Qualification Accredited

OCR
Oxford Cambridge and RSA

AS and A LEVEL

Delivery Guide

BIOLOGY A

H020/H420
For first teaching in 2015

Exchange Surfaces 3.1.1

Version 2

Introduction

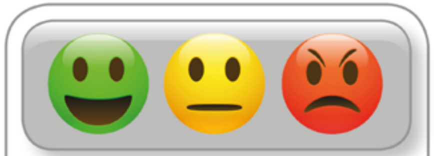
AS and A LEVEL
BIOLOGY A

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 resources.feedback@ocr.org.uk

Curriculum Content Page 3
Activities Page 4
Thinking Conceptually Page 6
Activities Page 7
Thinking Contextually Page 8
Activities Page 9



3.1.1 Exchange Surfaces		
(a)	the need for specialised exchange surfaces	To include surface area to volume ratio (SA:V), metabolic activity, single-celled and multicellular organisms. *M0.1, M0.3, M0.4, M1.1, M2.1, M4.1* HSW1, HSW3, HSW5, HSW8
(b)	the features of an efficient exchange surface	To include, • increased surface area - root hair cells • thin layer – alveoli • good blood supply/ventilation to maintain gradient – gills/alveolus.
(c)	the structures and functions of the components of the mammalian gaseous exchange system	To include the distribution and functions of cartilage, ciliated epithelium, goblet cells, smooth muscle and elastic fibres in the trachea, bronchi, bronchioles and alveoli. **PAG1** HSW8
(d)	the mechanism of ventilation in mammals	To include the function of the rib cage, intercostal muscles (internal and external) and diaphragm. HSW8
(e)	the relationship between vital capacity, tidal volume, breathing rate and oxygen uptake	To include analysis and interpretation of primary and secondary data e.g. from a data logger or spirometer. *M0.1, M0.2, M0.4, M1.3* **PAG10** HSW2, HSW3, HSW4, HSW5, HSW6
(f)	the mechanisms of ventilation and gas exchange in bony fish and insects	To include, • bony fish – changes in volume of the buccal cavity and the functions of the operculum, gill filaments and gill lamellae (gill plates); countercurrent flow • insects – spiracles, trachea, thoracic and abdominal movement to change body volume, exchange with tracheal fluid. HSW8
(g)	the dissection, examination and drawing of the gaseous exchange system of a bony fish and/or insect trachea	**PAG2** HSW4
(h)	the examination of microscope slides to show the histology of exchange surfaces.	**PAG1** HSW4

The structural design of systems of gas exchange at an organ dissection, tissue histology and cytology level form the foundations of understanding of topic 3.1.1 Exchange surfaces. Students need to recognise and name new cells and build visual awareness of how cells and tissues relate to one another in the mammalian lungs, the gills of a bony fish and the tracheal system of insects.

Practical work could involve examining whole lungs from the butcher as well as dissecting beneath the operculum of the head of a large fish such as a salmon from the fishmonger. Light microscope examination of slides of mammalian trachea, bronchi and alveoli, fish gills and insect tracheae is also required.

The resources listed include guides for carrying out these practical investigations, online histology atlas resources and resources detailing ventilation mechanisms in mammals and fish.

Activity 1
Dissecting Lungs (Nuffield Foundation)

https://pbiol.rsb.org.uk/cells-to-systems/ventilation-systems/dissecting-lungs

This link advises on running a demonstration or class pluck dissection activity, with health and safety notes. A student sheet can be downloaded to accompany the activity. This practical relates to **PAG2.**

Activity 2
Salmon Dissection (Fisheries and Oceans Canada)

http://www.pskf.ca/sd/

Step 1 provides photographs and an outline of the dissection of the head to reveal the gills and can be used alone without dissecting a whole fish as described in further steps. Salmon heads are recommended because they are large, so easy to work on, and either free or very cheap as normally discarded at the fresh fish counter. To see gills better, float the severed gill bars in a beaker of water. This practical relates to **PAG2.**

Students could also try to make their own temporary mounts of tiny sections of gill filament (linking to Module 1, 2.1.1(b) and **PAG1).**

Activity 3
Dissection of the Ventilation System of a Locust (Nuffield Foundation)

https://pbiol.rsb.org.uk/cells-to-systems/ventilation-systems/dissection-of-the-ventilation-system-of-a-locust

Stage 1 of this activity involves observation of breathing movements and spiracles of live locusts. This activity could be extended to measure the rate of dorso-ventral flattening and anterio-posterior telescoping of the locust's abdomen at different temperatures, related to the increase in metabolic activity in the ectothermic locust as ambient temperature rises. Calculation of the mean ventilation rate with appropriate units would involve maths skill *M1.2* and *M0.1* and plotting the results against temperature could cover *M3.2*.

