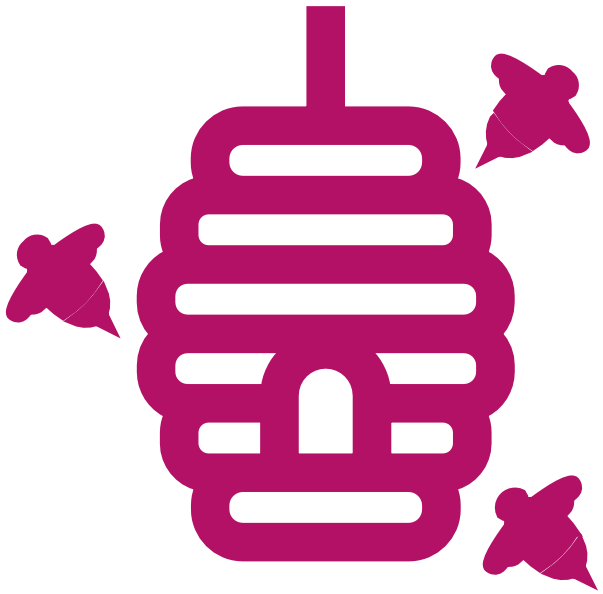
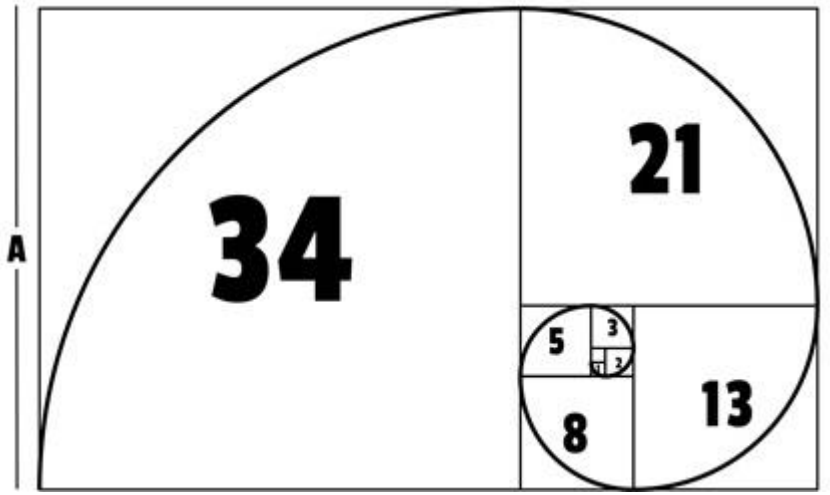


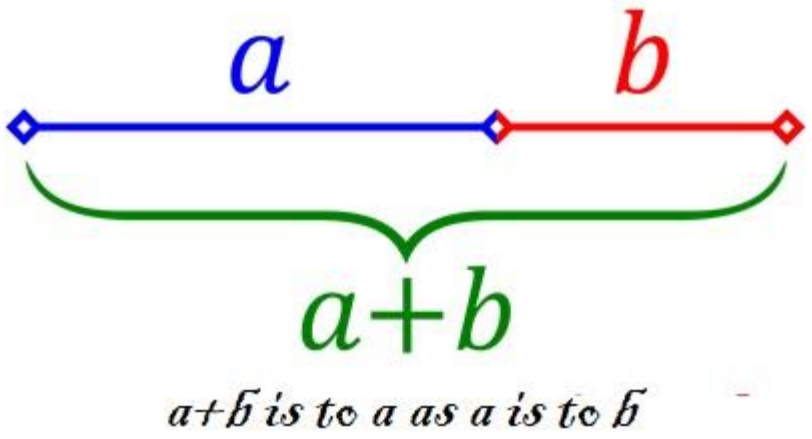
APPLICATION OF GOLDEN RATIO IN HONEYCOMB

ADITI RAJMOHAN

THE GOLDEN RATIO

- It is an irrational number represented by the Greek letter 'phi' (φ)
- Phi has the value of 1.6180339887 and is calculated as (1+ √5) divided by 2
- It is derived from the Fibonacci sequence of numbers .
- Throughout history, the golden ratio has been studied not solely by mathematicians and philosophers, but also by biologists, artists, architects and musicians since it was also for them an essential element for creation and keeping of order, form and beauty.



