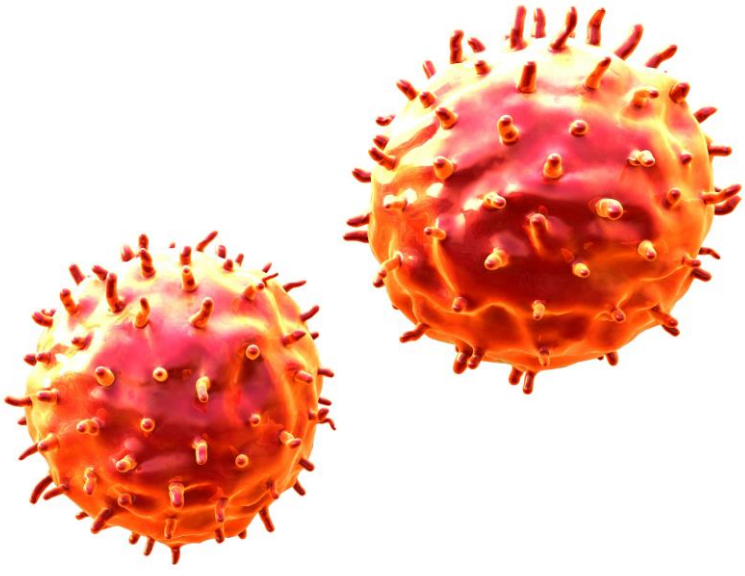
Cambridge Assessment International Education

Teaching Pack

Gas exchange in humans – model lung

Cambridge O Level

Biology 5090



Version 1.0

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Briefing lesson

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Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Gas exchange in humans – model lung

This *Teaching Pack* focuses on building and operating lung models.

Models are often used to illustrate how mechanisms work. Some readily available materials can be assembled in a simple model of the human thorax to illustrate how the diaphragm contributes to lung ventilation.

This experiment has links to the following syllabus content (see syllabus for detail):

- 8.3 Human gas exchange

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- make and record observations
- interpret and evaluate experimental observations
- evaluate methods

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 8.3 Human gas exchange
- 2.2 Osmosis
- 5.6 Absorption and assimilation

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners about the effects of physical activity on rate and depth of breathing.

Briefing lesson: Making and evaluating models

Resources	• colanders • pasta and rice • small cardboard box • balloon and balloon pump	• water • beakers • Worksheet A • sticky tape

Learning objectives	By the end of the lesson: • ***all*** learners should understand that some methods use models to represent a biological situation • ***most*** learners should understand that simple models are only approximate representations and be able to identify one or more weaknesses in a model • ***some*** learners will be able to evaluate one or more different models.

Timings	Activity
15 min	**Starter/Introduction** In groups of 2–4, ask learners to put some pasta and rice into water in a beaker and pour it through a colander into another beaker. Explain that this is a model for a cell membrane. Ask them to discuss what the different components of the model represent and discuss the good and bad points of the model. After five minutes, lead a class discussion on the model. Include that: • the colander represents the cell membrane; it allows some substances through but not others • the rice and pasta represent two substances with different particle sizes; one is able to cross the cell membrane whereas the other is not • the colander has holes that allow particles up to a certain size through but not larger ones; this is like a cell membrane. However, cell membranes are flexible whereas the colander is rigid • the rice and pasta are not dissolved in the water whereas substances crossing cell membranes are • substances cross cell membranes by diffusion or active transport rather than being washed through by a current of water. Discuss the idea of models and how they intend to aid understanding. Ask your learners the extent to which they feel this model is helpful to their understanding.
20 min	**Main lesson** In groups of 2–4, ask learners to use the cardboard box and balloon to construct a model to demonstrate turgor pressure in plant cells. You may need to prompt your learners to inflate the balloon inside the box to represent the cell membrane within the cell wall. Explain that evaluation involves identifying both strengths and weaknesses. Ask them to evaluate their model. *Continues on next page …*

15 min

Weaknesses they might identify are:

- the balloon and the box are hollow whereas cells are not;
- the cell wall is much thicker than the model suggests;
- the balloon is not attached to the box and can completely deflate inside the box, unlike a cell.

Strengths they might identify are:

- the box is much stronger than the balloon and prevents it bursting, as in a plant cell;
- the balloon stretches and presses on the box, like a cell membrane inside a cell wall;
- the box is flexible and distorts under pressure, like a cell wall.

Give your learners Worksheet A. In groups of 2–4, learners should discuss the model intestine and answer the questions. You might need to prompt your learners. Use the suggested answers to help you encourage the appropriate discussions.

