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AS and A LEVEL

Topic Exploration Pack

H020/H420

BIOLOGY A

Theme: Mechanisms of Ventilation and Gaseous Exchange in Bony Fish and Insects

April 2015

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Contents

This Topic Exploration Pack should accompany the OCR resource ‘Mechanisms of ventilation and gaseous exchange in bony fish and insects’ learner activities, which you can download from the OCR website.

Introduction

This topic exploration pack covers the AS and A Level Biology A Learning Outcomes 3.1.1(f) and (g):

3.1.1(f) the mechanisms of ventilation and gas exchange in bony fish and insects

3.1.1(g) the dissection, examination and drawing of the gaseous exchange system of a bony fish and/or insect trachea.

Once the need for specialised exchange surfaces and the features of an efficient exchange surface (3.1.1(a) and (b)) have been taught, students will learn the mechanisms of ventilation in humans, fish and insects (3.1.1(c) – (h)).

When teaching ventilation in humans, fish and insects, links can be made to specification reference 3.1.1(b) – the features of an efficient exchange surface. In addition to this, links can be made between each ventilation system eg air/water flow being a result of pressure changes within the organism.

Aims and Objectives

1. To understand how a unidirectional flow of water is maintained over the gills.
2. To define and be able to use the terms: operculum, gill filaments, gill lamellae/plates and buccal cavity when describing the above.
3. To explain why a countercurrent flow is more efficient at exchanging oxygen in fish than a concurrent flow.
4. To complete the dissection, examination and drawing of the gas exchange system of a bony fish and/or insect trachea.
5. To list the parts of the ventilation system in insects and explain how they are adapted for efficient gas exchange.
6. To explain how movement of the thorax and abdomen of an insect results in ventilation.

Suggestions for delivery

1. Starting with a quick recap of gas exchange in humans, followed by a discussion about why this system would not be an efficient system for fish would get students thinking about the issues that need to be overcome by fish when ‘breathing’ and why fish gills are the way they are.

2. A discussion about what students already know about ventilation in fish would be one way to highlight any misconceptions they might have.
3. Dissection of fish heads allows students to see the ventilation system in 3D which makes it easier for them to visualise water movement over the gills and gas exchange.
4. A variety of teaching and learning styles/activities can be used to engage students in what some may think of as a rather 'dry' topic eg picture or information from memory to introduce the topic, card sorts to remember a sequence of actions (ventilation in fish) in addition to modelling the theory (ventilation in insects). The latter will also give students the opportunity to use their presentation skills.
5. Using graphs and/or statistics when teaching countercurrent flow will allow students to use higher-level thinking skills to interpret data and apply their subject knowledge to novel situations.

Common student misconceptions

- Some students have the idea that fish 'gulp/suck' water into the mouth. Activity 4 should address this, but you may want to emphasise that it is the changes in pressure inside the buccal cavity that cause the water to flow from a relatively high pressure outside to a lower pressure inside, and not a 'sucking' action.
- Some students may believe that fish need to swim continuously in order to 'breathe'. Sharks and rays need to do this but in bony fish (teleosts), the flow of water over the gills due to pressure changes is enough.
- Some students will think that fish have lungs in addition to gills rather than the gills being the fish equivalent of human lungs.
- Some students will be under the impression that fish take in separate mouthfuls of water for breathing and for eating– they will not be aware that food is filtered out of the water moving over the gills at the same time as oxygen is being removed.

Useful websites

http://www.todayifoundout.com/index.php/2011/09/how-fish-gills-work/

http://futurescientists.tamu.edu/lesson11/page2.html

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

http://www.s-cool.co.uk/a-level/biology/gas-exchange/revise-it/gas-exchange-in-fish

http://www.s-cool.co.uk/a-level/biology/gas-exchange/revise-it/gas-exchange-in-insects

April 2015

Formative assessment

Some students will have studied gaseous exchange in fish at GCSE. You could use past GCSE exam questions to gauge their prior knowledge and plan your lessons to build on that knowledge (eg OCR Gateway Biology B, B632/02 paper, June 2011, Question 7).

