Respiration Introduction

A Level

Part A Respiration definition

Respiration is the process by which biological molecules (e.g. carbohydrates) are broken down into smaller molecules to produce energy. This energy is used to add a [ ] group to [ ], producing [ ], which acts as an energy storage molecule. It can then transfer this energy to other molecules by [ ] them.

Respiration can occur [ ] (without oxygen) or [ ] (with oxygen).

Items:

adenosine triphosphate (ATP) **methyl** **phosphate** **adenosine diphosphate (ADP)** **aerobically** **phosphorylating** **methylating** **anaerobically**

Part B Aerobic respiration equation

Complete the equation to give the correct (and balanced) general equation for aerobic respiration of one glucose molecule.

$$+ O_2 \longrightarrow 6\,CO_2 + 6$$

Part C Aerobic vs anaerobic

Fill in the table below to identify which processes are part of aerobic respiration, which are part of anaerobic respiration, and which are part of both.

Process	Part of which type of respiration
Glycolysis	
Link reaction (oxidative decarboxylation)	
Krebs cycle (citric acid cycle)	
Oxidative phosphorylation	
Fermentation	

Items:

aerobic respiration **anaerobic respiration** **both types**

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Glycolysis

A Level

Glycolysis is the process by which glucose is broken down into pyruvate. This process is the first step of both anaerobic and aerobic respiration.

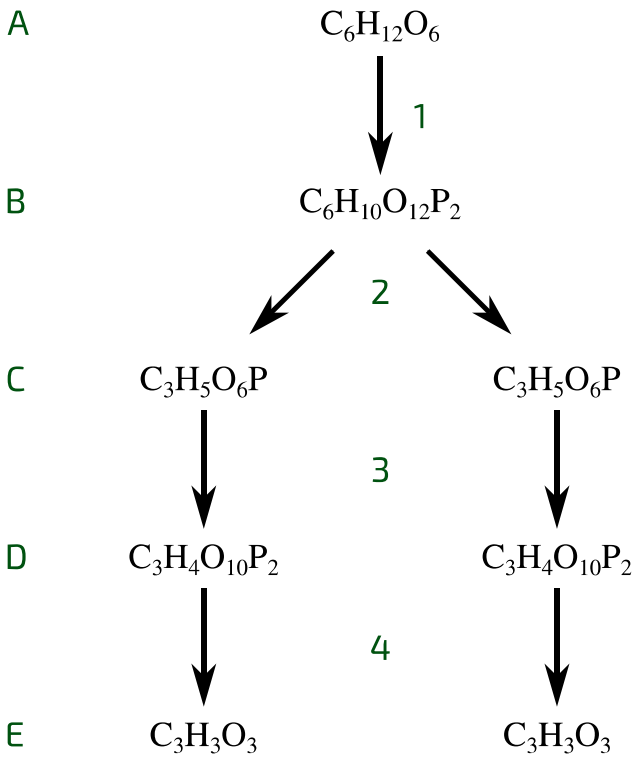

Figure 1: An overview of glycolysis. Molecules are labelled with letters (A-E), and individual steps (indicated by arrows) are labelled with numbers (1-4). Note that only some of the intermediate molecules/steps involved in glycolysis are shown.

Part A Match the molecules

Match the molecule names to the letters in **Figure 1**.

Letter	Molecule name
A	
B	
C	
D	
E	

Items:

pyruvate **glucose** **triose phosphate (glyceraldehyde-3-phosphate)** **hexose bisphosphate** **triose bisphosphate**

Part B Phosphorylation

What molecule is responsible for phosphorylating molecule A to help convert it into molecule B during step 1?

How many of these molecules are used up during step 1?

Part C Oxidation and reduction

During step 3, molecule C gains another phosphate group via free phosphate ions in the cell. For this to happen, it has to be oxidised (i.e. lose electrons).

What molecule accepts these electrons (i.e. is reduced)?

How many of these molecules are used up during step 3?

Part D Dephosphorylation

During step 4, molecule D is dephosphorylated to help convert it into molecule E.

