CAIE Biology A-level

Topic 12: Energy and Respiration

Flashcards

Why do we need ATP (energy)?

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- Anabolic reactions e.g. synthesis of DNA and proteins
- Active transport
- Movement
- Homeostasis

Why is ATP used for energy?

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- ATP is tri-phosphorylated. The removal of each phosphate releases energy.
- ATP is easily hydrolysed and water-soluble (easy to transport), making it a useful source of energy.

Name the four main stages of aerobic respiration and state where they occur.

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- **Glycolysis** - cytosol
- **Link reaction** - mitochondrial matrix
- **Krebs cycle** - mitochondrial matrix
- **Electron transport chain** - inner mitochondrial membrane

Outline the stages of glycolysis.

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1. Glucose (hexose sugar) phosphorylated to hexose bisphosphate by 2× ATP
2. Hexose bisphosphate splits into 2× **triose phosphate** (TP)
3. 2 molecules of TP oxidised to 2× **pyruvate**

Net gain of 2× reduced NAD (NADH) and 2× ATP per glucose.

Draw a flowchart to explain glycolysis.

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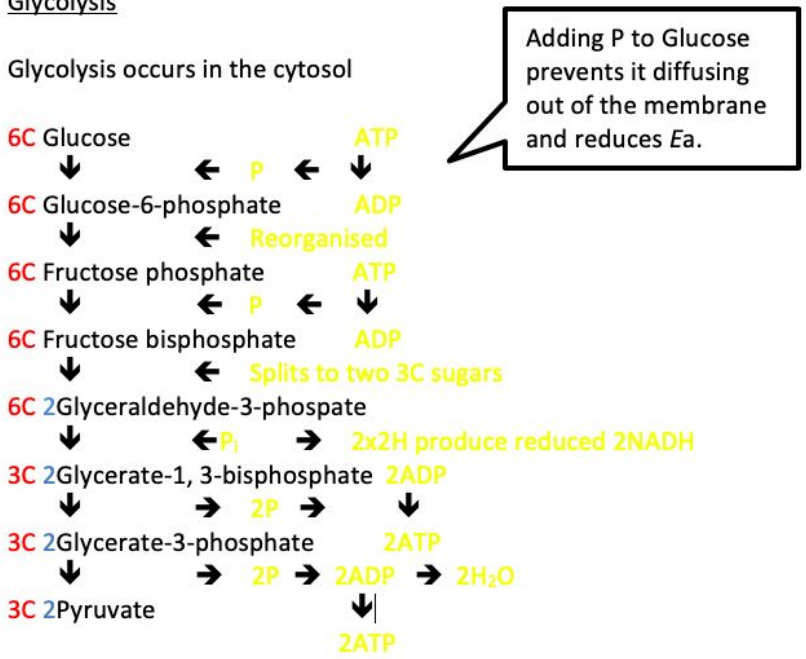

How does pyruvate from glycolysis enter the mitochondria?

How does pyruvate from glycolysis enter the mitochondria?

Via active transport (**oxygen** is required)

What happens during the link reaction?

What happens during the link reaction?

1. **Oxidative decarboxylation** and **dehydrogenation** of pyruvate to form **acetate**

   Net gain of CO_2 and 2× reduced NAD

2. Acetate combines with coenzyme A (CoA) to form **acetyl coenzyme A**

Draw a flowchart to summarise the link reaction.

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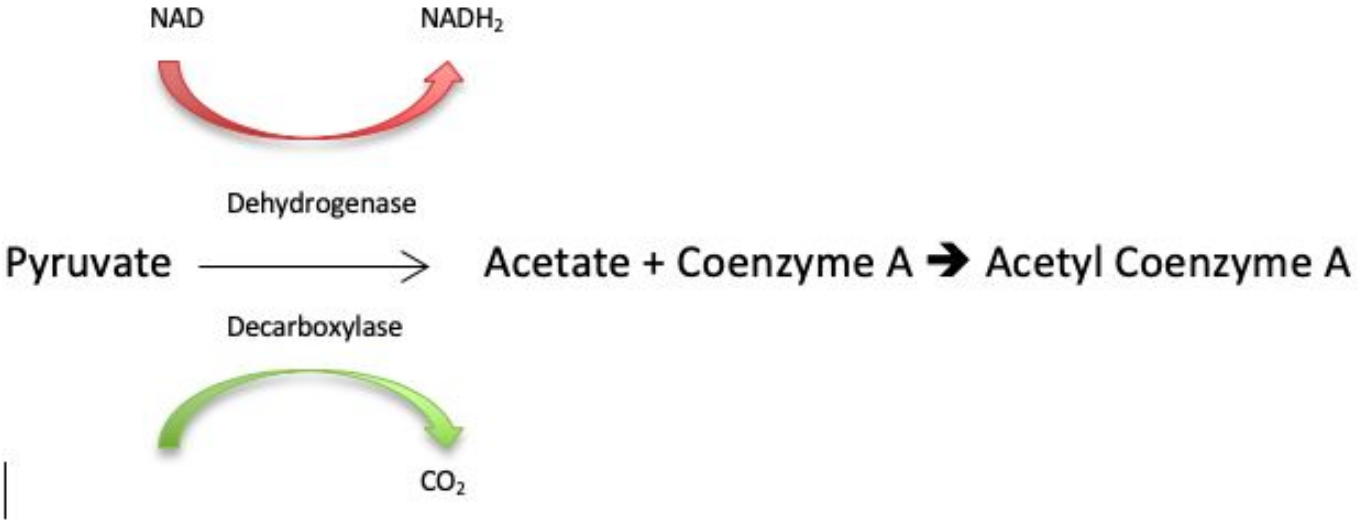

