Introduction to GCSE Science
Biomimicry

teachitscience
RESOURCES YOU CAN TRUST

AQA

Introduction

This teaching pack is a collection of teaching ideas and student-facing resources (all of which were specifically commissioned for the pack), on the overarching theme of Biomimicry to be used as an introduction to GCSE Science for Y9 students. The theme of Biomimicry was chosen as it is an exciting area of research that extends across scientific disciplines using inspiration from nature to help scientists solve contemporary problems. The pack aims to bridge the gap between what students will have studied at KS3 (e.g. energy transfer, chemical reactions and photosynthesis) and areas studied at GCSE (e.g. nanotechnology, nerve impulses and forces).

It is planned as a six-week unit of work (18 lessons). Included are:

- starter, main and plenary activities
- practical investigations
- suggestions for differentiation and extension of activities
- suggested assessment opportunities
- resources to develop mathematical skills and understanding
- differentiated weekly homework activities
- links to areas of current research and scientists.

It is arranged lesson by lesson, with several suggested starters, main and plenary activities. It lends itself to a 'pick and mix' approach; choose from the suggested activities the most appropriate for your students. It could be dipped into on an ad hoc basis or it could form the basis of a longer unit of work. The resources are all available in adaptable formats, making it easy to differentiate the tasks by ability.

The practical investigations are all designed to use materials and equipment that are all easy to resource. They could be extended into more substantial investigations.

To help with navigation, there is a contents table which summarises the resources found in each lesson. Included are several interactive resources, to access these please go to www.teachitscience.co.uk/aqa-biomimicry

Our special thanks go to the author, Jane Robertson, who has created and written this pack.

Cover image credits: Butterfly, burdock and spider © Jane Robertson 2015 / Hydrophobic red material © Glenn Gould 2007 https://flic.kr/p/4nBnom / Hydrophobic green leaf © Michael Whitehead https://flic.kr/p/4y1YyZ / Beetle drawings © Wellcome Library, London / Whale © Boss Tweed 2008 https://flic.kr/p/5NhjwN

Resources summary

Lesson	Resource
W1L1 Introduction to biomimicry	Introduction to biomimicry – starter activities
	Trying to fly: making a model of Cayley's glider
	Units and equations
	Week 1 homework
W1L2 Nanotechnology	Large and small prefixes
	Large and small prefixes (interactive whiteboard version)*
	Powers of ten
	What is nanoscience and technology?
W1L3 Developments in microscopy	Important developments in microscopy
	Different types of modern microscope
W2L1 Things that glow in the dark	Using fluorescence – background information
	Fluorescent chemicals
	Week 2 homework
W2L2 What can we learn from termite mounds?	Odd one out
	What can we learn from termite mounds?
	Cross section of a termite mound
W2L3 What's special about a lotus leaf?	What's special about a lotus leaf?
	Magnification activity

* To access please go to www.teachitscience.co.uk/aqa-biomimicry

Lesson	Resource
W3L1 Spiny-headed worms and skin grafts	Interviewing the professor
	Week 3 homework
W3L2 Desalination	Water cycle
	Water cycle (interactive whiteboard version)*
	World's population and water
W3L3 Freshwater in deserts	Freshwater in deserts
	Questions and answers
W4L1 Neural networks	The brain – true or false?
	Neural networks
	A brief history of neural networks
	Week 4 homework
W4L2 Mussel adhesive	How do mussels stick?
	How do mussels stick? (interactive whiteboard version)*
	Making a glue
	Comparing mussel strength
W4L3 Tardigrades and vaccines	The problems with vaccines
	Tardigrades under the microscope

* To access please go to www.teachitscience.co.uk/aqa-biomimicry

Lesson	Resource
W5L1 The Bombardier beetle	Scientist – who's who?
	Charles Darwin and the Bombardier beetle
	Week 5 homework activity
W5L2 Wind turbine blades	Wind turbine blades
	Investigation - comparing designs for a helicopter blade
W5L3 Silk moths and chitin	Silk moths and chitin
	Comparing polymers
	Shrilk
	Maths and measuring volume
	Match the Greek word with its meaning
W6L1 Artificial photosynthesis (1) **W6L2** Artificial photosynthesis (2)	Artificial photosynthesis –starter
	Is chlorophyll the only pigment in green leaves?
	Artificial photosynthesis - obstacles to overcome
	What am I?
W6L3 A new look at wood	A new look at wood
	Comparing concrete and wood
	Cellulose and other materials

* To access please go to www.teachitscience.co.uk/aqa-biomimicry

Week 1 Lesson 1

An introduction to biomimicry

Aim: To explore the many ways in which the design of materials and structures are modelled on biological forms and processes.