These phosphate groups are used to produce which molecule?

How many of these molecules are produced during step 4?

Part E Net results

Fill in the table below to give the net loss/gain of each molecule during glycolysis.

Molecule	Net result
glucose	−1
pyruvate	
ATP	
NAD^+	
NADH	

Items:

−2 | −1 | 0 | +1 | +2 | +3 | +4

The Link Reaction

A Level

The link reaction (also called pyruvate decarboxylation, or oxidative decarboxylation) is the stage of aerobic respiration that occurs after glycolysis.

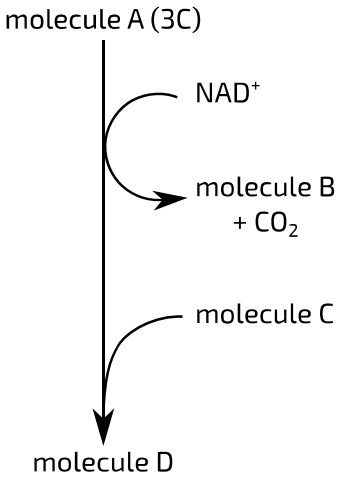

Figure 1: An overview of the link reaction. Certain molecules are labelled with letters (A-D). Molecule A is a three-carbon molecule.

Part A Match the molecule

Match the names to the molecules in **Figure 1**.

Molecule	Name
A	
B	
C	
D	

Items:

coenzyme A (CoA) | acetyl coenzyme A (acetyl CoA) | pyruvate | NADH (reduced NAD)

Part B Net results

Fill in the table below to give the net loss/gain of each molecule during this stage of respiration, **per molecule of glucose**.

Molecule	Net result
NAD^+	
NADH	
CO_2	

Items:

−2 | −1 | 0 | +1 | +2

Part C Cell location

Where does the link reaction occur in eukaryotic cells?

- at the inner mitochondrial membrane
- in the cytoplasm
- in the chloroplast stroma
- in the mitochondrial matrix
- at the thylakoid membranes
- at the outer mitochondrial membrane

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Krebs Cycle

A Level

Krebs Cycle (also called the citric acid cycle, or the tricarboxylic acid (TCA) cycle) is the stage of aerobic respiration that occurs after the link reaction.

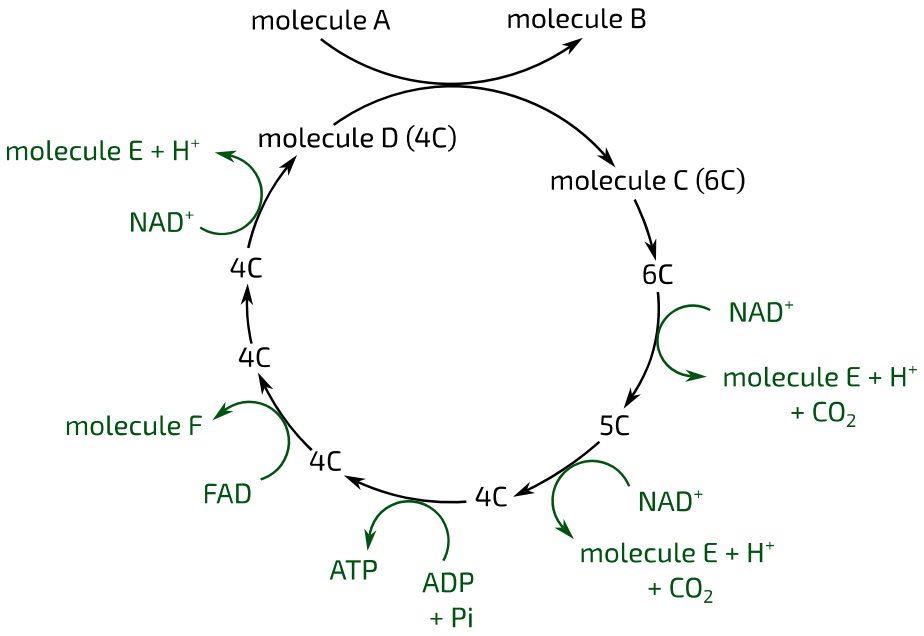

Figure 1: An overview of Krebs cycle. Certain molecules are labelled with letters (A-F). The number of carbons present in each intermediate molecule is shown e.g. 5C. Arrows represent the steps within Krebs cycle. Pi = inorganic phosphate.

