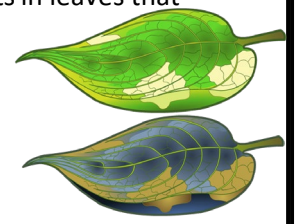
B4 – Bioenergetics

Photosynthesis

Endothermic chemical reaction that takes place in chloroplasts in leaves that produces glucose and oxygen from carbon dioxide and water



carbon dioxide	+	water	→ (light)	oxygen	+	glucose
$6CO_2$	+	$6H_2O$	→	$6O_2$	+	$C_6H_{12}O_6$

What do plants do with the glucose?

- Stored as starch
- Stored as fats and oils
- For making cellulose (for cell walls)
- For respiration
- For making amino acids (along with nitrates from soil)

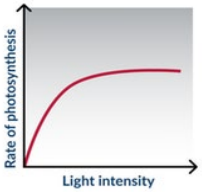
Testing the leaf for starch:

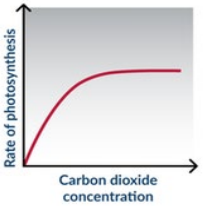
- Boil the leaf for 5 minutes to soften
- Put into heated ethanol to remove chlorophyll (turn off Bunsen burner!)
- Spread leaf on a white tile
- Add iodine
- In the places that contain starch the iodine will turn blue/black
- In a variegated leaf, only the parts containing chlorophyll turn blue black
- This shows chlorophyll is essential for photosynthesis

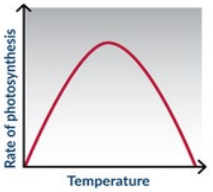
Factors the affect rate of photosynthesis

- Light
- Temperature
- CO_2 concentration

Whichever one is in the shortest supply is called the **limiting factor** – as it is the one limiting the rate of photosynthesis

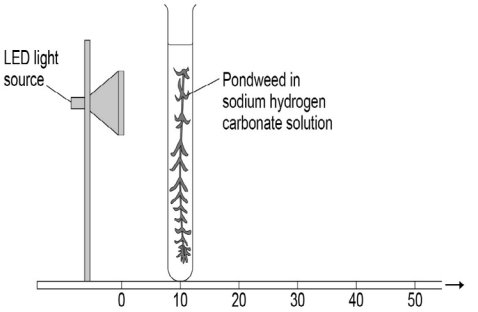






Increased light intensity increases the rate, but only up to a point, when CO_2 or temperature become limiting	Increased CO_2 conc increases the rate, but only up to a point, when light or temperature become limiting	Increased temperature increases the rate, but only up to a point, then the enzymes are denatured & rate drops

RP5 – Effect of light intensity on rate of photosynthesis



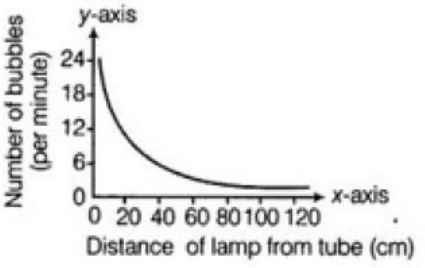
Independent variable: distance between lamp and plant (or light intensity)
Dependent variable – number of bubbles per second / rate of photosynthesis
Controls – temperature of solution, piece of pondweed

1. Measure 10cm length of pondweed and cut with scissors.
2. Place into beaker of 250ml $NaHCO_3$ solution. (this provides CO_2)
3. Place lamp 10cm away from pondweed – turn on lamp and leave for 2 minutes to adjust to light intensity.
4. Count number of bubbles produced in 60 seconds and record in table.
5. Repeat steps 3 and 4 for lamp distances of 20cm – 50cm at 10cm intervals.
6. Keep the temperature of the solution the same (LED light is used to not give off heat)

Inverse Square Law (HT only)

As distance of the lamp doubles the light intensity of the plant quarters $I = \frac{1}{d^2}$

Typical results:



As the **distance** between the lamp and the pondweed **increases**, the **number of bubbles per minute decreases**

B4 – Bioenergetics

Photosynthesis

1. What are the two reactants for photosynthesis?
2. What are the two products?
3. Where in a cell does this reaction happen?
4. Name two uses of glucose produced in photosynthesis.
5. What else is needed for plants to produce amino acids?
6. What chemical is used to test for starch?
7. Which parts of the leaf contain starch in a variegated leaf?

