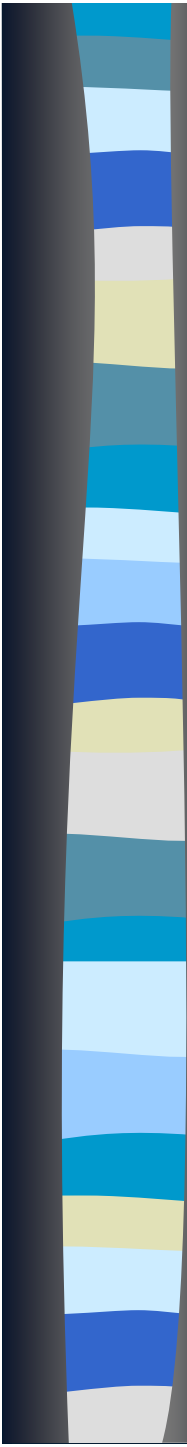




普通生物學實驗

General biology laboratory

- 課程名稱:實驗三、四課程講解
Lecture for experiments 3 and 4
- 授課教師名稱:阮淑慧
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學習目標: 如何利用化學試劑，簡單測量氧氣及二氧化碳的化學反應之變化，以認識細胞呼吸及光合作用的進行。

資料來源: Student Lab Manual for Biology
Labs On-Line

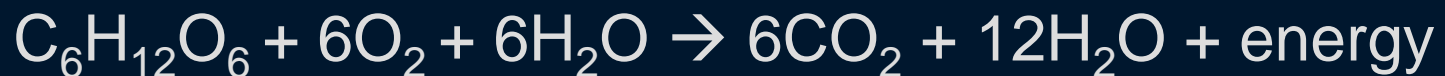
Summary: 設計簡單實驗並包括控制組，提出問題及以科學方法解決。



Aerobic Respiration

(Most Plants, Animals, Yeast)

- Cellular respiration — generally aerobic (oxygen needed)
- Occurs under plentiful O₂ supply.
- Nutrients are catabolized to CO₂ and H₂O.
- The most common example — glucose metabolism.





Anaerobic Respiration

(Some Bacteria)

- Some bacteria produce energy only by anaerobic respiration (an advantage in soil or stagnant ponds)
- An inorganic substances such as nitrate ions (NO_3^-) or sulfate ions (SO_4^{2-}) are used in place of O_2 and accept electrons at the “downhill” end of electron transport chains.

Ex. Methanogens + $\text{CO}_2 \rightarrow \text{CH}_4$ + energy
sulfur bacteria + $\text{SO}_2 \rightarrow \text{H}_2\text{S}$ + energy



Fermentation (some bacteria)

- End products — organic compounds.
- When insufficient O₂, human muscle cells can temporarily use a type of fermentation.
- Organic molecule + NADH
→ reduced organic molecule + NAD⁺
- 1. Ethanol fermentation: yeast
2. Lactic acid fermentation: muscle cells



Three Classes of Organisms

- **Strict aerobes**
 - can only survive under environment with oxygen
 - rely on aerobic respiration for energy
- **Anaerobes**
 - anaerobic bacteria, which do not use O₂
- **Facultative anaerobes**
 - yeasts and certain bacteria
 - O₂ available → aerobic respiration;
O₂ in short supply → anaerobic respiration of fermentation



Exp. 4 Cellular Respiration and Photosynthesis

■ Cellular respiration

- Cellular respiration is the stepwise enzymatic process by which cell extract energy from glucose, fatty acids, and other organic compounds.



Photosynthesis

- Only in green plants (∴ chloroplasts)
- Occurs only when the light is available (the light source is usually from the sun).
- $\text{Light} + \text{CO}_2 \rightarrow \text{O}_2 \text{ and glucose.}$



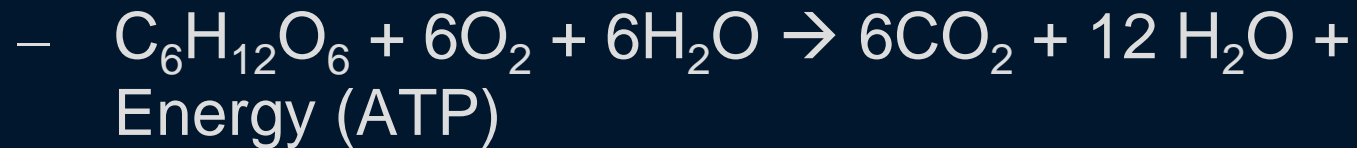
Two Ways to Test Aerobic Cellular Respiration