It is important that learners understand that the mixture inside the Visking tubing represents **digested** food. Class discussion could emphasise the idea that although the model does illustrate selective absorption based on molecular size, it has considerably more weaknesses than strengths.

10 min

Plenary

Summarise with your learners the key ideas from this lesson that:

- simple models can sometimes be useful to illustrate complex biological mechanisms
- models have strengths and weaknesses and identifying these can often aid biological understanding.

Lab lesson: Option 1 – run the experiment

Resources	• Teacher notes and method • *Teacher Walkthrough video* • Equipment as outlined in the Teacher notes • Worksheets B, D and E

Learning objectives	By the end of the lesson: • ***all*** learners should notice some of the expected results and record their observations • ***most*** learners should notice all of the expected results and record all the key observations • ***some*** learners will also notice and record more subtle results.

Timings	Activity
	**Starter/Introduction** Remind learners of the purpose of a model and how it is intended to aid understanding. Explain that the two models in this lesson are about ventilation and the composition of inhaled and exhaled air. Briefly review thoracic anatomy.
	**Main lesson** Run through the experimental set-up (Worksheet D) and method (Worksheet B) for **model 1** with your learners. Make sure you draw their attention to the precautions they should take, for example, the care needed when cutting the plastic bottle. Learners should collect their materials and construct model 1. They should discuss which anatomical structures they think each part of the model represents and evaluate how well they think it represents each structure. They should then operate their model and make and record their observations (Worksheet E).
	Run through the experimental setup (Worksheet D) and method (Worksheet B) for **model 2** with your learners. Make sure you draw their attention to the precautions they should take, for example, the care needed to ensure sucking and blowing through the correct straws. **Safety** Circulate the classroom at all times during the experiment so you can make sure that your learners are safe and that the observations they are making with each model are accurate. Learners should collect their materials and construct model 2. They should discuss which anatomical structures they think each part of the model represents and evaluate how well they think it represents the structure. They should then operate their model and make and record their observations (Worksheet E).
	**Plenary** Summarise the key observations leaners have recorded with a short class discussion.

Teacher notes

Watch the *Teacher Walkthrough* video and read these notes.

Each group will require:

- a plastic bottle
- scissors
- two balloons
- five straws
- glass rod
- sticky tape
- elastic band
- modelling clay
- two 250cm^3 conical flasks
- limewater
- Universal Indicator paper.

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

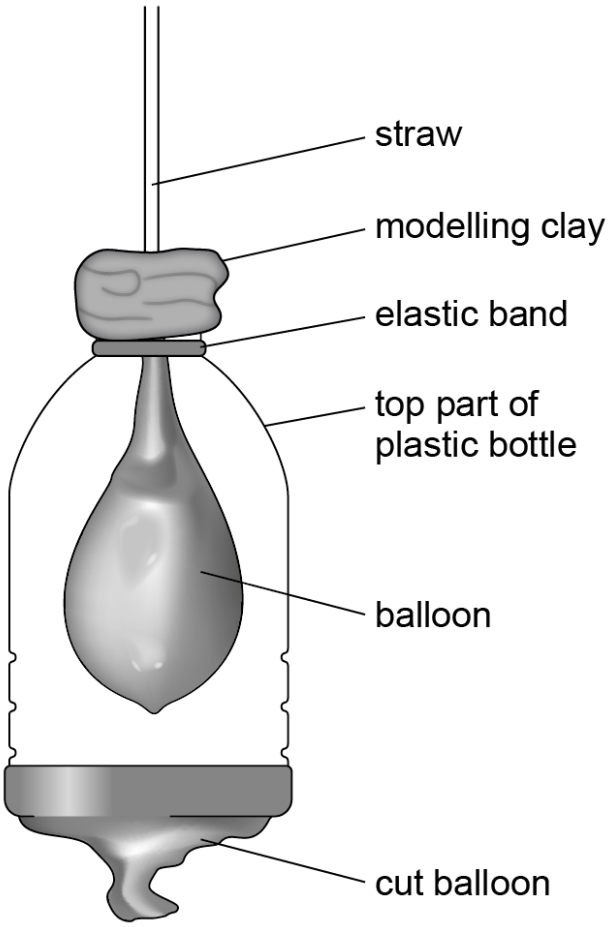
It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Limewater solution [a saturated solution of calcium hydroxide, less than 0.02 mol/dm^3]	 GHS07 (*moderate hazard* **MH**)	**In the eye:** limewater is unlikely to cause serious problems; flood the eye with gently running tap water for at least 10 minutes. See a doctor if there are any concerns. **Swallowed:** limewater is unlikely to cause serious problems. Wash out the mouth. See a doctor if there are any concerns. **Spilt on the skin or clothing**: wash with water. **Spilt on the floor, bench, etc.:** wipe up limewater or small amounts of compound with a damp cloth and rinse it well. For larger amounts of compound, scoop into a bucket, add water to the area followed by mineral absorbent (e.g. cat litter).
	Risk of cuts due to sharps, e.g. broken glass or scalpels.	**Minor cuts:** Rinse the wound with water. Get the casualty to apply a small, sterile dressing.

