



DARWIN
INSPIRED
LEARNING

Enquire
with Darwin

KS3

Module 1: Darwin's Bees

Small links in the chain of evolution

Circus: link 1

Fossil bees and comb (slides 2-4)

Look at the fossil evidence

- What do you notice about the packing of the cells?
- Do you think that this specimen is likely to contain wax?
- What plants might have been evolving in the same geological era?
- Would Darwin have had this geological evidence?

Circus: link 1

Fossil bees and comb

Bees are now thought to originate from meat-eating hunting wasps that developed a taste for nectar. The oldest known fossil bee to date is from the Upper Cretaceous (96-74 million years ago) and looks like bees in the same group today. There is later fossil evidence that, as the climate and land masses changed, bees adapted to survive and colonise new habitats.

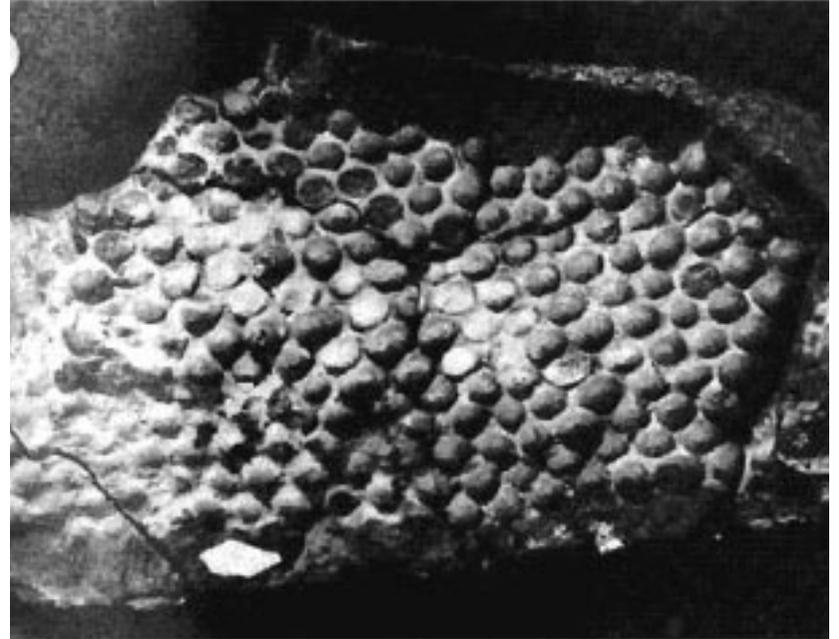


Oligochlora semirugosa
in amber from Miocene
(23-5 million years ago).

Circus: link 1

Fossil bees and comb

Fossilised comb from a social wasp's nest (Cretaceous period)



Circus: link 2

Arguments about the evolution of the comb

Different species of bees today show different stages in the evolution of comb building.

www.youtube.com/watch?v=LqreQmaJpmg&feature=endscreen&NR=1

Circus: link 2

Arguments about the evolution of the comb

The Mexican bee *Melipona* makes a rough comb of nearly spherical cells for holding larvae. The cells have flat sides where they happen to meet.

Honey and pollen are stored in pouches at the sides. The comb is built horizontally.

www.youtube.com/watch?v=JWOTczp0BiA&feature=related

Circus: link 2

Arguments about the evolution of the comb

The honeybee, *Apis*, builds its comb vertically.

The cells are in a double, intersecting layer and hexagonal.



Honeybee comb

Circus: link 3

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A theory of how bees might make a hexagonal comb (slides 8-10)

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Write a clear sentence to describe a theory of how bees might make hexagonal comb

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Darwin corresponded with George Robert Waterhouse in 1858.

