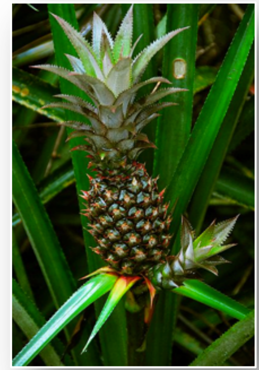
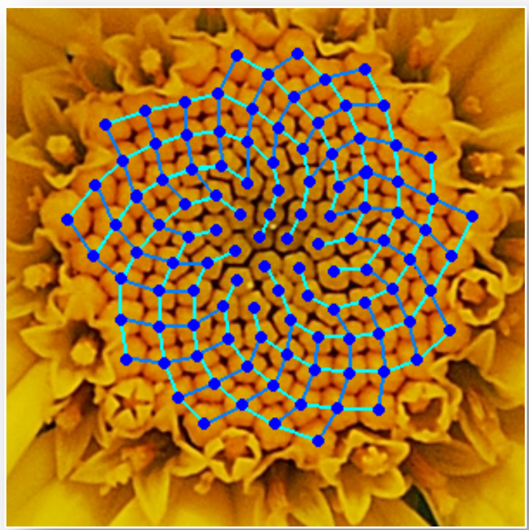
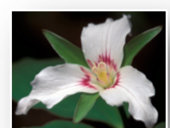
NatureGlo's eScience

Introduction & History of



The Golden Ratio & Fibonacci Numbers





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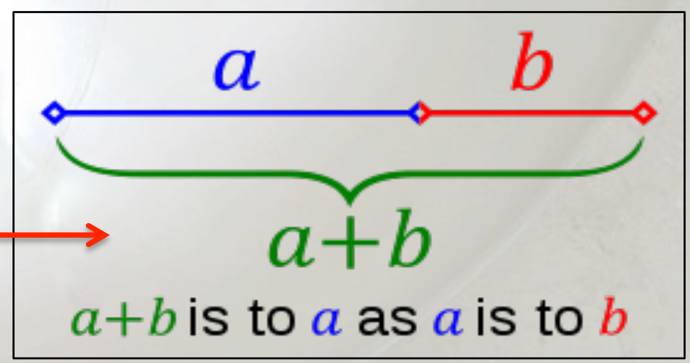
What is the Golden Number

- Golden number - 1.618033989
- Usually shortened to 1.618; doesn’t change number's value

- 1.618 - irrational number (can’t be expressed as a whole number or fraction)
- Ratio for beauty
- Never ends (infinite) or repeats

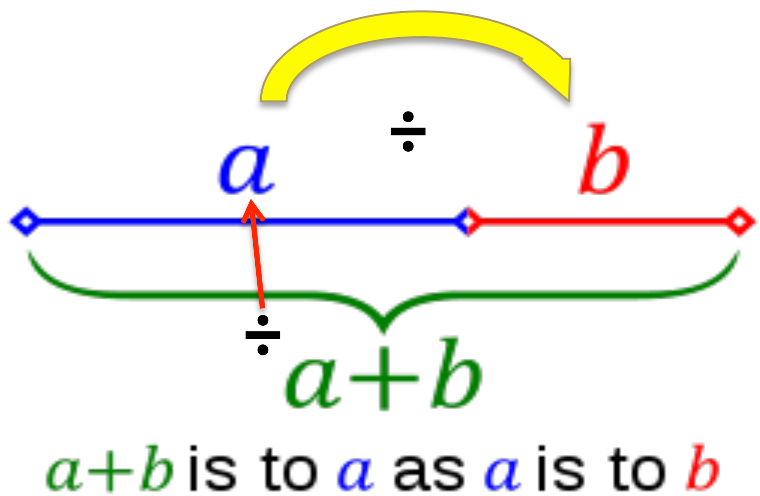
The Golden Ratio written as a proportion



Background Image – The cross-section of a chambered nautilus shell, one of nature’s logarithmic spirals is sometimes debunked as a golden spiral, but a better or more approximate fit is the Golden Spiral on a 180 degree rotation.

The Golden ratio Mathematical Proportion Diagram

What is a proportion? It is when two ratios or fractions are equal. A ratio compares values and shows how much of one thing is compared to another. Let's look at the diagram below.



Divide a line into two parts so that:

The whole length divided by the longer length is also equal to the longer length divided by the shorter length.

