SG205A. Ia The Sacred Geometry of Nature Part 1: Plants

Online Module
SG205A
(Interm V-A)

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Chapter 1:
Phyllotaxis: Harmonic Patterns in Plants
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SG205A.Id The Sacred Geometry of Nature - Intro

Yes, "Nature" is all-encompassing. We have been encountering Nature all along as we journeyed through the previous Sacred Geometry modules and browsed through examples of SG in various areas of knowledge, tradition and science. We have looked at the Human Body, DNA and the new biology. In SG301, we will look at SG on the celestial and the cosmological levels. In SG207 and SG308, we will encounter SG at the macro-ecology level, uncovering the harmonic aspects of Gaia and the co-creation of global peace on Earth.

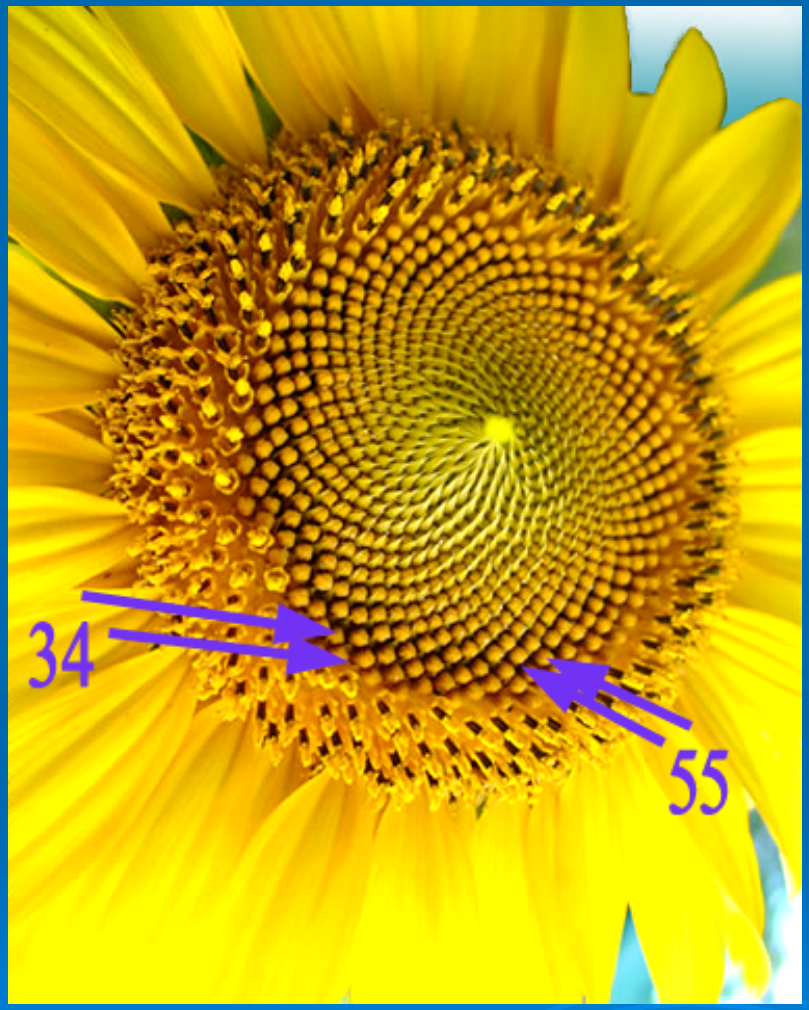
SG205 is focusing upon the "Nature" traditionally called Minerals, Plants, and Animals. In the native indigenous wisdom traditions speaking about the "stone people", the "plant people" and the "animal allies", these other realms of life are perceived as integral parts of the Web of Life where each element has its appropriate place and all contribute to the global harmony: the other realms partake of the same holographic and intelligent oneness.

Since the early 1800s, the science of Biology, as the study of life and living organisms, has painstakingly listed and described the characteristics of existing organisms and rendered the traditional model scientifically obsolete. First the mineral kingdom or inanimate matter has been replaced by the hierarchy of particles, atoms, and molecules organized in a variety of matrices. Then, plants and animals have been divided into "kingdoms" or domains now described as the Five Kingdoms of Nature: Bacteria or "Monera" (no nucleus), Protoctista such as algae (first organisms to have a nucleus), Fungi, Plants, Animals.

Recently, the boundaries between these realms have become more & more fuzzy. For instance, according to a recent study at the Carnegie Institution (Hazen, 2008), up to 2/3 of the more than 4,000 known types of minerals on Earth can be directly or indirectly linked to biological activity. Interestingly, the New Paradigm Science, expressing the quantum field understanding, is now reaching the same conclusion of inter-connectedness that tradition has upheld all along, thus completing another loop of consciousness evolution.

In SG205A, we are focusing on the following:

- **The development of Phyllotaxis or study of harmonic patterns in plants.**
- **Examples of geometric beauty in plants & flowers.**
- **A journey through the exquisite universes of pollen and seeds.**



SG205A. Chapter 1.
Phyllotaxis: Harmonic Patterns in Plants

In plant morphogenesis, there is a special area of fascinating study: *phyllotaxis* - the geometric arrangement of leaves on a plant stem (or seeds in a seed head).

A most striking phenomenon of harmonic regularities exhibiting a spiral pattern based on the Fibonacci series, phyllotaxis is also a hotly debated subject among scientists in terms of WHY these patterns should be so prevalent in the plant kingdom.

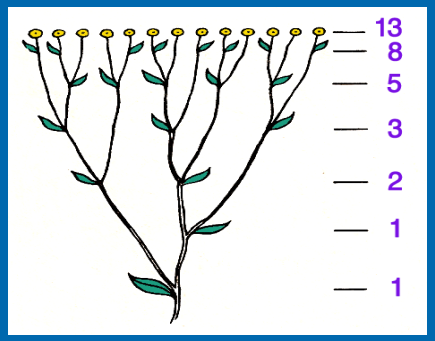
In this chapter, we will explore the history of phyllotaxis, define the terms of what is now a pluri-disciplinary area of research, give basic examples, study the ubiquitous PHI-based "Growth Angle", visit the dynamics of phyllotactic emergence at the plant apex (or *meristem*), and glimpse at some of the main explanations for this beautiful "harmonic mystery".

SG205A.1.1 What is Phyllotaxis?

Etymology: from the Greek *"phyllon"* = leaf and *"taxis"* = to organize".

Phyllotaxis is the study of the arrangement of elements in a plant and their mutual relationship. Phyllotactic patterns can apply to:

- ➔ The placement of twigs on branches.
- ➔ The number of petals in flowers.
- ➔ The number & geometry of seeds in seed heads.
- ➔ The number of leaves per turn of spiral.
- ➔ The *parastichies* (parallel spirals) of scales on pinecones & pineapples.



➔ The Sneezewort (*Achillea ptarmica*) displays the Fibonacci sequence.

Even though the *primordia* (the elements of these patterns) differ in location, number, size, shape and rate of formation and thus offer a vast variety of phyllotactic modes, there is, in plants using the spiraling pattern, a "prevailing tendency" (80 - 90%) to display Fibonacci numbers in the mutual proportions of their elements.

In simple terms, there is is an overwhelming presence of the Golden Ratio in the dynamics of plant growth.

Beyond observations and data gathering, the field of phyllotaxis has now turned into a multi-disciplinary subject of research (from bio-mathematics to morphogenesis) as the big question is raised: what is the origin of this convergence of phyllotactic patterns? Like many other aspects of nature studied by science, the patterns of harmonic order described by phyllotaxis are rooted in the very foundation of the universe.

This is also the question we have been addressing in this series of Sacred Geometry modules as we have been uncovering, both in ancient wisdom traditions and in cutting-edge science, the ubiquitous appearance of the Golden Ratio. We are harmonic beings learning to co-exist in a harmonic universe.

The function of PHI as a scale-invariant, fractal attractor of self-similarity is certainly widely used in the plant kingdom. But there is more: based on the practical optimization and efficiency of growth, phyllotaxis is also bridging over to aesthetics, health & well-being, and spirituality.

• Aesthetics - with the sense of the stunning or subtle Beauty pervading any genuine contact with nature: the magnificence of flowers, the protective power of trees and forests, the extraordinary miracles of seeds…

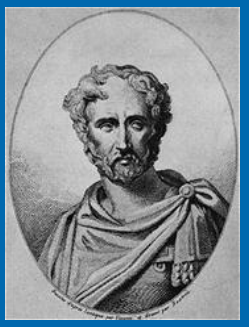
• Health - with the gift of life-force, renewal and well-being obtained from the company of plants and their "medicines". The harmonic frequencies of foods, herbs, flowers, trees are the new remedies…

• Spirituality - as we open to our symbiosis with the Web of Life and our partnership with the cosmos. A spiritual responsibility is dawning upon us: to protect and enhance the unique qualities, aromas, colors, shapes and expressions of Nature and re-learn the profound wisdom of attuning to the cosmos.

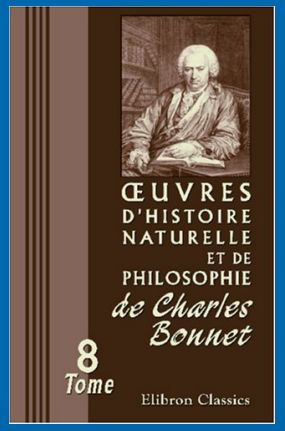
SG205A.1.2 Phyllotaxis - History

Hidden (and sometimes plainly visible) in the diversity of plants, there are mathematical constants that were intuited by keen observers of nature and great minds of ancient times. However, it is only in the first half of the 19th century that coherent descriptions of *phyllotaxis* were developed.

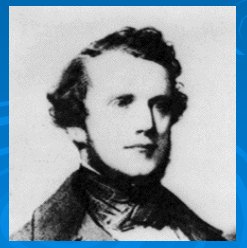
- **Aristotle's disciple Theophrastus (ca. 372 - 287 BCE) wrote in *Enquiry into Plants*: *"Those that have flat leaves have them in regular series".***
- **Pliny the Elder (23 - 79 CE) remarked, in his encyclopedic *Naturalis Historia*, that *"leaves arranged circularly around the branches… (have) regular intervals".***
- **Leonardo da Vinci (1452 - 1519) noted that the leaves were arranged in spiral patterns, with a symmetry of five.**
- **Johannes Kepler (1571 - 1630) was the first to see the relationship between these patterns and what has now come to be known as the "Fibonacci Series". Kepler wrote: *"It is in the likeness of this self-developing series (i.e. the Fibonacci series) that the faculty of propagation is, in my opinion, formed; and so in a flower the authentic flag of this faculty is shown, the pentagon."***
- **Nehemiah Grew (1641 - 1712), the English naturalist known as the "father of plant physiology", wrote in his *Anatomy of Plants* (1682): *"From the contemplation of plants men might first be invited to Mathematical Enquirys".***
- **In 1753, Scottish mathematician Robert Simson (1687 - 1768) discovered that the ratio of two successive Fibonacci numbers tends to the constant PHI. He also stated that this constant Phi is governing the growth patterns of plants.**
- **In his 1754 book *Recherches sur l'Usage des Feuilles dans les Plantes,* Swiss naturalist Charles Bonnet coined a term that was to herald a brand new domain of investigation: *phyllotaxis*. Bonnet also described the 2/5 ratio.**
- **In his *Metamorphosis of Plants* (1790), Goethe (1749 - 1832) formulated a theory of plant metamorphosis in which the archetypal form of the plant is to be found in the *leaf.* He wrote: *"From top to bottom a plant is all leaf, united so inseparably with the future bud that one cannot be imagined without the other".***
- **1831. Mathematical phyllotaxis begins with the works of Karl F. Schimper and Alexander Braun (published 1835).**
- **1837. The brothers Auguste and Louis Bravais introduced the cylindrical representation of phyllotaxis and recognized the importance of the ratios expressed in the Fibonacci series. They described the Growth Angle of 137.5°.**
- **Gaspard T. Lestiboudois, a French physician and botanist, formulated in 1848 the *"Law of Phyllotaxis"* (or Law of Hierarchical Distribution) which controls the distribution of simple and double nodes in phyllotactic Fibonacci fractions.**
- **In 1868, Wilhelm Hofmeister, a German biologist, proposed a model (the *Hofmeister Axiom*) for pattern generation: each leaf arises in the largest gap between the existing leaves (primordia), and as far away from them as possible.**
- **1917. Arthur Harry Church published his *On the Relation of Phyllotaxis to Mechanical Laws* in which he introduced the centric (polar) representation revealing the generative Fibonacci spiral.**
- **In the second half of the 20th century, many researchers brought bio-mathematical insights into the field of phyllotaxis: sphere packing, 5-fold symmetry, crystallographic methods, magnetic fluid experiments, and a large variety of computer simulation models… The "quest" continues…**
- **1994. Roger V. Jean proposes a unified concept of phyllotaxis.**



Pliny the Elder



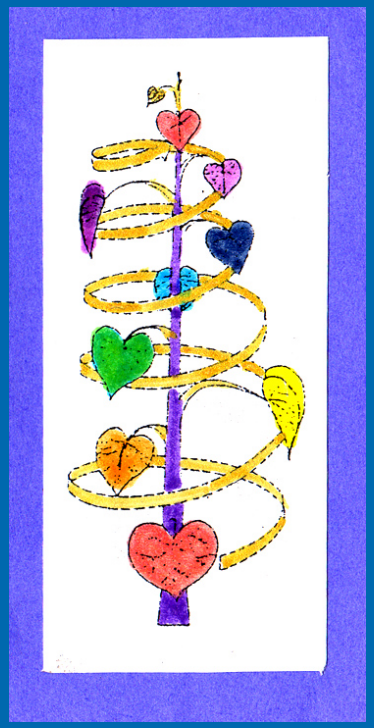
Charles Bonnet

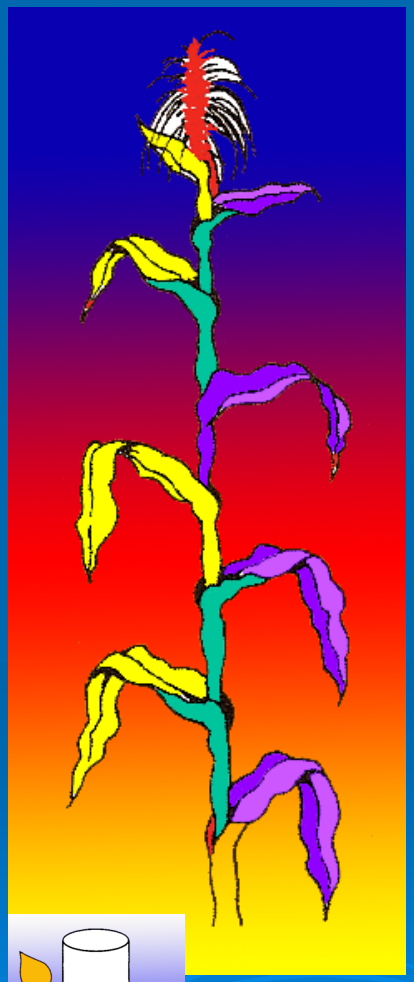


Auguste Bravais

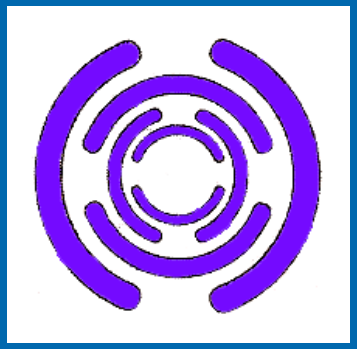
SG205A.1.3.1 Phyllotaxis Patterns (1) Main Types

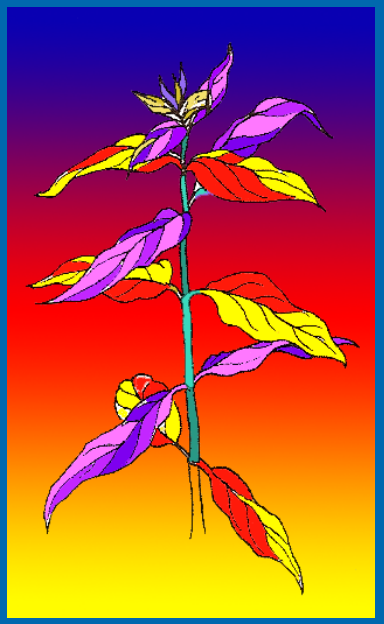
What are the common patterns of leaf arrangement? There are three main types: spiral, distichous and whorled. .