There are numerous opportunities throughout the suggested activities (below) to inform teachers which areas of the topic may need to be addressed further or clarified. For example, the correct ordering of cards to describe fish ventilation (Activity 4), correct explanations of why countercurrent flow is more efficient than a parallel concurrent flow (Activity 5) and a detailed description of insect ventilation using models (Activity 6).

Summative assessment

In addition to the exam-style question in Activity 7 (below), an internet search will provide more exam-style questions and mark schemes for use in class.

Activity 1 – Getting You Thinking

- Write the following question on the board:
  'Why won't the mammalian ventilation system work in fish?'
- Students spend 2-3 minutes discussing this in pairs.
- This is followed by a class feedback and discussion session.

Expected Duration: 7-8 minutes

Activity 2 – Introduction to the ventilation mechanism in fish

- Students work in groups of 3.
- The teacher has the 'picture information from memory' sheet on the table in front of them.
- One student from each group comes to the front to look at the sheet for 10 seconds.
- The student returns to their group and draws what they can remember onto a blank A3 sheet.
- The other two students in the group repeat these steps.
- Each group can send one student at a time to see the sheet as many times as they wish, over a total of 5 minutes, HOWEVER,
- When finished, the teacher gives a mark out of 20 for each group for accuracy and DEDUCTS 1 mark for each additional visit to see the sheet after the initial three viewings.

Expected Duration: 15 minutes for instructions, activity and debrief afterwards

Activity 3 – Dissection of a fish head

Most supermarkets or fishmongers will be happy to give fish heads for free/very low cost if you contact them in advance. Try to get them as fresh as possible as the gills will still be a dark red colour. Good fish to use are salmon, perch or mullet.

See the 'Dissection of a fish head' teacher notes (pg11) and the 'Activity 3 Fish Head Dissection' student sheet.

Here are some useful websites detailing fish dissection:

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

http://australianmuseum.net.au/image/Fish-Dissection-Gills-exposed/

http://www.cswnetwork.org/projects/pdf/197.pdf

http://www.dec.ny.gov/education/92833.html

Expected Duration: 45 - 50 minutes

Activity 4 – Ventilation in bony fish - card sort

- Students complete the card sort (see the 'Activity 4 Ventilation in bony fish' student sheet) to describe how a unidirectional flow of water is maintained over the gills.
- They can do this individually or in pairs.
- You may wish them to try to complete this without using their textbooks first, followed by checking and correcting any mistakes with the use of their textbook.

Correct Sequence of Cards

1. Mouth opens (operculum is closed)
2. The buccal cavity floor is lowered
3. This increases the volume and decreases the pressure of the buccal cavity compared to outside
4. Water rushes into the mouth down a pressure gradient
5. Opercular cavity expands
6. The buccal cavity floor is raised
7. The pressure inside the buccal cavity is now higher than in the opercular cavity
8. Water moves from buccal cavity over the gills into the opercular cavity
9. The mouth is now closed and the operculum opens
10. The sides of the opercular cavity move inwards, increasing the pressure
11. Water rushes out of the fish through the operculum

Expected Duration: 15 - 20 minutes

Activity 5 – Countercurrent flow/exchange

- Show the students graphs or images showing countercurrent vs. concurrent/parallel flow/exchange like the ones on the website below (an image search on the internet should provide additional graph options).
- Using this information, in pairs ask students to answer the following question:

  Why is a countercurrent flow a more efficient way for gas exchange in fish than a concurrent/parallel flow?

