



The Light-independent Stage (Calvin Cycle)

Subject & topics: Biology | Biochemistry | Photosynthesis

Stage & difficulty: A Level P3

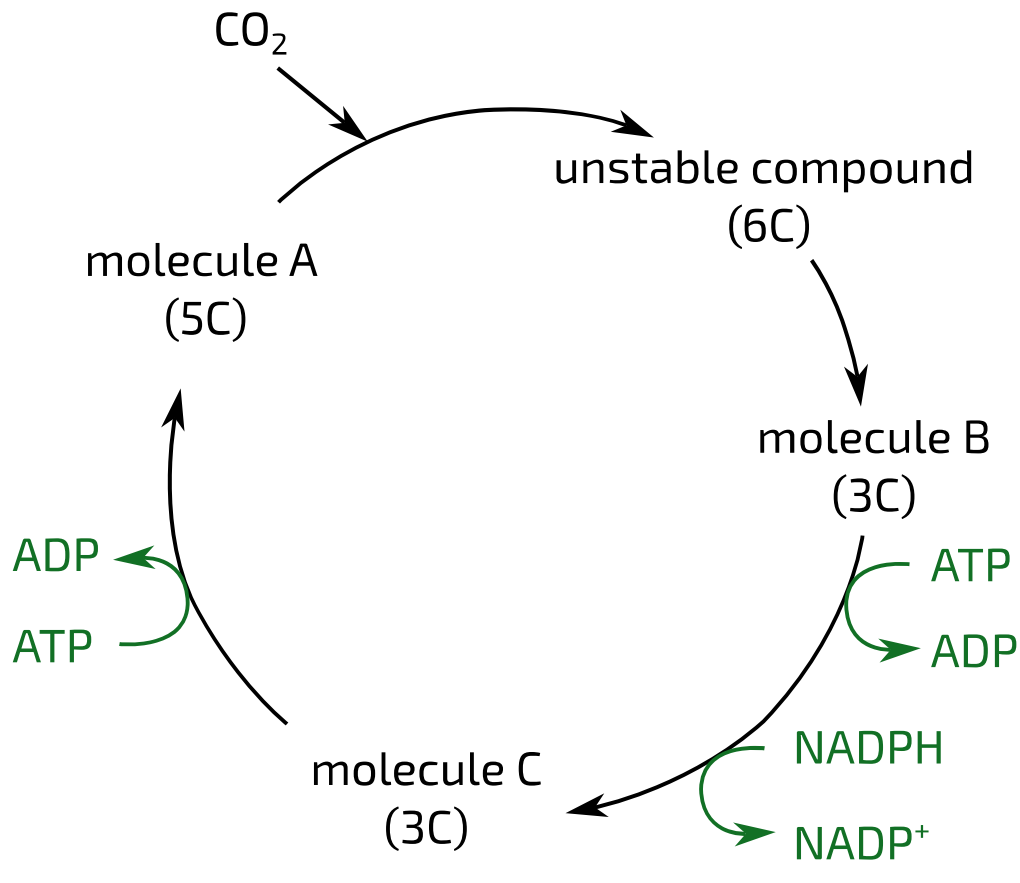


Figure 1: An overview of the light-independent stage of photosynthesis, also called the Calvin cycle. The number of carbons present in each molecule is shown e.g. 5C.

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.

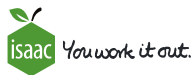
If 5 out of every 6 copies of molecule C are used in the regeneration of molecule A, how many molecules of CO_2 are required to produce one molecule of glucose?

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.



Adapted with permission from OCR A Level November 1999, Central Concepts in Biology, Question 5



Krebs Cycle vs Calvin Cycle

Subject & topics: Biology | Biochemistry | Photosynthesis**Stage & difficulty:** A Level P3**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:



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



Adapted with permission from OCR A Level January 2002 Central Concepts in Biology Question 2

Question deck:

STEM SMART Biology Week 35 - Photosynthesis 2



Leaf Discs Experiment

Subject & topics: Biology | Biochemistry | Photosynthesis**Stage & difficulty:** A Level C1

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) was/were responsible for producing ATP in each experimental group. If neither process occurred, select "neither".