Define “substrate level phosphorylation”.

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The synthesis of ATP by the transfer of a phosphate group from a phosphorylated intermediate to ADP.

What happens in the Krebs cycle?

What happens in the Krebs cycle?

Series of redox reactions that produces:

- ATP by substrate-level phosphorylation
- Reduced coenzymes
- CO_2 from decarboxylation

Begins when the acetyl group from Acetyl CoA (2C) reacts with oxaloacetate (4C).The cycle regenerates oxaloacetate.

Draw a diagram to explain the Krebs cycle.

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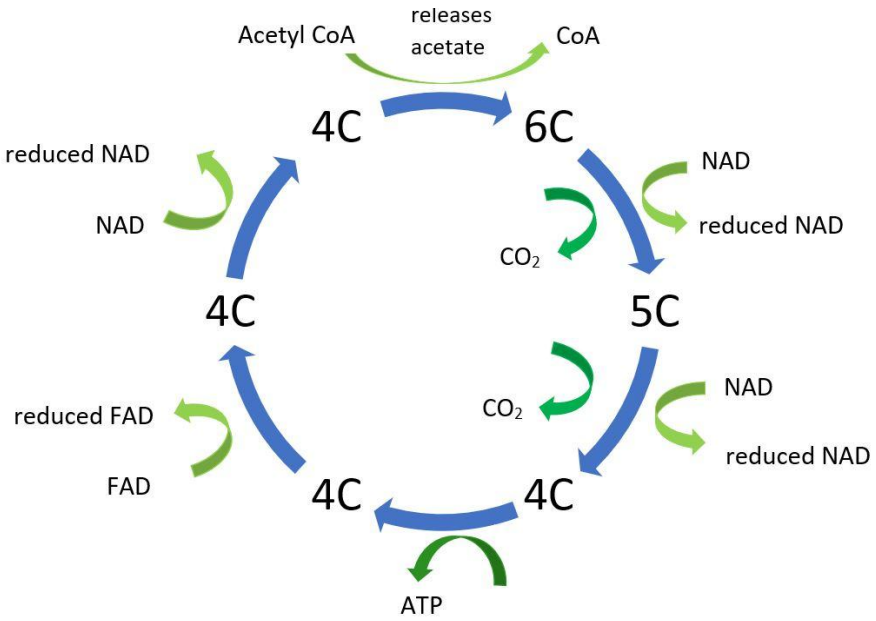

What is the electron transfer chain (ETC)?

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- Series of carrier proteins embedded in the membrane of the cristae of mitochondria
- Produces ATP through oxidative phosphorylation via chemiosmosis during aerobic respiration

What happens in the electron transfer chain (ETC)?

What happens in the electron transfer chain (ETC)?

- Electrons released from reduced NAD and FAD undergo successive redox reactions
- The energy released is coupled to maintaining the proton gradient or is released as heat
- Oxygen acts as the final electron acceptor

How does chemiosmosis produce ATP during aerobic respiration?

How does chemiosmosis produce ATP during aerobic respiration?

Some energy released from the ETC is coupled to the active transport of H^+ ions (protons) from the mitochondrial matrix into the intermembrane space.

H^+ ions move down their concentration gradient into the mitochondrial matrix via the channel protein ATP synthase.

ATP synthase catalyses ADP + Pi → ATP

Note: chemiosmosis also occurs in photosynthesis in chloroplasts.

Draw a diagram to represent the ETC and chemiosmosis.