Stage 2 instructs on locust tracheal system dissection. A downloadable worksheet is provided. The dissection of the dead locust relates to **PAG2** and gives an opportunity to practise biological drawing.

Activity 4
Anatomy Atlas, Respiratory System (Anatomy Atlases™)

http://www.anatomyatlases.org/MicroscopicAnatomy/Section11/Section11.shtml

This atlas is chosen because it is easy to find what you are looking for (e.g. mammalian trachea, alveoli) and the photomicrograph images are of good quality and pre-labelled. It could be used on the whiteboard as a labelling guide during practical microscopy work. There is also accompanying text describing structures.

Activity 5
Slide Box (T.C.Brelje & R.L.Sorenson)

http://www.histologyguide.org/slidebox/slidebox.html

One benefit of this resource is that it is easy to find a slide, such as a specific type of epithelium. The hyperlinks in the text alongside each image can be clicked on to zoom in to locate that structure on the image. A toolkit to the left allows zooming in and out and panning across the slide as with a real microscope. The images are also of high resolution. As the slides do not have labels it could be used for individual study, as the basis for homework, or as images on the whiteboard in class teaching, rather than as a reference during practical work like the anatomy atlas.

Activity 6
Gas Exchange Systems (biologymad.com)

http://www.biologymad.com/resources/M6GasExchange.pdf

This is a very thorough review of most of the content of section 3.1.1 Exchange surfaces. It could be used directly by students or on-screen, or some of the interesting data could be abstracted and used to generate worksheets, for example exploring size and surface area to volume ratio.

Ensure comprehensive resources such as this are used alongside the specification to identify the most relevant sections.

Activity 7
Mechanisms of Ventilation (Slideshare)

http://www.slideshare.net/scuffruff/lesson-5-mechanisms-of-ventilation

PowerPoint on lung ventilation mechanism and interpretation of spirometer traces (opportunity to cover mathematics skills e.g. *M1.3*).

Activity 8
Countercurrent Gas Exchange in Fish Gills (Craig Savage)

https://www.youtube.com/watch?v=cVFqME-NW9s or select the correct video from this page:

https://sites.google.com/a/parishepiscopal.org/savage-science/home/ap-bio-resources/savage-s-biology-video-tutorials/biodiversity-iv---animals

An informative five minute video on counter-current exchange in the gills of a fish. Students are asked to choose between two different bio-engineering options to maximise oxygen uptake. Figures are used to explain diffusion gradients. This would be a useful follow-up to fish dissection and revision of diffusion gradients generally.

Thinking conceptually

Approaches to teaching the content

Teaching could begin with basic principles and then consider the three different examples of exchange systems in animals and one in plants. Most of **3.1.1** Exchange surfaces is concerned with exchange of respiratory gases in mammals, fish and insects, but there is one reference to root hair cells **(3.1.1b)**, where the exchange concerns water and mineral ions instead.

An alternative route would be to start by relating structure to function in each organism in turn, and to derive from the anatomical studies the common features of gas exchange surfaces **(3.1.1b)** and the idea of increasing specialisation and efficiency of gas exchange surfaces as body size increases **(3.1.1a)**. An approach that climbs the phylogenetic hierarchy would deal with the animal examples in the order: insect, fish, mammal. Another approach would be to stress the difference between acquiring gaseous oxygen from air in a terrestrial environment by considering insects and mammals together, and contrasting this with obtaining dissolved oxygen from water in fish (synoptic link to **4.2.2g** adaptations).

After studying the gross anatomy of the exchange systems, either ventilation mechanisms or the cell level detail for each organism could come next. Some drawing together of common themes at the end of the topic is a good idea even if the principles **3.1.1(a)** (the need for) and **(b)** (the features of) were taught at the beginning.

Common misconceptions or difficulties students may have

Areas that may pose particular conceptual difficulties are:

- the mathematical skills required to calculate surface area to volume ratio of different sizes and shapes of bodies **3.1.1(a)**
- grasping the dynamic nature of diffusion gradients at exchange surfaces **3.1.1(b)**
- analysing spirometer data **3.1.1(e)**

Conceptual links to other areas of the specification – useful ways to approach this topic to set students up for topics later in the course

The grouping of exchange surfaces with transport in animals **(3.1.2)** and transport in plants **(3.1.3)** clearly indicates that acquiring respiratory gases (animals) or water and minerals (plants) should be linked functionally to the systems for transporting these and other substances.

