

Week 5 Lesson 1

The Bombardier beetle

Aim: Explore an aspect of chemistry found in an organism which is being researched by scientists.

Keywords: catalyst, chemical reaction, evolution, exothermic

Starter activity

1. Scientist – who's who?

Match the scientist with their areas of research and other achievements.

Main activities

1. Charles Darwin and the Bombardier beetle

The following activities are on the PowerPoint 'The Bombardier Beetle':

- The story of Charles Darwin's encounter with a Bombardier beetle
- Sequence the possible stages of evolution of the Bombardier beetle's defence mechanism
- Practical - exothermic reaction.

Plenary activity

1. Haiku

Students sum up the lesson or part of the lesson by writing a three line Haiku.

The first line should have 5 syllables, the second 7 and the third 5. Subjects could be Darwin, bombardier beetle, exothermic reactions, catalysts.

E.g. *Charlie learnt one truth
when out hunting for beetles.
Bug in mouth - no fun!*

Differentiation

Students who need support could be given a selection of words with syllables counted or marked by dots.

Week 5 homework activity

This task is in preparation for lessons next week on artificial photosynthesis. Students are asked to produce a PowerPoint which will be shown in the lesson next week. Assign each student a task or ask them to choose one. Tell them that the PowerPoints that they create will be shown in class the following week.

- Design a PowerPoint presentation which shows the substances that are involved in photosynthesis. Use a maximum of six slides.
- Design a PowerPoint presentation which describes the process of photosynthesis. You are allowed to use mathematical symbols, three words only and a maximum of three slides.
- Design a PowerPoint presentation which explains photosynthesis cryptically. Think of clues which Sherlock Holmes might decipher to give each part of the process. Use a maximum of six slides.

Starter 1

Who's who? – Teaching notes and answers

This is a tiny snapshot of scientists that students may have heard of, both historical and contemporary. For further information about inspirational scientists see the following links:

- For influential women scientists both historical and contemporary see this article from *The Independent*: www.independent.co.uk/news/science/women-in-science-pioneers-blaze-path-for-others-1924794.html
- *The Life Scientific* programme from Radio 4 has lots of interviews with current scientists: www.bbc.co.uk/programmes/b015sqc7
- The Royal Society webpage *Inspiring Scientists: Diversity in British Science*, records the life stories of 10 British scientists with minority ethnic heritage: royalsociety.org/policy/projects/leading-way-diversity/inspiring-scientists/
- The Royal Society of Chemistry has a series of short videos which ask inspirational scientists working in chemistry what motivated them to study chemistry: www.rsc.org/learn-chemistry/collections/faces-of-chemistry/inspirational-chemists

Caroline Herschel born 1750 died 1848	Astronomy - discovered 8 comets and catalogued star clusters The first female scientist to be paid a salary
Stephen Hawking born 1942	Cosmology and theoretical physics, author of <i>A brief history of time</i>
Dr Maggie Aderin-Pocock, MBE born 1968	Space science, optical instrumentation Presenter of the <i>The Sky at Night</i> , MBE awarded 2009
Baroness Susan Greenfield, CBE born 1950	Professor of Synaptic Pharmacology at Oxford University Member of the House of lords
Rosalind Franklin born 1920 died 1958	X-ray crystallography, important contribution to understanding of DNA structure in the 1950s.
Brian Cox, OBE born 1968	Professor of Particle Physics at University of Manchester Writer, TV presenter and keyboard player for 80s pop group D:Ream
Alice Roberts born 1973	Clinical anatomist and Professor of Public Engagement in Science at the University of Birmingham Writer and TV presenter.
Peter Higgs born 1929	Proposed the existence of a particle called Higgs boson; Nobel prize in Physics 2013
Dorothy Hodgkin born 1910 died 1994	Biochemistry and protein crystallography - discovered the structure of penicillin and vitamin B12: Nobel Prize for Chemistry 1964
Isaac Newton born 1643 died 1727	Physics and mathematics, discovered laws of gravity and motion

Who's who?

Use the information to match the scientist to their area of research and achievements.

Scientist	Areas of research and some achievements
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Main 2

The Bombardier beetle - PowerPoint

5.1: The Bombardier beetle

Teaching notes

Slide 9
 The suggested stages of evolution could be illustrated with a simple demonstration.
 • Place three different concentrations of hydrogen peroxide into different beakers.
 • First stage of evolution - Add a catalyst (copper oxide) to the weakest solution to show a mild decomposition reaction.
 • Second stage - add the catalyst to the second beaker to show a more vigorous reaction.
 • Third stage - add the catalyst to the third beaker to show the most vigorous, exothermic reaction.