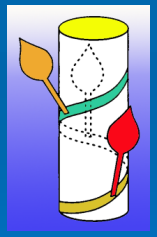


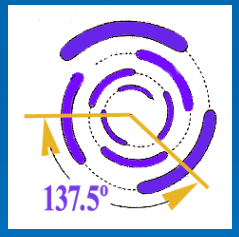


The spiral pattern appears in about 80% of plant species. Nearly all of the remaining 20% shows the other two patterns.







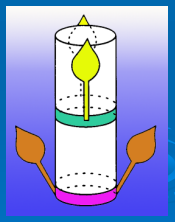


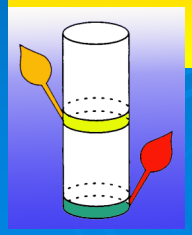
↑ SPIRAL (80%)

Each leaf is displaced above the one below by a constant angle (the "Growth Angle") of 137.5° based on PHI, the Golden Ratio.
One can usually trace two sets of spirals around the stem: they run in opposite direction and appear to cross one another (the *"parastichies"*).

↑ WHORLED ↑➔

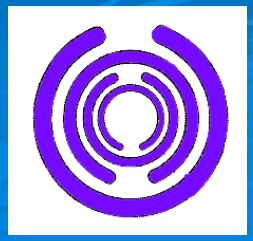
Little clusters (whorls) of leaves come up at regular intervals up the stem, with each whorl upset so that it is over the gaps of the whorl below it (*"alternate whorls"*). When the leaves in each whorl are just above the ones in another whorl, this is called *"superposed whorls"*. When two whorl "primordia" are involved, they are arranged at 90° from each other (*"decussate"*).
3 whorl primordia form *"tricussate whorls"*.





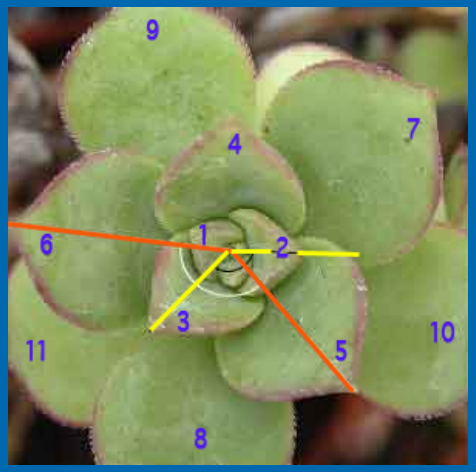
← DISTICHOUS →

Successive leaves sprout on opposite sides (180°) of the stem, thus determining two vertical rows of leaves (the *"orthostichies"*).



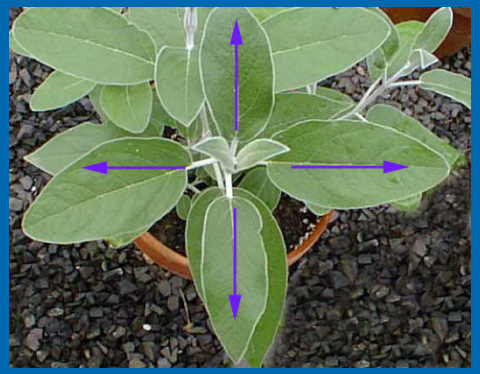
SG205A.1.3.2 Phyllotaxis Patterns (2) Examples

Here are top & side view examples of each phyllotaxis type.



SPIRAL

DISTICHOUS

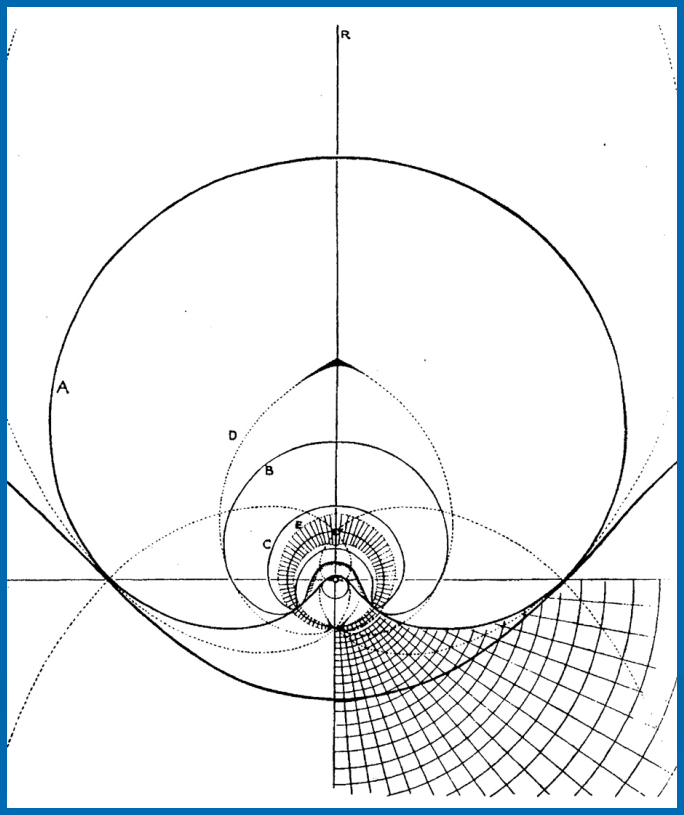


Whorled "decussate" (90º)

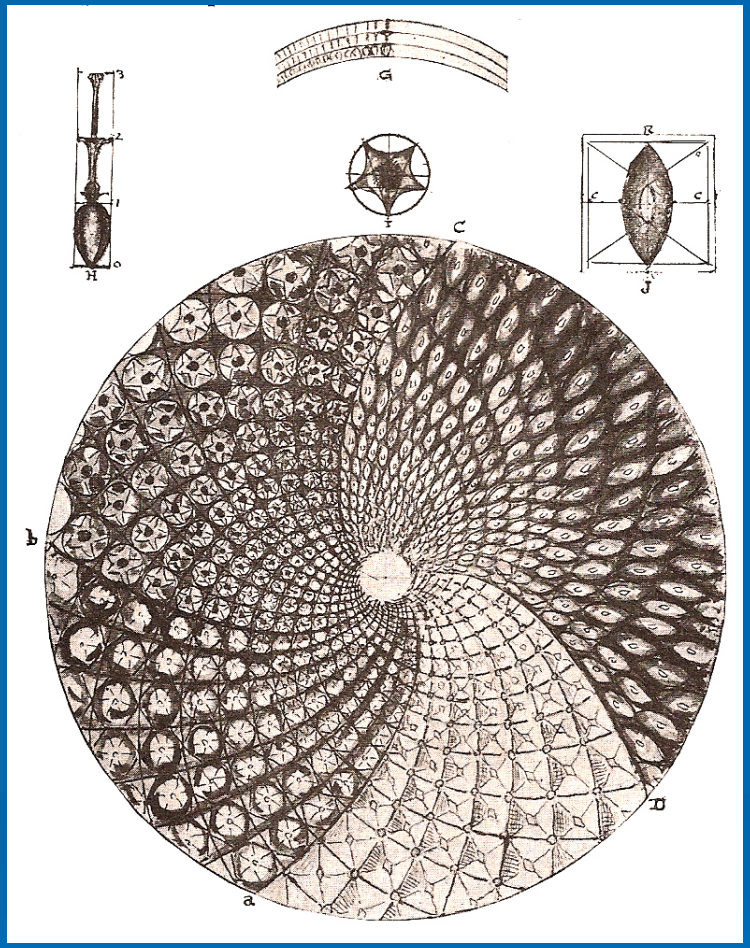
WHORLED

Whorled "tricussate" (120º)

SG205A.1.3.3 Phyllotaxis Patterns
(3) Historical Diagrams (1)

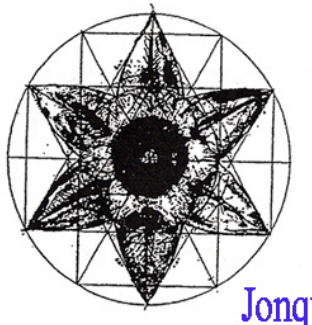


Distichous (1 + 1) phyllotaxis system. (A. H. Church. 1904).
A beautiful sketch evocative of the Golden Spiral Grail [SG104]

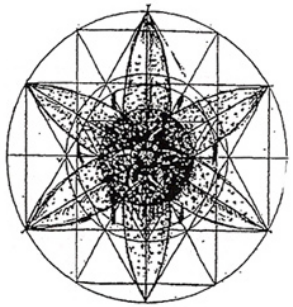


Stages of sunflower growth. (S. Colman. 1913.)

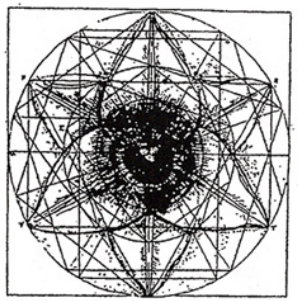
"Nature herself is rarely exact in every portion of any one flower, yet if she presents us with an object numbered by five, no possible reasoning offered can change the obvious fact that she intended the form to be pentagonal even if it is several degrees removed from a symmetrical measurement, for THE LAW OF UNIFORM GROWTH IS EXPRESSED BY THE AVERAGE OF GEOMETRIC CORRELATIONS AND NOT BY SINGLE DISCONNECTED MEASUREMENTS.
However exact her principles may be in the abstract, or however clearly to be proven by scientific methods, it is in the appearance that she seems to take most delight." (Samuel Colman. Harmonic Proportion and Form in Nature, Art and Architecture. 1913.)



