

The Light-independent Stage (Calvin Cycle)

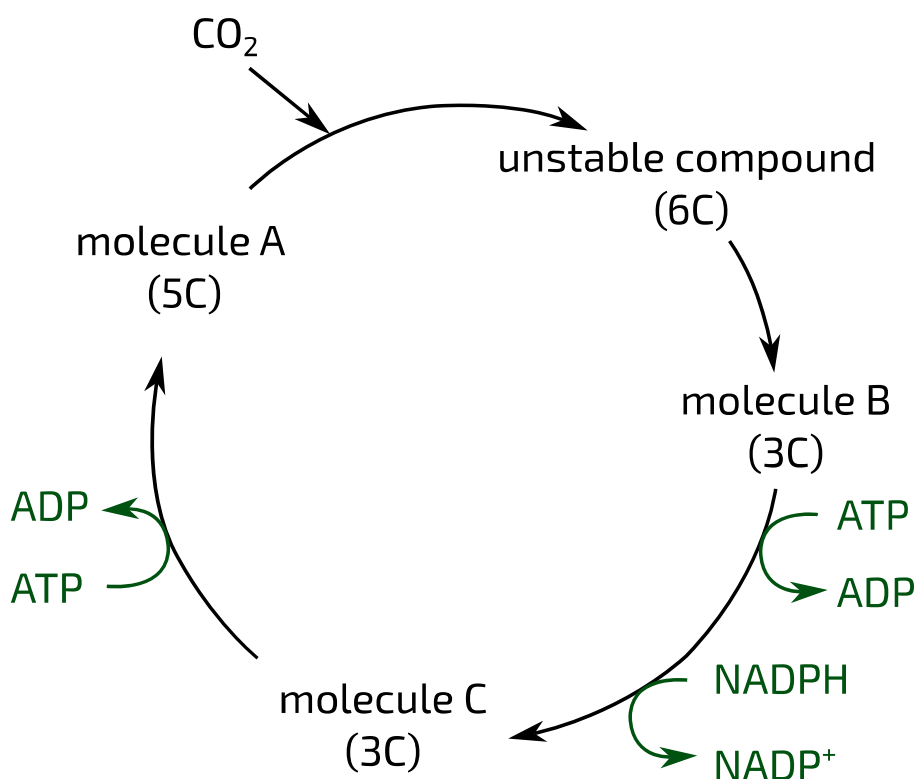


Figure 1: An overview of the light-independent stage of photosynthesis, also called the Calvin cycle. The number of carbons present in each molecule is shown e.g. 5C.

Part A Molecule A

What is the name of molecule A, the 5-carbon compound that reacts with carbon dioxide to form an unstable 6-carbon compound?

What is the name of the enzyme that catalyses this reaction?

Part B Molecules B and C

What is the name of molecule B, the 3-carbon compound that is reduced to form molecule C?

What is the name of molecule C, the 3-carbon compound that is used in the formation of sugars, lipids, and amino acids - as well as in the regeneration of molecule A?

Part C Numbers of molecules

For each molecule of CO_2 that is "fixed" (i.e. reacts with molecule A to form the unstable 6C compound), two copies of molecule C are produced.

If 5 out of every 6 copies of molecule C are used in the regeneration of molecule A, how many molecules of CO_2 are required to produce one molecule of glucose?

How many molecules of ATP would this require?

Note that one molecule of ATP is required to regenerate each copy of molecule A, and one molecule of ATP is required to convert molecule B into molecule C.

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Krebs Cycle vs Calvin Cycle

Part A Comparison table

	Krebs cycle	Calvin cycle
location	<input type="text"/>	<input type="text"/>
electron carriers: reduced or oxidised	<input type="text"/>	<input type="text"/>
carbon dioxide: used or produced	<input type="text"/>	<input type="text"/>
ATP: used or produced	<input type="text"/>	<input type="text"/>

Items:

cytoplasm

mitochondrial matrix

mitochondrial inner membrane

chloroplast stroma

chloroplast thylakoid membrane

reduced

oxidised

used

produced

Part B Electron carriers

What is the name of the main electron carrier in aerobic respiration?