There is also the conceptual link that both types of system, exchange systems and transport systems, are necessitated by increasing size and complexity of organisms, and by increased rate of metabolism **(3.1.1(a), 3.2.1(a), 3.1.3(a)** and **5.1.5(j)).**

An opportunity to measure physiological function (such as ventilation rates) is mentioned in learning outcome **5.1.1(d)**, ectotherms and endotherms.

Animal exchange and transport link synoptically to the topic of respiration **(5.2.2)** while plant exchange at the roots and water transport link to photosynthesis **(5.2.1)**.

The overlap between the epithelia (**2.1.6(h)** and **(i)**) and the histology knowledge of the lungs required for **3.1.1(c)** and **(h)** provides an opportunity for reinforcement in teaching.

Understanding of diffusion **(2.1.5d)** and osmosis **(2.1.5e)** is an important prerequisite for teaching exchange surfaces. Practical activities investigating diffusion in model cells such as agar cubes **(2.1.5d(ii))** can be used to illustrate both the importance of the diffusion distance with regard to a need for a transport system and the importance of surface area to volume ratio regarding the need for additional exchange surfaces in larger organisms.

Learner Activity 1
Effect of Size on Uptake by Diffusion (Nuffield Foundation)

https://pbiol.rsb.org.uk/exchange-of-materials/diffusion/effect-of-size-on-uptake-by-diffusion

This is a resource for running a basic practical activity to investigate the effect of surface area to volume ratio of three agar cubes on exchange. A student worksheet and spreadsheet for results is provided. To upgrade the activity to A Level, students could be given the opportunity to cut more cubes of different sizes, or to devise a range of shapes that utilise the same volume of agar but have different surface areas. Calculation of surface areas and volumes of cubes, cuboids and cylinders involves maths skill *M4.1*. The activity relates to **PAG8.**

Learner Activity 2
Importance of Surface area to Volume ratio video (Stephanie Castle)

https://www.youtube.com/watch?v=xuG4ZZ1GbzI

This short video clip (2 minutes 44 seconds) demonstrates the experiment described in the Nuffield resource.

Learner Activity 3
Clay Creatures' Vital Statistics

Students are given several pieces of modelling clay, each of the same weight or volume. Their brief is to design animals for different habitats and levels of activity, so that some maximise oxygen uptake and some are less efficient according to their needs. The students could name their creations and have the chance to explain each one's adaptations in pairs or to the class. Fast and slow organisms, terrestrial and aquatic habitats, and low oxygen environments (high altitude, polluted water, tidal mud) could be considered.

The surface area to volume ratio of each creature should be estimated *(M0.4)* before being calculated *(M4.1)* and the creatures could be ranked in order of surface area to volume ratio.

If the fiction were established that every mm of clay actually represents a µm, the calculations of surface area and volume would be more relevant to diffusion of gases. Some micrograph images of tiny multicellular animals like tardigrades, rotifers and water fleas could be shown on the whiteboard to compliment the students' ideas.

Learner Activity 4
Gas Exchange: Diffusion and Partial Pressure Gradients (Education Portal)

http://education-portal.com/academy/lesson/gas-exchange-diffusion-partial-pressure-gradients.html#lesson

This seven minute video lesson features animations and the text of the narration is also supplied. It could be used in class or for home study.

Learner Activity 5
Diffusion PowerPoint (D.G. Mackean)

http://www.biology-resources.com/biology-CD.html

This PowerPoint contains plenty of detail despite being pitched at key stage 4 and revises principles of diffusion and diffusion gradients within a gas exchange context in individual cells, human lungs, fish gills and plant leaves.

Learner Activity 6
Using a Spirometer (Nuffield Foundation)

https://pbiol.rsb.org.uk/cells-to-systems/ventilation-systems/using-a-spirometer-to-investigate-human-lung-function

This has procedural and health and safety notes on running a class spirometer practical, with a student worksheet with teacher notes on the practical and interpreting spirometer traces as well as a student consent form and a spreadsheet for analysis. There is scope for practising maths skills *M0.1*, *M0.2*, *M0.4* and *M1.3*.

Contexts

Suggested contexts for developing a broader and deeper understanding of the topics in 3.1.1 Exchange surfaces include:

- a project for students to build their own spirometer

and resources for discussion or individual student research into:

- gas exchange in giant insects
- humans breathing at very high altitude
- humans breathing underwater
- the use of oxygen in a medical context.

Learner Activity 1
No Cost Spirometer (Slidehare)

http://www.slideshare.net/gnriem/no-cost-spirometer-to-measure-vital-lung-capacity-dr-g-nagaraj?next_slideshow=1

PowerPoint describing construction of a home-made spirometer from plastic bottles. This could provide a creative student project if health and safety considerations are checked out. This could relate to **PAG12** and HSW4.