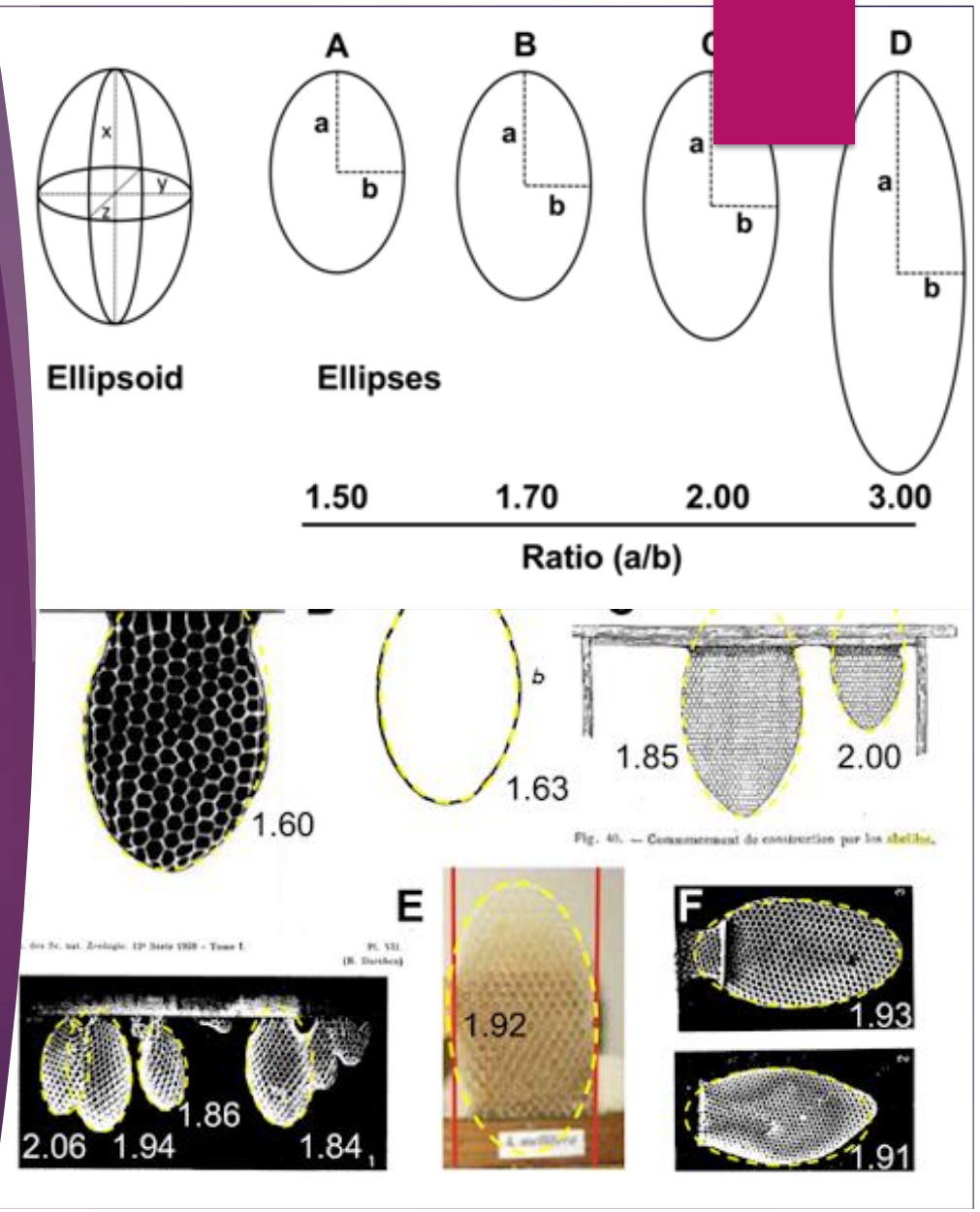


THE HONEYCOMB

- A honeycomb is certainly one of the impressive and beautiful structures.
- It contains the brood, honey and pollen within horizontally-arranged and parallel structures.
- It is a crucial part of the honeybees nest, whose composition, structure and function have been extensively reviewed.
- It can be seen that honeycombs do represent the signature or pattern of the ‘ellipse’ or oval.

APPLYING THE GOLDEN RATIO IN HONEYCOMBS

It is found that the general elliptical form of newly-constructed honeycombs could be drawn into a rectangle of modules with values approaching 2.00 or 1.62. So, it is proposed here that the elliptical form of the early stage honeycombs is not random, but follows mathematical rules reflecting the golden ratio.



APPLYING THE GOLDEN RATIO IN HONEYCOMB

The study of the early elliptical honeycomb might thus provide one more note into the hearing of the symphony of life.

The fact that the ratios of the honeycomb ellipses don't fit exactly with the values 2.000 or 1.618 can be explained by the observation that in the biological world, living systems are always only approaching their exact mathematical model.

We can hypothesize that the building of honeycombs by honeybees is following mathematical rules involving irrational numbers, namely the golden ratio and the square root of 2.

The architecture of the beehive is the revelation and representation of an ancient knowledge called 'gnomonicity', related to the word 'gnomon'.

WHY DO BEES MAKE HEXAGONS IN THEIR HIVES?

- When bees make hexagons in their hives, the six-sided shapes fit together perfectly . They can hold the queen bee's eggs and store the pollen and honey the worker bees bring to the hive.
- The hexagon is the strongest, compact and useful shape.
- In 1999, a mathematician at the University of Michigan named Thomas Hales was able to provide mathematical proof of what is known as the 'Honeycomb Conjecture'. Hales concluded that the more compact the shape of the honeycomb cell was, the less energy and wax a bee would use to build it, which means that bees could expend their energy on other important activities, specifically foraging and making honey.

REFERENCES

- GOLDEN RATIO (*SECTIO AUREA*) IN THE ELLIPTICAL HONEYCOMB

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