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THE UNNOTICED MYSTERY BEHIND WHAT WE COMMONLY SEE!

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Abstract : From seas to skies, from lands to heaven, mother Nature has administered over her creations with subtle modesty and liberty. Though we engage in continuous interaction with Nature in our day-to-day lives, we are unknown to the enigma that Nature hold for us. Humans tend to unveil the mysteries of Nature through logical reasoning and mathematical interpretation- one example of such a concept was the discovery of the idea of Golden ratio. This popular science article intends to introduce the readers to this beautiful mathematical 'riddle' witnessed in each and every components of Nature but go overlooked by Human eyes. The examples reported in the paper are just the reflection of few biological entities which can be extended further to other natural phenomenon and units.

Key words : Biological world, Golden ratio, Golden rectangle, Nature

1. Introduction

In the book "Across the Universe", Beth Revis (2011) has appreciated Nature by saying-

"The glitter in the sky looks as if I could scoop it all up in my hands and let the stars swirl and touch one another, but they are so distant, so very far apart, that they cannot feel the warmth of each other, even though they are made of burning."

From the time immemorial, the serenity and ambience of Nature has never failed to amaze us. Though Nature is hegemonic over mankind but it has always been the human race unveiling the shrouded secrets embedded in Nature, one of those secrets being the Symmetry of every living organisms around us. The idiosyncrasy of symmetry has been intriguing the scientific world since humans attained sense of mathematics and geometry (Livio, 2002). The quest to understand the symmetrical orientations of every living species was addressed through the idea of what we call as the *Golden ratio* (Hemenway, 2005). The Golden ratio, otherwise called the golden number or golden mean, is witnessed in diverse disciplines like architecture, music, art apart from every living organism around us (Hambidge, 1920; Dunlap, 1997). This paper is an attempt to bring together some interesting facets about the Golden ratio which is usually unnoticed in our day-to-day lives.

2. Golden ratio

In mathematics, two quantities are in the golden ratio if the ratio between the sum of those quantities and the larger one is the same as the ratio between the larger one and the smaller (Livio, 2002). The golden section is a line segment divided according to the golden ratio (Stankov, 1989). Suppose a line is broken into two pieces, one of length a and the other of length b (so the total length is a + b), and a and b are chosen in a very specific way: a and b are chosen so that the ratio of a + b to a and the ratio of a to b are equal, where $a>b>0$ (Fig. 1). It turns out that if a and b satisfy this property so that $a+b/a = a/b$ then the ratios are equal to the number Φ (https://oeis.org/A001622). Owing to its ubiquitous presence in the Nature, the Greeks have termed it as the golden ratio. Mathematical calculations have yielded the value of Φ as $(1+\sqrt{5})/2$, where Φ (phi) is attributed to the first letter in name of Greek sculptor and architect ***Phidias***, who first used this ratio in the statue named ***Parthenon*** (Borges, 2004).

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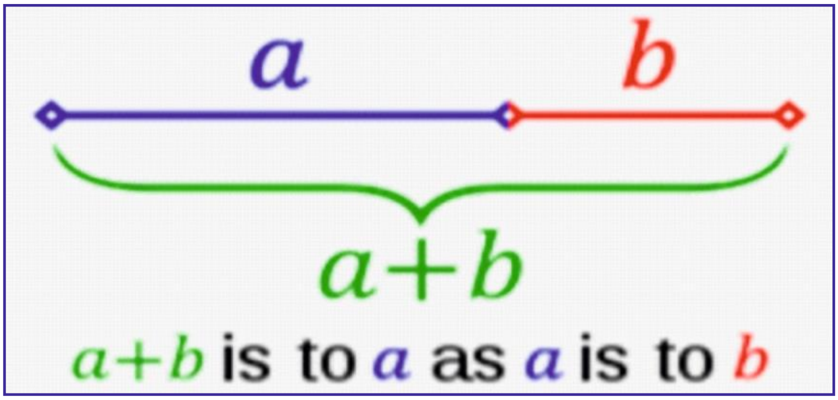

Fig.1: Golden Ratio (Image Courtesy: Wikipedia)

3. Golden rectangle

A rectangle is called golden rectangle if its length and breadth are in consociation with the golden ratio (Benjafield, 1976).

Here is a diagram which shows how to construct a golden rectangle (Fig. 2). A square is drawn first, the bottom side is bisected, such that the radius of the arc is equal to b/2 or 4 units in the given diagram. Then the rectangle is completed with the ratio of $\frac{13}{8}$, which will be termed as a golden rectangle.