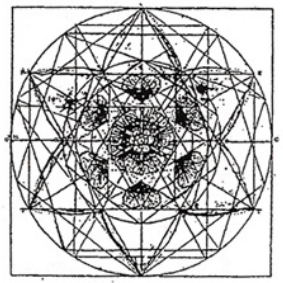
Jonquil



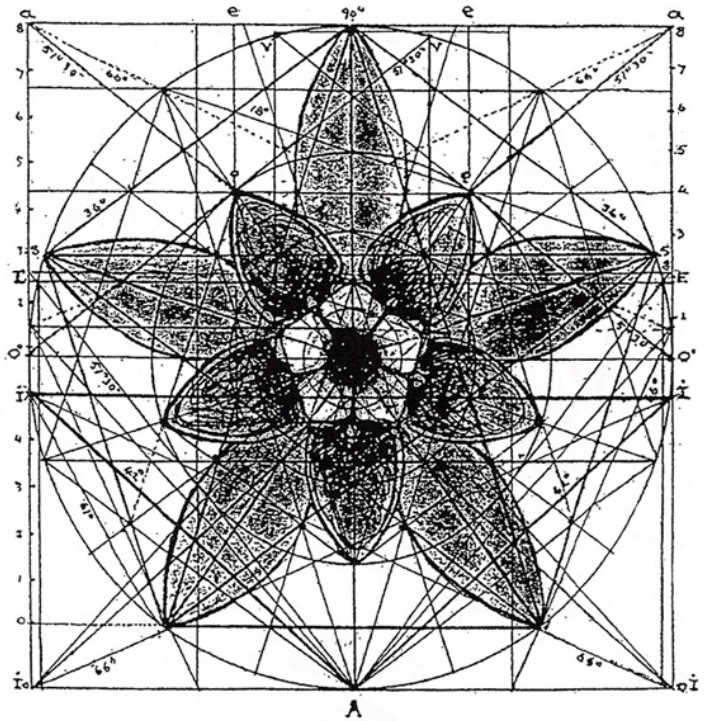
Tiger Lily



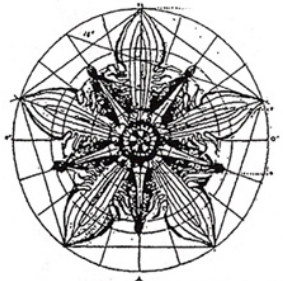
Easter Lily



Zygadenus Elegans

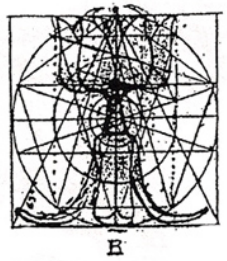


A



Parnassia

Henbane



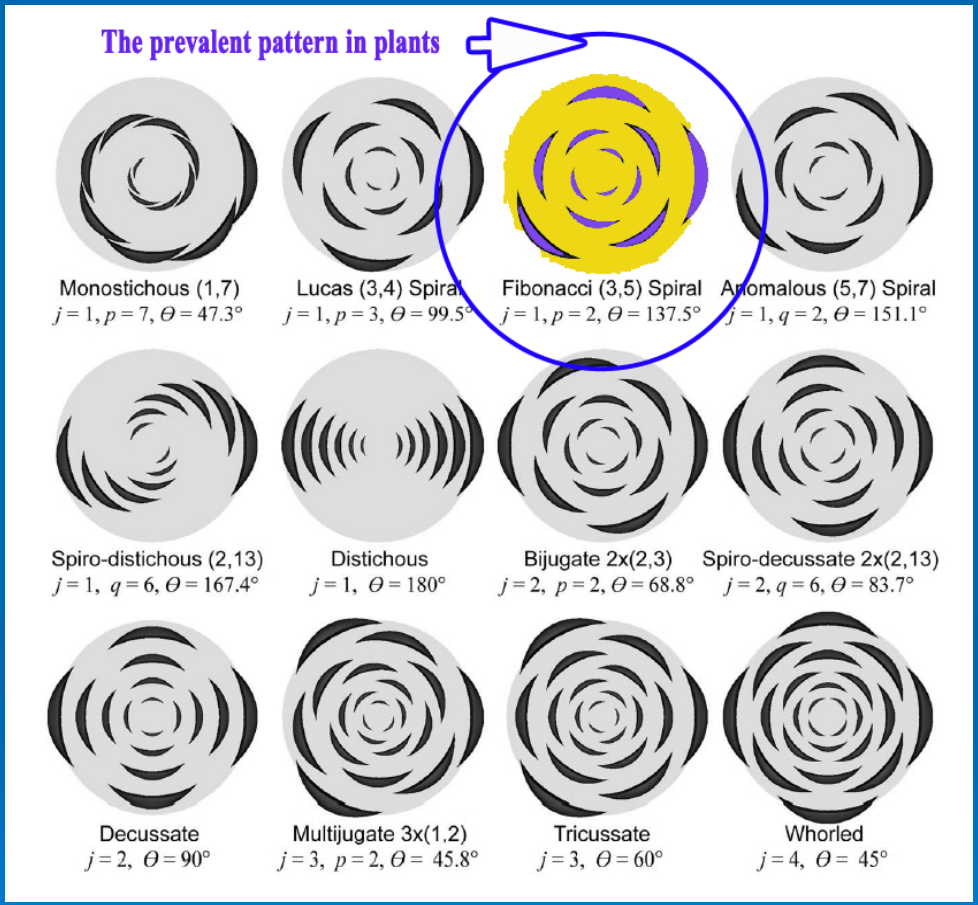
B

Milkweed

SG205A.1.3.4 Phyllotaxis Patterns (4) Historical Diagrams (2)

Geometries of various flowers.
Samuel Colman. Nature's Harmonic Unity (1911).

SG205A.1.4 Phyllotaxis - Relative Frequency of Patterns



↑ This diagram shows other types of phyllotaxis patterns that appear, in addition to the main prevalent pattern of the Fibonacci Spiral.
Diagram credit:
//openalea.gforge.inria.fr

The question naturally arises: can we give a relative frequency of appearance for the main patterns?

While there is a need for more data collection with a standard scientific protocol, the observation data available at the end of the 20th century are summed up by Roger V. Jean in his landmark *Phyllotaxis, A Systemic Study in Plant Morphogenesis* (1994). Roger Jean states:

"From data for 8 patterns and 12,750 observations… it follows that the usual saying, according to which the Fibonacci sequence arises in 95% of all the cases is realistic, the percentage being probably closer to 92%.

… Fibonacci phyllotaxis is more frequent than bijugate phyllotaxis which is more frequent than Lucas phyllotaxis."

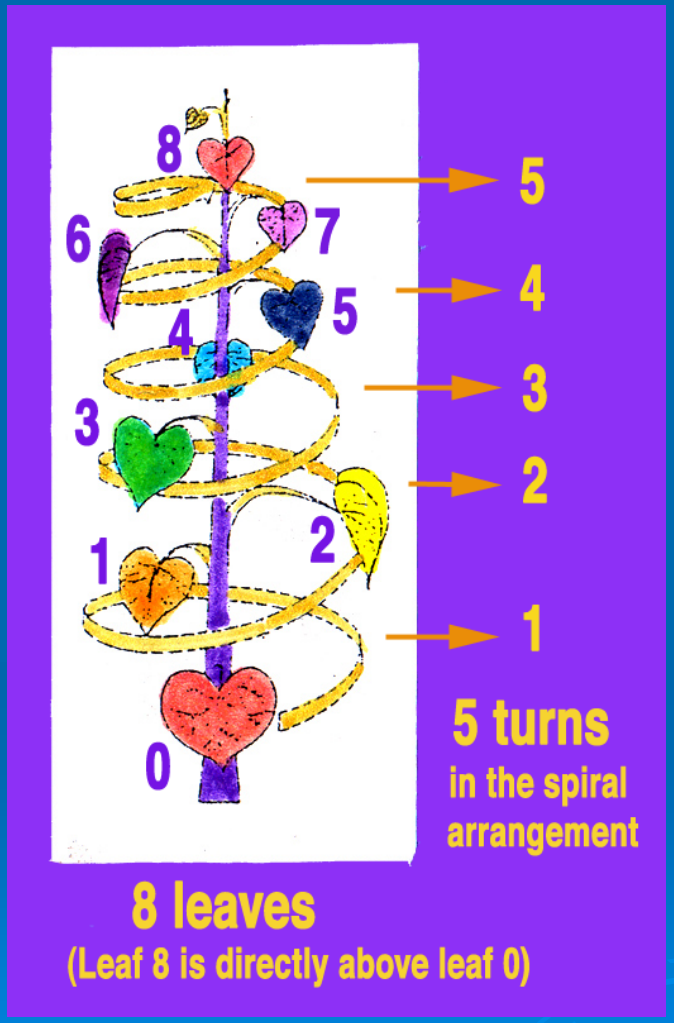
Pattern	Frequency	Angle	%
Fibonacci (1,2,3,5,8…)	11,641	137.5º	91.3
Bijugate 2 (1,2,3,5,8…)	666	68.8	5.2
Lucas (1,3,4,7…)	190	99.5º	1.5

↑ Table of frequency. R. Jean.

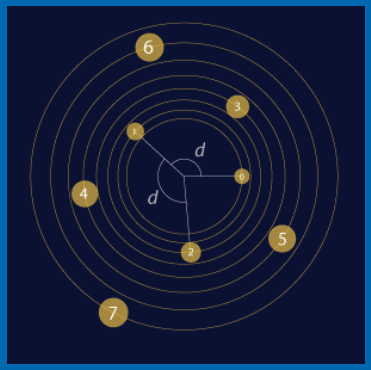
Note that the divergence angle of the bijugate pattern (68.8º) is half the Growth Angle of 137.5º.

SG205A.1.5.1 Spiral Phyllotaxis (1)

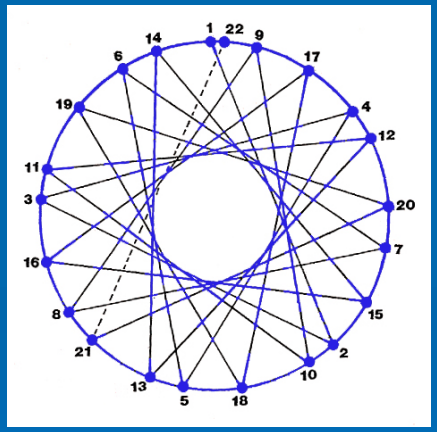
Spiral phyllotaxis is the most prevalent plant architecture.
It is based on the Fibonacci angle of divergence or Growth Angle.



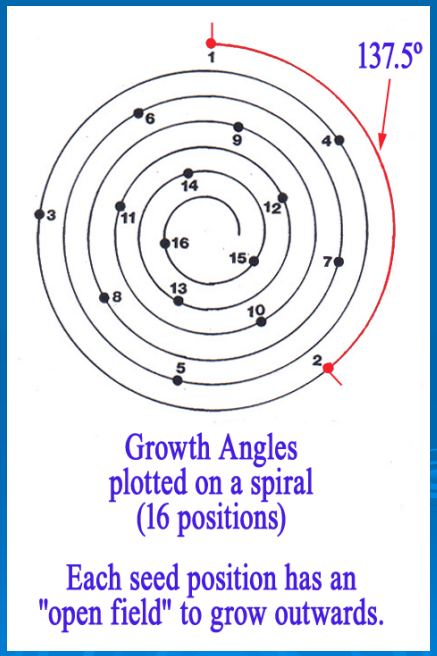
↑ Side view of a model plant exhibiting the spiral Fibonacci pattern between the primordia.



The best way to represent spiral phyllotaxis is the polar graph, also called a spiral lattice. Spiral lattices are configurations of points placed on concentric circles such that:
- **There is one point on each circle.**
- **The *divergence angle* (*d*) between points on successive circles is constant.**
- **The radius of successive concentric circles increases by a constant factor *G*, the expansion parameter (also called *plastochrone ratio*).**

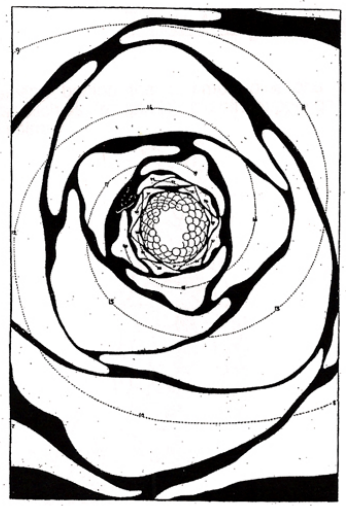


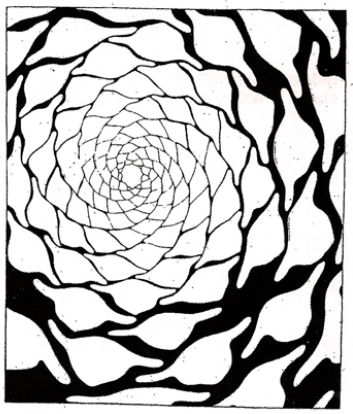
↑ Growth (divergence) angles plotted on a circle (22 positions). The sequence of seed positions forms a STAR PATTERN. Note the dotted line from 21 to 22: it takes 22 moves to get close to position #1 (but never exactly).



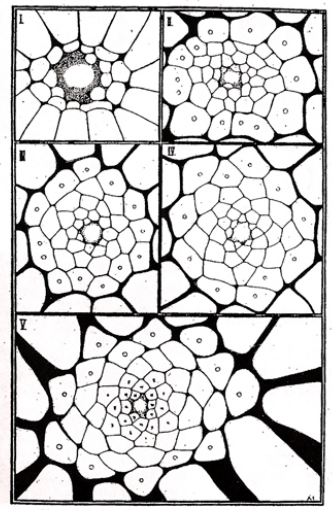
Reminder: a *primordium* is the early stage (small protuberance) in the development of a leaf, bract, petal, stamen, floret, sepal, root or other organ. The primordium is the building unit of phyllotactic patterns.

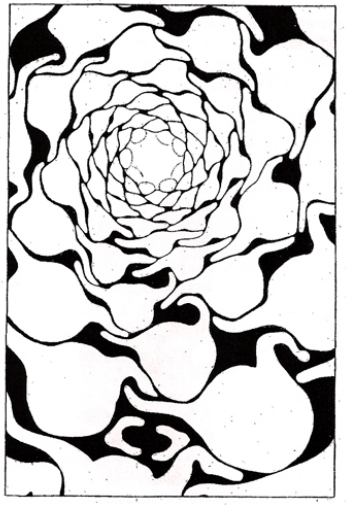
SG205A.1.5.2 Spiral Phyllotaxis (2)
Diagrams by Church



