



# A Review Paper on Fibonacci Numbers and its Amazing Applications

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**Abstract-** Fibonacci sequence of an Integers and the associated "Golden Ratio" are manifested in nature and in certain works of an art. Many of the natural things such as fruit sprouts of pineapple, branching in trees, arrangement of leaves on a stem, packing of sunflower seeds, hurricanes, galaxies, Human anatomy, planetary orbit, etc. Fibonacci sequence plays very important role in Architecture, Computer Science, Biology and Finance. The ratio of two consecutive terms of the Fibonacci sequence approximately equals to 1.618, which is called "Golden Ratio". This can be seen in works of Da Vinci (ex. Mona Lisa) and other classical artists. Golden ratio can be observed in human body proportions such as ratio of forearms to the hands. The Fibonacci sequence reflects efficiency and balance, which are principle of evolution and growth.

**Keywords:** : Fibonacci Numbers, Golden ratio

## I. INTRODUCTION

The Fibonacci numbers were first discovered by a man named Leonardo Pisano. He was known by his nickname, Fibonacci. Leonardo Pisano was born in Pisa in 1175. He became interested in mathematics when he was young following his father who was the representative of the Pisa merchants in the port city of Béjaïa, in Cabiria, region of present Algeria. Besides mathematics, Fibonacci also became passionate about geometry and Arabic algebra.

The Fibonacci sequence is a sequence in which each term is the sum of the two numbers preceding it. The terms of Fibonacci Sequence are given by the recursive relation defined by the equations

$F_n = F_{n-1} + F_{n-2}$  for all  $n \geq 3$  where  $F_1 = 1$ ;  $F_2 = 1$  where  $F_n$  represents the  $n^{\text{th}}$  Fibonacci number ( $n$  is called an index).

The Fibonacci sequence can elaborately written as {1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233.....}.

Golden Ratio- The ratio of two consecutive terms of the Fibonacci sequence approximately equals to 1.618034, which is called "Golden Ratio". (*abbreviated  $\varphi$* ). Any term in the Fibonacci sequence divided by the previous has a quotient of approximately 1.618034... That is,  $F_n / F_{n-1} = 1.618034$ . For the first few terms, this is a very loose

approximation, but as the number ( $n$ ) increases, the quotient coincides more exactly with this irrational value.

## II. MATHEMATICAL PROPERTIES

This section explores the theoretical foundation of Fibonacci sequence.

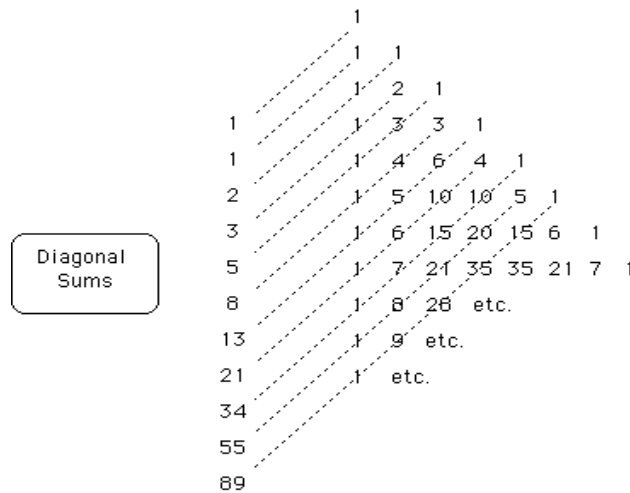
**Binet's Formula:** An explicit formula used to find  $n^{\text{th}}$  Fibonacci number without needing the preceding two terms. given by

$$F_n = \frac{\phi^n - \psi^n}{\sqrt{5}}$$

Where  $\phi$  is the golden ratio ( $\approx 1.618$ ) and  $\psi = 1 - \phi$

**Relation with Pascal's triangle:** The Fibonacci numbers are inherently linked to Pascal's Triangle.

Row 0:					1				
Row 1:					1	1			
Row 2:				1	2	1			
Row 3:			1	3	3	1			
Row 4:		1	4	6	4	1			
Row 5:	1	5	10	10	5	1			



### III. FIBONACCI SEQUENCE IN NATURE

Experiment on Rabbits: One of the most common experiments dealing with the Fibonacci Sequence is his experiment with rabbits. Fibonacci put one male and one female rabbit in a field. Fibonacci supposed that the rabbits never die and female always produces one male and one female.



The problem states that it takes one month for a rabbit pair to mature, and the pair will then produce one pair of rabbits each month as above. Fibonacci solution stated that in the first month there would be only one pair; the second month there would be one adult pair and one baby pair; the third month there would be two adult pairs and one baby pair; and so forth. When the total number of rabbits for each month is listed, one after the other, it generates the sequence of numbers for which Fibonacci is most famous:

1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377...

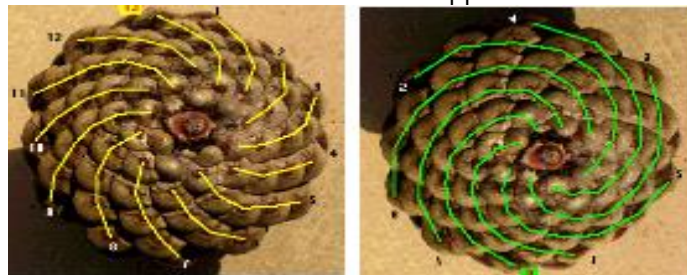
Fruit/flower/vegetable structure: In the vegetable kingdom the Fibonacci sequence can be found in the arrangement of leaves on a branch and seeds or stems of some flowers. The arrangement of leaves, seeds, and petal often follows Fibonacci sequence to maximize exposure to sunlight and space efficiency.