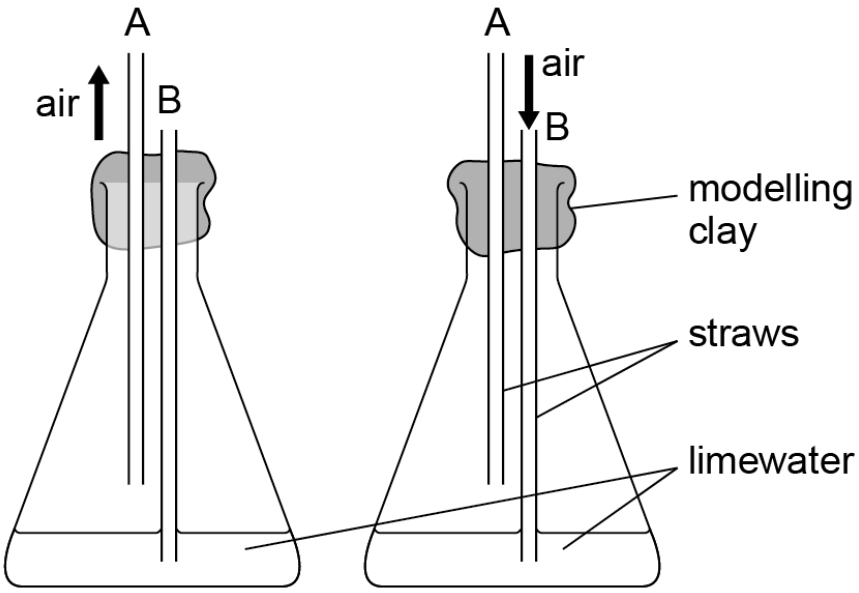
Substance	Hazard	First aid
	Wounds can lead to infection, especially if the blade or point is contaminated.	**Severe cuts**: Lower the casualty to the floor. Raise the wound as high as possible. If feasible, ask the casualty to apply pressure on or as close to the cut as possible, using fingers, a pad of cloth or, better, a sterile dressing (adding further layers as necessary). If the casualty is unable to do so, apply pressure yourself, protecting your skin and clothes from contamination by blood if possible. Leave any embedded large bodies and press around them. Send for a first aider.

Experiment set-up

Model 1: Investigating ventilation



Model 2: Investigating the differences in composition between inspired and expired air



Teacher method

This is your version of the method for this experiment that accompanies the *Teacher Walkthrough* video.

Do not share this method with learners. Give them Worksheet B.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 2–4 learners)
- the amount of materials, equipment and chemicals required
- whether you will ask your learners to pause and discuss the first model as a class before moving on to the second model.

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Steps	**Notes**
1. Learners should collect all the equipment they need from the front of the class and start by making model 1.	
2. Learners use scissors to cut the neck off one of their two balloons.	*Remind learners to be careful with scissors.*
3. Learners use scissors to cut off the bottom third of a plastic bottle and discard it.	*Remind learners that the cut edges of a plastic bottle can be sharp.*
4. Learners stretch the large part of the cut balloon tightly across the open end of the top part of the bottle and seal it in place with sticky tape.	*It is important that the join is airtight.*
5. A straw should be inserted into the neck of the other balloon and secured in position with an elastic band.	*It is important that the join is airtight.*
6. Learners make a ball of modelling clay slightly larger than the neck of the bottle and push a glass rod through it to make a hole.	
7. They should then pass the straw attached to the balloon through the	*It is important that the join is airtight.*

hole and seal the clay against the straw.

8. Learners lower the balloon attached to the straw through the neck of the bottle and seal the modelling clay in place.

It is important that the join is airtight.

9. Learners should discuss what each part of the model represents.

Suggested answers are provided.

10. Learners operate the model by repeatedly pulling the balloon representing the diaphragm downwards and then releasing it.

It is important they release the balloon rather than pushing it upwards so that the action of passive recoil is simulated.

