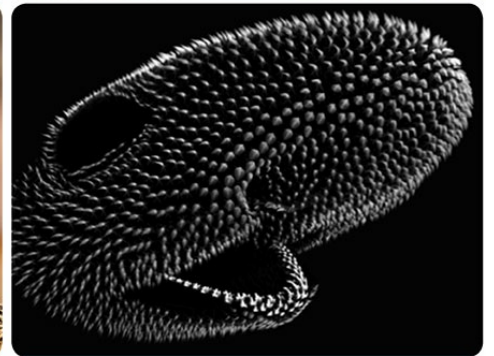# Maths theory holds the key to nature's beauty

Is maths the secret of beauty? Scientists have discovered that the world's most famous codebreaker was right when he proposed that natural shapes and patterns were ruled by a hidden formula.

Turing patterns: see them in tornados, pufferfish, cheetahs and shark denticles (bottom right).

Alan Turing is famed as the mathematician who helped cut short World War Two by two years, with his work cracking Germany's Enigma code.

But he made another remarkable, lesser-known contribution to science: a mathematical theory — now proved correct — that explains all of nature's patterns.

In the natural world, some shapes and patterns recur time and time again — from the immense, cosmic spirals of galaxies right down to the circles of dividing cells in an embryo.

Turing published his paper, "The chemical basis of morphogenesis" in 1952. In it, he theorised that these seemingly random designs are actually controlled by the interaction of two chemicals, which he called "morphogens". Different reactions between these chemicals produce a range of patterns, like spots, stripes and spirals.

Turing even worked out that the patterns produced can be predicted by two mathematical equations.

Today, modern computers can use Turing's equations to make patterns that mimic everything — from human fingerprints to the way that pools of water gather on the shore.

"There's an elegant simplicity and beauty in nature revealed by mathematical patterns and shapes," says physicist Max Tegmark, author of *Our Mathematical Universe*. The beauty of the natural world, it appears, is ordered by the laws of maths.

For thousands of years, humans have been trying to understand how mathematics shapes the world around us. The golden ratio (first described by the Greek mathematician Euclid, in the 4th century BC) has been regarded by artists throughout history as the perfect, most beautiful proportion.

The ratio is based on the Fibonacci sequence, where each step is equal to the sum of the previous two steps. This exact sequence appears in the flowering of an artichoke and the spirals of seashell. Even the proportions of the human body can be divided into the golden ratio.

We now believe that the ratio was replicated by architects in the design of Egypt's Great Pyramid and the Parthenon in ancient Greece. By the Renaissance, artists were using it to construct their paintings.

The eye of the beholder?

Is beauty really down to maths? Isn't beauty about looking at something and being overwhelmed by an ineffable wonder? It can't be explained by rules or laws. There aren't any right or wrong answers: it's just something that strikes you. Surely, real beauty is the opposite of maths.

But is beauty ever random? Doesn't all art obey rules? The paintings of Jackson Pollock may look like chaos, but there is order and decades of learning behind them. Why else, for thousands of years, have artists and architects studied the golden ratio if they could just make it up for themselves? Beauty depends on patterns of order beneath the surface.

Q & A

Q: What do we know?
A: Alan Turing's theory on patterns in nature was published in 1952. Recently, scientists have proven that so-called Turing patterns in hair follicles and chicken feathers are, as he believed, caused by two interacting chemicals. The work of researcher Natasha Ellison has found that Turing's equations can even predict non-visual patterns, like the movement of gang members around the streets of Los Angeles.

Q: What do we not know?
A: Why some patterns, like the Fibonacci sequence, recur so often in the natural world. Scientists have speculated that it might be the result of evolution, so it is the most effective way for plants to grow. The spiral shape allows for growth within a compact space.

ACTIVITIES

1. Write your own definition of "beauty". Is there anything that all beautiful things have in common? Then, discuss your answers as a class.

2. Write a paragraph about an object you consider beautiful, using the Fibonacci sequence (see Word Watch) to structure your sentences. So, the first sentence has one word. The second sentence also has only one word. The third sentence has two words. The fourth, three words and so on.

SOME PEOPLE SAY...

"The study of mathematics, like the Nile, begins in minuteness but ends in magnificence."
Charles Caleb Colton, English cleric and writer (1780-1832)

WHAT DO YOU THINK?

WORD WATCH

Enigma code – The Enigma was a type of machine used by the Germans to send secret messages during the war. Turing helped to build a machine called the Bombe to make it quicker to crack a code that the Germans changed every day.

Embryo – A fertilised egg that is developing into a fetus.

1952 –

The same year that Turing was convicted of "gross indecency" for homosexual acts. As a punishment, he was chemically castrated and died by suicide two years later. In 2013, he was given a royal pardon.

Golden ratio – Also known by the Greek number "phi", which stands for 1.618.

Fibonacci – The Fibonacci sequence is a series of numbers that begins 0, 1, 1, 2, 3, 5, 8... The next number is found by adding up the two before it.

Parthenon – An ancient Greek temple in Athens that was once dedicated to the goddess Athena. It was built around 440 BC. It is regarded as the highest example of ancient Greek architecture.

Jackson Pollock – Modern abstract, American artist (1912-1956), famed for pouring or splashing paint onto canvases to create his art.

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Notes