Learner Activity 2
Giant Insects Discussion Topic

https://www.nationalgeographic.co.uk/2019/04/giant-water-bugs-eat-turtles-ducklings-and-even-snakes

Giant water bugs eat turtles, ducklings, and even snakes (National Geographic 2019).

Meganeura Giant Dragonfly (Naked Science 2012)

https://www.youtube.com/watch?v=9kzorrSbaUA

Why Giant Bugs Once Roamed the Earth (National Geographic 2011)

http://news.nationalgeographic.com/news/2011/08/110808-ancient-insects-bugs-giants-oxygen-animals-science/

Students could be asked 'How big do insects grow?' in the context of the comparative inefficiency of the insect tracheal system. A Google image search for 'largest insect' should allow students to estimate the maximum size of modern insects like the Goliath Beetle, Titanic Longhorn Beetle and Atlas Moth. Dimensions and images of fossilised giant dragonflies could then be presented (e.g. with the video clip listed here) with the question as to why they grew so big then but not now.

The two article links provided give different answers, showing HSW7, HSW11.

Learner Activity 3
The 20 000 Foot Parachute Jump Conundrum

SkyDance (SkyDance SkyDiving) https://skydanceskydiving.com/halo-skydiving/

Spacejump (Pro-stunts Ltd) http://www.spacejump.co.uk/training.htm

The physiological zone for humans is from sea level to 10 000 feet. Above this supportive equipment is needed to avoid hypoxia. Usual skydiving takes people up to an altitude of 10 000 feet

The conundrum is to assume that a person jumps from higher than 10 000 feet with a parachute but no breathing apparatus. Should they open the parachute immediately and delay their fall though the altitudes where oxygen partial pressure is too low? Or delay opening the parachute to fall faster through this danger zone, and risk losing consciousness before opening the parachute. This problem is presented as something to stimulate student discussion or research based on a secure understanding of diffusion gradients at the alveoli so that the link is made between 3.1.1(b), (c) and (d) and the new context.

In fact two types of jump occur in the military, HALO (high altitude low opening, also used in skydiving) - see the SkyDance SkyDiving website https://skydanceskydiving.com/halo-skydiving/ and HAHO (high altitude, high opening) - such as Felix Baumgartner's record-breaking jump from the stratosphere, see https://www.youtube.com/watch?v=dYw4meRWGd4.

Learner Activity 4
Breathing Underwater Fiction and Reality

Why can't we breathe underwater? (How Stuff Works) http://science.howstuffworks.com/question386.htm

Biomimicry gills (b/60)
https://www.youtube.com/watch?v=yW8m8SdiH60

Aquaman Oxygen Crystal (International Business Times)
http://www.ibtimes.co.uk/scientists-denmark-create-crystal-which-would-allow-breathing-underwater-1468336

Harry Potter & the Goblet of Fire book pp. 428-429 (J.K.Rowling, Bloomsbury)

An optional context for adding an element of fun to this topic is to use the example of Harry Potter needing to breathe underwater for an hour. Most students will be familiar with the idea of scuba diving apparatus which could be referenced here. The explanation of why we can't extract oxygen from water with lungs could be used as the starting point if the Harry Potter context is left out. Discussion or research work on this topic could relate to learning outcomes **3.1.1(c), (d), (f)** and **(g)** and HSW1 and HSW9.

Learner Activity 5
Medical Context Resources

Medical Oxygen (BOC)
http://www.bochealthcare.co.uk/en/Products-and-services/Products-and-services-by-category/Medical-gases/Medical-oxygen/medical-oxygen.html

Helium-Oxygen mixtures for patients in respiratory distress (BOC)
http://www.bochealthcare.co.uk/en/Products-and-services/Products-and-services-by-category/Medical-gases/HELIOX21/HELIOX21.html

Oxygen Therapy Uses (News Medical)
http://www.news-medical.net/health/Oxygen-Therapy-Uses.aspx

These resources could be used to explore situations when lung function can no longer meet a person's oxygen needs unaided, and the science behind medical intervention to prevent hypoxia, related to **3.1.1(c), (d)** and **(e)** and HSW9.

Did you know?

OCR Resources: *the small print*

OCR acknowledges the use of the following content: N/A

Whether you already offer OCR qualifications, are new to OCR, or are considering switching from your current provider/awarding organisation, you can request more information by completing the Expression of Interest form which can be found here: www.ocr.org.uk/expression-of-interest

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our **Customer Support Centre**.

General qualifications
Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk

www.ocr.org.uk

Cambridge Assessment

CERTIFIED ISO 9001

UKAS MANAGEMENT SYSTEMS 001