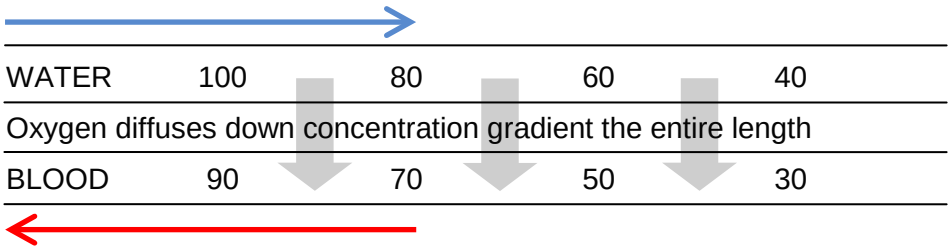
http://physicsmadeeasy.wordpress.com/biology-notes/gas-exchange/

Key points:

- In countercurrent flow/exchange, blood flows in the opposite direction to the flow of water.
- This results in the oxygen concentration gradient between the blood in the gills and the water being maintained across the entire length of the gill lamella.
- This causes oxygen to diffuse down the oxygen concentration gradient from the water to the blood.
- Even when the concentration of oxygen in the water is low at the opercular cavity end of the lamella, blood has just entered the gill lamella, therefore, is even lower in oxygen concentration. This means there is still a diffusion gradient allowing the diffusion of oxygen from the water into the blood.
- With parallel/concurrent flow, the concentration of oxygen in the water and in the blood in the gills will equalise, therefore no more oxygen exchange would take place.
- Note: For countercurrent flow gas exchange, the flow of water must be unidirectional, not tidal.

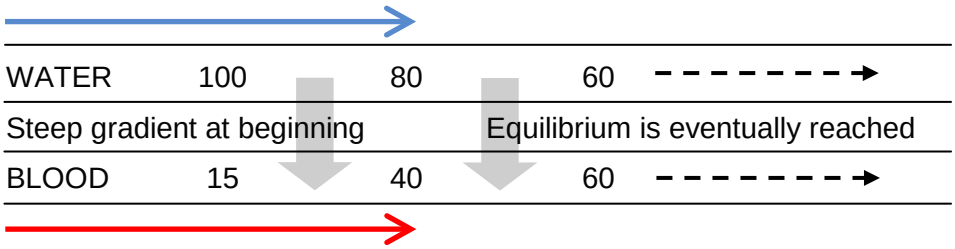
COUNTERCURRENT FLOW

% Oxygen Saturation



CONCURRENT FLOW

% Oxygen Saturation



Once equilibrium has been reached there is no net movement of oxygen into the blood, therefore, with a concurrent flow, blood will only be up to 60-70% saturated with oxygen.

Expected Duration: 15 minutes to answer the question, feedback and teacher to consolidate the key points

Activity 6 – Ventilation in insects

- Students make models (using modelling clay, card, pipe-cleaners etc.) and use a digital camera to take a series of photographs to show the breathing movements in an insect (eg a locust). These can then be used to make a movie or a PowerPoint presentation to present to the rest of the class. They can include all of the information in the presentation/movie itself, or use the presentation as a visual aid while they explain the process themselves.
- You may want to give them diagrams of a locust to use if they wish.
- It may also be useful to give them a list of keywords and ideas that must be used or explained eg spiracles, trachea, tracheoles, chitin, thorax, abdomen, muscles, pressure, ganglia, carbon dioxide/lactic acid.