Keywords: biomimicry, forces, base units, compound units, lift, thrust, drag, weight, gravity

Starter activities

1. Velcro survey

Students carry out a survey of who has any Velcro with them today. The activity can be found on Slide 2 of the PowerPoint 'Introduction to biomimicry – starter activities'. They could draw up a tally chart using categories such as:

Shoes, clothes (including coats/jackets), school bags, miscellaneous.

Ask them to discuss how they recorded their results, what they found and what type of graph they could construct from the results.

2. History of Velcro

Firstly, ask if anyone knows the history of Velcro or whether they can suggest what might have inspired its design. Use the PowerPoint 'Introduction to biomimicry – starter activities' to describe the observations that led to the development of Velcro.

Explain that this is a famous example of biomimicry.

Burdock, *Arctium lappa*, is a widespread plant of rough, weedy habitats. Its burrs can often be found from Sept – March. You may like to collect some to show students.

3. What is biomimicry?

Watch the TED-talk about biomimicry (there is also a link on slide 7 of the PowerPoint 'Introduction to biomimicry – starter activities).

www.ted.com/talks/janine_benyus_biomimicry_in_action?language=en

The whole clip is 17 minutes long. Leave the clip after the bullet train or after the shark/bacteria section (approx. 6 minutes). Ask students for examples of how people have looked to nature for ideas.

You could return to this video during subsequent lessons to illustrate the link to biomimicry.

Explain that students are going to do a series of lessons which cover many aspects of science, many of which were inspired in some way by the natural world.

Main activities

1. Cayley's glider

Humans have always been fascinated with flying. There are many examples of flying in nature. Students can explore early exploration of flight by making a model of one of the first gliders. See the resource 'Trying to fly: making a model of Cayley's glider'. The activity could be extended to allow students to investigate the effects of modifications on the flight of the glider.

2. Units and equations

There is follow on work (resource 'Units and equations') that introduces the common units of measurement that scientists use and gives students opportunities to develop their understanding of mathematical equations in Science.

Differentiation

Work through the examples with the class or groups of students who need more support. Other students may be able to work through independently. See the resource 'Units and equations' for more details.

Extension

There is a suggested extension activity in which pairs of students are encouraged to create their own problems using compound units that they can swap with another pair. See the resource 'Units and equations' for more details.

Assessment opportunity

This exercise provides an ideal opportunity to assess students' confidence when dealing with mathematical equations.

Plenary activities

1. Summarise a summary

Ask students to summarise the lesson in five bullet points, then three, then one and then finally in one word.

2. Units bingo

Ask students to draw a 3 x 2 grid and put into each square an abbreviated unit of measurement, these could be just base units (e.g. J or kg) or compound units (e.g. m/s) as well. Call out the name of a unit (for more challenge read out an equation e.g. distance ÷ time). Students cross out a square on their grids if they have the matching abbreviated unit.

3. Trying to fly

Show students images of early designs of flying machines. Ask students to put them in the order they were invented and explain the reasons for their choice. NASA has a useful website on the history of aviation:

www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/historyofflight.html.

4. Overarching plenary/homework

If you are following all the lessons in the teaching pack you may decide to encourage students to make a 'Collections' booklet. This could be completed at the end of each lesson. Suggested 'collections':

- keywords list
- list examples of bio-mimicry included in lessons e.g. fire flies, whale fins
- list and brief outline of some of scientific concepts included in lessons
- list and brief description of scientific concepts students are already familiar with
- description of how examples of bio-mimicry are being used
- an explanation of the potential of 2-3 examples of bio-mimicry
- an evaluation of the benefits of 2-3 examples of bio-mimicry
- examples of bio-mimicry not covered in lessons.