11. Learners should observe and record what happens to the 'lung' and 'diaphragm' with each movement.

You may prefer to have all groups complete the first model and discuss it as a class before leaners start to make the second model.

12. Learners should then build model 2.

13. Learners place a small volume of limewater into each of two conical flasks.

14. Learners make two balls of modelling clay slightly larger than the neck of the flasks.

15. Using a glass rod, they make two holes in each ball of clay.

16. They place the balls of clay into the necks of the flasks like bungs.

17. They then push a straw through each hole and seal them in place, adjusting their heights carefully as shown in the diagram of the experimental setup.

One end of one straw in each flask should dip into the limewater and the other should remain well above the limewater.

18. Learners should label the straws A and B as shown in the diagram of the experimental setup.

19. Learners operate the model by sucking on straw A of one flask and blowing through straw B of the other and repeating this cycle at least twenty times.

Labelling is intended to avoid learners inadvertently sucking up limewater.

20. Learners should discuss what each part of the model represents.

Suggested answers are provided.

21. Learners should watch for and record any changes to the limewater.

Their observations should show that the limewater in the flask being blown into initially becomes cloudy whereas there is no immediate change in the other flask. If learners continue, the cloudy limewater may clear again and the clear limewater may eventually become cloudy.

22. Learners should then test the limewater in each flask with Universal Indicator paper and record their observations.

Their observations should show that the paper in the flask that has been blown into turns green (or perhaps yellow) indicating neutral (or perhaps slightly acidic) conditions. The paper in the other flask turns purple indicating alkaline conditions.

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment, used materials and any unused chemicals to you.

The limewater should be flushed down the sink with plenty of water.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual Experiment video* • Worksheets C, D and E
Learning objectives	By the end of the lesson: • ***all*** learners should notice some of the expected results and record their observations • ***most*** learners should notice all the expected results and record all the key observations • ***some*** learners will also notice and record more subtle results.

Timings	Activity
10 min	**Starter/Introduction** Remind learners of the purpose of a model and how it is intended to aid understanding. Explain that the two models in this lesson are about ventilation and the composition of inhaled and exhaled air. Show the introductory section of the video about thoracic anatomy (00:00 – 00:45 min).
5 min	**Main lesson** Give your learners Worksheets B, C, D and E. Run through the equipment set-up (Worksheet D) for both models.
10 min	Show learners the section of the video making and operating model 1 (00:45 – 03:38 min). Learners should fill in the gaps in the method (Worksheet C) and record their observations (Worksheet E) as the 'diaphragm' is operated. You may need to replay the operation of the model several times so that learners can make sufficiently careful observations of both the 'lung' and the 'diaphragm'. Answers for the gap filling activity can be found in Worksheet C.
10 min	Pause the video and discuss model 1 with the class. Ask learners to suggest which anatomical structures they think each part of the model represents and to evaluate how well they think it represents each structure. Suggested answers are provided.
10 min	Show learners the section of the video making and operating model 2 (03:38 – 07:41 min). Learners should fill in the gaps in the method (Worksheet C) and record their observations (Worksheet E) as air is sucked and blown through the straws. You may need to replay the operation of the model several times so that learners can make sufficiently careful observations of the limewater and the Universal Indicator paper.
10 min	Pause the video and discuss model 2 with the class. Ask learners to suggest which anatomical structures they think each part of the model represents and to evaluate how well they think it represents each structure. Suggested answers are provided. Show learners the last section of the video.
5 min	**Plenary** Summarise the key observations learners have recorded with a short class discussion.

Debriefing lesson: Interpreting observations

Resources	• Completed Worksheet E • Worksheet F • Worksheet G
Learning objectives	By the end of the lesson: • ***all*** learners should be able to offer basic explanations of their observations • ***most*** learners should be able to explain in detail the changes in the limewater and Universal Indicator paper • ***some*** learners will be able to describe the responses of the balloon 'lung' in appropriate terminology.