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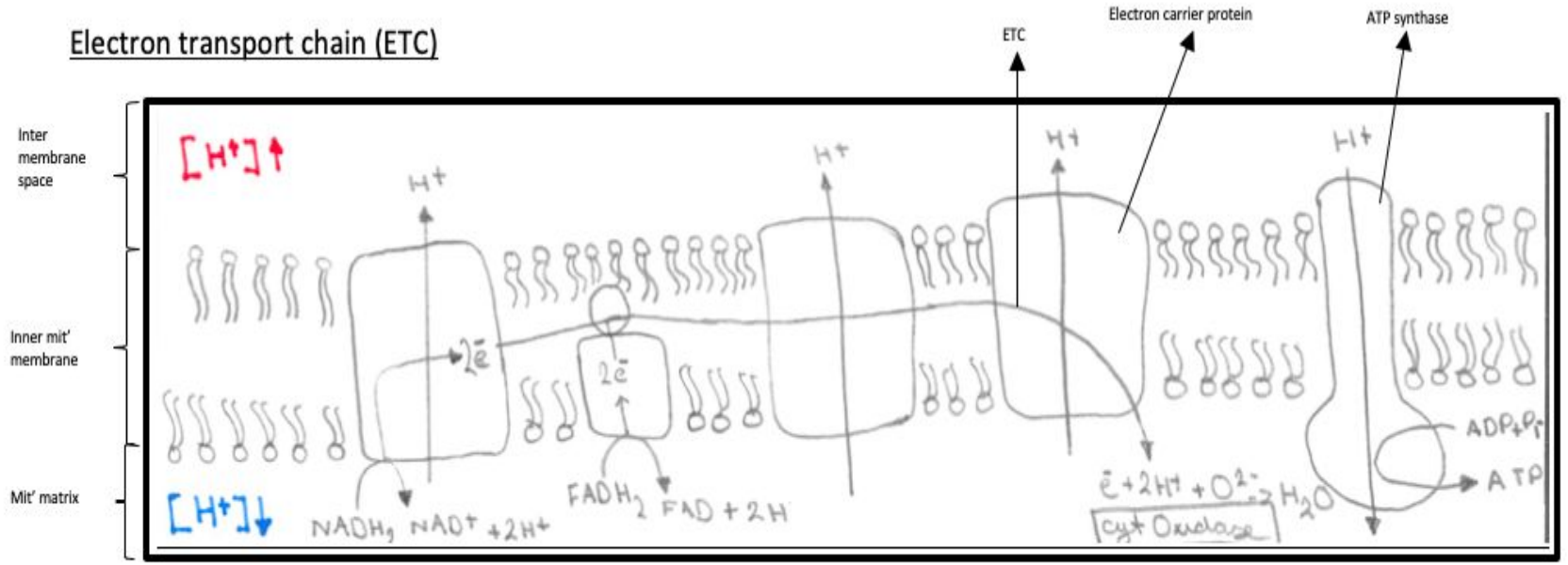

Mitochondrial membrane showing ETC & chemiosmosis

State the role of oxygen in the electron transfer chain.

State the role of oxygen in the electron transfer chain.

Final electron acceptor:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

Name the stages in respiration that produce ATP by substrate-level phosphorylation.

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- Glycolysis (anaerobic)
- Krebs cycle (aerobic)

What is the respiratory quotient? Write the equation.

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Ratio of CO_2 produced to O_2 consumed.

$RQ = CO_2/O_2$

What is the RQ of carbohydrates, lipids and proteins?

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- Carbohydrates: 1
- Lipids: 0.7-0.72
- Proteins: 0.8-0.9

What could an RQ of greater than 1 indicate?

What could an RQ of greater than 1 indicate?

- May indicate the conversion of carbohydrates to lipids
- RQ in anaerobic respiration is ∞

Why do different respiratory substrates have different relative energy values?

Why do different respiratory substrates have different relative energy values?

Depends on the number of hydrogens in the structure which are oxidised to water e.g. the number of hydrogens is greater in fatty acids than carbohydrates.

Outline anaerobic respiration in muscle cells.

Outline anaerobic respiration in muscle cells.

- Only glycolysis continues
- Reduced NAD (product of glycolysis) transfers the H to pyruvate, forming **lactic acid** and regenerating NAD
- Catalysed by enzyme lactate dehydrogenase

Draw a flowchart to show how lactic acid is produced during anaerobic respiration in muscle cells.