Waterhouse wrote about how the bees made circular cells:

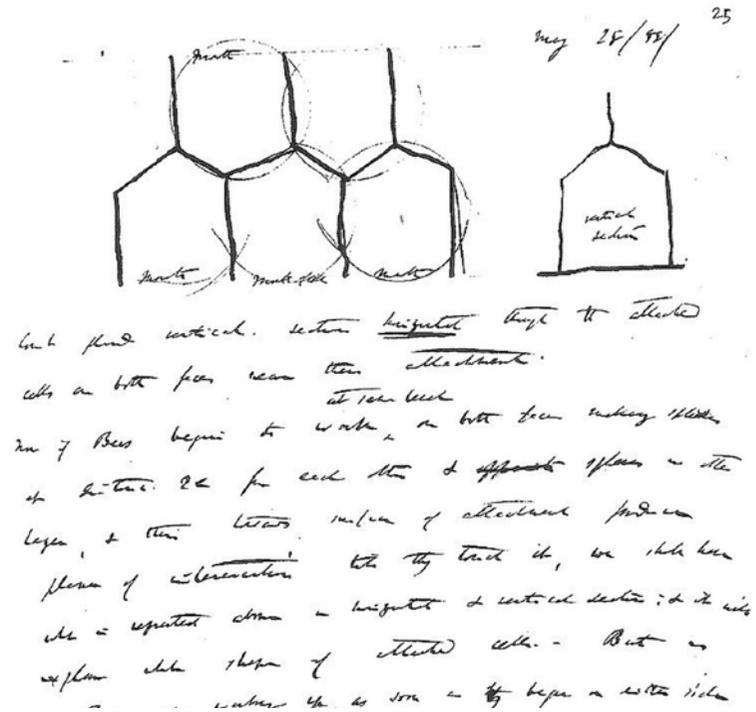
'...by keeping the body fixed in one position for some time & by working in all directions as far as she could reach, in her excavating, she would necessarily form a cavity in segments of circles and of definite size – the diameter being determined by her power of reaching.'

(Letter from G. R. Waterhouse, 10 February 1858.)

Circus: link 3

A theory of how bees might make a hexagonal comb

In his notes of 1858, Darwin is working out how to make hexagons from circles



Page from Darwin's notebook

Circus: link 3

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A theory of how bees might make a hexagonal comb

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What is the measurement of each angle? Draw a circle and then, without changing the radius, mark off arcs round the circle and join them up to form a hexagon.

Circus: link 4

Looking closely at the construction of a double layer of comb (slides 12-14)

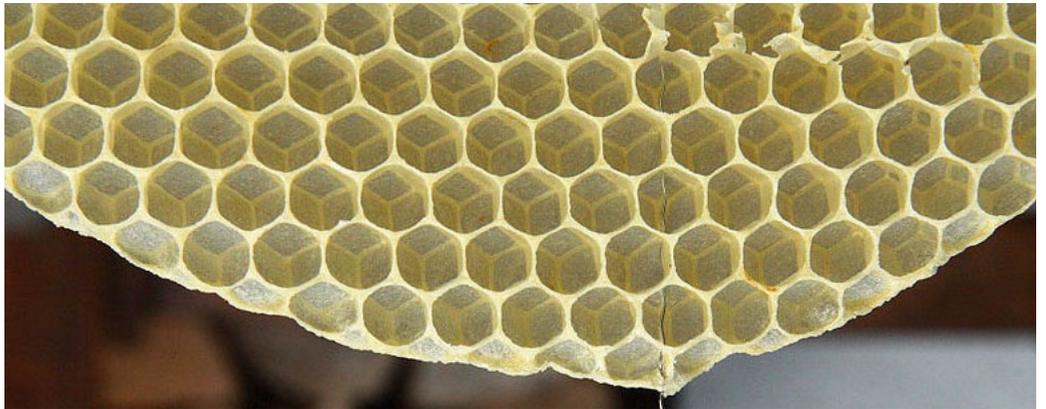
Try to answer the following questions using using the photo of the comb:

- How many sides does each cell have? Are they all identical?
- Is there any difference in the thickness of the walls?
- How many cells meet at each junction?
- What does the bottom of each cell look like? (Remember this is a double layer of cells so that the bees will work up the cells on both sides.)