Part A Match the molecule

Match the names to the molecules in **Figure 1**.

Molecule	Name
A	
B	
C	
D	
E	
F	

Items:

coenzyme A (CoA) **acetyl coenzyme A (acetyl CoA)** **citrate** **oxaloacetate** **NADH (reduced NAD)** **$FADH_2$ (reduced FAD)**

Part B Net results

Fill in the table below to give the net loss/gain of each molecule during this stage of respiration, **per molecule of glucose**.

Molecule	Net result
ATP	
NAD^+	
NADH	
FAD	
$FADH_2$	
CO_2	

Items:

−6 −5 −4 −3 −2 −1 0 +1 +2 +3 +4 +5 +6

Part C Cell location

Where does Krebs cycle occur in eukaryotic cells?

- at the outer mitochondrial membrane
- in the chloroplast stroma
- in the mitochondrial matrix
- at the thylakoid membranes
- at the inner mitochondrial membrane
- in the cytoplasm

Fermentation

A Level

Aerobic respiration is the main form of respiration in eukaryotic cells. However, some eukaryotic cells can respire anaerobically. This requires a process called fermentation.

Part A Why ferment?

Aerobic respiration is much more efficient at producing [ ] than anaerobic respiration. However, aerobic respiration requires oxygen to act as the final electron acceptor during [ ]. Without oxygen, this process will stop working.

Importantly, this means that [ ] will no longer be oxidised to regenerate [ ], which is necessary for every other stage of aerobic respiration. Fermentation allows the cell to regenerate this molecule when there is not enough oxygen for aerobic respiration, which means the cell can keep respiring anaerobically (i.e. cycle between [ ] and fermentation).

However, most cells cannot keep doing this indefinitely, as the products of fermentation are toxic at high levels.

Items:

ATP | ADP | oxidative phosphorylation | the link reaction | Krebs cycle | NADH (reduced NAD) | glycolysis | NAD^+

Part B Mammals

What is pyruvate reduced to in mammal cells during fermentation?

Part C Plants and yeast

What is pyruvate reduced to in plant cells and yeast cells during fermentation?

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Aerobic vs Anaerobic Respiration

A Level

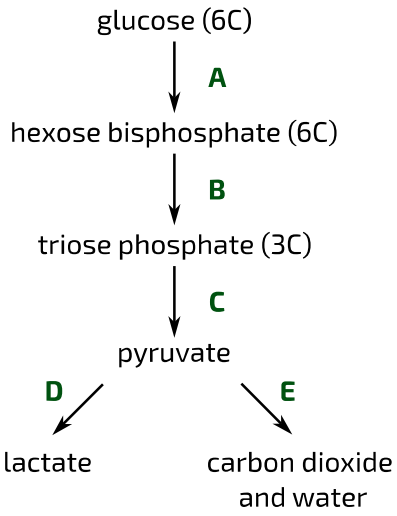

Figure 1: Two alternative pathways in mammalian respiration. Processes are shown as arrows and labelled A-E. Only some steps are shown in each process.

Part A Process names

Processes A, B, and C make up one larger process. What is the name of this process?

What is the name of process D?

Part B Using ATP

Select the process/processes in which ATP is used. Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Part C Oxidising NADH without ATP

Select the process/processes in which NADH (reduced NAD) is oxidised to NAD^+ **without** ATP formation. Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Part D Producing ATP

Select the process/processes in which ATP is produced **outside** the mitochondria. Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Part E Using oxygen

Select the process/processes for which oxygen is required. Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Part F Reducing NAD

Select the process/processes in which NAD^+ is reduced to form NADH (reduced NAD). Select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E

Adapted with permission from OCR A Level June 1999, Science Modular Central Concepts in Biology, Question 1