What is the name of the main electron carrier in photosynthesis?

Part C Limiting factors

Which of the following may act as limiting factors in the Krebs cycle? Select all that apply.

- ☐ CO₂ availability
 - ☐ NAD⁺ availability
 - ☐ NADH availability
 - ☐ NADP⁺ availability
 - ☐ NADPH availability
 - ☐ ATP availability
 - ☐ ADP availability
-

Which of the following may act as limiting factors in the Calvin cycle? Select all that apply.

- ☐ CO₂ availability
 - ☐ NAD⁺ availability
 - ☐ NADH availability
 - ☐ NADP⁺ availability
 - ☐ NADPH availability
 - ☐ ATP availability
 - ☐ ADP availability
-

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Leaf Discs Experiment

A Level



Leaf discs were cut from destarched plants and placed either in water or in a glucose solution, and were exposed to air enriched with carbon dioxide.

The discs were kept under these conditions for 24 hours at 20 °C in either light or dark.

At the end of 24 hours the leaf discs were tested for starch. The results are shown in the table below.

	Discs in water	Discs in glucose solution
Light	✓	✓
Dark	×	✓

Part A Respiration and photosynthesis

ATP is required in the synthesis of starch. ATP is produced by the phosphorylation of ADP during both respiration and photosynthesis.

In the table below, show which process(es) occurred in each experimental group.

	Discs in water	Discs in glucose solution
Light	<input type="text"/>	<input type="text"/>
Dark	<input type="text"/>	<input type="text"/>

Items:

photosynthesis only

respiration only

both respiration and photosynthesis

neither

Part B Testing for starch

What is the name of the test that would most likely be used to test the leaf discs for starch?

Part C Amino acid synthesis

The triose phosphate produced in the light-independent stage of photosynthesis can be used to produce glucose and other carbohydrates, but it can also be used to produce amino acids.

In addition to those found in carbon dioxide and water, which element (that is present in all amino acids) do plants need to produce amino acids?

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Chloroplasts and Mitochondria

A Level

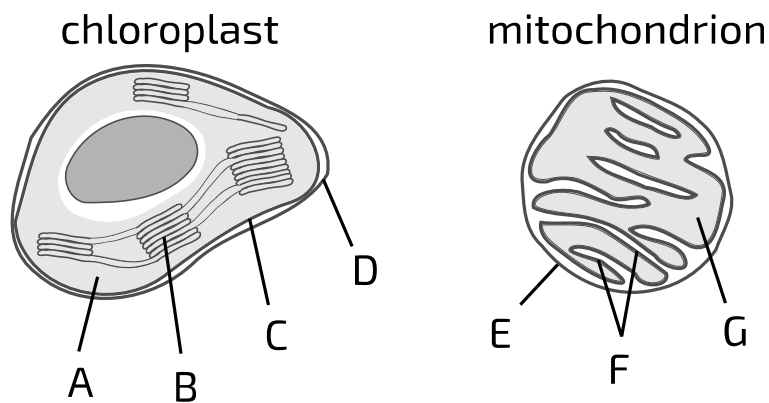


Figure 1: A diagram of a chloroplast and a mitochondrion. Different parts of the two organelles are labelled (A-G). The organelles are not shown to scale. The dark, oval-shaped structure in the chloroplast is a starch grain.

Part A Label the diagram

Match the descriptions to the labels in the table below.

Label	Description
A	<input type="text"/>
B	<input type="text"/>
C	<input type="text"/>
D	<input type="text"/>
E	<input type="text"/>
F	<input type="text"/>
G	<input type="text"/>

Items:

thylakoid membrane

chloroplast inner membrane

matrix

stroma

chloroplast outer membrane

mitochondrial outer membrane

cristae (folds of the mitochondrial inner membrane)

Part B Stages of photosynthesis

Match the labels from **Figure 1** to the following processes, to show where in the organelle they occur (or select "none of the above" if they do not occur in either organelle).

- The light-dependent stage of photosynthesis:
- The light-independent stage of photosynthesis:

Items:

A

B

C

D

E

F

G

none of the above

Part C Stages of aerobic respiration

Match the labels from **Figure 1** to the following processes, to show where in the organelle they occur (or select "none of the above" if they do not occur in either organelle).