Expected Duration: 60 - 80 minutes

Activity 7 – Exam-style question

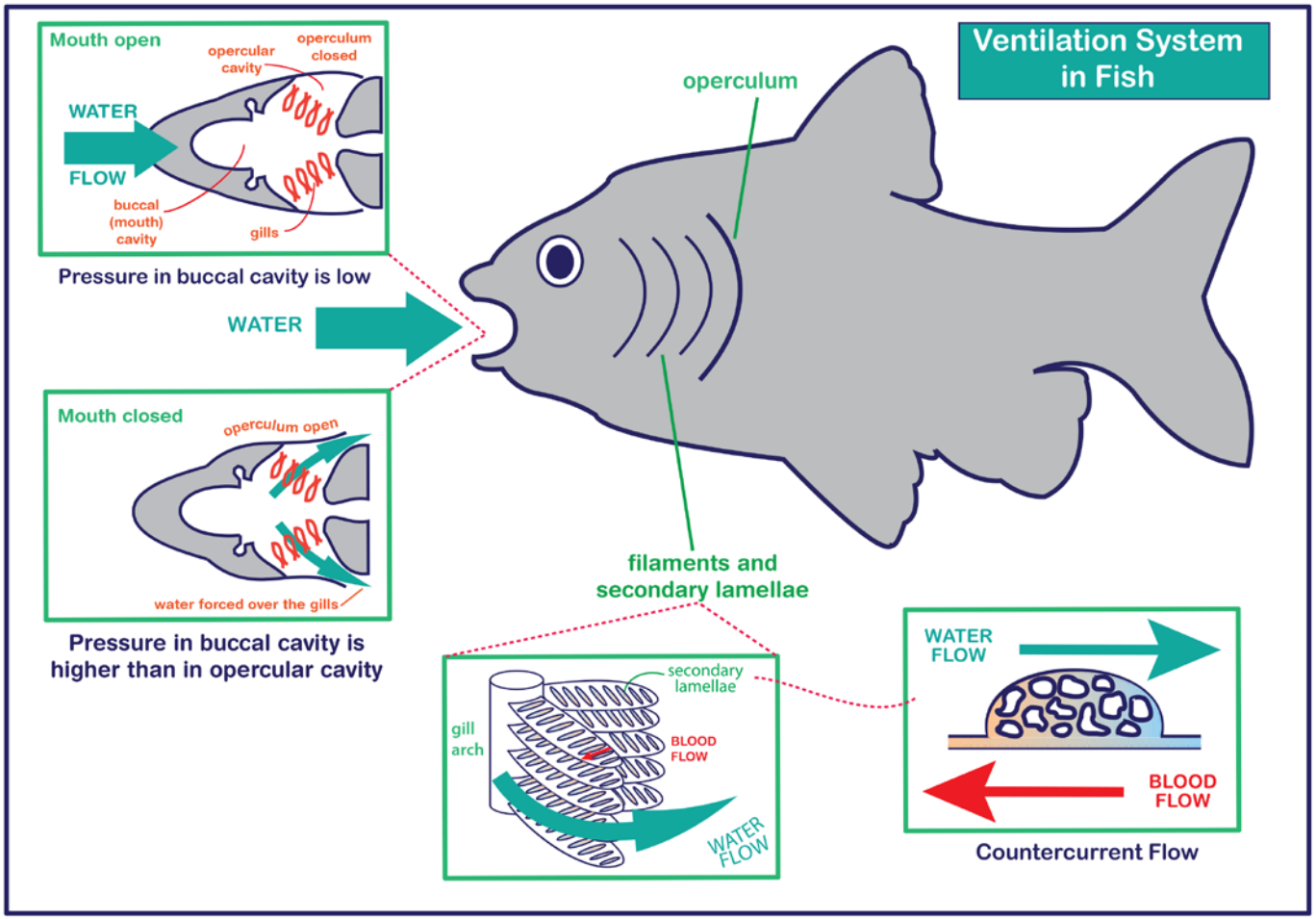
- Students complete question 1 on the following website:

http://www.s-cool.co.uk/a-level/biology/gas-exchange/test-it/exam-style-questions

(The answers are provided on the website).

Expected Duration: 15 minutes

Activity 2 Introduction to the ventilation mechanism in fish - 'Picture information from memory' sheet



Activity 3 Dissection of a fish head - Teacher Notes

Equipment

Fish heads – salmon, perch or mullet
Knives/scalpels
Magnifying lenses
Latex/plastic gloves
Dissection scissors
Forceps
Tray/board
Disinfectant
Waste bags

Main points to demonstrate to students:

- Open and close the mouth to show the lower part of the mouth moves (as part of the mechanism for changing the pressure inside the mouth/buccal cavity).
- Push the forceps into the open mouth and allow them to exit through the operculum at the side of the head (to show the path of water flow).
- Lift up the operculum to show the gills below, and then use the scissors to remove it.
- Cut through the bone at the top and bottom of the gills where they attach to the inside of the head to remove them.
- Use the forceps to lift up the gill filaments and cut them away from the skin they are attached to.
- To see the structure of the gills more clearly, you may want to place the gills in a beaker of water. The students can draw and label the gills.
- You can discuss the colour of the gills and why the shape of the gills is efficient for gas exchange.

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