Factors the affect rate of photosynthesis

1. What are the three main factors that affect the rate of photosynthesis?
2. What is a 'limiting factor'?
3. Why does increasing the temperature above a certain point cause the rate to drop?
4. Describe the effect of increasing the concentration of CO_2 on the rate of photosynthesis

RP5 – Effect of light intensity on rate of photosynthesis

1. What is the independent variable in this investigation?
2. What needs to be kept the same?
3. What is the dependent variable?
4. Why is an LED lamp used rather than a regular lamp?
5. Why is sodium hydrogen carbonate solution used?
6. What is a good range and interval for the distance measurements?
7. Why is the plant left for 2 minutes every time the lamp is moved?
8. Describe the relationship between distance and the number of bubbles per minute

B4 – Bioenergetics

Photosynthesis

1. What are the two reactants for photosynthesis? Carbon dioxide and water
2. What are the two products? Glucose and oxygen
3. Where in a cell does this reaction happen? chloroplasts
4. Name two uses of glucose produced in photosynthesis. Turned into starch or used in respiration
5. What else is needed for plants to produce amino acids? nitrates
6. What chemical is used to test for starch? Add iodine, it will turn black
7. Which parts of the leaf contain starch in a variegated leaf? Just the green parts

Factors the affect rate of photosynthesis

1. What are the three main factors that affect the rate of photosynthesis? Light intensity, carbon dioxide concentration, temperature
2. What is a 'limiting factor'? The factor that is in the shortest supply and is holding up photosynthesis
3. Why does increasing the temperature above a certain point cause the rate to drop? The enzymes get denatured
4. Describe the effect of increasing the concentration of CO_2 on the rate of photosynthesis it will increase the rate of photosynthesis up to a point, and then it will remain constant

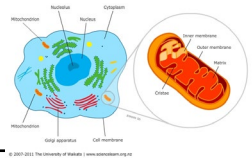
RP5 – Effect of light intensity on rate of photosynthesis

1. What is the independent variable in this investigation? Light intensity
2. What needs to be kept the same? Temperature, concentration of carbon dioxide
3. What is the dependent variable? Number of bubbles per minute
4. Why is an LED lamp used rather than a regular lamp? LED lamps don't get hot, so it wont affect the temperature of the water
5. Why is sodium hydrogen carbonate solution used? To provide carbon dioxide
6. What is a good range and interval for the distance measurements? 0-50 cm up in 10 cm
7. Why is the plant left for 2 minutes every time the lamp is moved? To make sure the rate of photosynthesis is constant
8. Describe the relationship between distance and the number of bubbles per minute. The closer the lamp is, the more bubbles of oxygen per minute.

B4 – Bioenergetics

Respiration

Respiration is a chemical reaction that happens in the mitochondria of cells to release energy from glucose.
There are two types – Aerobic and Anaerobic.



Aerobic: - with oxygen

oxygen + glucose → carbon dioxide + water

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

Organisms need energy for:
- chemical reactions to build larger molecules such as proteins, fats, glycogen
- movement
- keeping warm.

Exercise

During exercise, more energy is needed so that muscles can keep contracting.
This means more respiration is needed.

Increased breath depth - Get more oxygen into blood per breath and remove CO_2

Increased breathing rate - Get oxygen into blood quickly.

Increased heart rate - Get more oxygenated blood to muscles.

Heart beats harder - more blood is pumped with every beat.

