Spirals in Nature WIP

Keywords: 2017, Biology, Fibonacci, Flowers, Fruit, Mathematics, Maths&Stats, Nature, Petals, Spirals

Meta Description

Discover where the Fibonacci sequence and the golden ratio, important mathematical concepts, are found in nature through this hands-on investigation.

Learning Objectives

To be introduced to the concepts of the Fibonacci sequence and the Golden ratio.

To learn about the presence of mathematics in nature.

To understand why nature adopts these patterns.

Key Terms

Fibonacci number
Numbers in the Fibonacci sequence.

Fibonacci sequence
A number sequence beginning with the numbers 0,1. After these two terms, the next term in the sequence is always the sum of the two previous Fibonacci numbers.

Golden Angle
The golden ratio multiplied by 360 degrees.

Golden Ratio
The number 1.61803… is defined to be the limiting ratio of consecutive Fibonacci numbers.

Limiting ratio
The number that is approached when you divide a Fibonacci number by the Fibonacci number preceding it in the sequence.

Method

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Step 1
Participants should be aware of the collection of fruit and plant life available in the experiment.

Step 2
Begin by counting the number of spirals in each direction (clockwise and anticlockwise) on the pineapple (aided with the coloured tape), the number of petals on the flowers, the spirals on the pine cone etc. Take care not to destroy the delicate structure of the flowers.

Step 3
Now introduce and describe to the participants the Fibonacci sequence.

Step 4
Allow the participants to realize the fact that all the spirals and petals they counted are in the Fibonacci sequence.

Step 5
Consolidate this concept by showing participants images of sunflower seeds. Show that the number of spirals in the seedhead and the spirals in the stems of the plants consist of Fibonacci numbers.

Step 6
If the participants are curious, explain to them the Golden Ratio by obtaining two pairs of consecutive Fibonacci numbers, either from the sequence itself or from their recorded readings of the objects available, and divide the largest number by the smaller one to obtain the golden ratio.

Step 7
Explain the several other places the Golden Ratio and Fibonacci numbers crop up in nature and anatomy, as well as how it relates to the examples you've shown.

Alternative Method

- Any of the props used to display the presence of Fibonacci numbers in the experiment can be replaced with any other objects which have this characteristic, even if they were not mentioned in the materials list.

Precautions

1. Care must be taken that the participants involved are not allergic to any of the materials used.
2. Fruit should not be wasted after the demonstration.
3. Pinecones should be washed prior to the demonstration. Do so with warm water and soap.

Narrative

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The demonstration can be put forth as a form of investigation where the participants investigate the number of spirals in fruits and plants and make a link with the Fibonacci sequence/ golden ratio.

Questions

Why is there a Fibonacci number of spirals in the pineapple/flower/pinecone?
The spirals are just a phenomenon that we see with our pattern recognizing brains. But it gives an indication that the golden ratio is involved in the way the seeds are distributed.

How does the golden ratio manifest in plants?
The golden ratio is the ratio between successive Fibonacci numbers. The angle between one seed and another seed is the Golden ratio times 360 degrees in a sunflower.

Where else does the Fibonacci sequence appear?
The shell of a Nautilus contains proportions which are golden and it is said that proportions within animals and humans are golden as well.

Does the golden ratio appear in humans?
Many people are still debating over this, although it is said that the ratio between the proportions of your finger bones, the proportion of your hand to your forearm and even the distances between different parts of your face show the golden ratio, but this hasn't been shown to be true overall.

Where does it appear apart from nature?
The Ancient Greeks called this proportion golden because they saw it as the most beautiful and perfect ratio to ever exist. They even built some of their buildings based on this idea.

Brief Explanation

In the process of natural selection, plants develop features which give them the best chance for survival. Thus, when it comes down to reproduction, a plant which is able to pack more seeds into its fruit is more likely to survive than a similar plant which which is able to pack less seeds into its fruit. Note that the seeds of a pineapple are underneath the skin of the fruit and are indicated by dark dots while pinecone seeds hide on the outside behind their scales. These genetics get passed down and are refined until we obtain a very efficient way of packing seeds. In many cases this results in a Fibonacci spiral.

Mathematically, this is because the golden ratio produces one of the most efficient ways of distributing the seeds in a certain way so as to fit as many as it can.

