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Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- **Content**: A clear outline of the content covered by the delivery guide;
- **Thinking Conceptually**: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- **Thinking Contextually**: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk
### 2.2.3 Gas exchange in mammals and plants

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<td>how expired air resuscitation can be carried out on adults, children and babies in cases of respiratory arrest</td>
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<td>the process of gas exchange in terrestrial plants</td>
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<td>-------------------------------------------------</td>
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<tr>
<td>(f)</td>
<td>(i) the structure of stomata, their opening and closing</td>
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<tr>
<td></td>
<td>(ii) the microscopic appearance of stomata</td>
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</tbody>
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**PAG1**
In this unit, students will develop an understanding of the relationship between cells, tissues and organs in the context of the gas exchange systems in both plants (terrestrial) and mammals.

Students will be encouraged to use pre-existing knowledge of cell theory and microscopy (2.1.1). A consideration of the histology of different cell types runs throughout the unit and several student activities include microscope work to consolidate theory of cell structure and function.

- observations of tissues of the gas exchange system using alveoli...and...the microscopic appearance of stomata

Annotation of tissue drawings such as ciliated epithelium (tracheal slides) and epidermal layer (leaf slides) will allow students to make the progression from the structure of simple cells to that of differentiated cells suited for the purpose of gas exchange.

Students will then have the opportunity to consider the physical aspects of gas exchange by looking at gas exchange in the alveoli (including importance of diffusion concentration gradients, 2.1.1) and ventilation of the lungs. A firm understanding of the parameters that affect ventilation is required and students should appreciate the importance of precise definitions e.g. FEV1.

- To include consideration of tidal volume, breathing rate, vital capacity, residual volume, PEFR and FEV1.

As seen in other units of the course, First Aid is also approached and here it is in the context of expired air resuscitation. Students will gain knowledge of the procedure for treating cases of respiratory arrest in both adults and children.1

By moving onto the topic of gas exchange in plants, students will have the opportunity to revisit the concepts of diffusion, active transport (2.1.1) and osmosis (2.1.2), being vital to the movement of gases and the mechanism of stomatal opening and closing. A brief encounter with the differences in leaf structure of different terrestrial plants e.g. xerophytes, mesophytes at this stage will be of value when studying aspects of transport in plants (2.2.4) and adaptation of plants to their environment (3.1.3.e)

1 St John's ambulance website - EAR information
Good website for information on EAR (links with CPR)
Thinking Conceptually

Students will have already had some exposure to the workings of the gas exchange systems in mammals and plants at GCSE level. Prior knowledge of mammalian lung structure is enhanced through the early learning outcomes in this unit and any pre-existing misconceptions can be discussed during lung dissection and microscope work (see Thinking Contextually – Learner Activity 1). This is also a good stage in the course to link the gas exchange with the mammalian transport unit 2.2.2 and also to revisit role of mitochondria 2.1.1g (i.e. need/use for oxygen). There are websites which offer additional reading and aid consolidation of theory.1,2,3

Use of a spirometer will support learning with respect to the parameters that affect pulmonary ventilation4. Students will rarely focus on learning definitions verbatim, but in the case of lung parameters such as FEV1 and PEFR, they should be encouraged to do so as these are commonly misunderstood. It is also a good idea to stress the term ‘spirometer’ as so often it is confused with a ‘respirometer’ (found later in the course 4.1.1g for A Level students only).

The mechanism of gas exchange in plants provides the difficult concept of stomatal opening and closing. Students can use computerised animations5 and learner activities to support the theory of how changes in water potential occurring within guard cells enables gases to enter and exit leaves. Misconceptions surrounding transport across cell membranes (2.1.1) may become evident at this stage and can be revisited and addressed again.

Students’ conceptual grasp of lung function can be tested and extended by considering the desirability of matching perfusion by the blood with ventilation by air6. The causes and consequences of mismatch between ventilation and perfusion and ideas as to how such a mismatch might be clinically identified could produce an interesting class discussion.