During intense exercise, there is just not enough oxygen getting into the body.
The muscles start to respire anaerobically.
The build up of lactic acid can cause cramp/stitch.
(HT ONLY) When exercise is over, the lactic acid has to be oxidised to CO_2 and H_2O. The amount of oxygen needed to do this is called the oxygen debt

Anaerobic respiration

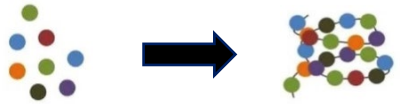
Respiration without oxygen

In animal cells = **glucose → lactic acid**
In plant/yeast cells = **glucose → ethanol + carbon dioxide**
In yeast, this is fermentation and is used in brewing and baking

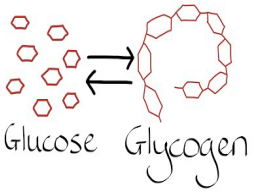
	Aerobic	**Anaerobic**
Oxygen used?	Yes	No
Waste products	CO_2 and H_2O	Lactic acid (animals) Ethanol + CO_2 (plants/yeast)
Energy released	Lots	Much less

Metabolism

Metabolism is the sum of all the reactions in a cell or the body.
The 'metabolic rate' is the rate at which all of these reactions take place.
An example of a reaction = making proteins using amino acids from digestion.



More examples:
- glucose → glycogen (in muscles/liver)
- respiration
- protein → urea
- glycerol and fatty acids → fats



B4 – Bioenergetics

Respiration

1. What is respiration?
2. Where does respiration take place?
3. What does aerobic mean?
4. Give two uses for the energy released from respiration
5. What are the two types of respiration?
6. What are the reactants in respiration?
7. Write the equation for respiration below

Exercise

1. Describe two changes to breathing during exercise
2. Why does breathing need to change during exercise?
3. What happens to heart rate during exercise?
4. When does anaerobic respiration happen?
5. Which chemical builds up in muscles during anaerobic respiration?

Anaerobic respiration

1. What is anaerobic respiration?
2. What is 'fermentation'?
3. What is the waste product of anaerobic respiration in humans?
4. What are the waste products of anaerobic respiration in plants and yeast cells?
5. Which type of respiration releases most energy?

Metabolism

1. What is the metabolic rate?
2. Give two examples of metabolic reactions other than respiration
3. What is glucose stored as in muscles?
4. What are fats made of?

B4 – Bioenergetics

Respiration

1. What is respiration? The chemical reaction that releases energy from glucose
2. Where does respiration take place? mitochondria
3. What does aerobic mean? Using oxygen
4. Give two uses for the energy released from respiration muscle contraction, keeping body temperature at 37°C
5. What are the two types of respiration? Aerobic and anaerobic
6. What are the reactants in respiration? Glucose and oxygen
7. Write the equation for respiration below
   Glucose + oxygen → carbon dioxide + water

Exercise

1. Describe two changes to breathing during exercise breathing gets faster and deeper
2. Why does breathing need to change during exercise? To get more oxygen in for respiration, and to get rid of more carbon dioxide
3. What happens to heart rate during exercise? It pumps harder and faster
4. When does anaerobic respiration happen? When there is not enough oxygen to respire aerobically – usually during intense exercise
5. Which chemical builds up in muscles during anaerobic respiration? Lactic acid

Anaerobic respiration

1. What is anaerobic respiration? Respiration without oxygen
2. What is 'fermentation'? Yeast respiring without oxygen
3. What is the waste product of anaerobic respiration in humans? Lactic acid
4. What are the waste products of anaerobic respiration in plants and yeast cells? Ethanol and carbon dioxide
5. Which type of respiration releases most energy? aerobic

Metabolism

1. What is the metabolic rate? The rate at which all chemical reactions in cells happen
2. Give two examples of metabolic reactions other than respiration making proteins, making fats
3. What is glucose stored as in muscles? glycogen
4. What are fats made of? Fatty acids and glycerol