$= 1.618\ldots = \Phi$, or phi

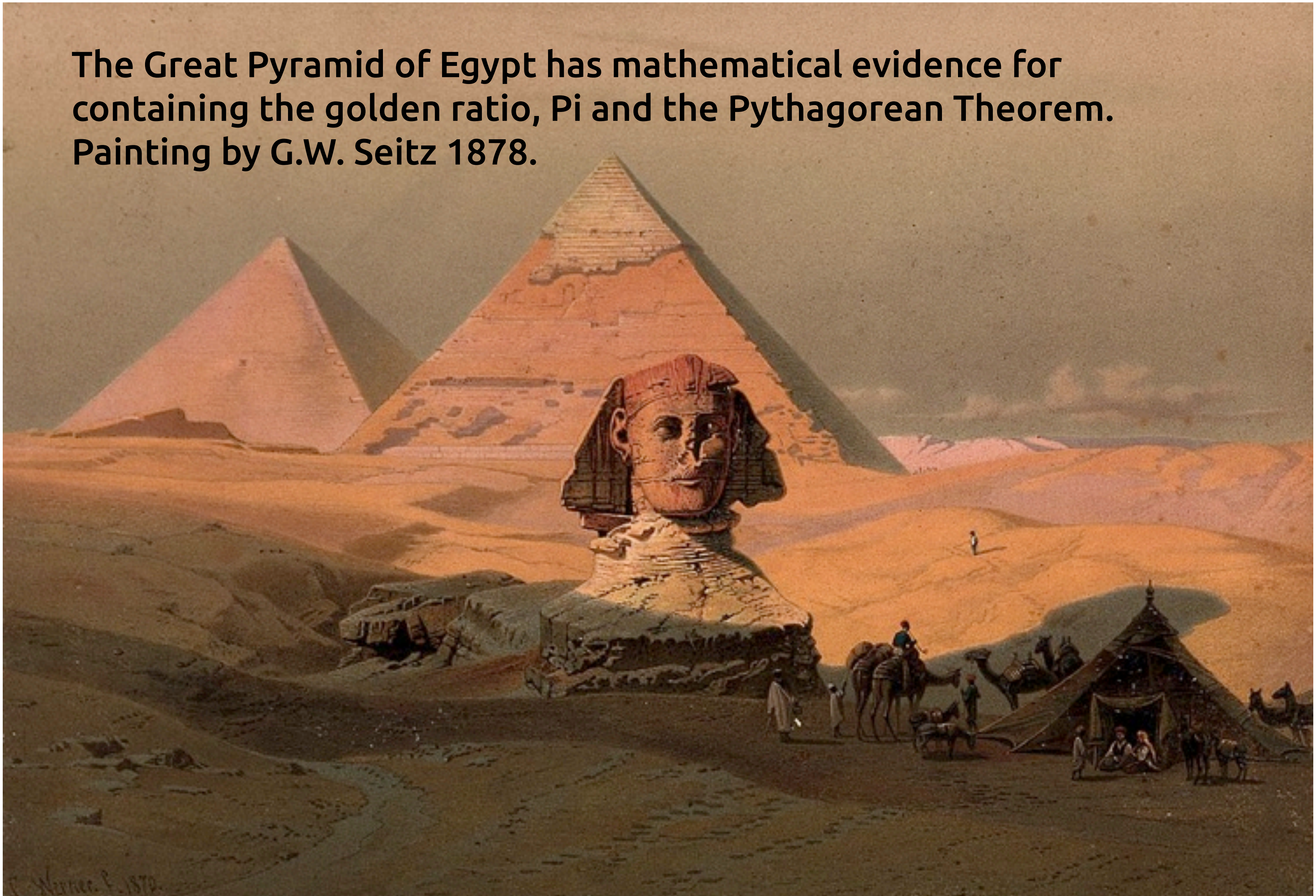
History of the Golden Ratio & Fibonacci Numbers (2574 – 1200 AD)

- 2575 BC - Egyptian pyramid design has strong evidence for golden ratio
- 448-432 B.C. - Greek Parthenon design and proportions golden
- 490 - 430 B.C. - ancient Greek artist Phidias used golden ratio in sculpture work
- 428-347 B.C. - philosophers including Plato studied and used golden ratio in works

- 300 B.C. – mathematician, Euclid's thirteen volume work Elements, referred to dividing line at point of 0.6180399; explained as way to divide a line in extreme and mean ratio
- 1200 A.D. - Fibonacci number series written about by Leonardo of Pisa aka Fibonacci & popularized in west

Background Image – The pyramids of Giza, Egypt.