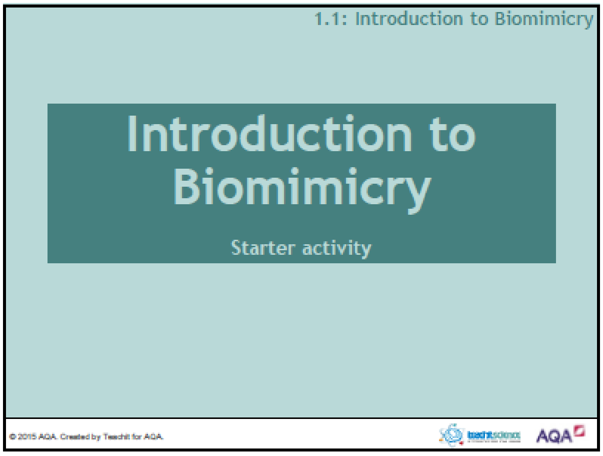
Week 1 homework activity

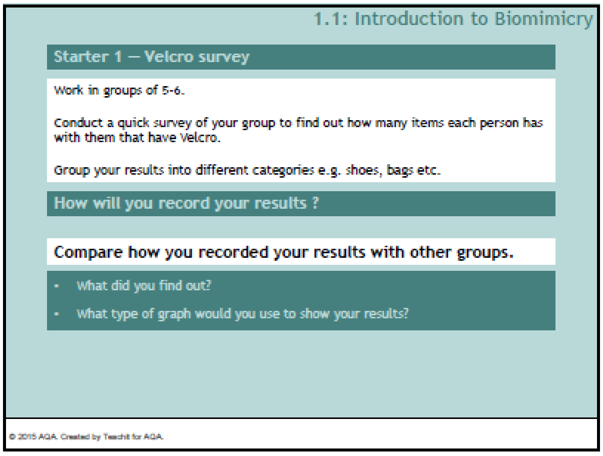
Ask students to bring in an old pair of over-the-knee length socks or tights. These will be used in ***Week 4, lesson 1: Neural networks***.

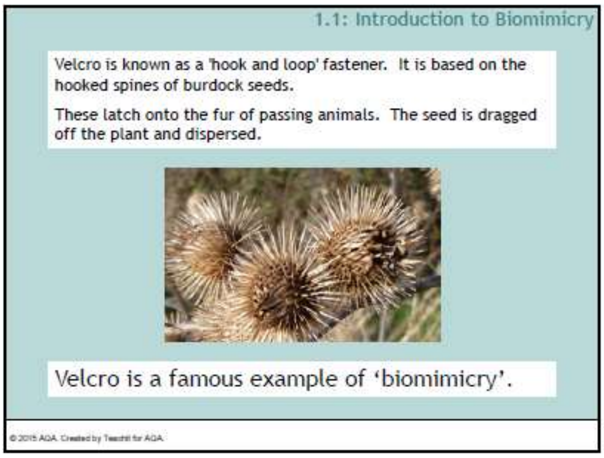
The following homework is in preparation for ***Week 2, lesson 2: What can we learn from termite mounds?*** Ask students to research African mound-building termites. There is a handout sheet with a video link and questions. Depending on the ability of the students they could be assigned one or all of the questions to research.

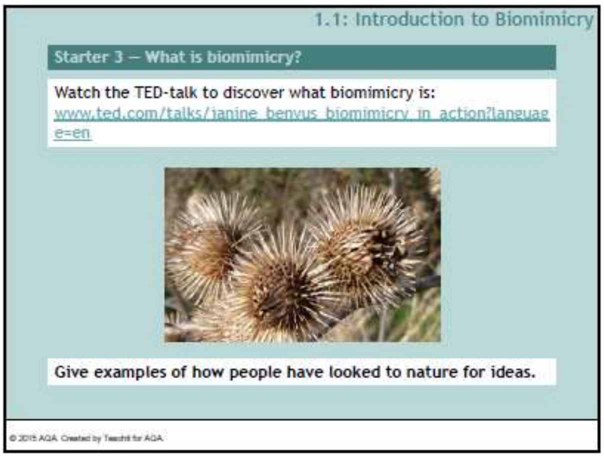
Starter 1, 2 and 3

Velcro survey? / History of Velcro / What is biomimicry? – PowerPoint









Main 1

Trying to fly: making a model of Cayley's glider –

Teaching notes

The pieces could be cut out before the lesson for the students to assemble. Test the gliders by seeing which travels the furthest. Time could be allowed for students to suggest and make modifications to the design.