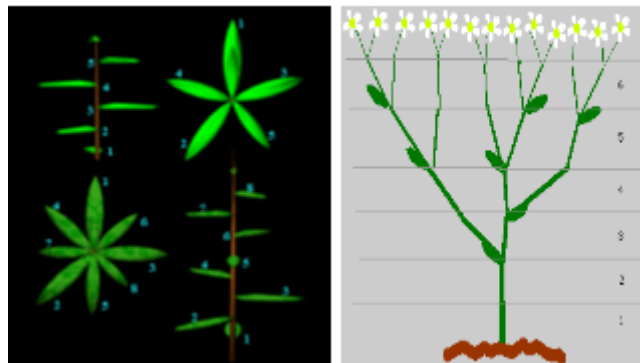
Sunflowers: their seeds follows spiral that corresponds to Fibonacci sequence. There are 55 spirals spiralling outwards and 34 spirals spiralling inwards in most daisy or sunflower blossoms.



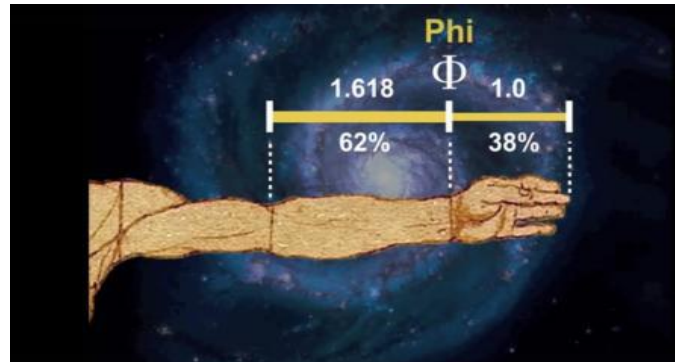
Pinecones and Pineapple:



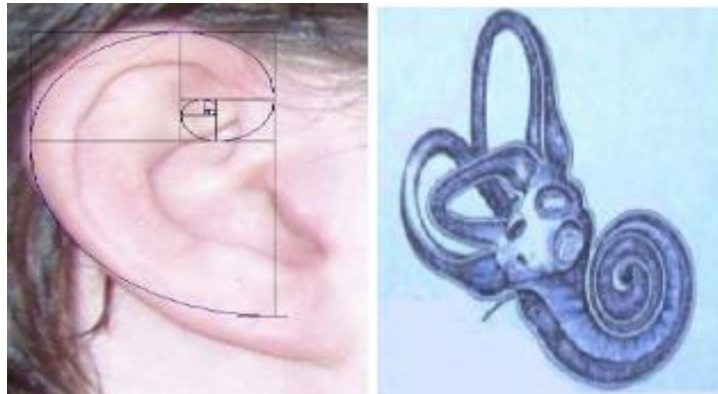
Phyllotaxis: leaf arrangement on stem:



Human Anatomy: Every human has two hands, each one of these has five fingers and each finger has three parts which are separated by two knuckles . All of these numbers fit into the sequence. Moreover the lengths of bones in a hand are in Fibonacci numbers

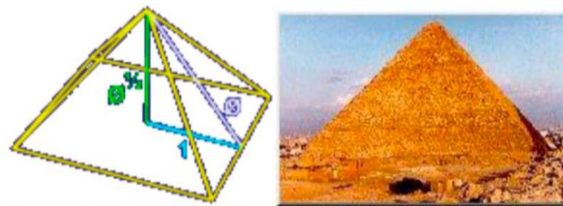


The cochlea of the inner ear forms a Golden Spiral

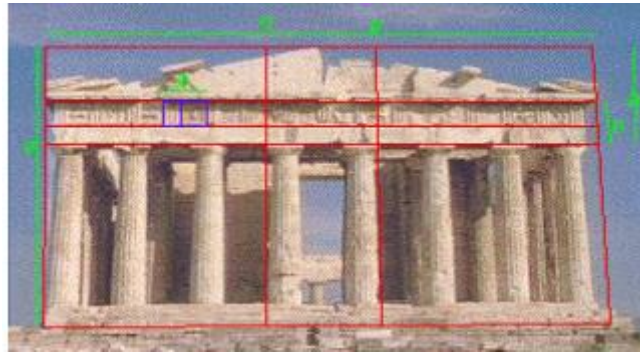


#### IV. APPLICATIONS OF FIBONACCI SEQUENCE

**Architecture:** The Golden Ratio is also frequently seen in natural architecture also. Perimeter of the pyramid, divided by twice its vertical height is the value of  $\phi$ .



Golden section (Gend, 2014) appears in many of the proportions of the Parthenon in Greece. Front elevation is built on the golden section.



## V. TECHNOLOGY & COMPUTER SCIENCE

Recently Fibonacci sequence and golden ratio are of great interest to the researchers in many fields of science including high energy physics, quantum mechanics, Cryptography and Coding. In the world of data structure and algorithms, efficient searching is the cornerstone of performance. The Fibonacci search checks for the desired elements in a way that reflects the Fibonacci sequence, minimizing the range of search at each step.

The Fibonacci sequence and golden ratio, enhance data security, key generation, and hash table efficiency. Its unique properties address specific weaknesses in traditional cryptographic structures.

## VII. CONCLUSION

The Fibonacci sequence is not just a mathematical curiosity but a fundamental, efficient pattern in nature, a foundational principle in computer science, and a tool for artistic design and market analysis. The Fibonacci sequence reflects efficiency and balance, which are principle of evolution and growth. Nature follows this sequence because they often lead to optimal survival outcomes, like maximizing space or energy use.

In essence, Fibonacci sequence is a mathematical representation of the natural order and beauty in the universe.

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