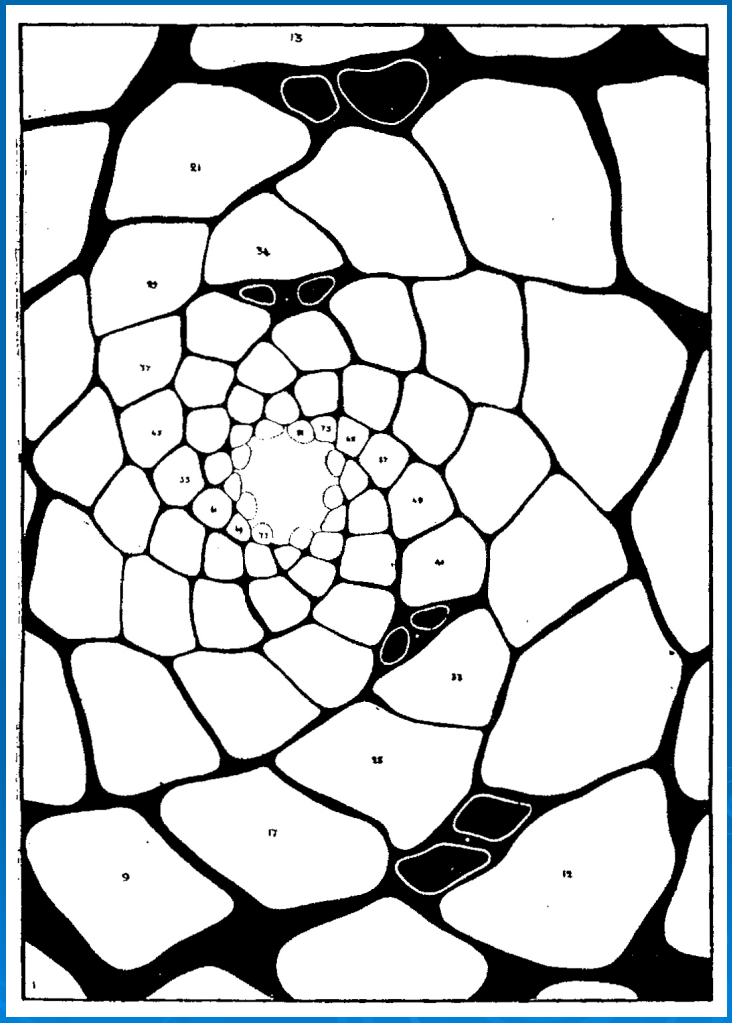


5 + 8 and 8 + 13
Growth Patterns
in plants



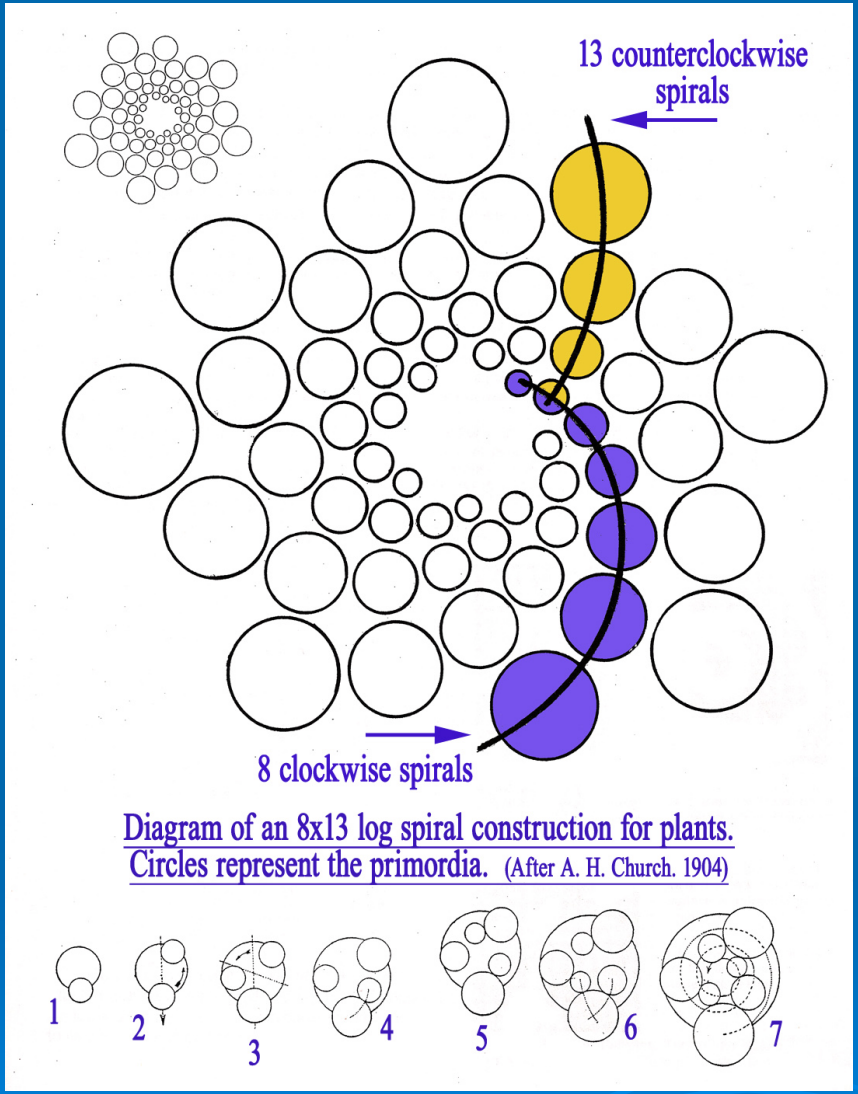


(All drawings from: Arthur H. Church.
On the Relationship of Phyllotaxis to Mechanical Laws. 1904.)



↑ Transverse section of the growing point of a lateral branch of *aurocaria excelsia*. System 8 + 13. (A. H. Church).

SG205A.1.6.1 Parastichies (1)



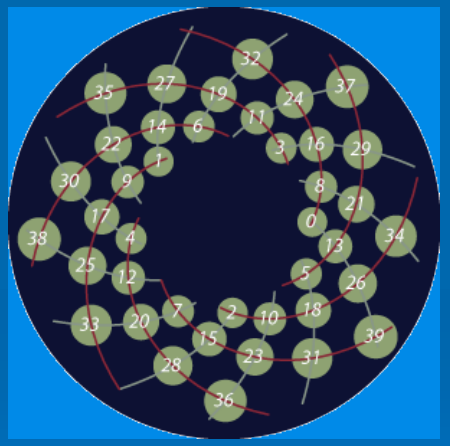
⬆ Top view of a standard flower (or seed head)

➔ Right diagram: //www.math.smith.edu

When the sides of the primordia are in contact, the spirals that are perceived are called *parastichies* (Greek *"para"* = besides and *"stichos"* = row).

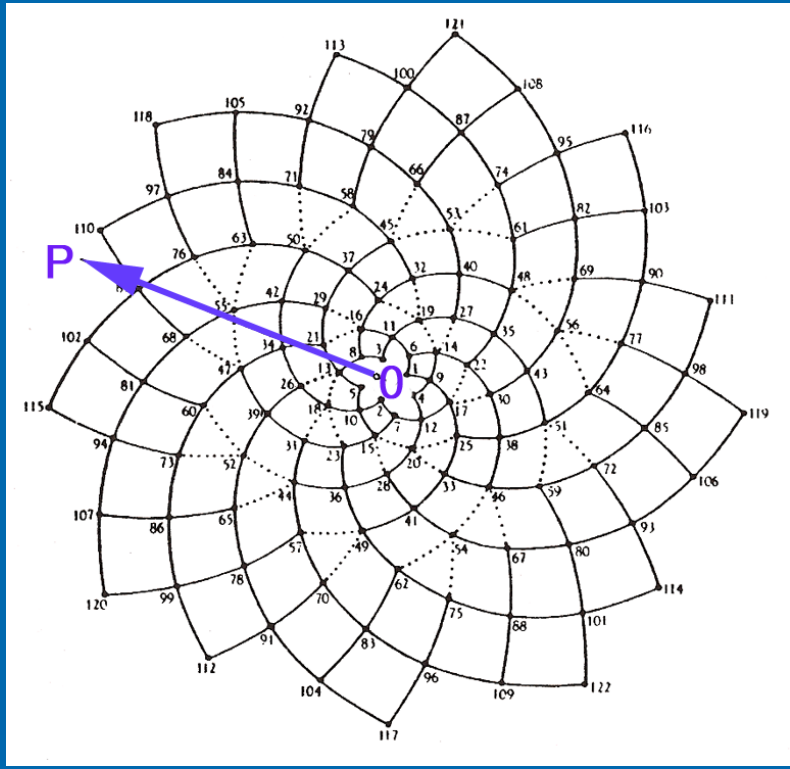
The parastichies are named in contrast with the genetic spiral or main axial row. The parastichies running in the same direction constitute a *family of contact parastichies* and two such families winding in opposite directions with respect to the axis of the plant are called a *contact parastichy pair*.

Example: a parastichy pair formed by a family of 13 spirals in one direction and 8 spirals in the opposite direction is denoted (13,8).



⬆ **Parastichy numbers are related to which points are closest to a given point. The nearest neighbor to point 0 is point 13. One of the grey parastichies in the figure passes through the points labeled 0, 13, 26 etc. The difference between the numbers on two neighboring points in this parastichy is always 13, which is the number of grey parastichies. This is true for all of the grey parastichies. Similar statements hold for the red parastichies. The next nearest neighbor to point 0 is point 8. Points 0 and 8 lie on a red parastichy and 8 - 0 = 8. The next nearest neighbor to point 7 is point 15. Points 7 and 15 lie on a red parastichy and 15 - 7 = 8.**

SG205A.1.6.2 Parastichies (2)

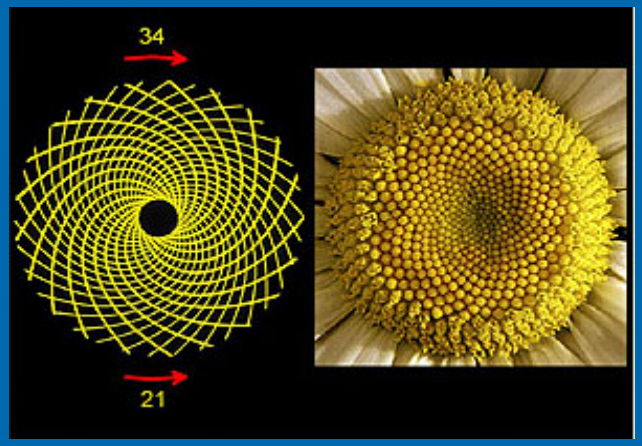


↑ Geometrical diagram of a plant apex.

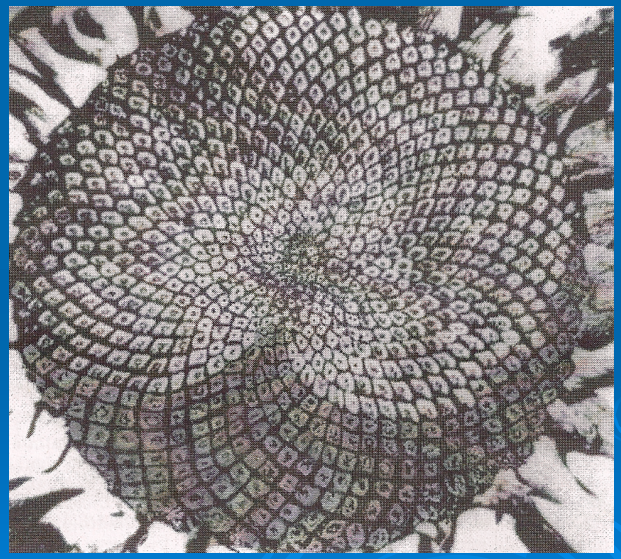
In the inner part, there is a (8, 13) opposed parastichy pair. In the outer part, there is a (13, 21) opposed pair.

The Fibonacci numbers alternate on each side of the line OP, where O represents the center of the apex. This center is the common pole of all the spirals and the origin of the primordia.
The divergence angle is the Growth Golden Angle.

[After F. J. Richards: *The Geometry of Phyllotaxis* (1948); and R. V. Jean: *Phyllotaxis* (1994).]



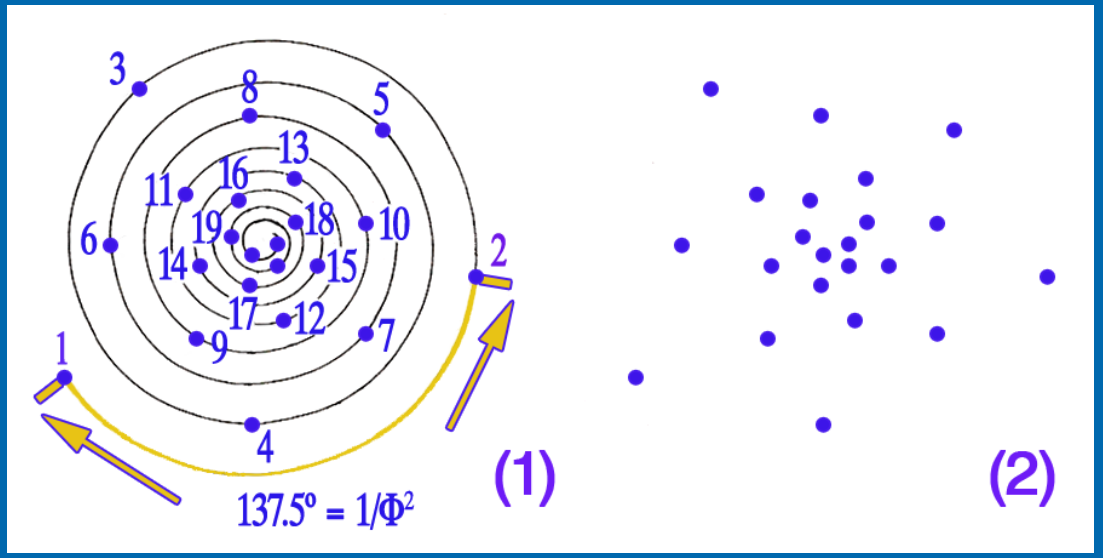
↑ Top view of a standard flower (or seed head) showing a parastichy pair (21, 34).



↑ *Capitulum* (head) of a sunflower.
The seeds show a spiral pattern of two spirals running in opposite direction. This is a "contact parastichy pair (34, 55)".

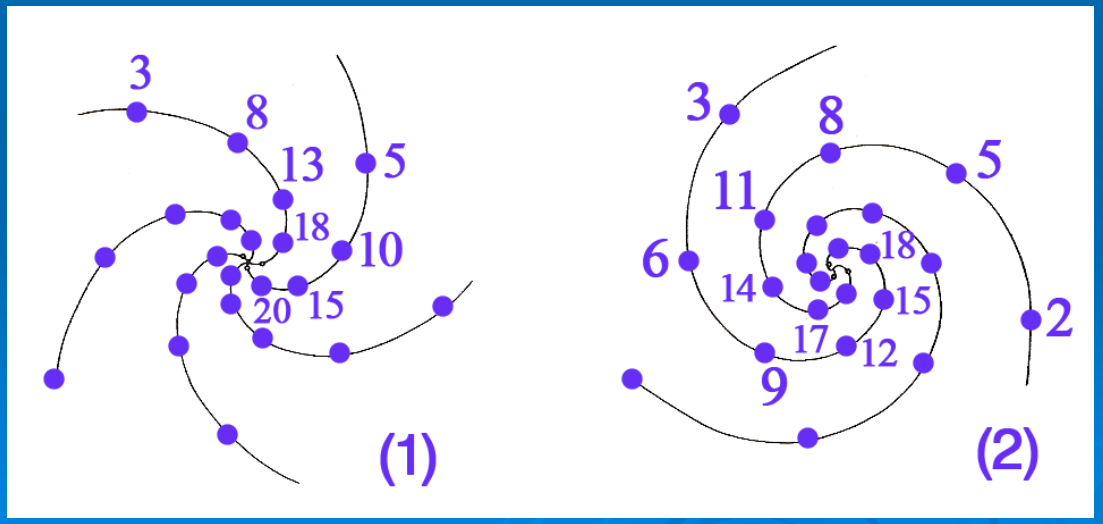
(Credit: A. H. Church. 1904)

SG205A.1.6.3
Parastichies (3)



← Left (1): spiral polar lattice with 21 points distributed at the Golden Angle of 137.5°.

← Right (2): when erasing the spiral, we are left with the points in the same configuration.



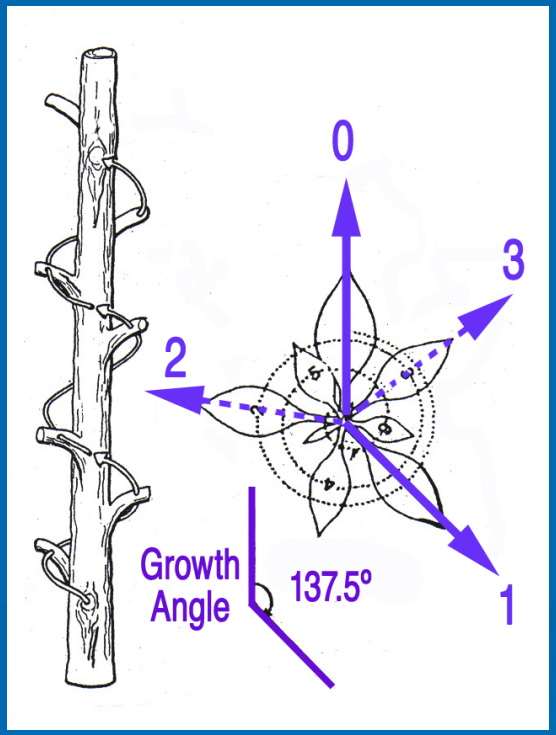
← From the same set of points, we draw the parastichy pair:

Left (1): the CW (clockwise) family of 5 parastichies linking points from 5 to 5.