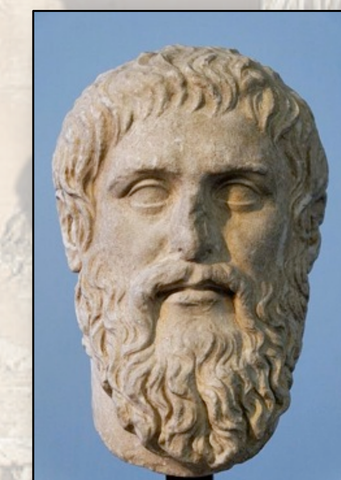
The Great Pyramid of Egypt has mathematical evidence for containing the golden ratio, Pi and the Pythagorean Theorem. Painting by G.W. Seitz 1878.



The Parthenon & Plato (448 – 347 BC)

- 448-432 B.C. Greek Parthenon - design and proportions found golden in column heights & widths & root support beam dividing line

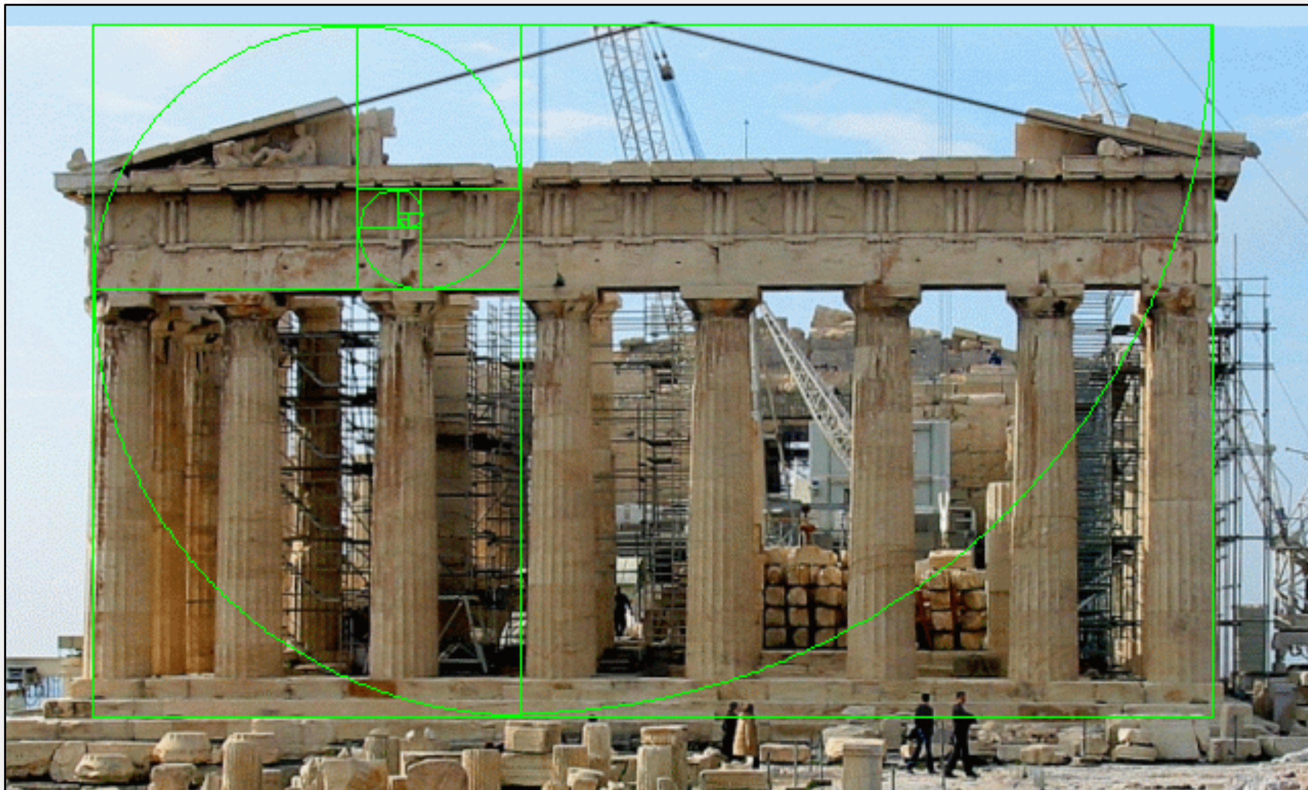
- 428-347 B.C. Plato – described golden ratio in dialogue, *Timaeus* which describes 5 possible regular solids (Platonic solids: the tetrahedron, cube, octahedron, dodecahedron and icosahedron), some Platonic solids related to golden ratio



Plato

Background image - Porch of Maidens or The Caryatid Porch of the Erechtheion, Athens, 421–407 BC.

The Greek Parthenon 448-432 B.C.



