**A simple model of aerobic cellular respiration**

**Part 1**

Aerobic cellular respiration takes place in the cells that make up our bodies.

The diagram shows a simple model of aerobic cellular respiration, including what it uses as fuel and what cells get from it.

Some of the labels are missing!

**What cells get from it**

**What it uses as fuel**

**Aerobic**

**cellular**

**respiration**

**To do**

1. Add the missing labels into the empty boxes to complete the model.

**Part 2**

The diagram shows a simple model of aerobic cellular respiration in humans. The model shows what aerobic cellular respiration uses as fuel and what cells get from it.

**What cells get from it**

**What it uses as fuel**

glucose from carbohydrate food

oxygen

**Aerobic**

**cellular**

**respiration**

energy

for life processes

carbon dioxide

water

**To answer**

1. What happens in the middle part labelled ‘Aerobic cellular respiration’?

Two of the boxes below can be joined together to form the answer.

Draw a line to link the correct **start of the answer** to the correct **end of the answer**.

**…end of the answer**

**Start of the answer…**

…that takes place inside cells.

…that takes place inside the body,

but not inside cells.

…that takes place only in the lungs.

A single chemical reaction…

A series of chemical reactions…

A process that does **not** involve

chemical reactions…

*Biology > Big idea BCL: The cellular basis of life > Topic BCL3: Biochemistry > Key concept BCL3.2: Cellular respiration*

|  |
| --- |
| **Diagnostic question** |
| **A simple model of aerobic cellular respiration** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Energy for life processes is provided by a chemical process called cellular respiration inside all living cells, which uses glucose (from food) as fuel. |
| Observable learning outcome: | Describe aerobic cellular respiration using a simple model of the process, including what it uses as fuel (glucose plus oxygen) and what it makes as waste products (carbon dioxide and water). |
| Question type: | Modelling, linking ideas |
| Key words: | cellular respiration |

**What does the research say?**

In many curricula, students are required to learn about respiration at multiple points. Students could get the impression that what they were told “last time” was wrong. To avoid this, it may be helpful to be explicit about the fact that we use *models* of respiration to explain it, and that models containing different amounts of detail – but all describing the same process – are useful at different stages of learning about it. The EEF *Improving Secondary Science* guidance report advocates explicitly teaching pupils about models to help them develop a deeper understanding of scientific concepts (Holman and Yeomans, 2018).

Aerobic

cellular

respiration

energy

water

glucose from carbohydrate food

oxygen

carbon dioxide

At ages 11-14, a simple model of the inputs and outputs of the process may be good enough to explain what aerobic respiration requires, what the outputs of the process are, and to make predictions about the effects of decreasing or increasing an input. (Note, however, that the use of a word or symbol equation has been avoided in the BEST 11-14 resources, as it may reinforce the misunderstanding that photosynthesis is a single reaction.)

Many studies have noted that secondary school students incorrectly think breathing and (cellular) respiration are the same thing (e.g. Haslam and Treagust, 1987; Songer and Mintzes, 1994; Wierdsma et al., 2016). An in-depth analysis was conducted by Seymour and Longden (1991) with 13-16 year-olds. 32% of the students incorrectly thought that respiration and breathing are the same thing; and 57% thought that respiration took place (only) in the lungs. Seymour and Longden note that in order to fully understand the difference between breathing and respiration, students must accept that respiration is a biochemical process that takes place inside cells.

**Ways to use this question**

Part 2 should **not** be shown to students until they have completed part 1.

Students should complete the questions individually. This could be a pencil and paper exercise. Alternatively, part 1 could be done as a card sort exercise using the cards printed and cut out from the end of this document, and part 2 could be done using the presentation with an electronic voting system or mini white boards.

If using the cards from the end of this document for part 1, you will notice that two copies of each label have been provided. This is because some students may wish to put the same label in both boxes (i.e. they may think a particular substance is both a requirement and a product of photosynthesis, perhaps because they think it is unchanged by the reaction –akin to e.g. chlorophyll).

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

For a more challenging activity, some students could be asked to think up their own answers for part 1, rather than being given cards to arrange into the boxes.

**Equipment**

For each student/pair/group, for optional card sort activity:

* cards, printed and cut out from the end of this document

**Expected answers**

*Part 1*

**What it uses as fuel**: glucose from carbohydrate food, oxygen

**What cells get from it**: energy for life processes, carbon dioxide, water

Students who select ‘air’ as a fuel should be challenged to be more specific about which gas/substance from the air is used as a fuel for aerobic cellular respiration. Students who place ‘light’ in either box, or who get the fuels and products the wrong way around, may be confusing cellular respiration and photosynthesis (Cañal, 1999).

*Part 2*

|  |  |  |
| --- | --- | --- |
| A series of chemical reactions… | –– | …that takes place inside cells. |

**How to respond - what next?**

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs. Responses often work best when the activities involve paired or small group discussions, which encourage social construction of new ideas (meaning making) through dialogue.

The following BEST ‘response activities’ challenge students to apply their understanding of the model to predict how cellular respiration in animals and plants will change the composition of air or the colour of an indicator solution, and could be used in follow-up to this diagnostic question:

* Response activity: Flames
* Response activity: Respiration indications

If students appear to be mixing up cellular respiration and photosynthesis, the fifth column in the progression toolkit for this key concept provides diagnostic questions and response activities to further probe and challenge their understanding.

If students struggle with the idea that cellular respiration is a process of chemical change, it may be helpful to revisit the following BEST resources to make sure students are secure in their understanding of key concepts related to chemical change:

* Key concept CPS3.1: Rearrangement of atoms
* Key concept CCR1.1: Formation of new substance
* Key concept CPS4.2: Conservation of mass

**Acknowledgments**

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Images: UYSEG

**References**

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Songer, C. J. and Mintzes, J. J. (1994). Understanding cellular respiration: an analysis of conceptual change in college biology. *Journal of Research in Science Teaching,* 31(6)**,** 621-637.

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**Print and cut out cards for card-sort activity**

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|  |  |  |  |
| --- | --- | --- | --- |
| glucose from carbohydrate food | glucose from carbohydrate food | water | water |
| carbon dioxide | carbon dioxide | oxygen | oxygen |
| energy  for life processes | energy  for life processes | air | air |
| mitochondria | mitochondria | light | light |

✁

|  |  |  |  |
| --- | --- | --- | --- |
| glucose from carbohydrate food | glucose from carbohydrate food | water | water |
| carbon dioxide | carbon dioxide | oxygen | oxygen |
| energy  for life processes | energy  for life processes | air | air |
| mitochondria | mitochondria | light | light |

✁

|  |  |  |  |
| --- | --- | --- | --- |
| glucose from carbohydrate food | glucose from carbohydrate food | water | water |
| carbon dioxide | carbon dioxide | oxygen | oxygen |
| energy  for life processes | energy  for life processes | air | air |
| mitochondria | mitochondria | light | light |

✁

|  |  |  |  |
| --- | --- | --- | --- |
| glucose from carbohydrate food | glucose from carbohydrate food | water | water |
| carbon dioxide | carbon dioxide | oxygen | oxygen |
| energy  for life processes | energy  for life processes | air | air |
| mitochondria | mitochondria | light | light |