This short YouTube video shows a similar model of the glider:

www.youtube.com/watch?v=nKZwEIRxJOc

The *How things fly* website from the Smithsonian National Air and Space Museum is useful for background information:

howthingsfly.si.edu/forces-flight/four-forces.

Trying to fly: making a model of Cayley's glider

Sir George Cayley 1773 - 1857

- Regarded as one of the most important people in the history of aeronautics.
- He was the first person to understand some of the forces which interact during flight.
- He applied the scientific methods of investigation to his research work.
- In 1804 he designed and built a model monoplane glider on which the glider you are about to build, is based.
- In 1849 he built a large gliding machine and tested it with a 10 year-old boy on board - the boy survived (but not his name!).

Task 1 - making the model monoplane glider

Apparatus

- 1 drinking straw (3mm diameter if possible)
- Blu tack
- 2 clear plastic lids (8cm diameter, e.g. yoghurt pot lids)
- scissors
- indelible pen

Method

Before starting, test the straws on their own – how well do they fly?

You will need 3 spheres of Blu tack – diameters as shown in diagram.

If using clear plastic lay it on the diagram, trace the shapes from the diagram onto the clear plastic and cut out.

Cut out 2 kite shapes. Cut one in half lengthways.

Attach the spheres of Blu tack as shown in the diagram.

A should stand proud of the straw by 5mm. The centre of the edge of the wide end of the 'wing' rests on this. A small flap of Blu tack can be pressed on top to secure it.

B is used to secure the end of the 'wing'.

C can be pushed into and wrapped around the end of the straw. The Blu tack needs to project beyond the end of the straw so the 3 tail fins can be pushed in.

Tail fins need to be at right angles to each other.

Now decide how you will test your glider – remember to throw it like a dart not like a javelin!

Task 2 – forces of flight

The four forces of flight are:

lift **thrust** **drag** **weight**

Each force has an opposite force which works against it.

1. Can you pair up the four forces?
2. Draw a diagram of your model glider and label the four forces which act on it. Use arrows to show the direction of each force.

3. Complete these sentences:

The glider goes upwards if .... and .... are greater than

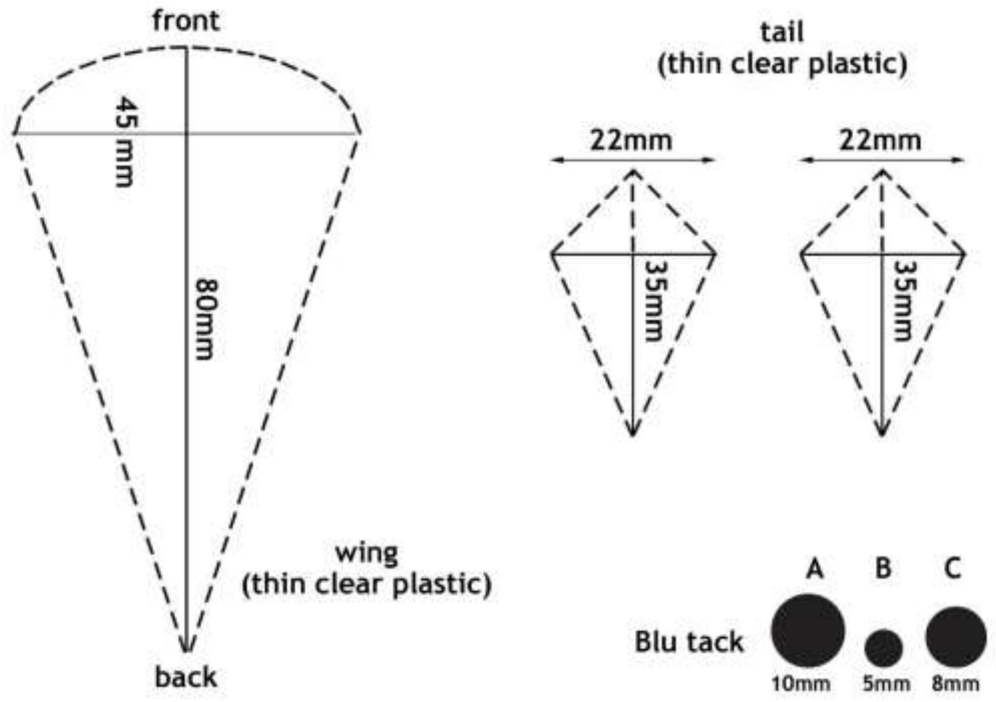
.... and..................................