The most accurate diagram showing the Golden ratio's dimensions for the Parthenon by not starting the golden rectangle at the bottom step, as is traditionally yet, inaccurately shown. Image by Meisner, Gary B. (2013, January 20). The Parthenon and Phi, the Golden Ratio, Retrieved December 29, 2014, from http://www.goldennumber.net/parthenon-phi-golden-ratio/

Ancient Greek Sculptor Phidias 490 – 430 BC

- Sculptor
- Painter
- Architect
- Made golden ratio Parthenon statues

Phidias's Athena Parthanos, exhibiting the golden ratio.

Euclid of Alexandria, "the Father of Geometry" - 325–265 BC

Euclid's statue

- Greek mathematician
- Euclid's book, *Elements* (300 BC) - first recorded golden ratio definition
- *The Elements,* golden ratio definition – Euclid wrote, "a straight line is said to have been cut in extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the less"

Background – Oldest surviving fragment of Euclid's Elements

Golden Number & Fibonacci Number Series - 1509 – 1900s

Background – da Vinci's drawing of an Icosahedron solid with net from the *de Divina Proportione.*

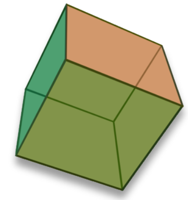
- 1509 A.D. - Leonardo da Vinci illustrated book by Luca Pacioli, *de Divina Proportion(The Divine Proportion)* with **5 Platonic Solids drawings** (some solids proportions golden); da Vinci referred to Golden Ratio as *Section Aurea* or Golden Section
- Early 1600's - Johannes Kepler discovered elliptical orbits of planets as they circled sun; referred to Divine proportion in explanation
- 1900's - term Phi used as another name for Golden ratio

Leonardo Da Vinci's Drawings of the Platonic Solids

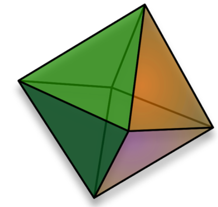
Tetrahedron Cube Octahedron Icosahedron Dodecahedron

The Five Platonic Solids & Phi

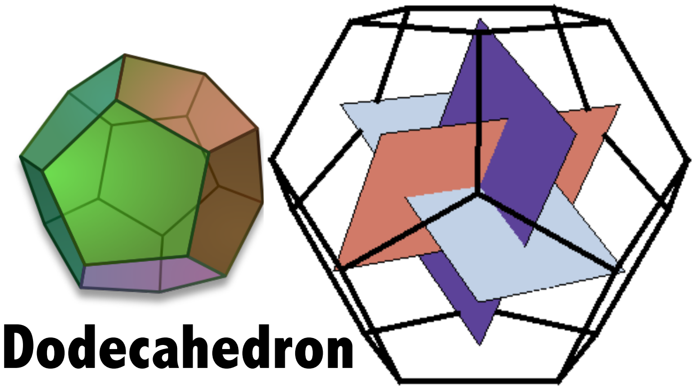
Tetrahedron



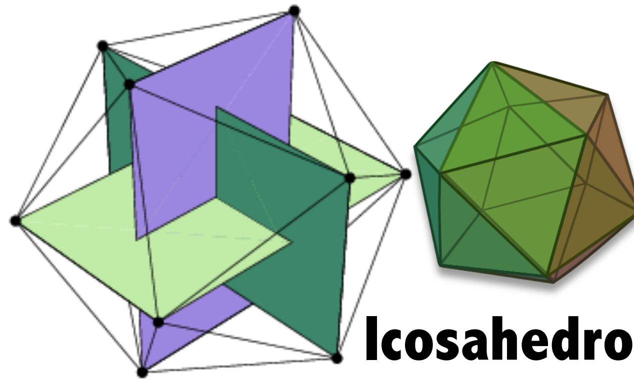
Hexahedron



Octahedron



Dodecahedron

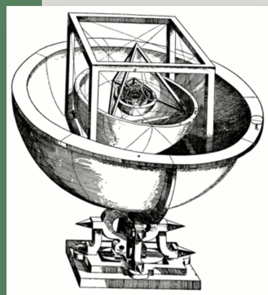


Icosahedron

By joining the mid-points of the dodecahedron's faces, we can get three golden rectangles all at right angles to each other with edges in the ratio 1 to Phi. Since the icosahedron is the dual of the dodecahedron, meaning able to fit cleanly inside with all corners touching the dodecahedrons faces, if we join the icosahedron vertices, it also yields the same three golden rectangles, thus making both platonic solids golden.