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

Items:



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?



Adapted with permission from OCR A Level June 2001, Central Concepts in Biology, Question 5

Question deck:

STEM SMART Biology Week 35 - Photosynthesis 2

Chloroplasts and Mitochondria

Subject & topics: Biology | Biochemistry | Photosynthesis

Stage & difficulty: A Level P3

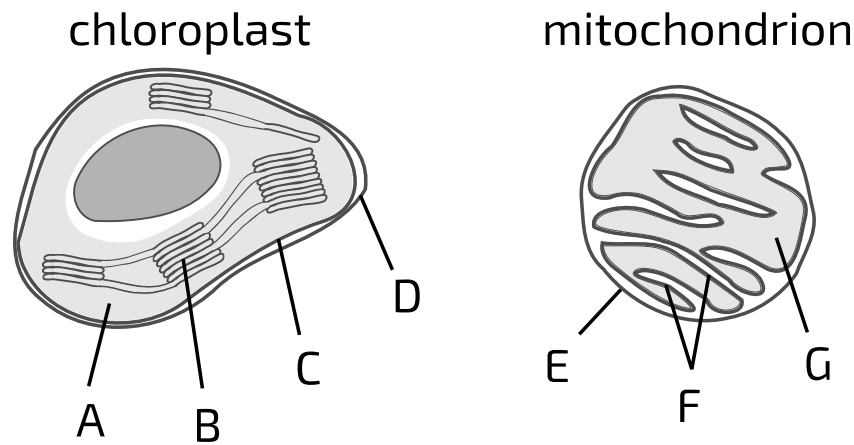


Figure 1: A diagram of a chloroplast and a mitochondrion. Different parts of the two organelles are labelled (A-G). The organelles are not shown to scale. The dark, oval-shaped structure in the chloroplast is a starch grain.

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:



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:



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:



Created for isaacphysics.org by Lewis Thomson

Question deck:

STEM SMART Biology Week 35 - Photosynthesis 2



STEM SMART Biology Week 35 - Photosynthesis 2 >

Photosynthesis vs Respiration

Subject & topics: Biology | Biochemistry | Photosynthesis

Stage & difficulty: A Level P3

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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Question deck:

STEM SMART Biology Week 35 - Photosynthesis 2



STEM SMART Biology Week 35 - Photosynthesis 2 >

Daylight Needed for Growth

Subject & topics: Biology | Biochemistry | Photosynthesis**Stage & difficulty:** A Level C3

Plants carry out both respiration and photosynthesis. In most plants, the rate of photosynthesis will be higher than the rate of respiration during the day, but lower during the night. In order for a plant to grow (produce biomass) over a period of time, the overall rate of photosynthesis must be greater than the overall rate of respiration during this period.

A particular plant has a total leaf surface area of 15 m^2 . During daylight, the rate of photon absorption by these leaves is $100 \mu\text{mol photons m}^{-2} \text{ s}^{-1}$, and for every $1 \mu\text{mol}$ of photons absorbed, $0.04 \mu\text{mol CO}_2$ are fixed.

The plant respire at an average rate of $0.5 \text{ mol glucose per day}$ (24 hours).

Calculate the minimum number of hours of daylight per day required for this plant to grow (produce biomass) each day.

Assume that respiration only occurs aerobically and that all CO_2 fixed is converted into glucose by the Calvin cycle.

Give your answer to the nearest hour.

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Question deck:

STEM SMART Biology Week 35 - Photosynthesis 2



Photosynthesis Summary

Subject & topics: Biology | Biochemistry | Photosynthesis

Stage & difficulty: A Level P3

Part A

Reducing chlorophyll ▾

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

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



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



Part C

Radioactive labelling >

Carbon dioxide labelled with ^{14}C 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 ^{14}C ?

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