- Glycolysis:
- The link reaction:
- Krebs cycle:
- Oxidative phosphorylation:

Items:

A	B	C	D	E	F	G	none of the above
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Photosynthesis vs Respiration

Part A Processes

In the table below, identify whether the processes occur during respiration or photosynthesis, and give the specific stage during which that process occurs.

Process	Respiration or Photosynthesis	Stage
A 6-carbon compound goes through a series of reactions to produce a 4- carbon compound. CO_2 is produced.	<input type="text"/>	<input type="text"/>
Water is split into oxygen, hydrogen ions (protons), and electrons.	<input type="text"/>	<input type="text"/>
Oxygen reacts with electrons and hydrogen ions (protons) to produce water.	<input type="text"/>	<input type="text"/>
CO_2 reacts with a 5-carbon compound to produce a 6-carbon compound, which then breaks down into two 3-carbon compounds.	<input type="text"/>	<input type="text"/>
Glucose is broken down into two pyruvate molecules. NADH and ATP are produced.	<input type="text"/>	<input type="text"/>
Pyruvate is used to make acetyl CoA. NADH and CO_2 are produced.	<input type="text"/>	<input type="text"/>

Items:

respiration

photosynthesis

glycolysis

the link reaction

Krebs cycle

oxidative phosphorylation

the light-dependent stage

the light-independent stage

Part B Locations

In the table below, identify whether the stages are part of respiration or photosynthesis, and give the specific location of that stage.

Stage	Respiration or Photosynthesis	Location
the link reaction	<input type="text"/>	<input type="text"/>
Calvin cycle	<input type="text"/>	<input type="text"/>
Krebs cycle	<input type="text"/>	<input type="text"/>
non-cyclic photophosphorylation	<input type="text"/>	<input type="text"/>
oxidative phosphorylation	<input type="text"/>	<input type="text"/>
glycolysis	<input type="text"/>	<input type="text"/>

Items:

respiration

photosynthesis

cytoplasm

mitochondrial matrix

mitochondrial inner membrane

chloroplast stroma

chloroplast thylakoid membrane

Part C ATP production

Which of the following stages directly result in the production of ATP? Select all that apply.

- ☐ glycolysis
- ☐ the link reaction
- ☐ Krebs cycle
- ☐ oxidative phosphorylation
- ☐ the light-dependent stage
- ☐ the light-independent stage

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Photosynthesis Summary



Part A Reducing chlorophyll

Which process releases electrons that return chlorophyll molecules to their reduced state?

- ☐ carbon fixation
 - ☐ phosphorylation of ADP
 - ☐ active transport of hydrogen ions across the thylakoid membrane
 - ☐ activation of photosystem I
 - ☐ reduction of glycerate phosphate to triose phosphate
 - ☐ photolysis of water
 - ☐ oxidation of NADPH (reduced NADP)
 - ☐ regeneration of ribulose biphosphate (RuBP)
-

Part B Linking stages

Which of the following are products of the light-dependent stage that are used in the light-independent stage? Select all that apply.

- ☐ ribulose biphosphate (RuBP)
 - ☐ NADPH (reduced NADP)
 - ☐ ATP
 - ☐ NADP⁺
 - ☐ CO₂
 - ☐ O₂
 - ☐ ADP
 - ☐ glucose
-

Part C Radioactive labelling

Carbon dioxide labelled with ¹⁴C has been used to identify the intermediate compounds in the light-independent stage of photosynthesis.

Which of the following compounds would be the first to contain the ¹⁴C?

- ☐ glucose
 - ☐ glycerate phosphate
 - ☐ lactic acid
 - ☐ ribulose biphosphate (RuBP)
 - ☐ acetyl CoA
 - ☐ triose phosphate (glyceraldehyde 3-phosphate)
 - ☐ citrate
 - ☐ oxaloacetate
-

Question elements adapted with permission from CIE A Level November 2000 Paper 2 Question 26, CIE A Level June 1999 Paper 2 Question 26, and CIE A Level June 2001 Paper 2 Question 24

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