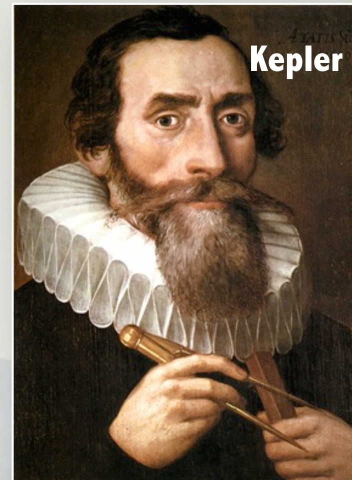
Computer graphic models of the 5 Platonic Solids, of which da Vinci illustrated in *The Divine Proportion* written by Luca Pacioli, around 1498. Creative Commons images used.

Golden Number History Timeline: Johannes Kepler (1571 – 1630)



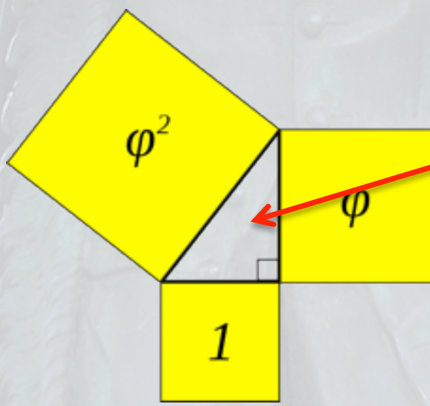
Kepler's Platonic solid model of the Solar system.

- Kepler proved golden ratio is limit ratio of consecutive Fibonacci numbers; he described as "precious jewel"
- He quoted: "Geometry has two great treasures: one is the Theorem of Pythagoras, and the other the division of a line into extreme and mean ratio; the first we may compare to a measure of gold, the second we may name a precious jewel."
- Theorem of Pythagoras & division of a line into extreme & mean ratio combined in Kepler's triangle.



Kepler

Background image - Statue of Johannes Kepler in gardens at the Linzer Schloss photographed by Aldaron.



A Kepler triangle - A right triangle formed by three squares with areas in geometric progression according to the golden ratio.

Different Names of the Golden Number

- Golden mean
- Golden section
- Golden number
- Golden ratio (most popular)
- Golden section
- Golden proportion
- Golden cut
- Extreme mean & ratio
- Mean of Phidias
- Divine section
- Medial section
- Divine proportion
- Phi (also very popular)

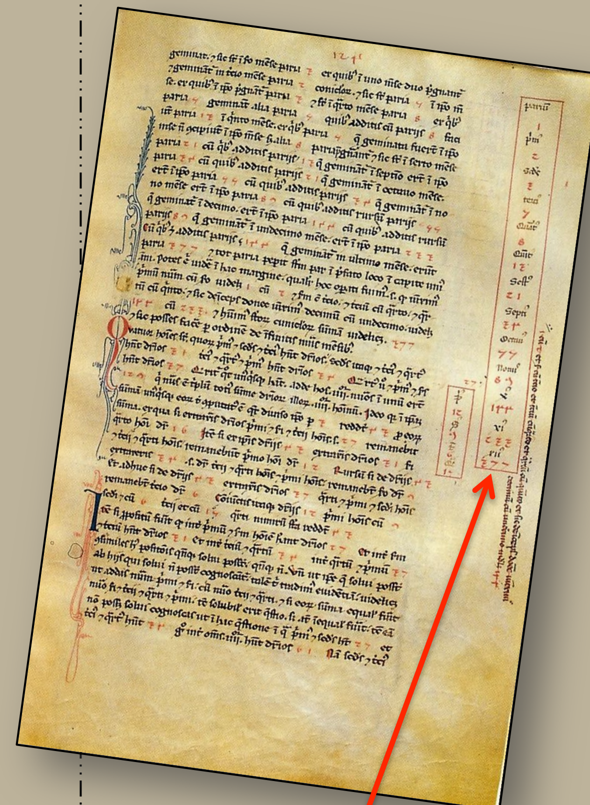
Φ

The 21st Greek alphabet letter used as the symbol for *phi.*

Fibonacci Numbers

History – 6th century to 19th Century

- 6th century India – ancient Indians knew about Fibonacci number series, invented & used Hindu Arabic numerals (1 – 9 and 0)
- 1202 AD – Leonardo of Pisano (aka Fibonacci) introduced India's number series to west in book "*Liber Abaci*" (page right) or *Book of the Abacus*, with the famous Rabbit Sequence known as Fibonacci number series (0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55…etc.)
- 19th-century - "Fibonacci sequence" first named by number theorist Edouard Lucas