The glider maintains a level flight and constant speed when the forces are ....

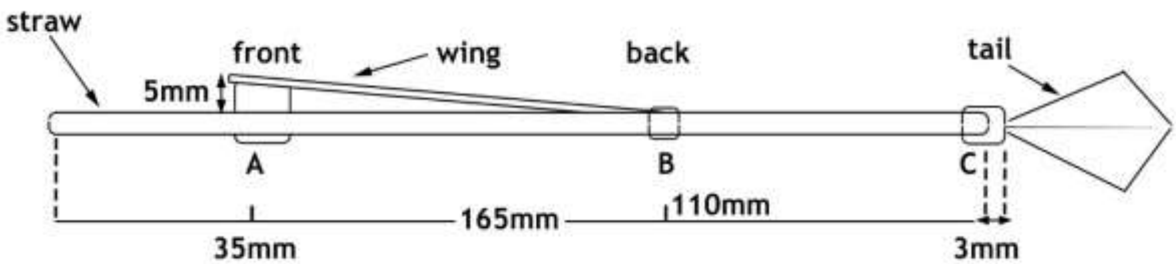
Words to choose from:

- balanced
- unbalanced
- thrust
- gravity
- lift
- weight
- drag

Trying to fly: making a model of Cayley's glider — Template



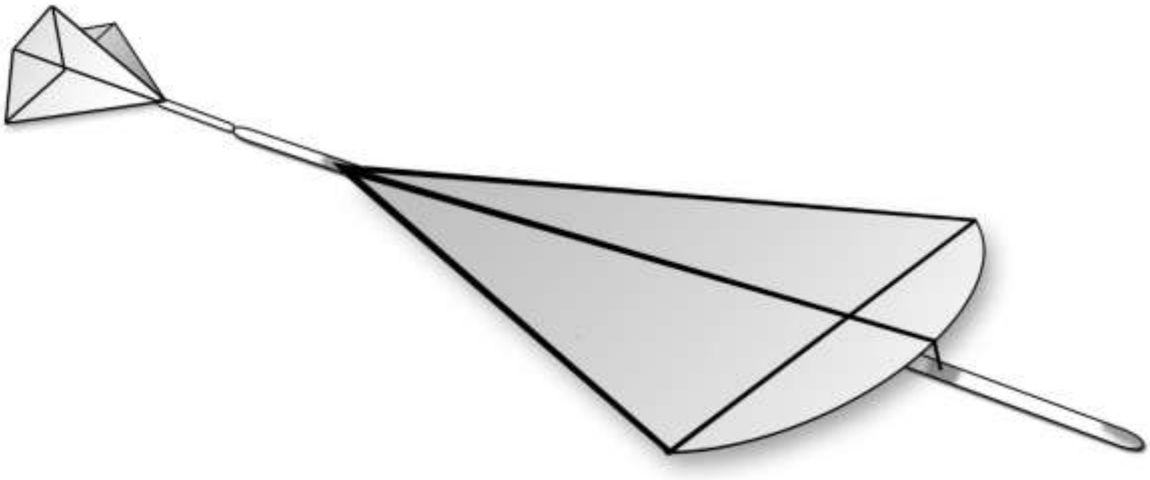
How to assemble the glider



Finished glider
(Not to scale)

Trying to fly: making a model of Cayley's glider –

Finished glider



Main 2

Units and equations — Teaching notes

Task 2 is designed to get students recognising how they instinctively solve mathematical problems and that equations are a way to represent that process. Take the opportunity to ask students to describe/explain how they worked out the problems - each student will often have their own way of working out mathematical problems.

Differentiation

Depending on the ability of the students it may be appropriate to work through the problems as a class. Some students may be able to work through independently and find all of the possible solutions.

Students who need most support may need to be given each equation to work out.

e.g. distance = 12 metres   time = 6 seconds

speed = distance ÷ time

speed = 12 ÷ 6

speed = …. m/s

Extension

Working in pairs, students could create their own examples similar to the ones above. They could create ones which they think might apply to the following examples:

- a snail, cheetah and a peregrine falcon
- a child on a tricycle, a Tour de France cyclist and a motorcycle courier delivering blood.

