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## **MATHEMATICAL CONCEPTS IN *NUMBERS IN NATURE: A MIRROR MAZE***

Below are a list of descriptions and definitions associated with the mathematical concepts presented in *Numbers in Nature*.

Ratios provide clues to the relationship between two things such, as lengths, quantities or volumes. The **Golden Ratio, or phi ( $\phi$ )**, is one of nature's most common ratios and can be a useful tool to analyze the proportions of many natural and man-made objects. Many things in nature, art, architecture and the man-made world demonstrate proportions that are *approximately* (but not exactly) the Golden Ratio. The value when the Greek letter phi represents the Golden Ratio is 1.6180339887... The Golden Ratio is present in Fibonacci spirals. Examples: proportion of bone lengths in human hands, insect bodies, DNA molecules.

A **fractal** is a detailed pattern that looks similar at any scale and repeats itself. A fractal's pattern gets more complex as you observe the fractal at larger scales. Examples: snowflakes, tree branching, lightning, a fern.

**Natural selection** describes how most well-adapted organisms and individuals within a species will tend to survive, so over time, the species will optimize itself for a given set of living conditions.

A **pattern** is a set of shapes or numbers that repeats in a characteristic way and can be described mathematically.

A **geometric pattern** is made up of repeating shapes.

A **numeric pattern, or sequence**, is a list of numbers that occur in some predictable way and can be used to describe real-world things (i.e., population growth).

An **additive number sequence** is a set of numbers where each number is equal to the sum of the two numbers that come directly before it in the series.

A **Fibonacci sequence** is a specific additive number sequence where the first two numbers in the sequence are 0 and 1, and each following number is obtained from the sum of two preceding. Examples: the seeds in some sunflower species, number of petals on certain flowers, Romanesco broccoli.

A **ratio** describes the relationship between two numbers, quantities or volumes, and how for every amount of one thing, how much of something else exists. A ratio can be written as a fraction.

A **proportion** describes the relationship between two ratios.

A **spiral** is a curve that starts from a center point (origin) and gets further and further away as it circles around that point. Examples: pinecones, pineapples, hurricanes.

A **logarithmic spiral** is a special type of spiral where the distance between each turn of the spiral is progressively larger than the one before it. Not all logarithmic spirals are Fibonacci spirals. Examples: a sheep's horn, a nautilus shell.

Something is **symmetric** if it looks the same on both sides. Objects can be symmetrically reflected across a line, or rotated around a point.

A **tessellation** is a repeating geometric pattern that fills a space (2D or 3D) entirely without leaving any gaps. The floorplan of the mirror maze is a tessellation of equilateral triangles.

A **Voronoi pattern** provides clues to nature's tendency to favor efficiency: the nearest neighbor, shortest path, and tightest fit. Each cell in a Voronoi pattern has a seed point. Everything inside a cell is closer to it than to any other seed. The lines between cells are always halfway between neighboring seeds. Examples: corn on the cob, honeycombs, foam bubbles, the cells in a leaf, giraffe skin, a head of garlic.

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