Notes: numbers refer to websites on page 9
The following websites provide optional support for consolidation of knowledge and understanding. Background reading:

1. John Wiley website - ventilation and gas exchange
   http://www.johnwiley.net.au/highered/interactions/media/Respiration/content/Respiration/resp1a/frameset.htm

2. Austin Community College website – respiratory system
   http://www.austincc.edu/apreview/PhysText/Respiratory.html

3. National Heart, Lung and Blood Institute – respiratory system
   http://www.nhlbi.nih.gov/health/health-topics/topics/hlw/system.html

The ‘Get Body Smart’ tutorials provide an excellent additional resource for supporting delivery of spirometer work:

See also Learner Resource 2

4. Get Body Smart – tutorial on spirometer

The following weblink provides a good animation as it shows microscopic view as well as animated representation:


6. Getty Images picture of a resin cast to illustrate the close matching between perfusion (via blood vessels) and ventilation (via airways)
   http://www.gettyimages.co.uk/detail/photo/resin-cast-of-a-human-lung-section-showing-high-res-stock-photography/72728673
**ACTIVITIES**

In this unit there is ample opportunity for students to observe prepared slides using a light microscope (Learner Activity 1 and 2) relates to PAG1 or prepare their own slides as in Learner Activity 3. The use of photomicrographs throughout the microscope work (Learner Resource 1) will allow students to gain confidence in interpreting what they see, enabling them to identify the cells and tissues that work together in gas exchange systems. It may also be of advantage to consider allowing students to observe real mammalian lungs (obtainable from many butchers or local abattoirs) to locate the different tissues in situ.

Once structures have been identified, students will look at the physical process of ventilation and parameters such as tidal volume and breathing rates (Learner Resource 2 relates to PAG10) whilst consolidating mathematical skills in manipulating and solving equations M0.1, M2.2, M2.3, M2.4. Classic spirometers or hand held data loggers are available which produce traces for interpretation, analysis and evaluation.

As with some of the earlier units, the opportunity to study First Aid arises with the use of expired air resuscitation and, once again, participation and a visit to the websites of appropriate organisations are actively encouraged.

There are a variety of activities that link the learning outcomes associated with gas exchange in plants (Learner Activities 2, 3 and 4). Microscope work to show appearance of stomata, and modelling of stomatal opening and closing both add to the student experience and help strengthen knowledge and depth of understanding. The knowledge acquired here regarding stomata links with the following unit on transport systems in plants (2.2.4) and with units further in the course involving photosynthesis (4.2 for A Level students only).

Notes: numbers refer to websites on page 13
### Activities

<table>
<thead>
<tr>
<th>Learner Activity 1</th>
<th>Resources</th>
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<tbody>
<tr>
<td><strong>Observation of lung tissue</strong> <em>(relates to PAG1)</em></td>
<td><img src="LearnerResource1.png" alt="Learner Resource 1" /></td>
</tr>
</tbody>
</table>

This activity supports individual or paired microscope work to observe different aspects of lung tissue. Using prepared microscope slides of lung tissue such as alveoli and bronchial sections, students draw and annotate their field of view.

1. Place the prepared slide of lung tissue under the microscope and choose an appropriate magnification to view the cells/tissues.
2. Using Learner Resource 1, identify the types of cell/tissue in your field of view*.
3. Draw what you see and annotate your diagrams.

* Dependent on the prepared slide, you will be aiming to identify: squamous epithelial cells, ciliated epithelial cells, smooth muscle and cartilage.

<table>
<thead>
<tr>
<th>Learner Activity 2</th>
<th>Resources</th>
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</thead>
<tbody>
<tr>
<td><strong>A microscopic view of stomata</strong> <em>(relates to PAG1)</em></td>
<td><img src="LearnerResource3.png" alt="Learner Resource 3" /></td>
</tr>
</tbody>
</table>

In this activity, students use light microscopes to view prepared slides of transverse sections of leaf and epidermal layers of leaf to view stomata and guard cells. Photomicrographs in Learner Resource 3 can be used to support interpretation or where certain prepared slides are unavailable.

1. Obtain prepared slides to show leaf sections of: a mesophytic plant e.g. geranium, xerophytic plant e.g. oleander, a plant growing in low CO2 conditions e.g. plantain lily
2. Observe prepared leaf sections under the light microscope choosing appropriate magnification.
3. Identify stomata and guard cells.
4. Describe and explain the differences observed between the different terrestrial plants.
### Thinking Contextually

