mammals

section III

MAINTENANCE OF LIFE

10 RESPIRATION: RELEASING ENERGY FROM FOOD

Do you know?

1 What is **respiration**?

2 Why do organisms need to respire?

3 How does respiration take place?

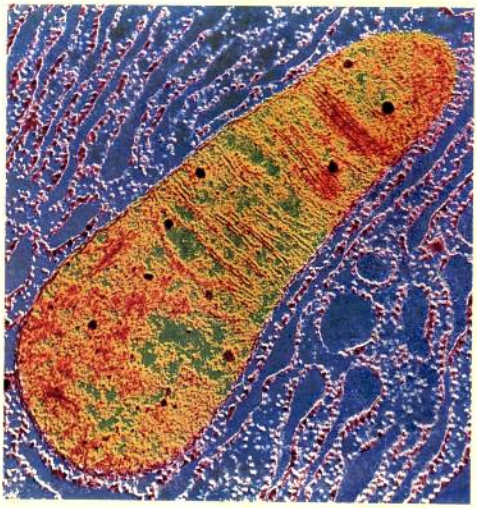
4 What is the difference between burning and respiration?

5 How is the energy released in respiration used in organisms?

6 What are the differences between **aerobic** and **anaerobic respiration**?

7 What is the **importance** of anaerobic respiration?

Go through this chapter. It will help you learn about these!



10.1 How can the energy stored in food be released?

One main function of food for humans is to provide energy for body activities. Carbohydrates and fats are energy-rich food substances. However, the energy stored inside them is in the form of chemical energy which our cells cannot use directly. In this chapter, you will learn how the stored chemical energy is released and changed into useful forms for body activities.

Do you remember?

What are the other uses of food besides providing energy?

(Hint: Refer to Unit 7.1 for the answers.)

What happens when a piece of food is burnt?

Food gives out energy when it is burnt. During the process, the food reacts with oxygen and releases the energy stored as **heat** and **light**. At the same time, the food molecules are broken down mainly into **water** and **carbon dioxide**. For example:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{burning}} \underset{\text{(heat and light)}}{\text{energy}} + \text{carbon dioxide} + \text{water}$$

If glucose is burnt **completely**, all the energy in it will be released. Burning is a fast reaction which takes place in **one single step**. It is a simple process which releases the energy stored in food.

What is respiration?

Although burning can release energy from food, organisms do not use this method. This is because the large amount of heat released during the process will kill the cells. In fact, organisms release energy from food gradually through a process called **respiration**.

Respiration is the process by which **organisms release energy from food for their body activities**. It is an **oxidation** (氧化作用) process involving many **enzymes**. Unlike burning, during respiration, food is broken down step by step through **a series of chemical reactions** in a **gradual** and **controlled** manner. Each reaction releases some energy and is controlled by different enzymes. In respiration, **glucose** is the main food substance involved. Usually, oxygen is needed, and glucose is eventually broken down into carbon dioxide and water.

The process can be summarized by the following word equation:

$$\text{glucose} + \text{oxygen} \xrightarrow[\text{enzymes}]{\text{respiration}} \underset{\substack{\text{(heat and}\\ \text{high-energy}\\ \text{compound)}}}{\text{energy}} + \text{carbon dioxide} + \text{water}$$

Additional information

Other sources of energy
(其他能量來源)

Besides glucose, we can also use other carbohydrates and fats to release energy. However, fats must first be changed to glucose or a substance called acetyl Co-A (乙醯輔酶-A) before they are oxidized in respiration.

As shown by the above equation, carbon dioxide is given out during respiration. To find out if this really happens, do Practicals 10.1 and 10.2 using **hydrogencarbonate indicator** (碳酸氫鹽指示劑) and **lime water** (石灰水).

The production of carbon dioxide by organisms can be taken as a sign of respiratory activities.

Do you remember?

Which process in other organisms makes use of the carbon dioxide produced in respiration to make nutrients?