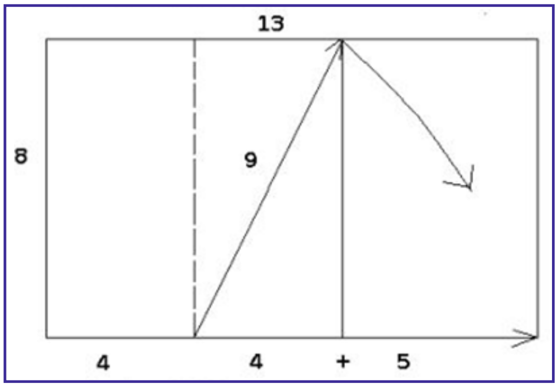

Fig. 2: Golden RectangleImage Courtesy: Wikipedia

4. Fibonacci Series and its relation with Golden ratio

Back in 1202, Leonardo Fibonacci introduced the concept of *Fibonacci Series* in his book *Liber abaci*, a significant book on mathematics published in the 12^{th} Century. Fibonacci series appeared in the solution to the problem that dealt with the population growth of rabbits in an ideal situation as mentioned: "A certain man put a pair of rabbits in a place surrounded on all sides by a wall. How many pairs of rabbits can be produced from that pair in a year if it is supposed that every month each pair begets a new pair which from the second month on becomes productive?" (Scott and Marketos, 2014).

Starting with 0 and 1, each new number in the series is simply the sum of the two before it. The Fibonacci sequence can be depicted in the form of- 0,1, 1, 2, 3, 5, 8,13, 21, 34, . . ., where any number of the sequence is called Fibonacci number.

The value of Φ is related to Fibonacci series by the following relation: If we divide each consecutive Fibonacci number by its predecessor, we will find that the results gradually converge on Φ like $^{3}/_{2}$ is 1.500, $^{5}/_{3}$ is 1.667, $^{8}/_{5}$ is 1.600, $^{13}/_{8}$is 1.625 and so on.

5. Golden ratio and the Biological world

5.1: The Human Arm

The human body has latent presence of the golden ratio that bring our attention to the lower arm that extends to the hand. The length of the lower arm (from the elbow joint to the fingers of hand) of an adult man is measured in two different aspects: First the length from elbow till wrist is measured and then the length of palm is measured as shown (Fig. 3). Upon dividing the former by latter, the ratio is found out to be 1.618 which is equal to golden ratio ($^{(1+}\sqrt{5}^{)}/_{2}$) (Abu-Taieh and Al-Bdour, 2018).

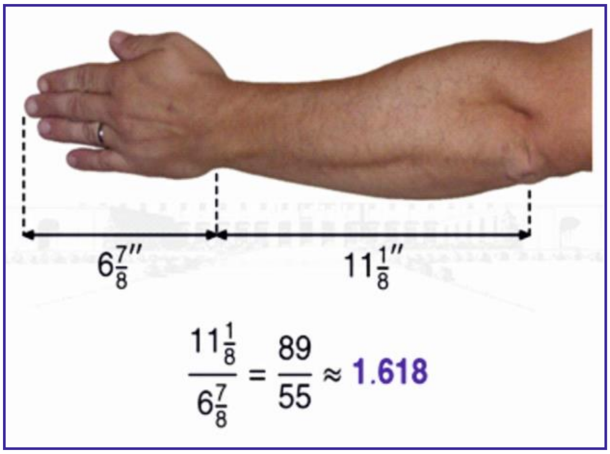

Fig. 3: Human hand and Golden ratio
Image Courtesy: Akhtaruzzaman and Shafie, 2011

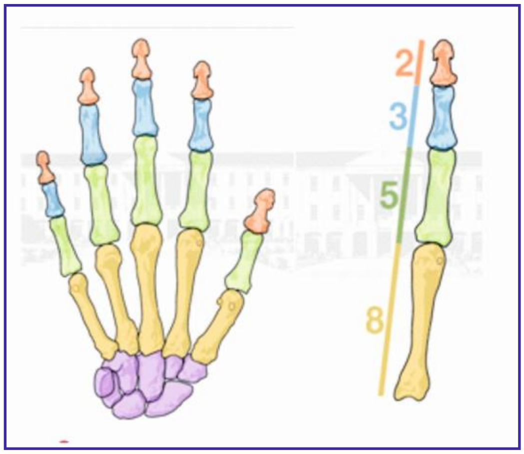

Fig. 4: Human fingers and Golden ratio
Image Courtesy: Akhtaruzzaman and Shafie, 2011

5.2: Human fingers

There are five fingers in the human hand that arise from the palm that consists of the metacarpal bones (yellow bones in the given image). Each finger (anatomically called digits) has three phalange bones (represented by the green, blue and red bones) except the thumb which contains two phalange bones. It is found that the length of corresponding bones is present in the golden ratio (Fig. 4). For example, the red uppermost bone whose length is taken as 2 cm and the next bone is 3 cm. The sum becomes 5 cm and if we divide 5 by 3, we get 1.66 which is near to the value of Golden ratio (Murali, 2009); needless to mention, it is subjected to the concerned human being and can't ascertained with generality for every individual.

5.3: Flower Petals

The petals on a flower always have one of the Fibonacci sequence (Fig. 5). Omotehinwa and Ramon (2013) have said, "*There are very common daisies with 34 petals and also some daisies have 55 or 89 petals. Human cannot give certain or particular answers to why nature found the arrangement of plant structures in spiral forms or shapes which is exhibiting Fibonacci numbers.*"

5.4: Seed heads

The head of a flower is also subject to Fibonaccian sequence. Typically, seeds are produced at the center, and then migrate towards the outside to fill all the space (Fig. 6). Sunflowers provided an example of these spiraling patterns. In some cases, the seed heads are so tightly packed that total number can get quite high Fibonacci number (Omotehinwa and Ramon, 2013).