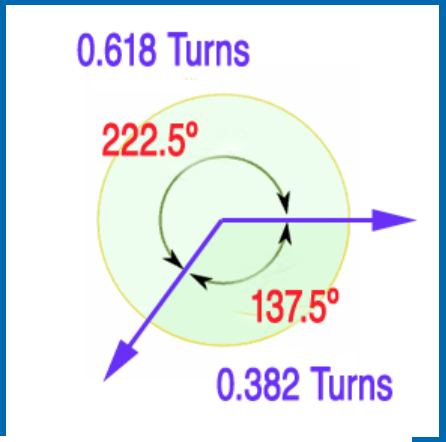
Right (2): the CCW (counterclockwise) family of 3 parastichies linking points from 3 to 3.

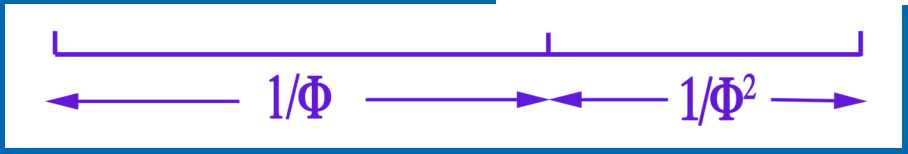
SG205A.1.7.1 The PHI-based Growth Angle (1)

In the spiral Phyllotaxis pattern (80% of plant species), the *angle of displacement* between each leaf is a constant angle of 137.5°. This Growth Angle is Phi-based and is therefore also called the Golden Angle of Growth.

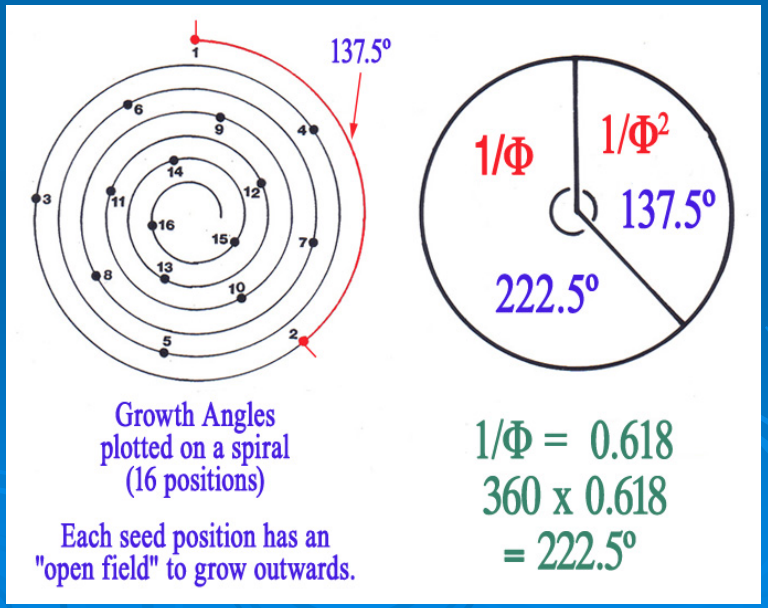


Indeed, when you fold the Golden Section line into a circle, you obtain the Growth (Golden) Angle of 137.5°.





$360°/\Phi^2 = 137.5°$



$1/\Phi^2 = 2 - \Phi = .382 \qquad \Phi^2 = 2.618$

$360° \times 1/\Phi^2 = 360° \times (2 - \Phi) = 360° / \Phi^2$

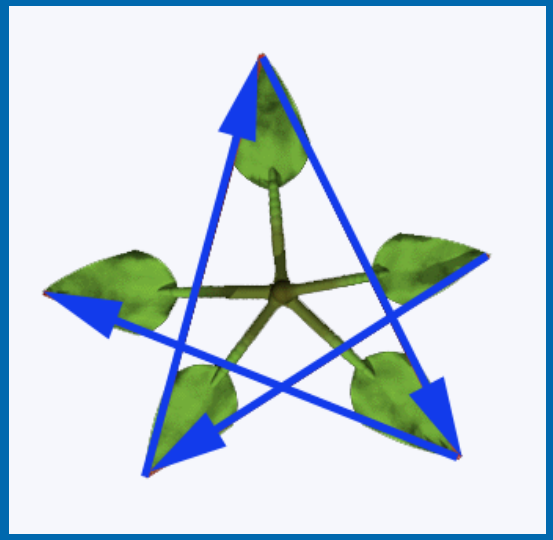
$360° \times .382 = 360° / 2.618 = 137.5°$

SG205A.1.7.2 The PHI-based Growth Angle (2) 5-pointed Star Dynamics

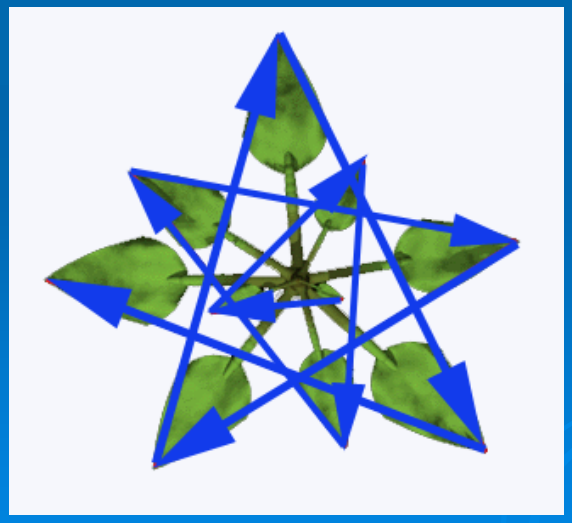
When plants using the 137.5º spiraling geometry are viewed from above (looking down their axis), an interesting off-balance 5-pointed star pattern becomes visible.

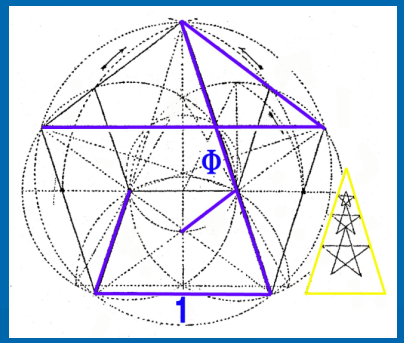
The two images on the left (from www.natures-word.com) show the dynamic 5-pointed design first with with five leaves, and then with ten leaves. The red lines in both images connect the tips of the leaves in the order that they grow up the stem. The "lopsided" Phi-based 5-pointed tracing in time & space can thus be more easily understood.

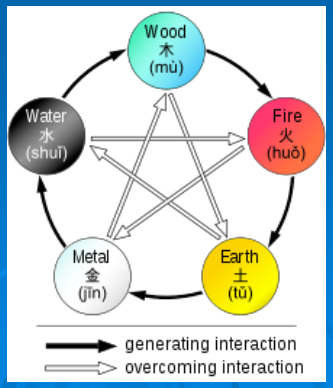
This parallels the traditional "magical" tracing of the pentagram or pentacle as well as the Creative Cycle of the Chinese 5 Elements. It also is close to the position of the Da Vinci Man.

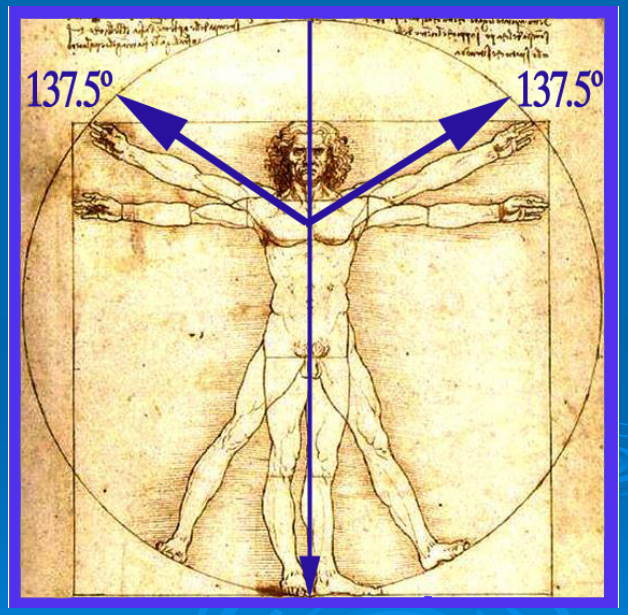


↑↓ Dynamic 5-pointed star pattern formed by the spiraling Growth angle of 137.5º.





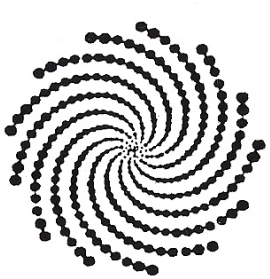




↑ A classic position in Aya's Sacred Body Geometry Yoga (Anjali Yoga) is the Da Vinci Human where the arms are placed at approximately Growth angle distances.

SG205A.1.7.3 The PHI-based Growth Angle (3)

How exact should the Golden Growth Angle be? Answer: exactly itself!



136.5°

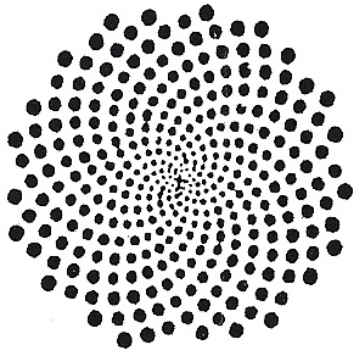
360 / 136.5
= 2.637...

1

137.3°

360 / 137.3
= 2.6219...

2



137.5°

360 / 137.5
= 2.618...

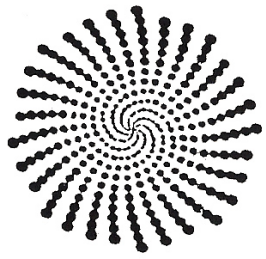
3

(Credit: R. V. Jean)

137.6°

360 / 137.6
= 2.616...

4



138°

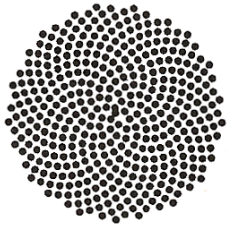
360 / 138
= 2.608...

5

In the above series of circular renditions for various divergence angle, the central figure (#3) is the Growth Angle standard model: the two parastichies are clearly visible and harmoniously going in the two opposite directions.

- In the case of 136.5° (#1) and 138° (#5) there is a difference of one full or half degree compared to the 137.5° model and the difference in pattern is dramatic: the seeds tend to cluster in curved lines from the center rather than to equally fill the space.
- In the case of 137.3° (#2) and 137.6° (#4) there is a difference of 1 or 2 tenths of a degree and yet the patterns are not delivering packing efficiency.

Conclusion: nature's harmonic patterns of optimum efficiency in space-time are extremely exact, down to at least 3 decimals. 0.621 (137.3°) or 0.616 (137.6°) will not work: we need 0.618, the fractional part of the Golden Number!

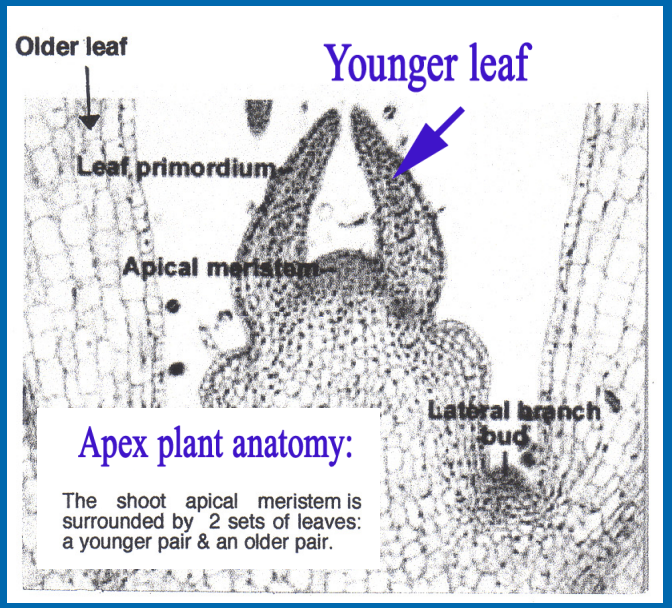


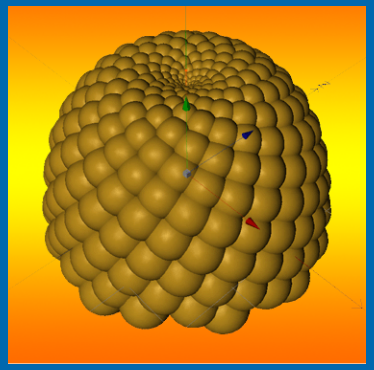
137.5°

360 / 137.5
= 2.618...

← Another computer rendition of the Growth Angle of 137.5°

SG205A.1.8.1 PHI in the Meristem (1)





Computer model of a meristem

Close-up view of the spiral motion of a meristem.

All the elements of a plant grow from a single tiny group of cells right at the tip of the growing plant. This growing point is called the *meristem* (Greek *"merizein"* = to divide) or shoot apex. The meristem previews the pattern followed on a larger scale when the seeds develop on the seed head, or turn into leaves, buds or petals.

The only active area is the meristem where new cells are formed. There is a separate meristem at the end of each branch or twig where new cells are formed and growing upwards and outwards. Once formed in the meristem, the new cells grow in size and the growing point keeps moving. Cells earlier down the stem get bigger and so the growing point rises.

The growth root system, called the *root apical system*, is where the root cells are formed to grow downwards.