Timings	Activity
10 min	**Starter/Introduction** Review the reaction between carbon dioxide and limewater and the colour range for Universal Indicator paper (pH 1–14). calcium hydroxide + carbon dioxide → calcium carbonate + water
20 min	**Main lesson** Ask learners to review their recorded observations (Worksheet D) for Model 2 and then give them Worksheet E to complete as a way of interpreting their observations. Ensure that your learners understand that interpreting observations means finding explanations for what they saw happening and that more than one interpretation statement may have to be linked to an observation to provide a complete explanation.
5 min	Ask learners to write their conclusion (Worksheet E) regarding the composition of inhaled versus exhaled air. You may need to help your learners to compose a concise sentence summarising that exhaled air contains more carbon dioxide than inhaled air.
15 min	Based on their recorded observations (Worksheet D), ask your learners to write a summary of how ventilation works using appropriate terminology to describe volume and pressure changes in the thorax. You may wish to provide some scaffolding to support your learners in this extended writing task (Worksheet F).
10 min	**Plenary** Discuss with your learners to what extent they feel the models helped their understanding of ventilation and the composition of inhaled and exhaled air.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
A: Model intestine	**18**	**25**
For use in *Lab lesson: Option 1:*		
B: Method	**19**	**—**
D: Equipment set-up	**21**	**—**
E: Table of observations	**22**	**—**
For use in *Lab lesson: Option 2:*		
C: Method	**20**	**26**
D: Equipment set-up	**21**	**—**
E: Table of observations	**22**	**—**
For use in the *Debriefing lesson:*		
E: Table of observations	**22**	**—**
F: Interpreting observations	**23**	**27**
G: Writing about ventilation	**24**	**—**

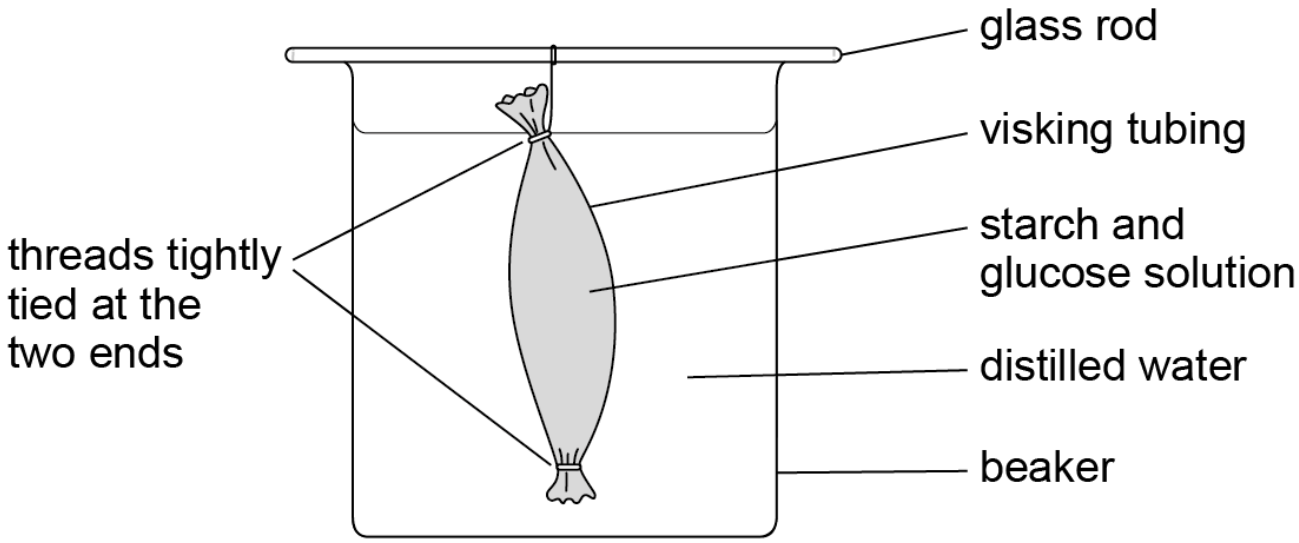
Worksheet A: Model intestine

A model of a small intestine can be made by suspending a section of Visking tubing in a beaker of distilled water.

Visking tubing has microscopic pores so molecules that are small enough can pass through it.

After it is set up, the model is left for a while and then the distilled water is tested to see if it contains any starch or glucose.

Look carefully at the diagram and then answer the questions.



1. Predict the results of the tests on the distilled water. What do you think the model helps you to understand?

2. Suggest what the following parts of the model represent in a human?
   a) Visking tubing
   b) distilled water
   c) starch and glucose solution
   d) beaker.

3. Evaluate the model, remembering to include its strengths as well as its weaknesses.

Worksheet B: Method

1. Collect all your equipment from the front of the class.
2. Cut the neck off one of the balloons.
3. Cut the base off the plastic bottle.

Take care when cutting the bottle.

4. Stretch the balloon tightly over the open end of the bottle and secure with sticky tape.
5. Put a straw through the neck of the other balloon and secure it with an elastic band.
6. Make a ball of modelling clay slightly larger than the neck of the bottle.
7. Using a glass rod, make a hole through the centre of the modelling clay.
8. Push the straw through the hole and seal the clay against the straw.
9. Lower the balloon through the neck of the bottle and seal the modelling clay around the neck.