"A page of Fibonacci's Liber Abaci from the *Biblioteca Nazionale di Firenze* showing (in box on right) the Fibonacci sequence with the position in the sequence labeled in Latin and Roman numerals and the value in Hindu-Arabic numerals." Image in the public domain. Wikipedia

The Fibonacci Number Series History Overview

- Fibonacci number integer sequence: 0, 1 ,1 , 2, 3, 5, 8, 13, 21, 34, 55, 89, 144,...
- Starting with first 2 numbers, each subsequent number is sum of previous two numbers

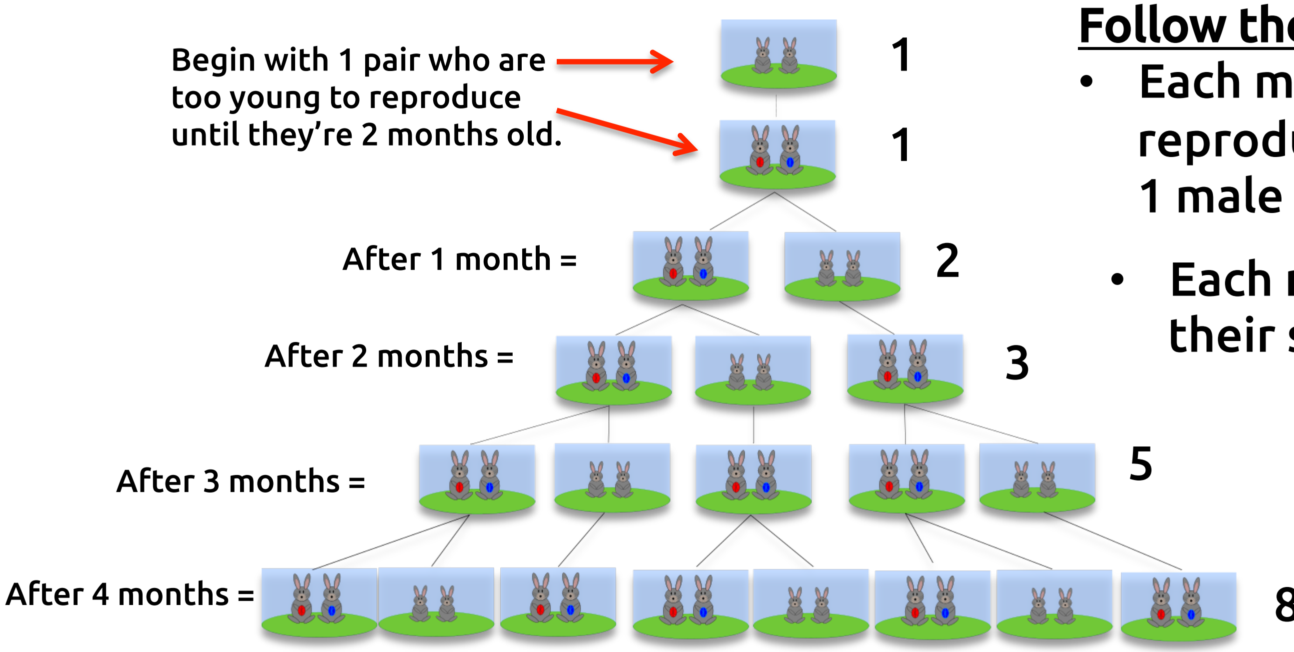
Portrait of Leonardo of Pisa aka Fibonacci

- Related to Golden ratio by dividing each larger number by previous smaller number
- Going through sequence, numbers get closer & closer to golden number (1.618)
- Fibonacci helped spread Hindu-Arabic numbers (0,1,2,3,4,5 etc.) across Europe

The Fibonacci Rabbit Sequence

In his book *Liber Abaci*, Fibonacci presented a story problem about the speed of ideal rabbit breeding in a year. Here's the story's summary.

If a pair of newborn rabbits, male and female were placed in a pen and reproduce, how many pairs of rabbits will they have in a year?



<u>Follow these rules</u>:

- Each month the original pair reproduces a new pair (always 1 male & 1 female)
- Each new pair can breed by their second month
- They never die
- Answer is on following slide

Image created by Michael Frey & Sundance Raphael.