Fig. 5: Flower petals and Golden ratio
Image Courtesy: Omotehinwa and Ramon, 2013

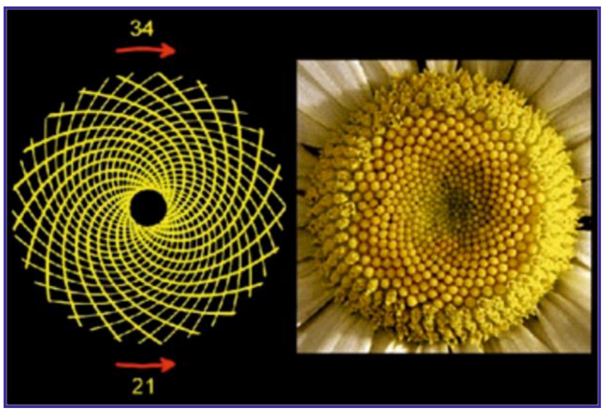

Fig. 6: Seed heads and Golden ratio
Image Courtesy: https://in.pinterest.com/pin/557250153867017569/

5.5: Human teeth

The front two incisor teeth form a golden rectangle, with a phi ratio in the height to the width (Fig. 7). The ratio of the width of the first tooth to the second tooth from the center is also the ratio of phi. The ratio of the width of the smile to the third tooth from the center is phi as well (Rana et al., 2014).

5.6: Human DNA

Deoxyribonucleic acid (or DNA) is the principle genetic material in the human body and is said to be the foundation as it the basis of our genetic inheritance from parents to offspring. It is found in the chromatin materials of the nucleus present in our cells. The DNA transcribes to RNA which then translates to various amino acids finally yielding proteins. The DNA is a double helical structure with one major groove and one minor groove (Fig. 8). It has been observed that the ratio of major groove to minor groove is equal to the value of Golden ratio, thus, proving that even the smallest evidence of life prefaces the existence of Golden ratio (Perez, 1991).

5.7: Shell of Snails

The unique properties of the golden rectangle are evident in lower organisms like mollusks. This shape, a rectangle in which the ratio of the sides a/b is equal to the golden mean (phi), can result in a nesting process that can be repeated into infinity — and which takes on the form of a spiral (Fig. 9). It is also called the logarithmic spiral and prevalently witnessed in all the shelled members of Mollusks (Falbo, 2005).

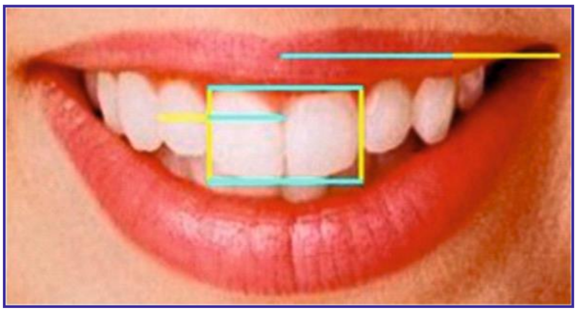

Fig. 7: Human Teeth and Golden ratio
Image Courtesy: https://www.goldennumber.net/face/

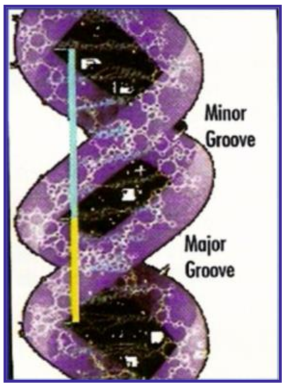

Fig. 8: Human DNA and Golden ratio
Image Courtesy: https://www.golden-number.net/dna/

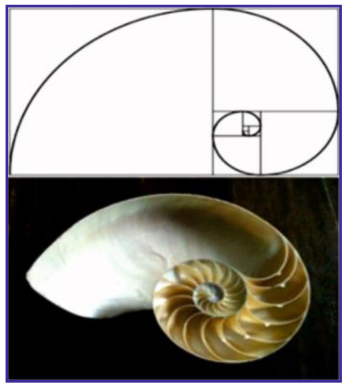

Fig. 9: Snail Shell and Golden ratio (Golden rectangle)
Image Courtesy: https://io9.gizmodo.com/15-uncanny-examples-of-the-golden-ratio-in-nature-5985588

6. Conclusion

The Nature's panorama is worth to be appreciated. Everything- living or nonliving- in our environment demonstrates the existence of Golden ratio. Starting from Da Vinci's Mona Lisa to the Pyramid of Giza, every attractive creation shows the invincible *golden ratio* as an integral part of their identity. Therefore, the scientific endeavors should be streamlined to explore the Natural phenomenon through the lens of mathematical sciences!

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