Circus: link 4

Looking closely at the construction of a double layer of comb

If possible, use a hand lens to examine a piece of real empty comb, made by honeybees



Empty comb made by honeybees

Circus: link 4

Looking closely at the construction of a double layer of comb

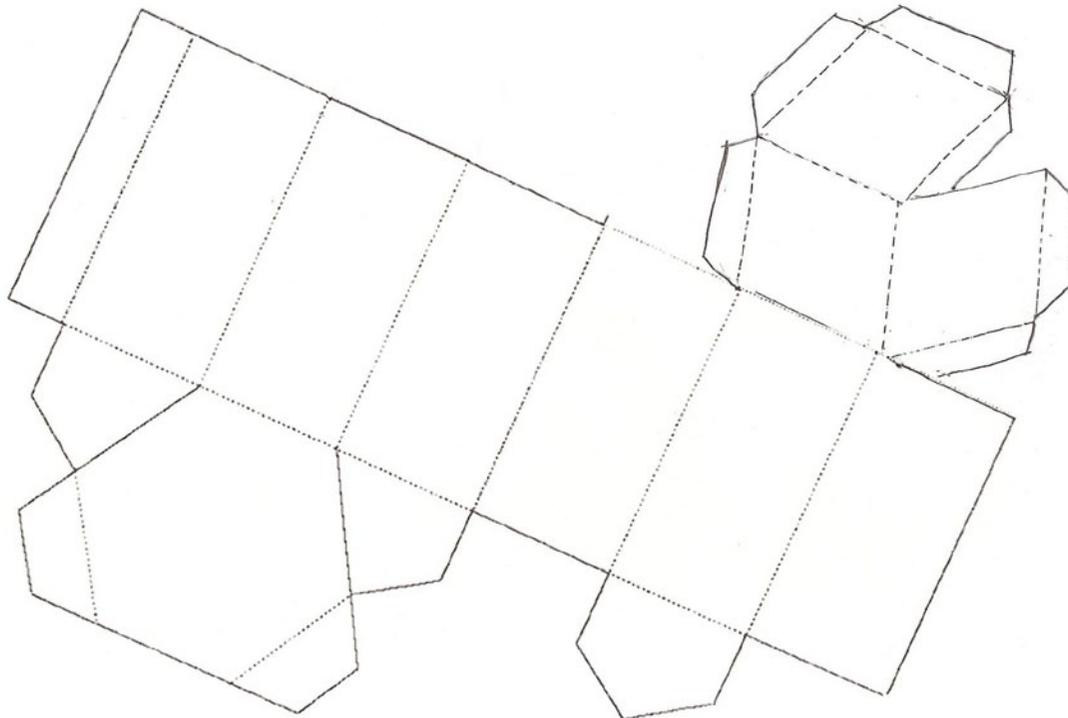
Darwin experimented with building models of comb to see how they fitted together.

- Use the template (next slide) to make a cell out of thin card.
- Glue the base but leave the top open.
- How do the bases fit together?
- What advantage for the bee colony do you think this structure will have over single cylindrical cells?

Circus: link 4

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Looking closely at the construction of
a double layer of comb
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A comb cell template



Circus: link 5

A model of a whole comb using bubbles (slides 15-17)

- Make a raft of bubbles by blowing with a straw into a small pot of bubble mixture until there are lots of bubbles. Look closely at how they join together.
- Wet the surfaces of the plastic CD case with bubble mixture, gently lay the bubbles on it and fold the plastic lid on top.



Circus: link 5

A model of a whole comb using bubbles

What is the surface area to volume ratio?

- What happens where the bubbles meet?
- Can you make some perfectly hexagonal shapes?
- A spherical bubble takes up the smallest possible surface to volume ratio. If the bubbles are of equal size, the wall where they join will be flat. What do you notice when there are three bubbles in a line?
- What advantage is this small surface to volume ratio to the bee?