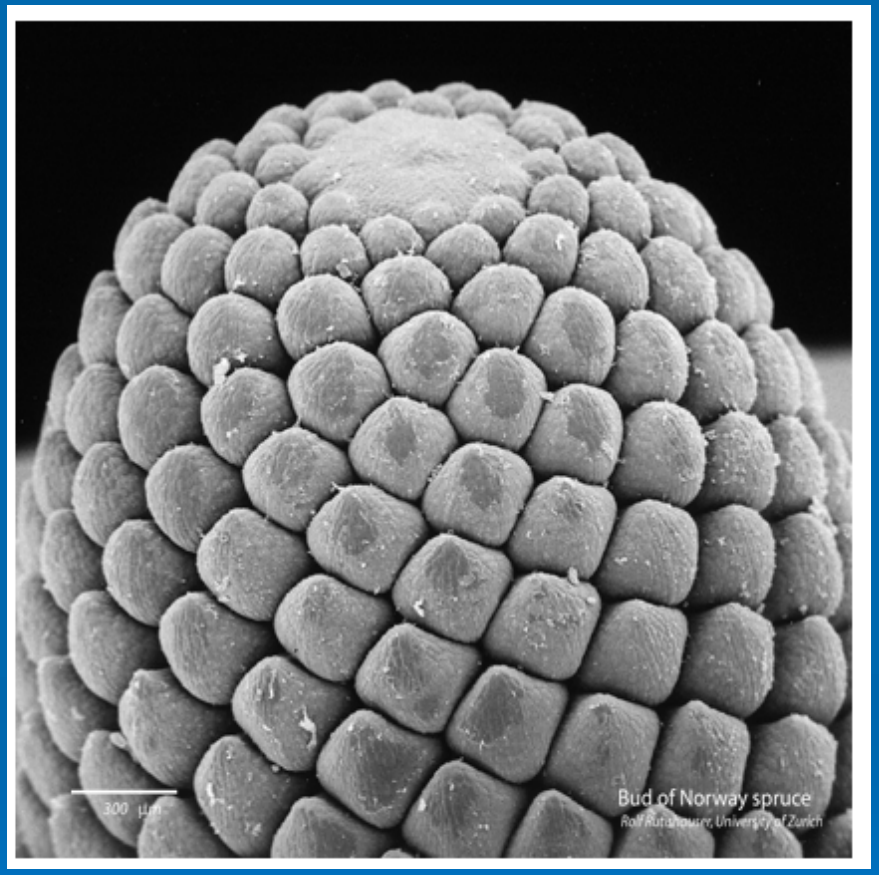
A meristem moves in a circular fashion in space, or in a helical fashion in space-time. The stem moves by a specific angle, called the GROWTH ANGLE, and then a new cell appears; the stem moves again by the same angle and another cell is formed…

A new leaf, seed or petal is made every .618 or 1/Φ turn.

In terms of degrees:
.618 x 360° = 222.5°
The reciprocal angle is:
360° - 222.5° = 137.5°

This fixed angle of turn is:
PHI turns per new cell or PHI cells per turn

SG205A.1.8.2 PHI in the Meristem (2)



www.td-grafik.de Image: University of Zurich.

The single fixed GROWTH ANGLE can produce the optimal design no matter how big the plant grows. Once a seed is positioned on a seed head, the seed continues out in a straight line pushed out by other new seeds, but retaining the original angle on the seed head. No matter how large the seed head, the seeds will always be uniformly packed (equally spaced) on the seed head.

Leaves on the plant will be optimized (optimally packed) so that:
- **Each leaf gets the maximum sun exposure and casts the minimum shadow on the others.**
- **Each leaf gets the largest possible area exposed to falling rain so the rain is directed back along the leaf and down the stem to the roots.**
- **For flowers, it also gives the best exposure and orientation to attract insects for pollination.**

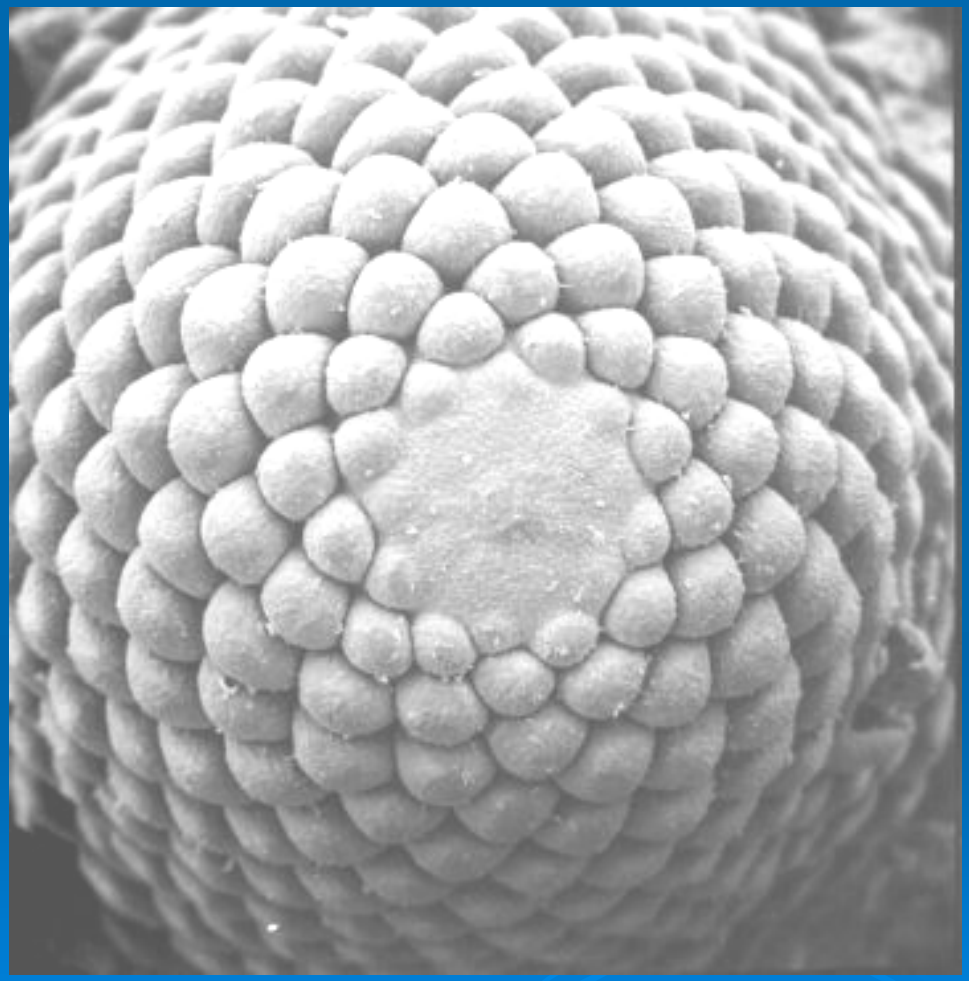
Maximum exposure, minimum superposition: energy flows best. This can be approached with various mathematics but it is only maximized and optimized with the Golden Ratio. This is why the Golden Number, traditionally, has been revered as "sacred" knowledge.

The reason why a Phi-based single divergence angle produces uniform packing, no matter how much growth appears after it, is because PHI is the BEST irrational number: it does not settle down to a rational approximation for a long time (see infra).

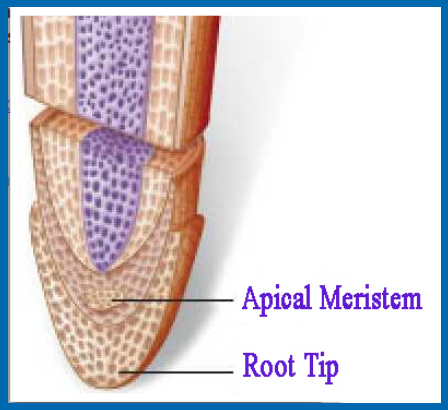
Note: the Golden Growth Angle principle was proven in a 1992 experiment by Douady and Couder (see infra).

In 1868, W. Hofmeister proposed the following axiom:
- **New leaf primordia always arise in the largest gaps between existing primordia.**
- **Once they form, the primordia move radially away from the center.**
- **As time increases, the rate at which new primordia move away decreases.**

SG205A.1.8.3 PHI in the Meristem (3)
Phyllo Mandala



↑ Top view of the apical meristem. Norway spruce.
University of Zurich. http://www.sciencenews.org



← A magnificent mandala
of harmonic growth.

Stop here for a moment
and take the time to gaze
at the hub of this mandala:
it is holding many teachings.

Can you count the 8-13 spirals?

SG205A.1.9.1 Harmonia Plantarum (1) Hans Kayser

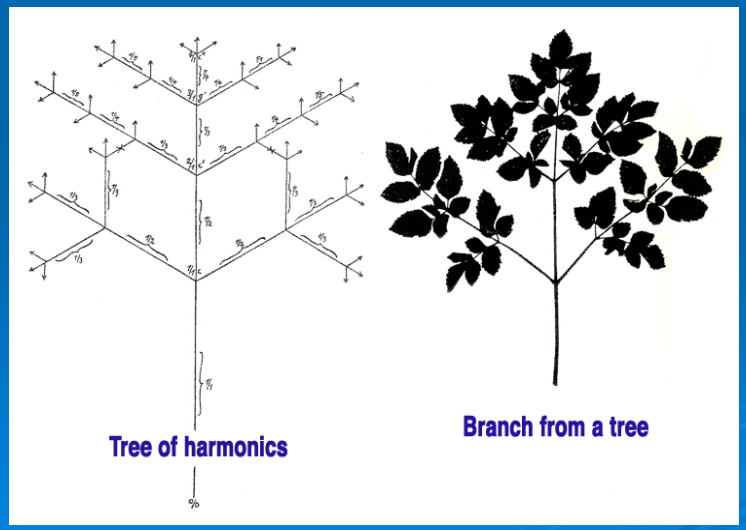
SG308 will be devoted to "The Science & Consciousness of Harmonics". There we will look in depth into the pioneering work of Hans Kayser (1891-1964), a German "Renaissance man" who, in the 20th century, resurrected the knowledge of Pythagorean harmonic science.

Hans Kayser

In the 1920s, following up on the footsteps of Kepler and Goethe, Hans Kayser developed a theory of universal harmonics based upon the *Lambdoma (*or "Pythagorean Table" ◆SG102.2.8). Kayser found that the principles of harmonic structure in nature and the fundamentals of music harmonics were essentially the same. Kayser called himself a "harmonist" and, with other researchers, founded the German School of Harmonics. Kayser and fellow researchers devoted much of their life to the study of many scientific disciplines with the goal to restore to science this "lost knowledge" of harmonics.

Kayser believed that through understanding the connection between music and mathematics, it would be possible to create an understanding of the relationship between tone and numbers. In so doing qualities (tonal sensations) could be derived from quantities (numbers) and quantities could be derived through qualities, thus healing the schism between science and spirit. A lot of this earlier German-school research is now validated by the new developments in quantum physics, quantum biology, fractals, quasicrystals, the geodesics of Fullerenes and phyllotaxis…

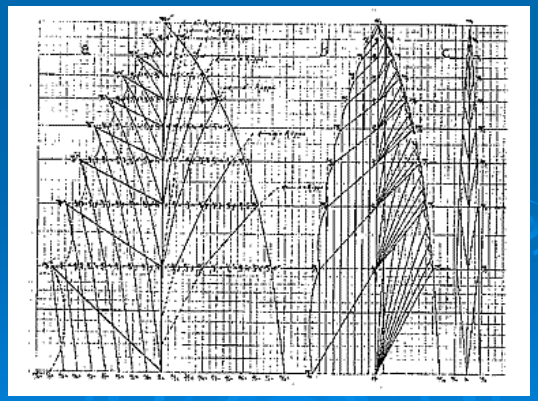
Here, we give glimpses of Kayser's insights regarding plants in the form of visual diagrams as found in his book *Harmonia Plantarum*, published in Germany in 1943, and finally translated in English (2010) by Ariel Godwin through the Kayser Translation Project of the Sacred Science Institute. Kayser makes the presence of harmonics in plants plainly visible.



Hans Kayser. Harmonia Plantarum. 1943/2010.

Look up the informative site devoted to Hans Kayser's work: http://hanskayser.com

← "If we use the monochord division as a basis, (we can) draw the string sections with their true relative lengths as vertical axes and allow the same division to continue on both sides at the node points. Then the result is a diagram of a plant branch."

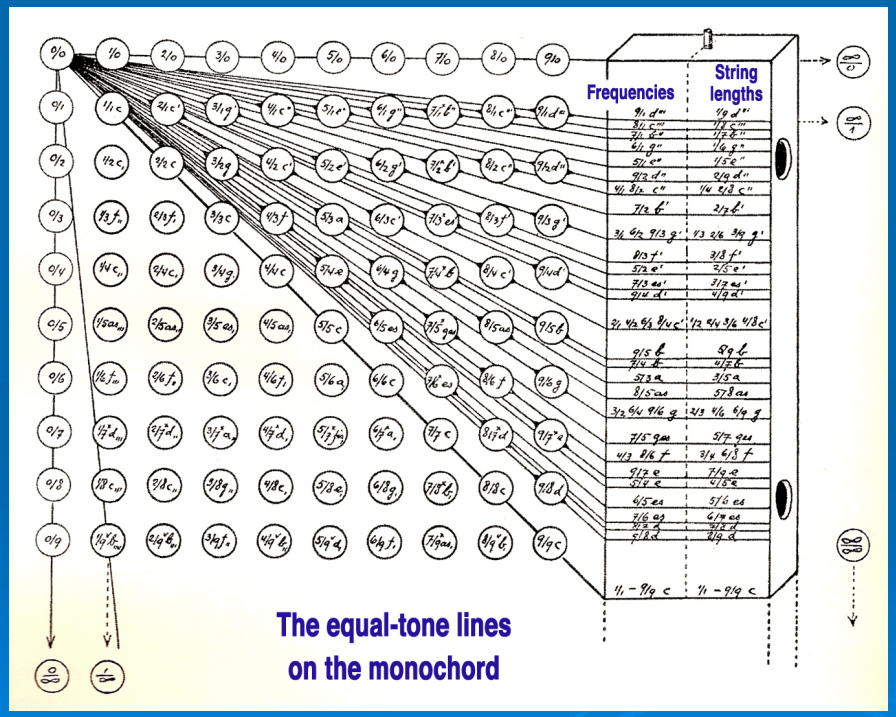


Phyllotactic diagrams by Kayser.