What does each part of your model represent and how well do you think it represents each?

10. Pull the balloon stretched across the bottle downwards and observe and record what happens.
11. Release the balloon and observe and record what happens.
12. Repeat these actions several times and continue to observe what happens.
13. Next, place some limewater into each of two conical flasks.
14. Make two balls of modelling clay slightly larger than the necks of the flasks.
15. Using a glass rod, make two holes through the ball of modelling clay.
16. Seal the balls of modelling clay into the necks of the conical flasks.
17. Push a straw through each hole and adjust the height of each pair of straws so that one dips into the limewater and the other is well above the limewater.
18. Label the straws A and B as shown in the diagram of the setup.

Ensure that you label the two straws correctly.

What does each part of your model represent and how well do you think it represents each?

19. Place the two flasks side by side. Simulate inhalation by sucking air through straw A of one conical flask.
20. Simulate exhalation by blowing air through straw B of the other conical flask.
21. Repeat this cycle and observe and record any changes in the limewater.
22. Remove the modelling clay and dip a piece of Universal indicator paper into the limewater in each flask. Observe and record what happens.

Look over your observations from the experiment and start to evaluate your findings.

Worksheet C: Method

1. Collect all your equipment from the front of the class.
2. Cut the neck off one of the _____
3. Cut the base off the _____

Take care when cutting the bottle.

4. Stretch the balloon tightly over the open end of the _____ and secure with sticky tape.
5. Put a _____ through the neck of the other balloon and secure it with an elastic band.
6. Make a ball of modelling clay slightly larger than the neck of the bottle.
7. Using a glass rod, make a hole through the centre of the _____
8. Push the straw through the hole and seal the clay against the straw.
9. Lower the_____ through the neck of the bottle and seal the modelling clay around the neck.

What does each part of your model represent and how well do you think it represents each?

10. ____ the balloon stretched across the bottle_____ and observe and record what happens.
11. _____ the balloon and observe and record what happens
12. Repeat these actions several times and continue to observe what happens.
13. Next, place some _____ into each of two conical flasks.
14. Make two balls of modelling clay slightly larger than the necks of the flasks.
15. Using a glass rod, make two holes through the ball of modelling clay.
16. Seal the balls of modelling clay into the necks of the conical flasks.
17. Push a straw through each hole and adjust the height of each pair of straws so that one _____ the limewater and the other is well above the limewater.
18. Label the straws A and B as shown in the diagram of the setup.

Ensure that you label the two straws correctly.

What does each part of your model represent and how well do you think it represents each?

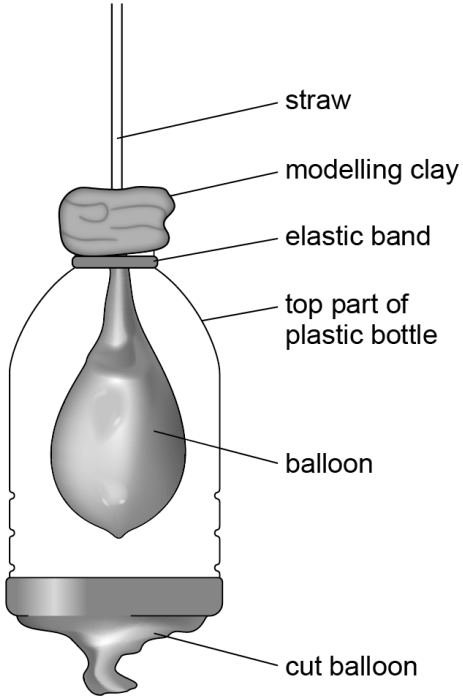
19. Place the two flasks side by side. Simulate _____ by sucking air through straw A of one conical flask.
20. Simulate _____ by blowing air through straw B of the other conical flask.
21. Repeat this cycle and observe and record any _____ in the limewater.
22. Remove the modelling clay and dip a piece of _____ into the limewater in each flask. Observe and record what happens.

Look over your observations from the experiment and start to evaluate your findings.