<table>
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<tr>
<td><strong>Learner Activity 3</strong>&lt;br&gt;Preparing slides to show stomata</td>
<td></td>
</tr>
<tr>
<td>In this activity students can either prepare a leaf section or make an impression of the epidermal surface layer.</td>
<td></td>
</tr>
<tr>
<td><strong>a) Preparing leaf sections</strong></td>
<td></td>
</tr>
<tr>
<td>1) Cut a small potato in half and wedge a leaf between the two halves. (The potato is simply used as a support to hold the leaf while cutting.)</td>
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<tr>
<td>2) Using a sharp blade, pare away thin leaf cuts allowing them to fall into a petri dish of water.</td>
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</tr>
<tr>
<td>3) Using a small paint brush, pick up a thin leaf section from the water and place on clean microscope slide.</td>
<td></td>
</tr>
<tr>
<td>4) Add 1-2 drops of water and cover with a cover slip</td>
<td></td>
</tr>
<tr>
<td>5) View under light microscope x200-400</td>
<td></td>
</tr>
<tr>
<td>6) Leaf sections may be too thick or the light not strong enough to see stomata</td>
<td></td>
</tr>
<tr>
<td><strong>b) To make impressions of the leaf surface and stomata</strong></td>
<td></td>
</tr>
<tr>
<td>1) Paint clear nail varnish onto the underside of a leaf and allow to dry.</td>
<td></td>
</tr>
<tr>
<td>2) Once dry peel off the nail varnish layer with tweezers and press onto a clean microscope slide.</td>
<td></td>
</tr>
<tr>
<td>3) Observe impression under light microscope to see stomata and other surface features.</td>
<td></td>
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</tbody>
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### Thinking Contextually

<table>
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| **Learner Activity 4**  
**Studying the opening and closing of stomata**  
This activity enables students to build a model stoma with 'balloon' guard cells. It is a small group or demonstration activity. Observe the video clip and then construct stomata from balloons as shown. Placement of masking tape or sellotape down the inside of the model 'guard cells' will show the effect of how the stoma opens when the guard cells fill with water (balloons inflate). | **7 Nuffield Foundation – spirometer practicals**  
Good website for providing practical information on use of spirometer. |
| Learner Resource 2 gives a summary of the spirometry parameters and definitions and could be a useful information sheet to give to students when using the following websites: | **8 Pasco website – data loggers for lung function**  
http://content.yudu.com/Library/A1zybg/PascoDatalogging2013/resources/88.htm  
Provides a good spread sheet for looking at the use of data-logging for measuring lung function. |
| | **9 David Maxwell- YouTube video animation**  
www.youtube.com/watch?v=QiMURLROjR8  
Practical information for stomatal opening and closing |
Learner Resource 1 Gas Exchange in Mammals

Cells and tissues

Light micrograph of a transverse section through a mammalian lung (x 5)

Light micrograph of section through lung showing alveoli and capillaries (x 100)

Interpretation of mammalian lung micrograph
- The four large pink rings in the low power micrograph are the bronchioles showing their smooth muscle walls and internal lining of folded ciliated epithelium.
- The red rings are veins and arteries, with the arteries having thicker walls than the veins.
- The rest of the tissue is made up of air sacs (alveoli).
- The higher power micrograph shows several alveoli with their network of very fine capillaries to enable the exchange of oxygen and carbon dioxide between the air and the blood.
Squamous epithelium (x 650)

Light micrograph of a section through the wall of a bronchus in the lungs (x 1500)

Ciliated epithelium (x 1400)
**Learner Resource 2: Lung Parameters and Spirometry**

**Tidal Volume (TV)** = volume breathed in and out in relaxed breathing

**Inspiratory Reserve Volume (IRV)** = extra volume inhaled with maximum effort

**Expiratory Reserve Volume (ERV)** = extra volume expired with maximum effort

**Vital capacity (VC)** = IRV + TV + ERV

**Residual Volume (RV)** = volume left in the lungs after maximum exhalation

**Functional Residual Capacity (FRC)** = ERV + RV

**Forced Expiratory Volume in 1 second (FEV1)** = maximum volume that can be forcibly exhaled in one second

**Peak Expiratory Flow Rate (PEFR)** = maximum rate of flow during forced exhalation (after breathing in to total lung volume)
Learner Resource 3 Observing stomata

How do stomata differ?

Leaf epidermis showing stomata (x 750)

Photomicrograph of a xerophyte leaf (pin cushion plant) (x 160)

Photomicrograph of a mesophyte leaf (tea plant) (x 180)

Leaf epidermis of plant living in low CO₂ atmosphere (plantain lily) (x 750)

See page 11
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