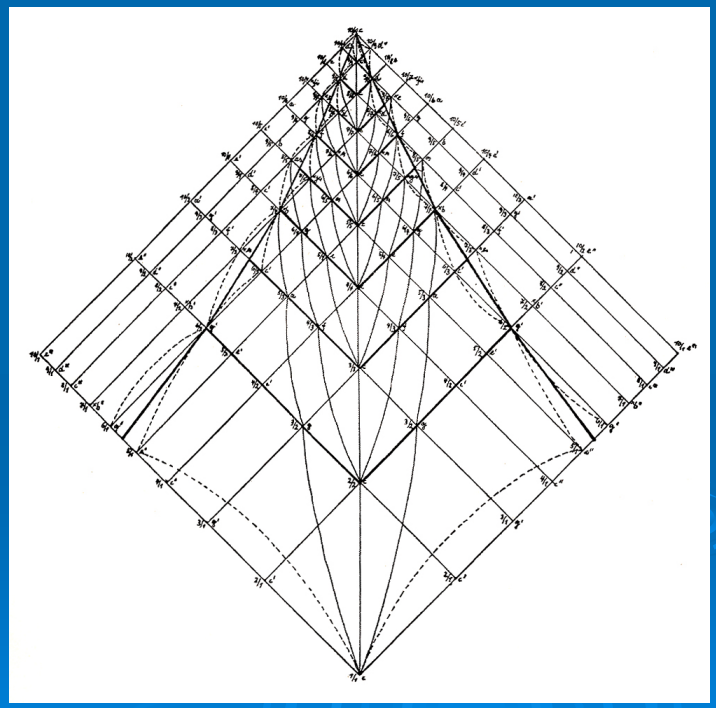
SG205A.1.9.2 Harmonia Plantarum (2) Plants & Music

Hans Kayser's life work has been a search for "*the sound of the blue flower*" i.e. the essential similarity between music and plants, between the laws of harmonics and the laws of form. This search is at the core of Sacred Geometry. As demonstrated on the monochord: when we divide the string of a monochord by simple whole number ratios, we get the *overtone series*. Kayser's effort (and his Harmonic School's program) was to apply this natural law to the sciences. [◆SG201: The Monochord, Music & Cymatics"].

The basics of Harmonics is the natural phenomenon of the overtone series [◆SG201.2]. Mathematically speaking, this is an effect of "quantization" as a group theory pattern. In the specialized branch of mathematics known as *group theory*, the grouping or "geometry" of the numbers is an independent factor of crucial meaning. Kayser developed the understanding of tones as "sound-images", paralleling and anticipating the discovery of "*cymatics*" by Swiss researcher Hans Jenny [◆SG201.5]



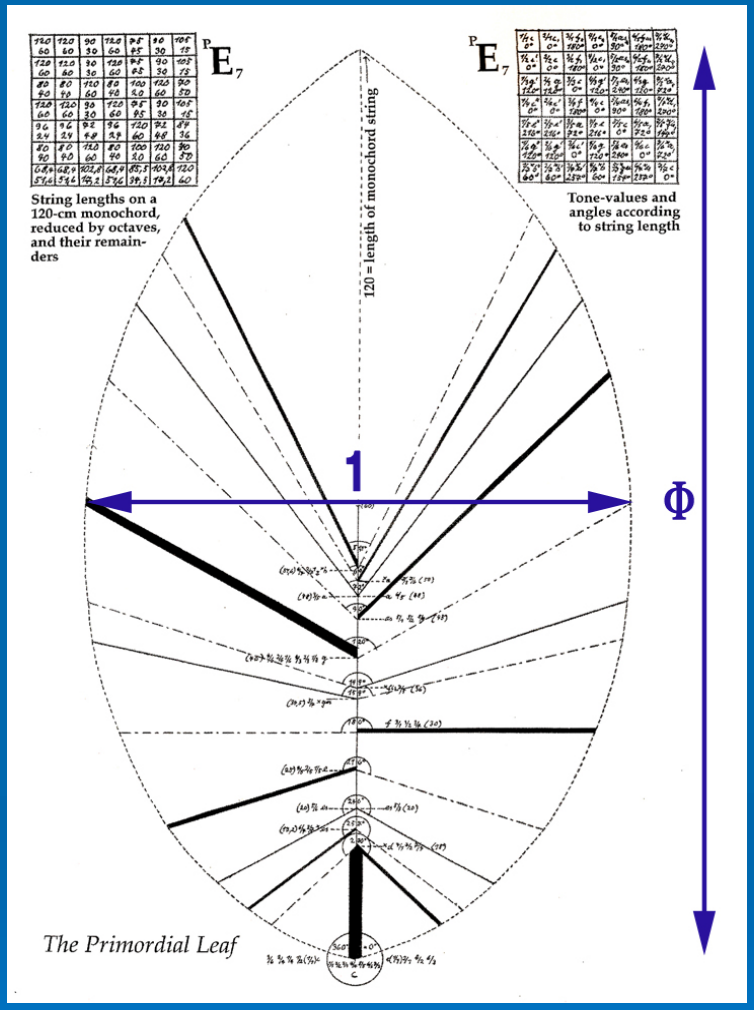
↑ This diagram shows frequencies and string lengths (as their reciprocals). The lines join equal ratio tones. H. Kayser. *Harmonia Plantarum*. [See the full Lambdoma grid ◆SG201.1]



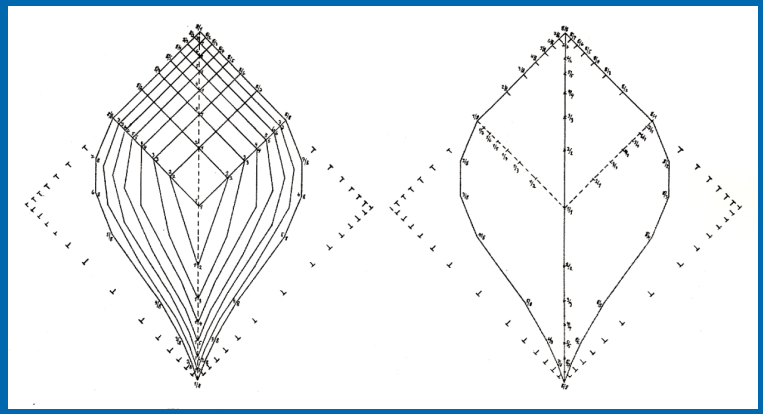
↑ Analogy of leaf shapes drawn on a logarithmic grid of harmonic tone development. (*Harmonia Plantarum*).

SG205A.1.9.3 Harmonia Plantarum (3)
More Kayser Diagrams

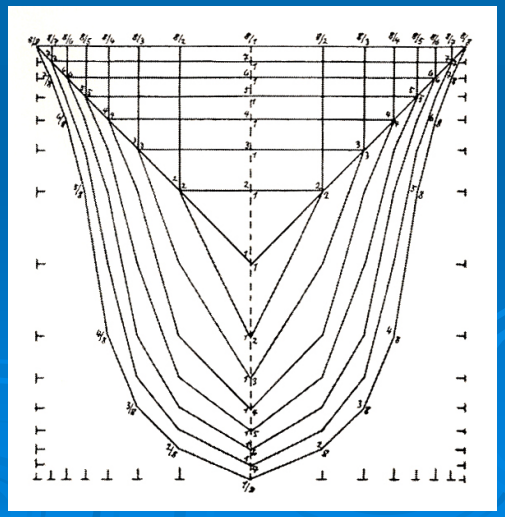
Kayser found that connecting and mirroring various harmonic index numbers (superimposed on grids of harmonic tone diagrams) gives archetypal forms seen in nature. Below are two examples.



↑ ***"If we set the ascension angles and branch lengths according to the measure of the corresponding ratios, (we get) the construction of the primordial leaf."*** **Regardless of the harmonic index used, the form of the primordial leaf remains the same - as an expression of the geometry of music harmonics.**
"This discovery confirms the fundamental idea of Goethe's morphology of plants in an entirely new manner". (H. Kayser)

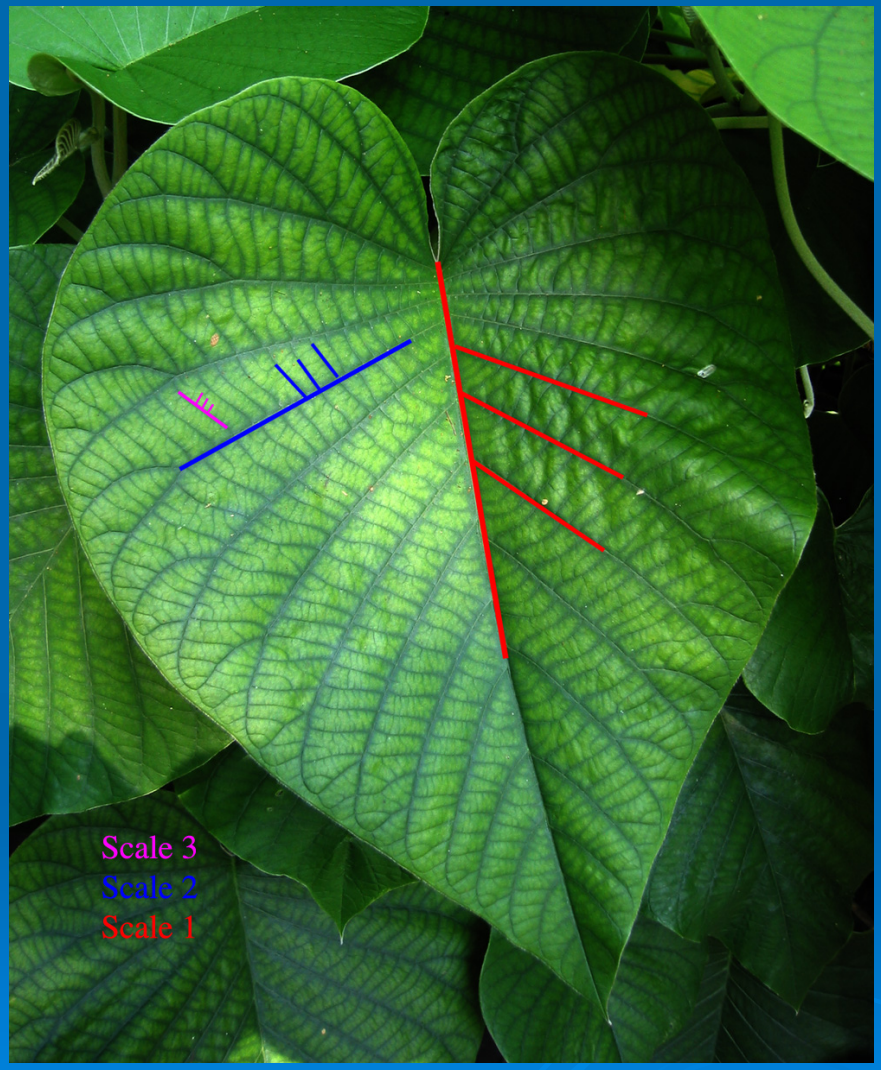


↑ **The gnomonic evolution of the form of the leaf.**



← **Gnomonic transition from a central triangular tone grid to a rounded shape, reminding us of the form of the tulip flower as well as other calyx forms.**

SG205A.1.10.1 Harmonics in Plants (1) - Phi

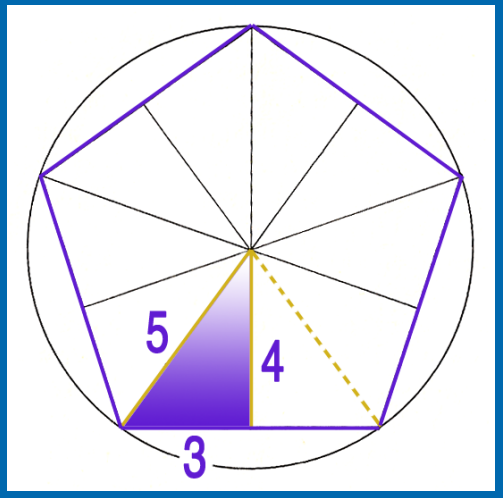


↑ Beautiful fractal leaf structure from Paul Bourke (University of Western Australia).

← ↑ Golden Proportions can be easily revealed with a Golden Gauge…

… or the software of PhiMatrix™ 1.618 (www.phimatrix.com)

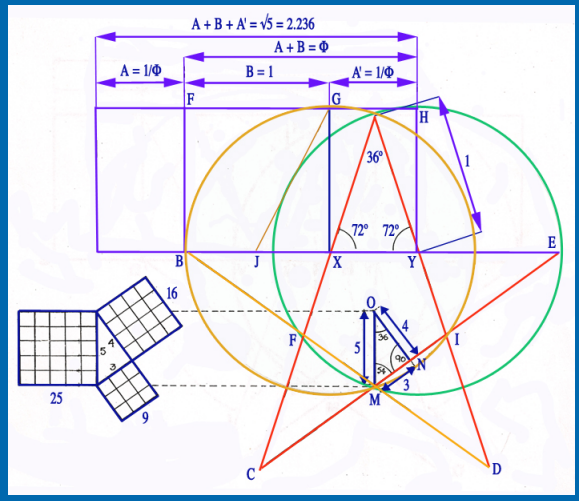
SG205A.1.10.2 Harmonics in Plants (2) - The 3-4-5 Triangle



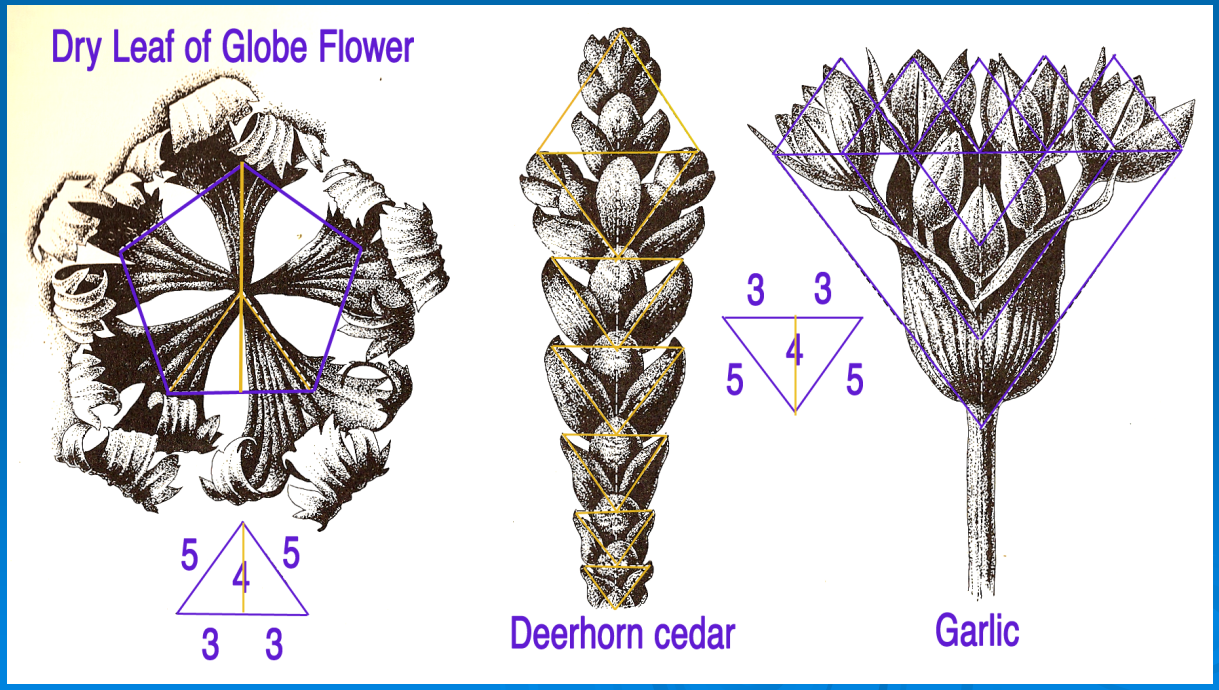
The 3-4-5 Triangle inscribed in a pentagon.