The following link shows a clip from the Royal Institution Christmas lectures where Richard Dawkins discusses the evolution of the Bombardier beetle:
www.youtube.com/watch?v=0vDkG7T7T8E

For the whole series follow this link - www.rsi.org.uk/Christmas-Lectures/Christmas

Slide 10
 An appropriate risk assessment needs to be carried out before students do the practical.

Slide 11
 For further information www.bombardierbeetle.com/typical.htm


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5.1: The Bombardier beetle

The Bombardier beetle

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5.1: The Bombardier beetle



Who is this?

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5.1: The Bombardier beetle

In his early twenties, Charles Darwin was a university student at Cambridge. The biggest craze at the time was beetle collecting. It was very competitive and young men spent many hours wandering through the countryside hunting for rare and unusual beetles.



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5.1: The Bombardier beetle



Out hunting one day, Darwin came across a rare beetle. He caught it and carried it in his hand. Minutes later, he found a second, equally unusual species which he grabbed. Then to his amazement, a third unfamiliar beetle scuttled by. Hands full, Darwin popped one beetle for safe keeping into his mouth and reached to grab the third before it could escape.

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5.1: The Bombardier beetle

With unspeskable disgust and pain Darwin discovered he had put a Bombardier beetle in his mouth: the only creature able to defend itself by mixing and squirting a boiling hot chemical towards its attacker. Hot acid burnt Darwin's mouth. He spat the beetle out and in his agitation, lost all three beetles.



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5.1: The Bombardier beetle



Not only can Bombardier beetles produce this toxic chemical they have a sophisticated valve mechanism which enables them to direct the spray forwards, backwards and to the side.

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5.1: The Bombardier beetle

How could an animal have such an intricate and potentially dangerous defence mechanism?

"If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down. But I can find out no such case."

(Charles Darwin, The Origin of Species: A Facsimile of the First Edition, Harvard University Press, 1964, p. 189)

Which theory is Darwin referring to in this quotation?

Theory of evolution by natural selection

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5.1: The Bombardier beetle

How could the Bombardier beetle evolved its defence mechanism?

Beetles have been on Earth for about 300 million years, that's before the arrival of flowering plants and dinosaurs and gives plenty of time for evolution to progress. Can you put the following statements in the correct order to show how evolution may have occurred in the Bombardier beetle?

A. Predators would be repelled by the weak hydrogen peroxide. The beetle's chance of survival would be increased. Its offspring may inherit this ability.

B. A method of directing the spray towards the predator would make the defence mechanism even more effective. These beetles would survive to pass on their genes.

C. Over time the beetles may then have evolved simple glands, one gland producing hydrogen peroxide, the other releasing the catalyst. The chemicals are mixed immediately the animal is threatened. These beetles which could produce a stronger chemical would be more effective at deterring predators.

D. Some beetles stored the weak hydrogen peroxide they naturally produced and secreted it when they are attacked.

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5.1: The Bombardier beetle

Practical - an exothermic reaction

Apparatus

- 100 cm³ beaker
- 2x 10 cm³ measuring cylinder
- Thermometer
- 1M sodium hydroxide (caustic)
- 1M hydrochloric acid

Method

1. Measure 10 cm³ of sodium hydroxide in measuring cylinder and pour into a beaker.
2. Take the temperature.
3. Measure 10 cm³ of hydrochloric acid in measuring cylinder and pour into the beaker of sodium hydroxide.
4. Take the temperature and calculate the temperature difference.

Questions

1. What type of reaction is it?
2. Write out the ionic equation for the reaction (b) the symbol equation?
3. How could you increase the amount of thermal energy released?
4. Suggest why energy is released during this reaction.

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5.1: The Bombardier beetle

Research and the Bombardier beetle

Scientists are interested in the Bombardier beetle because of its sophisticated spray system.

Why do you think they are interested in it's spray system, what applications might it have?

Read the article from the BBC about research by a team at Leeds University: www.bbc.com/news/science-environment-13379124

Questions

- What advantage would this spray mechanism have over current aerosol sprays?
- What areas do researchers think may benefit from their research?

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Week 5 homework

Preparation for photosynthesis

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