(Hint: This process takes place only in green plants only. Refer to Chapter 9 for the answers.)

Let's go to Practical 10.1

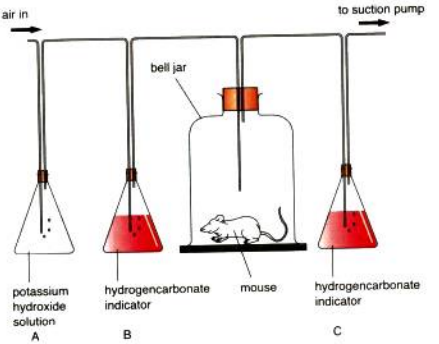
WB P.1

To find out if carbon dioxide is given out by mouse

Hydrogencarbonate indicator is a good indicator for detecting carbon dioxide. Its colour changes with the concentration of carbon dioxide in air:

Colour of indicator	CO_2 concentration in air
Purple	< 0.03%
Orange/Red	≈ 0.03%
Yellow	> 0.03%

The air breathed out by a mouse is passed through hydrogencarbonate indicator to check if the mouse has given out carbon dioxide.



1 Set up the apparatus as shown in the diagram.

2 Turn on the suction pump to draw a continual stream of air through the set-up for 30 minutes or more.

3 Observe any colour changes in flasks A, B and C.

Results and discussion

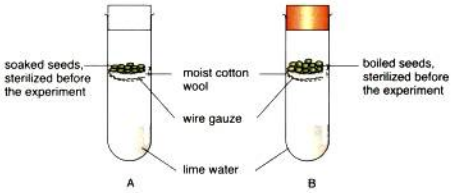
The indicator in flask B turns purple. This shows that the air entering the bell jar is free of carbon dioxide. The indicator in flask C turns yellow after some time. These results show that carbon dioxide is given out by the living mouse.

The potassium hydroxide solution in flask A is to absorb any carbon dioxide in the air. This prevents carbon dioxide from entering the bell jar.

Let's go to Practical 10.2

WB P.3

To find out if carbon dioxide is given out by germinating seeds



1 Set up two boiling tubes as shown in the diagram. Use two different sets of seeds:
   a soaked seeds, sterilized before the experiment
   b boiled seeds, sterilized before the experiment

2 Leave the tubes for a few hours.

3 Look for any changes in the colour of the lime water.

Results and discussion

The lime water in tube B remains clear while that in tube A turns milky after a few hours. These results show that germinating seeds have given out carbon dioxide.

Activity

Designing experiments

Using hydrogencarbonate indicator, can you design experiments simpler than Practicals 10.1 and 10.2 to demonstrate the release of carbon dioxide by

1 respiring animals such as mice?
2 plants (e.g. germinating seeds)?

Where does respiration take place inside the cell?

Respiration takes place in all living plant and animal cells **all the time**. Some of the reactions take place in the cytoplasm and some in the **mitochondria** (refer to Unit 3.2 for details). However, most energy is released from reactions inside the mitochondria. Active cells (which require a lot of energy e.g. muscle cells, liver cells and sperms (精子)) contain a lot of mitochondria. (You will learn about sperms in Unit 20.6).

Fig. 1 Mitochondria are also called the 'power house' of cells

KEY LEARNING

How can the energy stored in food be released?

What is respiration?

- **Respiration** is the process by which **organisms release chemical energy stored in food for body activities**.
- It is an **oxidation** process involving a series of **enzymatic** reactions. It breaks down food substances and releases energy in a **controlled** and **gradual** manner.
- **Glucose** is the main substrate for respiration. Usually, oxygen is needed, and glucose is broken down into carbon dioxide and water to release energy.
- It takes place in all living cells **all the time**.

10.2 *In what forms are energy released?*

Energy is mainly released as **ATP** (腺苷三磷酸) during respiration. However, some energy is lost as **heat**.