- No oxygen → aerobic cellular respiration
 - No O_2 → Winkler test → white precipitate
 - O_2 → Winkler test → yellow or brown precipitate
- Presence of CO_2 → aerobic cellular respiration (phenol red will turn yellow)
 - $MnCl_2 + 2KOH \rightarrow Mn(OH)_2$ (white precipitate) + $2KCl$
 - $2Mn(OH)_2 + O_2 \rightarrow 2MnO_2$ (reddish brown to yellow precipitate) + H_2O
 - $O_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+$ (↓ pH value) + HCO_3^-

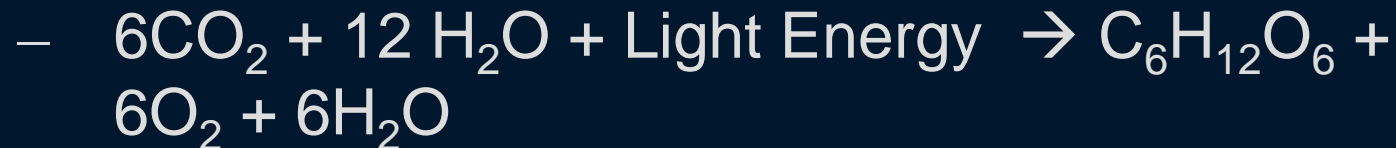


Green Plants In the Light Cycle

- Mitochondria \Rightarrow Respiration



- Chloroplasts \Rightarrow Photosynthesis

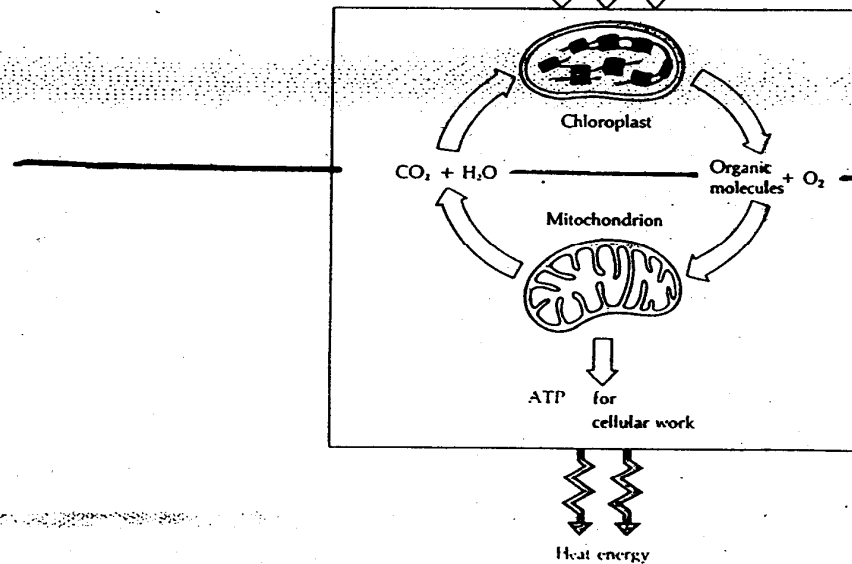
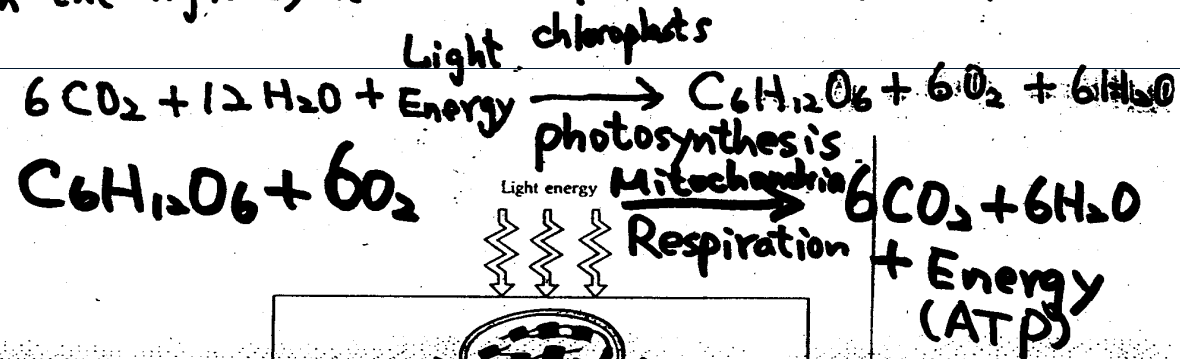


- Only those plants with chloroplasts will undergo photosynthesis

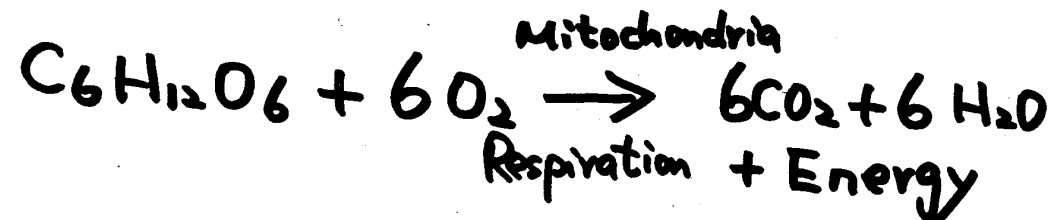
- In the dark cycle: only respiration

Green plant

In the light cycle: 1. Respiration 2. Photosynthesis



In the dark cycle: Only respiration





■ Think

- How do you design a controlled experiment to test your hypothesis?