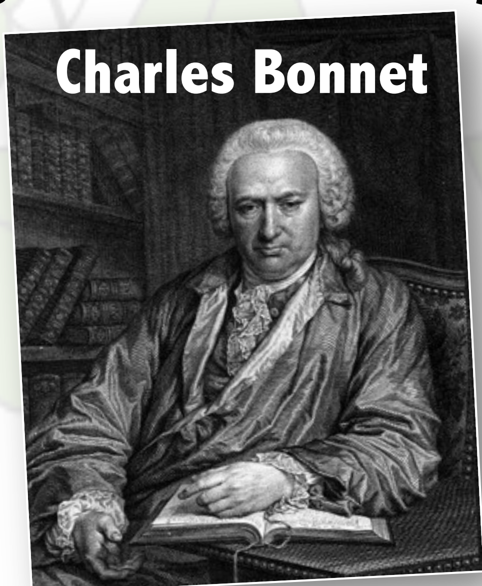
Monument of Leonardo da Pisa (Fibonacci), made by Giovanni Paganucci, completed in 1863, in the Camposanto di Pisa.

Previous slide rabbit problem answer: The rabbit pairs would have reproduced 233 rabbit pairs by the 11th month. 233 + 144 pairs equals 377 pairs at the end of one year or 12 months..

Golden Number & Fibonacci Numbers History Timeline: Bonnet & Ohm

- **1720–1793 <u>Charles Bonnet</u> –** pointed out plant spiral phyllotaxis going clockwise and counter-clockwise were frequently two successive Fibonacci numbers

- **1792–1872 <u>Martin Ohm</u>** is believed to be first to use term *goldener Schnitt* or golden section



Martin Ohm

Background – Spiral phyllotaxis leaves of plants revealing Fibonacci numbers.

Golden Number & Fibonacci History Timeline: Lucas & Barr

Edouard Lucas

(1842–1891) Edouard Lucas – French mathematician gave numerical sequence now known as Fibonacci sequence its present name

(20th century) Mark Barr - suggested Greek letter phi (φ), initial letter of Greek sculptor Phidias's name, as golden ratio symbol

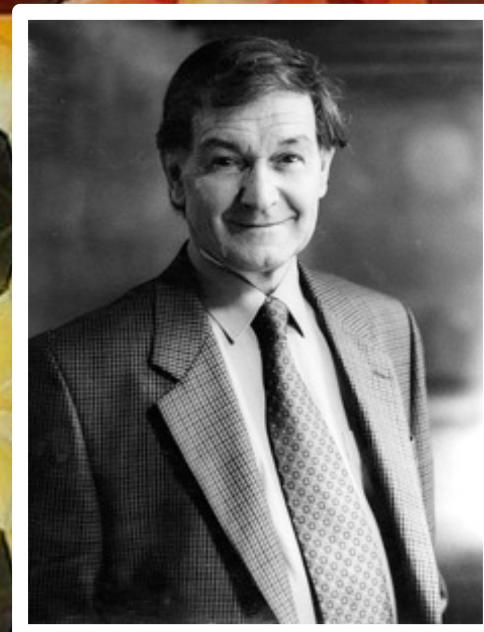
Φφ

The 21st letter of the Greek alphabet representing the golden number or ratio.

Golden Number History Timeline: Roger Penrose - 1931

1931 Roger Penrose:

- Described symmetrical pattern with golden ratio in aperiodic tilings field
- Work led to quasicrystal discovery exhibiting previously thought impossible crystal symmetries



Sir Roger Penrose

Background - Oil painting by Urs Schmid (1995) of a Penrose tiling using fat and thin rhombi.

Learn more about the Golden number and Fibonacci by visiting Natureglo's eScience Virtual Library website resource pages below. **For best results, copy and paste the links into your browser.**