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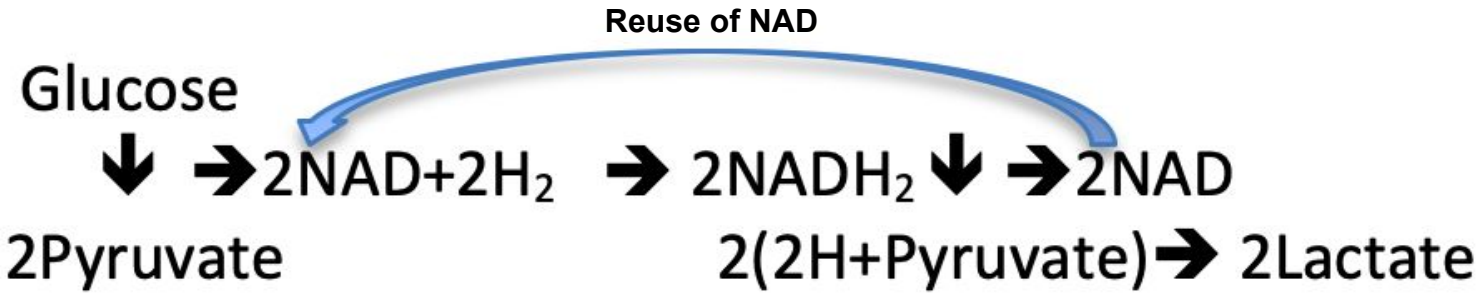

Outline anaerobic respiration in plants and microorganisms.

Outline anaerobic respiration in plants and microorganisms.

- Only glycolysis continues
- Pyruvate is decarboxylated to form ethanal
- Ethanal accepts a H from reduced NAD making ethanol. NAD regenerated for glycolysis
- Less ATP is produced than in aerobic respiration

Draw a flowchart to show how ethanol is produced during anaerobic respiration in plants and microorganisms.

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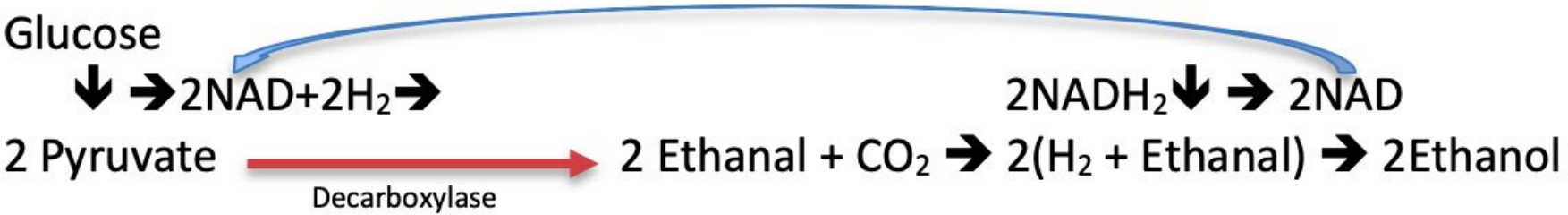

Name two types of molecules that can be used as alternative respiratory substrates.

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- (amino acids from) proteins
- (glycerol and fatty acids from) lipids

Compare the efficiency of aerobic and anaerobic respiration.

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Hydrolysis of 1 mole glucose produces 2880 kJ. 1 molecule ATP produces 30.6 kJ. In aerobic respiration 32 ATP are gained whereas in anaerobic 2 ATP are gained.

- Aerobic efficiency= [(32 × 30.6)/2800] × 100 = 34%
- Anaerobic efficiency= [(2 × 30.6)/2800] × 100 = 2.1%
- Aerobic respiration is = 34/2.1= 16.2× more efficient than anaerobic

Define oxygen debt and oxygen deficit.

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- **Oxygen debt** (also referred to as Excess Post-Exercise Oxygen Consumption or EPOC) is the amount of additional O_2 needed after exercise to return body systems to their previous state

- **Oxygen deficit** is the volume of O_2 required during exercise minus volume of O_2 obtained

How is rice adapted for growth in a low oxygen environment?

How is rice adapted for growth in a low oxygen environment?

- Rapid growth maintains flowering parts above water line allowing gas exchange through the leaves
- Aerenchyma in stem allows gases to move to submerged parts of the plant
- Hydrophobic coating on leaves maintains air film around plant
- Root cells produce alcohol dehydrogenase to offset ethanol toxicity from anaerobic respiration

How can DCPIP be used to measure respiration in yeast?

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To establish the chemiosmotic gradient, H^+ is pumped out of the matrix. H^+ reduces DCPIP producing a colour change from blue to colourless. The rate at which this change takes place allows us to measure the rate of respiration in yeast.

Define the term “respirometer”.

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A device used to determine respiration rate in living organisms by measuring the change in volume of oxygen or carbon dioxide.

How could a student calculate the rate of respiration using a respirometer?

How could a student calculate the rate of respiration using a respirometer?

volume of O_2 produced or CO_2 consumed/ time × mass of sample

volume = distance moved by coloured drop × $(0.5 \times \text{capillary tube diameter})^2 \times \pi$