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In the case of leaves on a stem, the Fibonacci spiral does not develop in order to pack as many leaves as possible, but to distribute the leaves in such a way as to not let the leaves block each other's sunlight. A spiral helps it accomplish this, and the golden ratio is a very efficient way of doing so which explains why we see it in nature. These patterns are thought to have evolved over a great many years.

Detailed Explanation

Phyllotaxis is the study of the way leaves are distributed on the stem of a plant.The distribution of leaves around a stem is optimal when every leaf receives the optimum amount of sunlight. Plants achieve this by distributing leaves in such a way that the amount of light being blocked by other leaves is reduced. Research in Phyllotaxis has found that many plants achieve this by distributing leaves around the stem in a spiral pattern. When measured, it is found that these leaves are distributed around the stem by the golden angle. This leaves the plant having some essence of the Fibonacci sequence within the spiral patterns of the leaves.

In fact, such a packing can be simulated mathematically by plotting points radially outwards with the angle between the points differing by the Golden angle.

After 10 points plotted,

Spirals in Nature (steamexperiments.com)

Image not found or type unknown

After 100 points plotted,

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100 points plotted

Image not found or type unknown

After 1000 points plotted

1000 points plotted

Image not found or type unknown

Applications and Research

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Applications
The golden ratio has been used in historical monuments and architectural works as it was perceived to the pinnacle of perfection and beauty when it came to choosing the proportions of buildings.

The golden ratio also has an application in certain types of optimization problems. It is used as a tool by researchers to create algorithms in computer programs which can come to an answer very fast. An algorithm is a set of mathematical steps for solving certain problems. The ratio would form a small part of the algorithm. It is used in particular in algorithms which search for a minimum value in a large amount of data.

In photography, the centre of the golden spiral is taken to be a picture's point of interest.

Finally, the golden ratio has had great success in stock market analysis to analyze and predict stock market fluctuations by looking at the distances between high or low points in the stocks.

Research
Fibonacci numbers crop up in many natural systems such as in the study of the positions of leaves on the stem of plants in the area of Phyllotaxis.

Fibonacci sequences form part of a general group of objects called 'Recurrence relations' which are of enormous interest due to their wide and vast applicability in many disciplines. This theory was then generalized and has been applied to the the field of cryptography, which is focused on encoding important information for security purposes. It is used in everything from internet banking to government operations.

Researchers have also found a relationship between the symmetry of atoms in their spin and the golden ratio.These small advances in our understanding of atoms continue to help develop existing knowledge on quantum physics. Quantum physics is an important field in modern technology which has lead to the development of very powerful computers known as quantum computers.

Investigation

- To further investigate the topic, do some background reading into why pineapples and pinecones have this a Fibonacci number of spirals. When doing background reading remember to use reliable sources such as reputable publications and established university websites.
- Would anything that have spirals on it, have a Fibonacci number of spirals? You can test it out with other plants, fruits and vegetables!
- Read up on other areas of science where these Fibonacci patterns occur, including astronomy. When doing background reading remember to use reliable sources such as reputable publications and established university websites.

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Subjects

Biology
Maths & Stats

Education

Secondary
Post Secondary
University
Informal

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Time Required

~10 minutes
Preparation: 1 minute
Conducting: 10 minutes
Clean Up: 1 minute

Cost

0 – 10 €

Recommended Age

13 – 16
>16

Number of People

2 participants

Supervision

Not Required

Location

Indoors
Outdoors
Festivals
Laboratory

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Materials

Coloured tape

Flowers with 1,2,3,5,8 or 13 petals

Pictures of flowers with larger number of petals (e.g. sunflower)

Pineapple

Pinecones

Ruler

Contributors

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Sources

Fibonacci in Nature

Spirals and the Golden Ratio

Additional Content

Phyllotaxis: The Fibonacci Sequence in Nature (Beginner)

Golden Ratio Overview(Beginner)

Phi Concepts and Applications(Intermediate)

Fibonacci Number and Nature (Intermediate)

The Fibonacci Sequence: New Research Surprises Scientists (Intermediate)

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Science: Sunflower Spirals Obey Laws of Mathematics(Advanced)

Link found between Golden Ratio and Atomic Symmetry (Advanced)

Final Report Summary – PIP (Power-Integral Points on Elliptic Curves) (Advanced)

Cite this Experiment

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