■ Test

- Think again and design it again.
- Do you consider and control all the variable factors?



Experiment 1

Does germinating wheat produce carbon dioxide? (Please see instructions on page 5-2) use the following materials to design an experiment to test whether the germinating wheat produces carbon dioxide. Test tubes, stoppers, screws, phenol red solution, distilled water, germinating (living) wheat, dead wheat.

- A. Hypothesis:
- B. Description of experiment:
- C. Observations:
- D. Conclusions:



Experiment 2

Does the green plant elodea produce carbon dioxide? (Please see instructions on page 5-4). Use the following materials to design an experiment to test whether the green plant elodea produce carbon dioxide. Green plant elodea, water, bottles, and foil.

- A. Hypothesis:
- B. Description of experiment:
- C. Observations:
- D. Conclusions:



Experiment 3

- Does the green plant elodea use oxygen?
(Please see instructions on page 5-9). Use the following materials to design an experiment to test whether the green plant elodea use oxygen. Green plant elodea, water, bottles, and foil.
 - A. Hypothesis:
 - B. Description of experiment:
 - C. Observations:
 - D. Conclusions:



Experiment 4

- Do humans produce carbon dioxide? Use the following materials to design an experiment to test whether humans produce carbon dioxide. Test tubes, straws, phenol red solution, distilled water.
 - A. Hypothesis:
 - B. Description of experiment:
 - C. Observations:
 - D. Conclusions:



Experiment 5

- Do fish use oxygen? Use the following materials to test whether fish use oxygen. Fish, water, 2 jars, and 2 small bottles.
- A. Hypothesis:
- B. Description of experiment:
- C. Observations:
- D. Conclusions:



Experiment 6

- Does yeast use oxygen? Use the following materials to design an experiment to test whether yeast use oxygen. Several screw-type bottles, yeast suspension, 5% glucose, and water.
 - A. Hypothesis:
 - B. Description of experiment:
 - C. Observations:
 - D. Conclusions:



Exp 1

- Does germinating wheat produce carbon dioxide?
 - Solution:
 - Tube 1: with phenol red only → no color change
 - Tube 2: with phenol red + screw → no color change
 - Tube 3: with phenol red + screw and dead seeds → no color change
 - Tube 4: with phenol red + screw + and living seeds → color change red -> yellow

CO₂ makes phenol red turn yellow.
Phenol red ph needs to be adjusted to ph=7.0.



Exp2

- Does the green plant elodea produce carbon dioxide?
 - Solution:
 1. Dark + H₂O + elodea → red ⇒ yellow ↑ CO₂
 2. Dark + H₂O → no change
 3. Light + H₂O + elodea → no change (CO₂ is recycled for photosynthesis)
 4. Light + H₂O → no change
 - In the dark cycle:
 - $C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 6CO_2 + 12H_2O + \text{energy (ATP)}$
 - Mitochondria, respiration
CO₂ makes phenol red ⇌ yellow



Experiment 3

- Does the green plant elodea use oxygen?



Exp 4 :

■ Do human produce carbon dioxide?

– Solution:

- Tube 1: H_2O + pump + phenol red \rightarrow no change
- Tube 2 : H_2O + blow expired air into tube gently + phenol red \rightarrow red \Rightarrow yellow
- CO_2 makes phenol red turn yellow.



Exp. 5:

- Do fish use oxygen:

- Solution:

1. Water (with fish in it) → white precipitate (Mn(OH)_2)

because fish use O_2 in water

2. Water (with no fish in it) → brownish precipitate (MnO_2).

If the water contains O_2 , the wrinkler test will show yellow to brownish precipitate.



Exp. 6:

■ Does yeast use oxygen?

– Solution:

- Tube 1: glucose or H₂O present → yellow precipitate
- Tube 2: H₂O + glucose → yellow precipitate
- Tube 3: yeast + H₂O → yellow precipitate
O₂ present MnO₂
- Tube 4: H₂O + glucose + yeast → white precipitate
(use up O₂ ⇒ Mn(OH)₂)