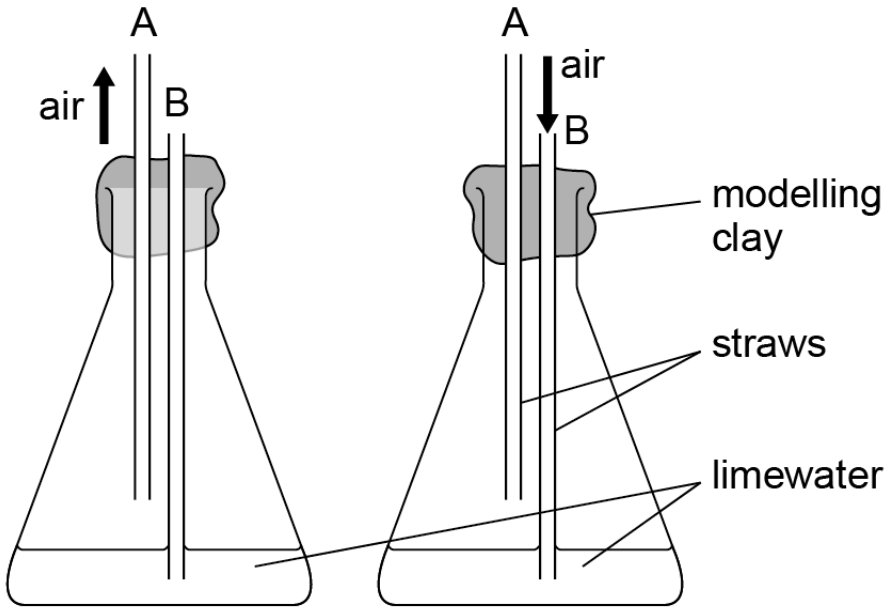
Worksheet D: Equipment set-up

Make sure that you follow the diagrams carefully and take care when cutting the plastic bottle.

Model 1



Model 2



Worksheet E: Observations

Action (what you did)	**Observation (what happened)**
Model 1 'Diaphragm' pulled down	
Model 1 'Diaphragm' released	
Model 2 Suck through straw A	
Model 2 Blow through straw B	

Worksheet F: Interpreting observations

Interpreting an observation means finding an explanation for what happened.

For each observation on the left, draw one or more lines connecting to appropriate interpretations on the right.

	exhaled air only contains a very small amount of carbon dioxide
When air is blown through straw B the limewater turns cloudy and white.	calcium carbonate and water is neutral
	inhaled air contains a large amount of carbon dioxide
After air has been sucked through straw A, Universal Indicator paper dipped into the limewater becomes purple.	carbon dioxide reacts with limewater to produce insoluble calcium carbonate and water
	exhaled air does not contain carbon dioxide
	limewater is acidic
When air is sucked through straw A, the limewater stays clear and colourless.	inhaled air only contains a very small amount of carbon dioxide
	exhaled air contains a large amount of carbon dioxide
After air has been blown through straw B, Universal Indicator paper dipped into the limewater becomes green.	inhaled air does not contain carbon dioxide
	calcium carbonate and water is acidic
	limewater is alkaline
	a small amount of carbon dioxide is not enough to react with limewater

Now, write a single sentence conclusion about one difference between inhaled and exhaled air.

……

……

……

Worksheet G: Writing about ventilation

When you write about ventilation, you must use the right words and phrases.

Use this sheet to help you to write a summary of how ventilation works.

Writing check
1. Have you written a paragraph about breathing in and a paragraph about breathing out?
2. Check you have used each of these words or phrases:

- pressure in thorax decreases
- volume of thorax decreases
- pressure in thorax increases
- volume of thorax increases
- air moves into lungs
- air moves out of lungs
- diaphragm contracts
- diaphragm moves downwards
- diaphragm relaxes
- diaphragm moves upwards
- inhalation
- exhalation.

Worksheet A: Answers

The tests would show that the distilled water contains glucose but does not contain starch. The model helps understanding of the idea that only small soluble molecules can be absorbed by the small intestine.

- Visking tubing – small intestine
- distilled water – blood
- starch and glucose solution – digested food
- beaker – blood vessels/circulatory system

Weaknesses they might identify are: the Visking tubing is smooth, unlike the villi in the small intestine, the water is at room temperature as opposed to human body temperature, the water is not circulating as blood does, the digested food is not being stirred around in the way that peristalsis does in the small intestine; there is no active transport operating in the model, unlike in the small intestine.

Strengths they might identify are: like the small intestine, the Visking tubing allows small molecules across but not large ones; the Visking tubing forms a narrow tube, like the small intestine.

Worksheet B and C: Answers

Model 1

What does each part of your model represent and how well do you think it represents each?