Circus: link 5

A model of a whole comb using bubbles

- A bee uses 20 times the energy it used when making one unit of honey, to make one unit of wax.
- What advantage are the hexagonal cells in saving wax and energy?

Circus: link 6

Experiments with blocks of wax (slides 18-20)

The observation hive at Darwin's home at Down House.

There are two frames of comb in the hive, one above the other.

The bottom frame is a brood chamber and will contain eggs and larvae.

The top frame will contain mainly stored pollen, and nectar being processed into honey.



Circus: link 6

Experiments with blocks of wax

The wax is extruded as flakes between the scales under the abdomen of the 10-12-day-old worker and passes to its mouth where it is chewed to make it soft before it can be used to build the comb.

The bees add and take away wax at the working edge of the comb.



Underside of a worker honeybee

Circus: link 6

Experiments with blocks of wax

Darwin put a block of wax in with a recent swarm.

- Describe the place in the middle where the bees have scooped pits in the wax. How do you think they did this? (Magnify the image.)
- Look at the comb starting to be built from the wax. What shape are the cells where they join?



The result of a recent repetition of the experiment.

Circus: link 7

Experiments with red wax in hives (slides 21-22)

Darwin fixed 'a thin narrow knife edged ridge of wax coloured with vermilion' to the top bar.

The result of a recent repetition of the experiment.



Circus: link 7

Experiments with red wax in hives

What does the spread of the colour tell you about how the bees work?

In another experiment, Darwin put a thin layer of red wax on the edges of developing cells. He discovered:

'...that the colour was most delicately diffused by the bees – as delicately as a painter could have done with a brush – by atoms of the coloured wax having been taken from the spot on which it had been placed and worked into the edges of the growing cells all round.'

What does this description tell us about how bees manipulate the wax?

Cells used to store honey and pollen

Collecting bees store nectar in a second stomach and return to the hive where other worker bees remove the nectar and digest it for a short while. Bees and larvae can be fed on nectar as it comes into the hive but, when there is more nectar than required, it is converted into honey. This process takes place in the warmest part of the hive. A bee exposes small drops of nectar on her tongue. Honeybees create a draft through the hive by fanning their wings. Once dry enough, the honey is stored in the cells. The honeycomb is capped with wax to preserve the honey

Workers will push the pollen baskets off into cells which will store only pollen. Pollen provides bees with much of their protein.

Cells used to store honey and pollen

A worker bee visits flowers.

She collects pollen and nectar between the 12th and 21st days of her life.

A worker bee can extend her mouthparts so that they form a tube. She draws the watery nectar up from the flower.

She takes the nectar to the hive. It is processed into honey and stored in the cells.



Cells used to store honey and pollen

A worker also collects pollen which she mixes with a little nectar and presses it into pollen baskets on her back legs.

She adds more from each flower and takes it back to the hive.

Pollen is stored in cells to feed the larvae.



Resource materials

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Know, Want to know, Learnt (KWL) chart

Know	Want to know	Learnt

Resource materials

Conflicting concepts mind map

How do honeybees build comb? What do you think?

Bees must make the cells strong but use just enough wax in the process

Cells of honey comb are strong and made of wax. Small flakes of wax under the abdomen are chewed and used to build comb.



Underside of a worker honeybee.

The wax gland will only secrete wax if bees cluster together to raise the temperature. Bees are social insects and work together.

Cells are where the larvae are reared. Cells are used later to store honey i.e. food for winter.

Bees never begin one cell at a time, always several; they can judge distance and angles.



Bees must be 'heaven guided' to make perfect 3D hexagonal cells.

Making wax takes a lot of effort. About 7KG of honey is needed for bees to make 1KG of wax.

One honeybee will make just half a teaspoon of honey in its lifetime.

Bees work from wax at the top of the comb and add downwards.

A 3D hexagonal cell cannot have started out as a cylindrical cell

Bees build 3D hexagonal comb cells back to back to provide 2 plates of cells locked together.

Bees work from wax at the bottom of the frame and add upwards.

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