ATP

Most of the energy is released as **ATP** (**a**denosine **tri**phosphate). ATP is a small molecule which is a **temporary store of energy**. Unlike the chemical energy stored in glucose, the energy stored in ATP is in a readily usable form. This energy can be easily and quickly released in a single step when it is needed. For example, if a drop of ATP solution is added to a piece of fresh pork muscle, the muscle will contract immediately. However, when a drop of glucose solution is added, no movement is observed.

ATP is formed from a molecule called **ADP** (**ad**enosine **di**phosphate) inside cells with the supply of **energy** and **phosphates**. When glucose is broken down during respiration, the energy released allows ADP to react with phosphates to form ATP. As a result, the energy is held in the ATP.

ADP + energy from respiration + phosphates ⟶ ATP (higher-energy compound)

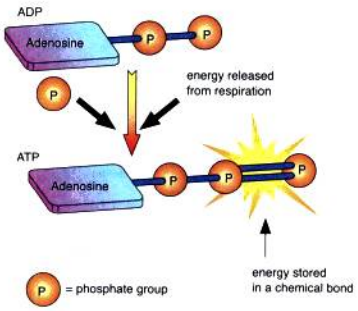


Fig. 2 Formation of ATP

ATP molecules store the released energy temporarily inside cells. When energy is needed by cellular activities, e.g. muscle contraction, ATP inside cells provides the energy to the process quickly.

ATP ⟶ energy + ADP + phosphates

ADP released can then be reused for further respiratory reactions.

Heat

Some of the chemical energy in food is lost as heat. The heat maintains the body temperature of those animals that can control their own body temperature. These include mammals and birds.

An increase in temperature can therefore be taken as another sign of respiration. Heat production in animals and plants can be investigated in Practicals 10.3 and 10.4 by using a differential air thermometer (相異空氣溫度計) and thermos flasks (保暖瓶).

Additional information

Human needs for ATP
(人類對ATP的需求)

A human at rest uses about 40 kg of ATP a day. During heavy exercise, a human may use as much as 0.5 kg of ATP a minute (i.e. 720 kg a day)!

An analogy for ATP
(ATP的比喻)

ATP is just like our money. We work and turn our efforts into money. We can save money and use it to buy things at any time we want.

Additional information

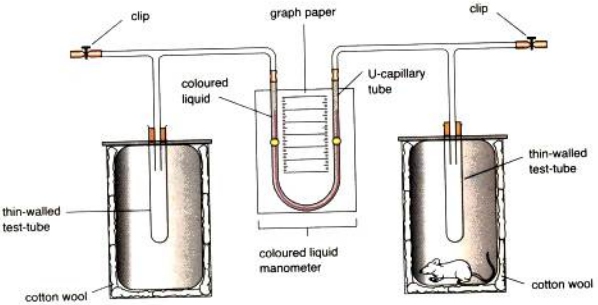
Heat production (熱能生產)

If you put your hand into a heap of grass a few hours after it has been cut from a grass field, you may feel that it is warm. This is because the bacteria, which are causing the decay of the grass, are undergoing respiration and releasing heat.

Let's go to Practical 10.3

WB P.5

To find out if a living mouse produces heat using a differential air thermometer



1 Set up the differential air thermometer as shown.

2 Open the clips on both sides of the thermometer before the experiment starts. Wait until the coloured liquid levels in both sides of the capillary tube are balanced.

3 Close the clips. Observe any changes in the liquid levels.

Results and discussion

At the end of the experiment, the liquid level on the animal's side is pushed down and the level on the other side rises. This is because the animal liberates heat which warms up the air in the test-tube on its side. The expansion of air inside the tube pushes the liquid level down. This experiment therefore shows that a living mouse releases heat. Remember there is no change in total quantity of gas molecules since one molecule of O_2 used = one molecule of CO_2 produced.

The clips are opened before the experiment to equalize pressure on both sides of the U-capillary tube. The cotton wool is used to prevent heat loss.