They could use them to write a set of problems which they swap with another pair.

Units and equations — Answers

Task 2

1.

a. speed = 6 m/s, time = 2 s (or vice versa), distance = 12 m
b. speed = 6 m/s, time = 3 s (or vice versa), distance = 18 m
c. speed = 7 m/s, time = 5 s (or vice versa), distance = 35 m

2.

a. 20 m ÷ 4 s = 5 m/s (or 4 ÷ 20 = 0.2 m/s)
b. 15 m ÷ 5 s = 3 m/s (or 5 ÷ 15 = 0.3 m/s)
c. 91 m ÷ 7 s = 13 m/s (or 7 ÷ 91 = 0.1 m/s)

3.

a. 2, 6 2 x 6 = 12 m
b. 8, 5 8 x 5 = 40 m
c. 7, 9 7 x 9 = 63 m

4.

a. 21 m ÷ 3 m/s = 7 s (or 3 m ÷ 21 m/s = 0.14 s)
b. 48 m ÷ 6 m/s = 8 s (or 6 m ÷ 48 m/s = 0.13 s)
c. 60 m ÷ 12 m/s = 5 s (or 12 m ÷ 60 m/s = 0.20 s)

5. distance = speed x time

6. time = distance ÷ speed

Units and equations

Many scientific investigations involve measurement to find out how much of a particular quantity an object has (e.g. length or mass). There are several different measurements which can be taken depending on what quantity you want to find out. Each quantity has its own base unit of measurement. Here are some you may be familiar with.

Task 1

1. **What other units may be used for some of these measurements? Fill in the last column of the table.**

Quantity	Base unit	Abbreviation	Other units used
length	metre	m	
time	second	s	
mass	kilogram	kg	
electric current	amp	A	
temperature	Celsius and Kelvin	C and K	
energy	joule	J	
area	square metre	m^2	
volume	cubic metre	m^3	
force	newton	N	

Scientists also need to calculate other quantities. They do this by combining two or more base units together into an equation.

2. **The table shows some compound units and the quantities that they represent. Use the information that you have been given to complete the table.**

Quantity	equation using base units	compound unit
density	mass ÷ volume	kg/m^3
	distance ÷ time	m/s
power	energy ÷ time	
pressure		N/m^2
work done	force ÷ distance	

3. **When you tested your glider how did you compare it with other gliders?**

Did you measure how far it travelled?

....

....

....

4. **What else do you need to know to calculate the speed of your glider?**

....

....

....

Task 2

Here are some measurements from the flights of a model glider. For each flight they wrote down, in no particular order, measurements for time, distance and speed. The group didn't write down any units.

1. **For each of the three flights can you decide what each measurement is for - speed, distance or time? There is more than one correct answer.**
   - **a.** 6, 2, 12
   - **b.** 18, 6, 3
   - **c.** 7, 35, 5

2. **Can you find the speed from just two measurements? Give your answers to 1 significant figure.**
   - **a.** 4, 20
   - **b.** 15, 5
   - **c.** 91, 7

3. Now imagine you have been asked to find the distance from two measurements. How will you do this?

- **a.** 2, 6
- **b.** 8, 5
- **c.** 7, 9

4. How about calculating time from two measurements? Give your answer to 2 decimal places.

- **a.** 21, 3
- **b.** 6, 48
- **c.** 12, 60

5. You know that speed = distance ÷ time. This is called an equation.

- Can you write an equation which shows how to calculate distance if you know the speed and time of your glider?

- What would be the equation to show time if you know the speed and distance of your glider?

Week 1 homework

1. Please bring in an old pair of over-the-knee length socks or tights.

2. A research task for a future lesson about termite mounds.

Watch the following clip of David Attenborough talking about termites from the BBC series *Life in the undergrowth*:

www.youtube.com/watch?v=xGaT0B__2DM

Answer these questions:

- What are termites?
- Where do termites live?
- Why are termites known as 'nature's architects'?

Week 1 homework

1. Please bring in an old pair of over-the-knee length socks or tights.

2. Research task for a future lesson about termite mounds.

Watch the following clip of David Attenborough talking about termites from the BBC series *Life in the undergrowth*:

www.youtube.com/watch?v=xGaT0B__2DM

Answer these questions:

- What are termites?
- Where do termites live?
- Why are termites known as 'nature's architects'?