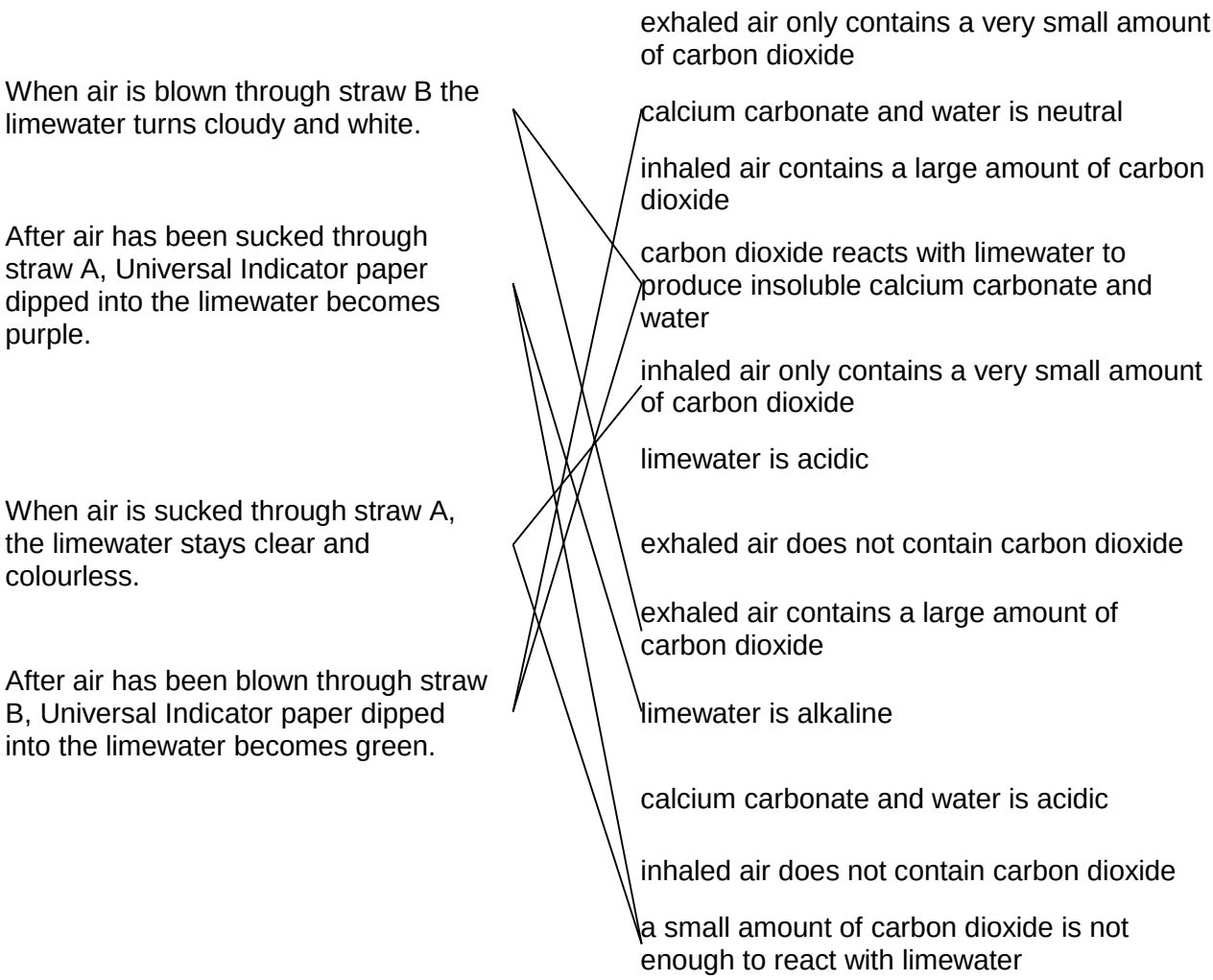
Whole balloon – lungs, balloons can stretch like lungs but humans have two lungs and there is only one balloon; balloons are hollow whereas lungs are not
Plastic bottle – thorax/ribcage, lungs completely fill thorax (with heart) but balloon does not fill bottle, bottle is rigid, ribs can move
Part balloon – diaphragm, balloons are flexible like the diaphragm; diaphragm is made of muscle and can contract but balloon needs to be pulled, diaphragm at rest is concave but balloon is flat
Straw – airways, airways consist of progressively narrower tubes

Model 2

What does each part of your model represent and how well do you think it represents each?

Conical flasks – lungs, lungs are elastic, glass flasks are rigid; inhalation and exhalation both take place in each lung but are separated in the flasks
Straws – airways, airways consist of progressively narrower tubes; there is only one trachea but there are two straws per flask

Worksheet F: Answers



The sentence that learners create should contain one difference between inhaled and exhaled air. Allow any suitable sentence.

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