LESSON CARD

Animal, Vegetable, Mineral

An activity suitable for Australian years 2–12

AUSTRALIAN MATHS TRUST

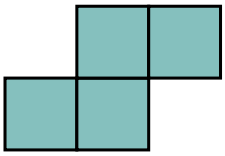
Learning areas: Shape, geometric reasoning, congruence, symmetry, transformations, logic and enumeration, patterns and algebra.

Resources: Lots of square tiles of the same size (plus triangles, hexagons or cubes for further challenges).

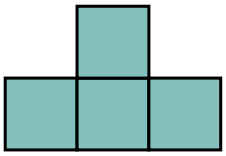
Visit www.amt.edu.au/resources-for-the-classroom for additional resources for this and other activities. Links to the applicable Australian Curriculum content descriptors are on page 4.

Animal, Vegetable, Mineral

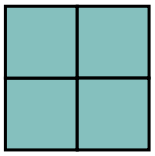
Place 4 identical squares side by side so that they share entire edges. There are many different shapes (called *polyominoes*) that can be made, such as:



shape 1



shape 2



shape 3

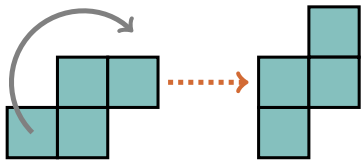
Some shapes are *animals* because they can move around. Some shapes are *vegetables* (plants) because they can flap around in the breeze, but never actually go anywhere. And some shapes are *minerals* (rocks) because they cannot move at all.

Rules

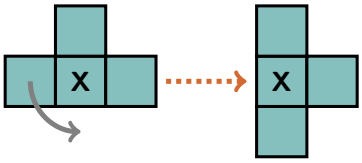
- Squares are not allowed to overlap.
- Squares must share an entire edge, so being joined only at a corner is not allowed.
- You can only move a shape if it is possible to pick up *one* square and place it somewhere else so that the new shape formed is exactly the same as the one you started with.
- Flipping the shape over is allowed, as seen in the first example.

Examples

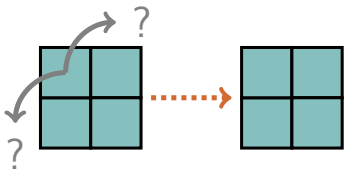
- Shape 1 is an **animal**: moving the square at the bottom-left as shown results in a new shape of the same type. Even though it has been flipped over and rotated, we count it as being the same shape. Repeating this step, the shape is able to move to different places.



- Shape 2 is a **vegetable**: moving the square at the bottom-left as shown results in a new shape of the same type. However, the square marked '**X**' can never be moved so the shape always stays anchored to the same spot.



- Shape 3 is a **mineral**: there is no way to move one square at a time without changing the shape of the 2×2 block.



Challenges

(a) Find the other two shapes made from 4 squares and decide whether they are animals, vegetables or minerals.

(b) Find all of the shapes made from 5 squares and decide whether they are animals, vegetables or minerals.

(c) Some animals are snakes (1D): they can travel any distance but only forwards or backwards along a fixed line. Other animals are mice (2D): they can travel anywhere in the plane. Decide whether the animals found so far are snakes or mice.

(d) Repeat (b) and (c) with 6 squares.

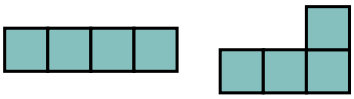
(e) How many different snakes can you make from 7, 8, 9, ... squares?

(f) Explore what happens when you use equilateral triangles or regular hexagons instead of squares, or different combinations of regular shapes.

(g) Explore what happens in 3D when you use cubes or other regular solids. In addition to snakes (1D) and mice (2D), we now also have birds (3D).

Some answers

(a) The other two shapes made from 4 squares are both animals:

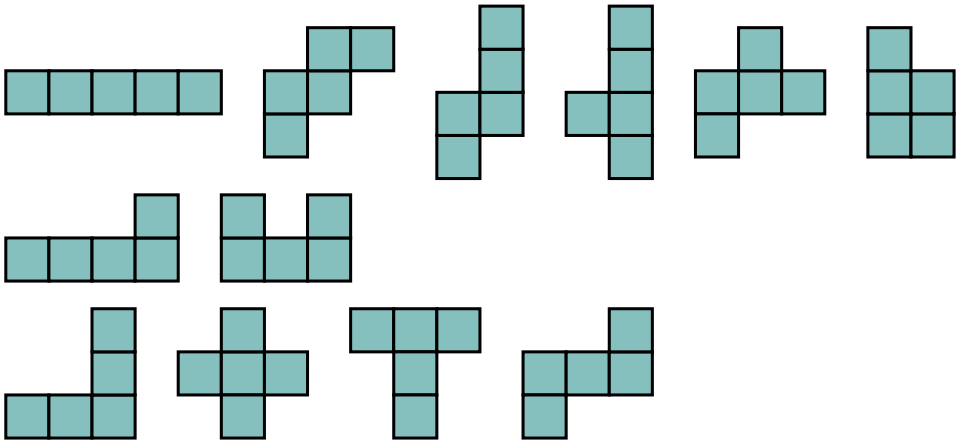


(b) There are 12 shapes made from 5 squares:

animals

vegetables

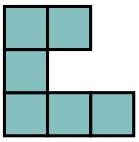
minerals



(c) For 4 squares, the zigzag animal in the examples (Shape 1) is a snake which can only travel on a diagonal line, the row of squares in part (a) above is a snake which can only travel horizontally, and the L-shape in part (a) is a mouse because it can travel in any direction.

For 5 squares, the first four animals listed in part (b) are snakes and the last two are mice.

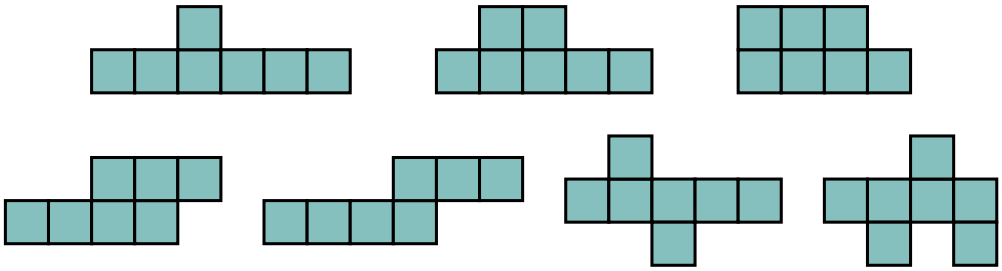
(d) There are 35 shapes made from 6 squares: 5 animals, 17 vegetables and 13 minerals (see https://en.wikipedia.org/wiki/Polyomino for the full list of possible shapes). There is one curious 6-square animal shown below. While it cannot travel very far, it should not count as a plant because no square is always anchored to the same spot.



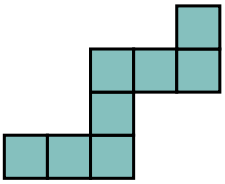
There are three snakes and one mouse, but the shape above is neither because it has a restricted habitat (0D). Ask your students to come up with their own name for such an animal.

(e) There are two basic kinds of snake which can be made with any number of squares: a horizontal (or vertical) row of squares or a diagonal zigzag pattern. See the first two 5-square snakes in part (b).

There are also seven additional 7-square snakes which can only travel horizontally (although some of them might be better described as lizards!):



There is one additional 8-square snake, which travels diagonally:



There are nine additional 9-square snakes, which are similar in style to the seven 7-square snakes. There is one additional 10-square snake, which is similar to the 8-square snake.

Extension: Investigate whether there is a rule for the total number of snakes for a given number of squares.

For further hints and tips, contact mail@amt.edu.au.

Australian Curriculum content descriptors

The following is not intended to be an exhaustive list, but indicates how the above activity aligns with various stages of the mathematics curriculum. Follow the links to the ACARA website for elaborations.

- Year 2, ACMMG046 Identify and describe half and quarter turns
- Year 3, ACMMG066 Identify symmetry in the environment
- Year 4, ACMMG088 Compare and describe two dimensional shapes that result from combining and splitting common shapes
- Year 4, ACMMG091 Create symmetrical patterns, pictures and shapes
- Year 5, ACMMG114 Describe translations, reflections and rotations of two-dimensional shapes, and identify line and rotational symmetries
- Year 6, ACMMG142 Investigate combinations of translations, reflections and rotations
- Year 8, ACMMG200 Define congruence of plane shapes using transformations
- Year 10, ACMMG244 Apply logical reasoning, including the use of congruence and similarity, to proofs and numerical exercises involving plane shapes