Bees and Their Hives

Key Learning Content

This film explains how bee hives, as well as being beautiful tessellations, are designed for efficiency. Tessellations are defined, and the regular tessellated patterns of triangles, squares and hexagons shown on screen. But which tessellation will allow the most honey to be stored in the resulting prisms, for the same outlay of wax? Comparative volumes are shown on screen, demonstrating that bees choose the best option.

Advanced knowledge of algebra is not essential, but will be useful for students wishing to reproduce the calculations given in the film.

Core Outcomes

Learning Points

- Be able to understand the term 'regular polygon', and recognise the line and rotational symmetry of regular polygons.
- Be able to find the surface area of simple shapes using the area formulae for triangles and rectangles.
- Be able to find the volume of right prisms using an appropriate formula.

Suggested Activities

- Calculate the areas of simple and compound shapes.
- Calculate the volumes of uniform prisms.

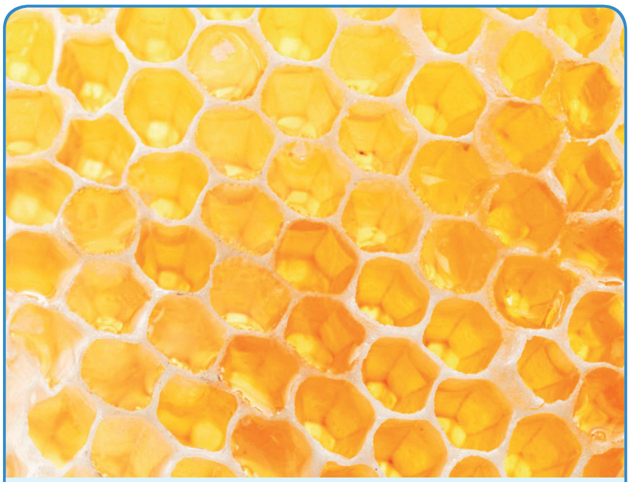
Extension Outcomes

Learning Points

- Be able to calculate ratios of volumes to surface areas for different prisms.
- Be able to interpret ratios of volumes to surface areas to assess the storage efficiency of different prisms.

Suggested Activities

- Reproduce the calculations shown in the film for the storage efficiency of triangular, square and hexagonal prisms.
- Change the modelling assumptions used in the film and check that the conclusions still hold.



Hexagonal honeycomb can store the maximum amount of honey for the same outlay of wax as a square and triangular prism.

Related Films

To use before the lesson plan:

Straight Lines: Bee Lines

This film makes the simple point that bees always appear to take the shortest route – a straight line – between any two points, whether in two or three dimensions.

Tessellated Designs

This film defines a tessellation, shows examples in various contexts, and demonstrates that there are only three possible tessellations of regular polygons.

To use after the lesson plan:

Beating the U-Boats

This film tells the story of how, using the properties of circles, supply ships in the Second World War were protected from attack.

Fractals: The Menger Sponge

This film describes the iterative construction of a fractal shape and how a regular design repeated indefinitely can have surprising consequences.

Primed for Survival

This film introduces prime numbers through the life cycle of insects.

Guide Lesson Plan

Introduction

Get some soapy water and a bubble blower and blow bubbles for the class. Ask students to look at the shapes of bubbles formed and describe the typical bubble. Ask the students why they think bubbles tend to be spherical. Discuss.

Show Film

Bees and Their Hives

Main Activity

Foundation

Give students formulas for areas of rectangles, triangles, circles and trapeziums, and set simple problems. Go over the definition of a prism, then give the formula for the volume of a prism. Set students exercises to work out the volumes of right-angled prisms with rectangular, triangular and circular cross-sections. Then set the task of working out the area of a regular hexagon of side length one, and the volume of hexagonal prisms of different dimensions.

Main Activity

Advanced

Tell students that they are going to reproduce the comparative volume figures shown in the film for triangular, square and hexagonal-based prisms. Assume that the depth of the beehive / the height of each prism is 1cm, and that the length of the sides of the triangle, square and hexagon ends are also 1cm. Then get students to work out the total surface area of each prism (including both ends) and the volume of each prism. Divide the volume by the surface area of each prism to get the numbers shown in the film, the volume per cm^2 of wax surface.

Extension Activity

Foundation

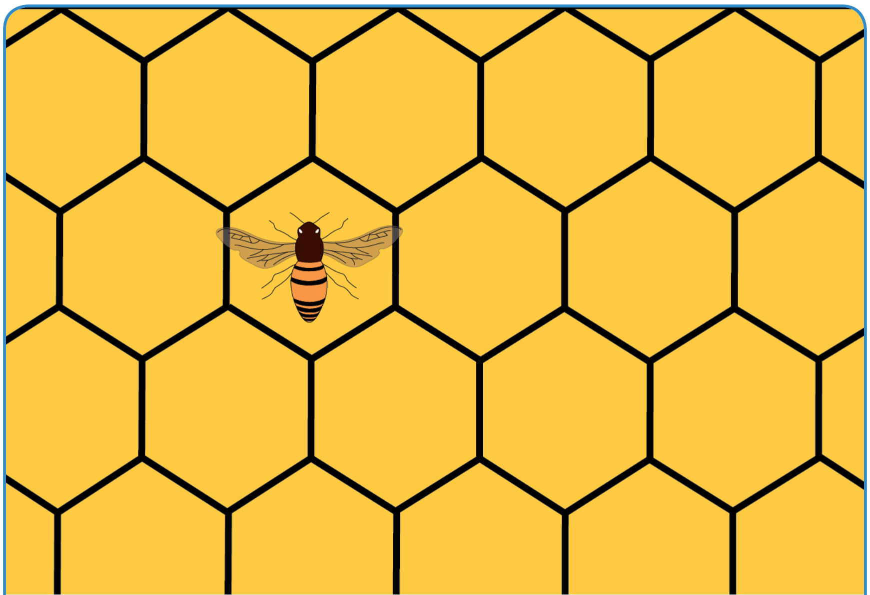
Calculate the surface areas of the hexagonal prisms used above, then divide the volumes by the surface areas. Ask students what they notice about their results as the prisms get larger. (Answer: the ratio of volume to surface area rises.)

Advanced

Get students to consider how sensitive the results shown in the film are to the modelling assumptions used. Rerun the calculations with different assumed depths of the hive, and with different side lengths for the triangle, square and hexagon.

Optional Extra

It can be shown that the most efficient way to enclose any given area is with a circle (in terms of lowest perimeter-to-area ratio). Consider why the hexagonal prism is a better solution than a cylinder for the bees, and check the maths by calculating the ratio of total storage volume to surface area for stacked cylinders (with 'lost' storage volume between the cylinders).



Tessellation is a repeating geometric pattern, which leaves no gaps between shapes.