Golden number resource page:
http://hascmathart.weebly.com/golden-ratio.html

Fibonacci resource page:
http://hascmathart.weebly.com/mathartist-fibonacci.html

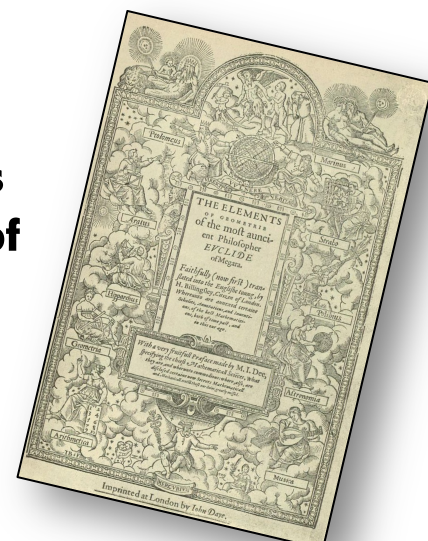
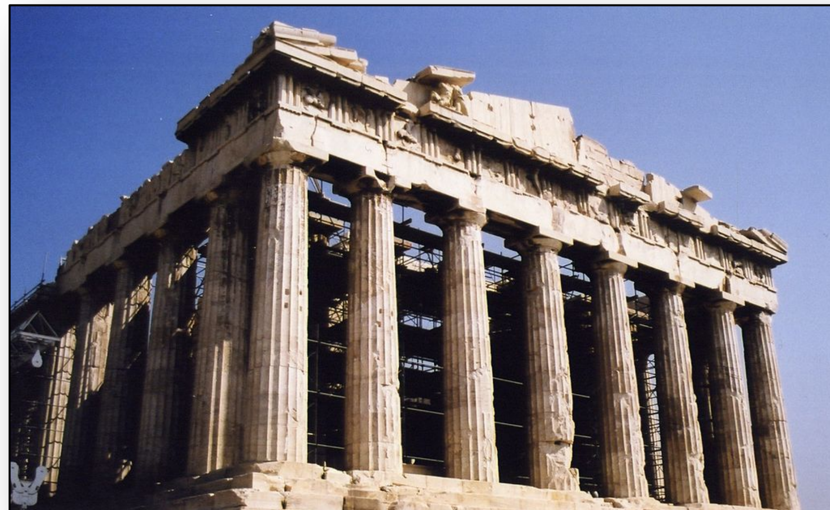


Image – Title page of Sir Henry Billingsley's first English version of Euclid's Elements, 1570. Image in the public domain.

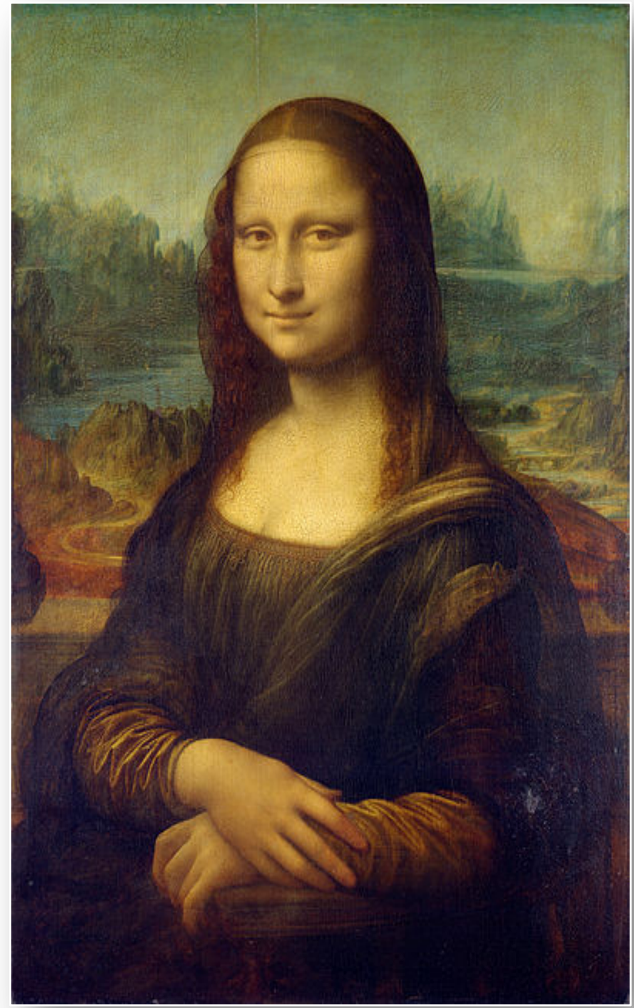
References Used

1. Livio, Mario (2002). The Golden Ratio: The Story of Phi, The World's Most Astonishing Number. New York: Broadway Books. ISBN 0-7679-0815-5.
2. Richard A Dunlap, The Golden Ratio and Fibonacci Numbers, World Scientific Publishing, 1997
3. "The Golden Ratio". The MacTutor History of Mathematics archive. Retrieved 2007-09-18.
4. Weisstein, Eric W., "Golden Ratio", MathWorld.
5. Hemenway, Priya (2005). Divine Proportion: Phi In Art, Nature, and Science. New York: Sterling. pp. 20–21. ISBN 1-4027-3522-7.
6. Slide #8: Meisner, Gary B. (2013, January 20) The Parthenon and Phi, the Golden Ratio, Retrieved December 29, 2014, from http://www.goldennumber.net/parthenon-phi-golden-ratio/



Many of the proportions of the Parthenon exhibit the golden ratio. Image in the public domain.

Thank you for watching!



Leonardo da Vinci's Mona Lisa. Image in the public domain.