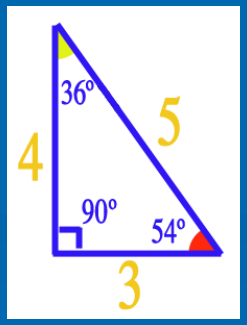
Pythagorean Triangles are right-angled triangles where all 3 sides are whole numbers. The most well-known of these "Pythagorean Triples" is the 3-4-5 Triangle. The 3-4-5 triangle is the 10th division of a pentagon which is the geometry of the Golden Ratio. Two 3-4-5 triangles (joined by their "3" side) form a Golden Gnomon. [◆SG106.2].

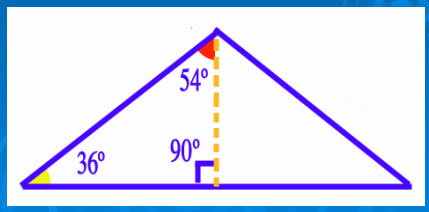
The 3-4-5 triangle is frequently found in plant patterns as shown below (with images from G. Doczi's The Power of Limits).

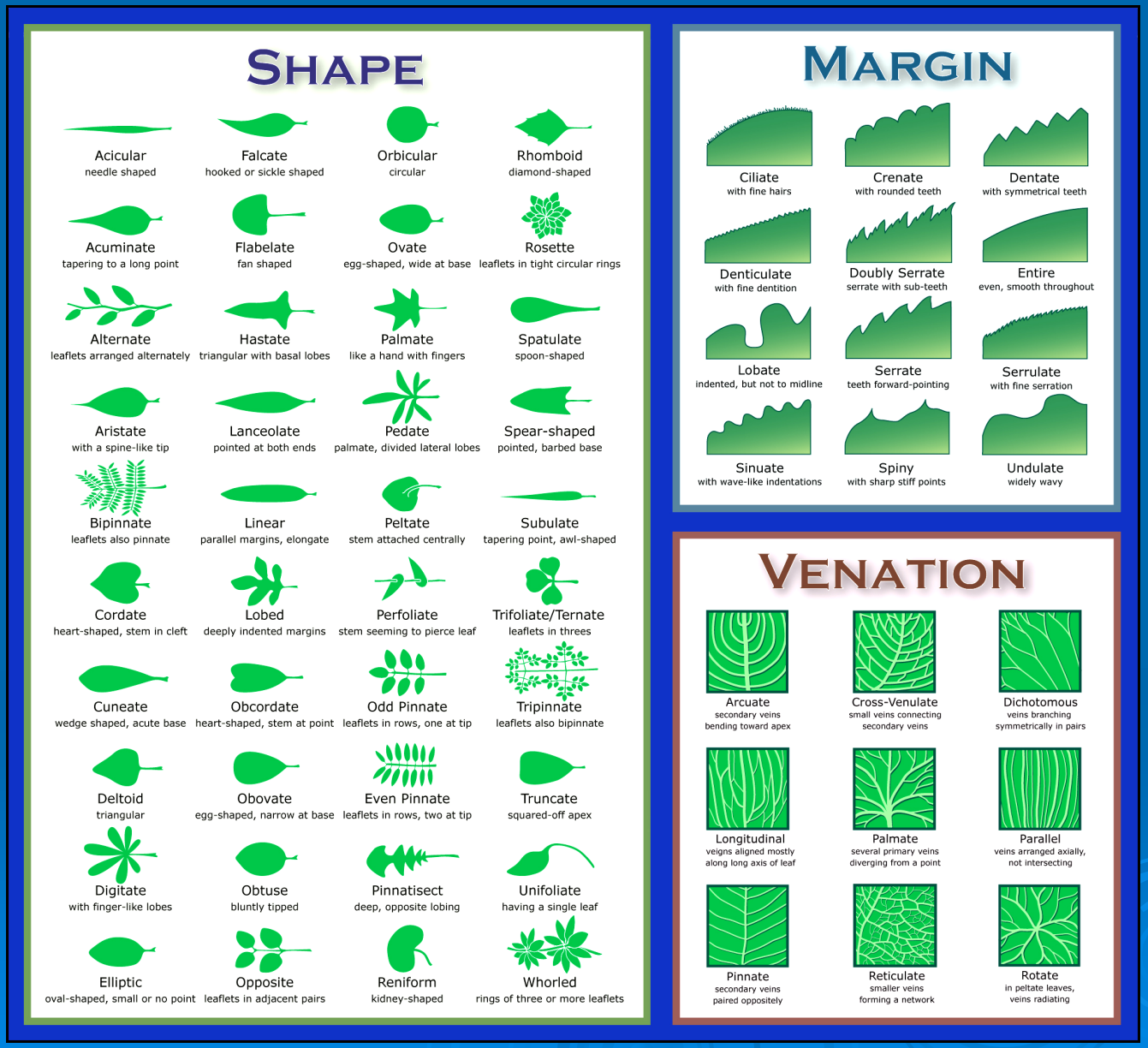


The 3-4-5 Triangle and the Pythagorean theorem.









SG205A.1.11.1 Leaf Proportions (1) - Morphology

The morphology of leaves is a whole spatial language by itself.

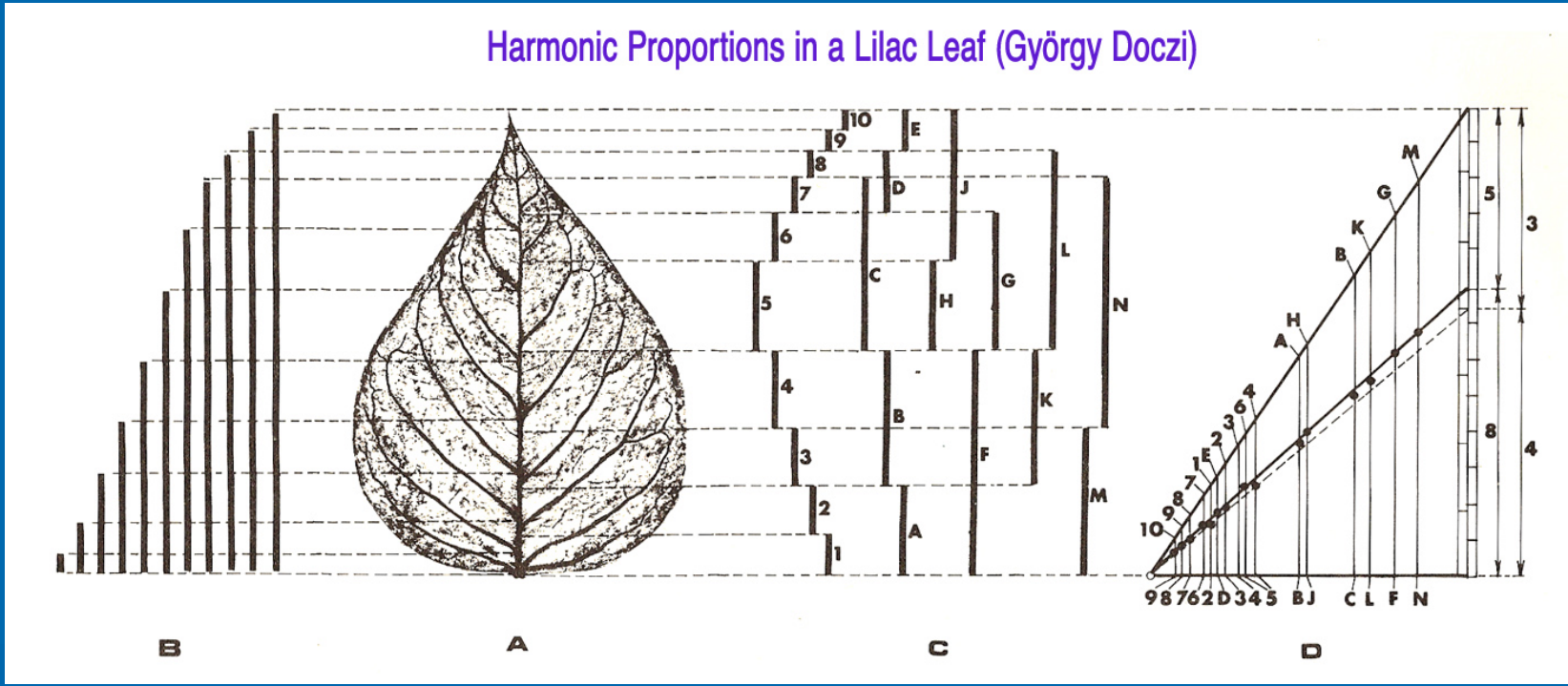
No matter what the end shape is, there is always a harmonic coherence in the proportions, the fractality or the ratios of the elements of the leaf.

Suggestions for further study:

- **Evolution of leaf shapes in a single plant or tree, from bud to maturity. (See studies by Bose, Edwards… ◆SG203B)**
- **Harmonic tone diagrams of archetypal leaf shapes. See *supra* Kayser's work.**
- **Fractal mathematics of reduction factor in venation.**
- **"Dinergy" analysis of Doczi (next two pages).**

← Chart from:
www.search.com

SG205A.1.11.2 Leaf Proportions (2) - Lilac

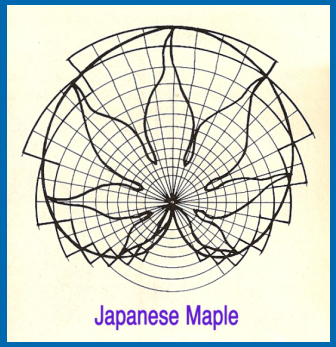


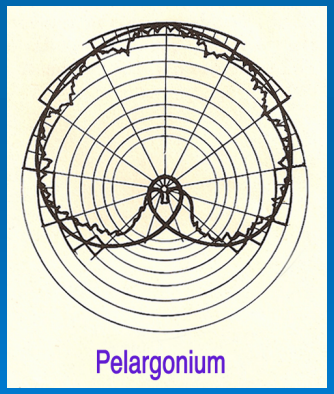
In the above diagram (from the book *The Power of Limits*), sacred geometry architect G. Doczi looks into plant growth in terms of musical harmony. This example of the growth patterns in the Lilac leaf can be extended to other leaves in the sense that all the minors & majors (large and small veins & branches) unite with their neighbors by ratios of the whole numbers that create the root harmonies in music.

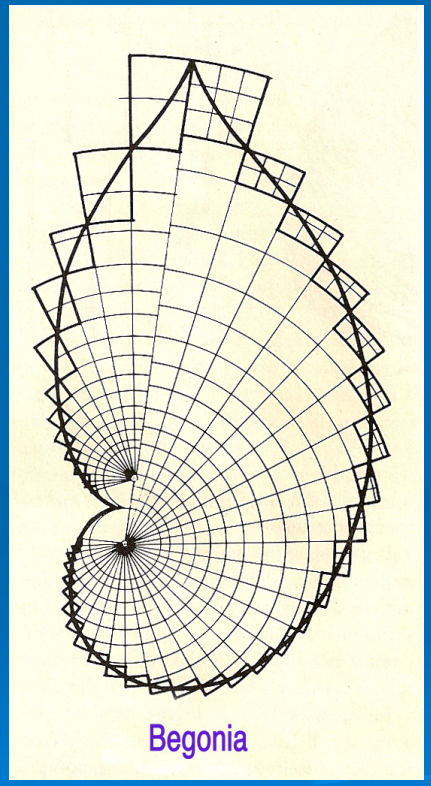
A: rubbing of the back side of a lilac leaf.
B: the distances between the starting points of the veins along the midrib group themselves in a harmonic order, like organ pipes.
C. The distances between consecutive veins (marked 1 to 10) form a similar series.
D. The distances and their groupings have been lined up by neighboring pairs.
Their proportional relationships fall within the narrow limits of the golden section's reciprocal (Small Phi or φ) = 0.618
This is approximated by 5:8 = 0.625 (dash-dotted line) and the 3:4 = 0.75 proportion of the pentagonal Pythagorean 3-4-5 Triangle, corresponding to the *diapente* (fifth) and *diatessaron* (fourth) musical harmonies.

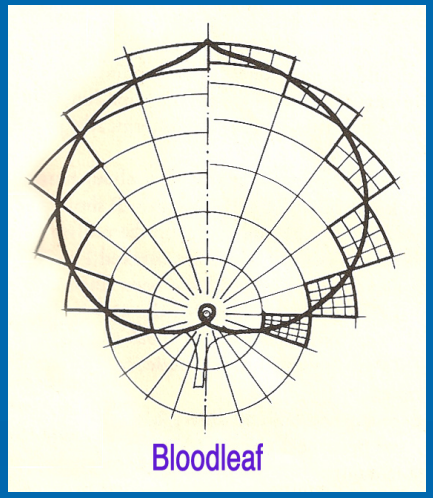
SG205A.1.11.3 Leaf Proportions (3) Dinergy Diagrams

Below are examples of outlines of leaf patterns reconstructed by G. Doczi with his "dinergic" method of combining radiating & rotating lines.
Says Doczi: ***"If one looks at these patterns not as still pictures but as traces of the dinergic process which brought them into being, then the outlines of these leaves become their story, recorded in the silent language of patterns…. The power of the Golden Section to create harmony arises from its unique capacity to unite the different parts of a whole so that each preserves its own identity, and yet blends into the greater pattern of a single whole."***

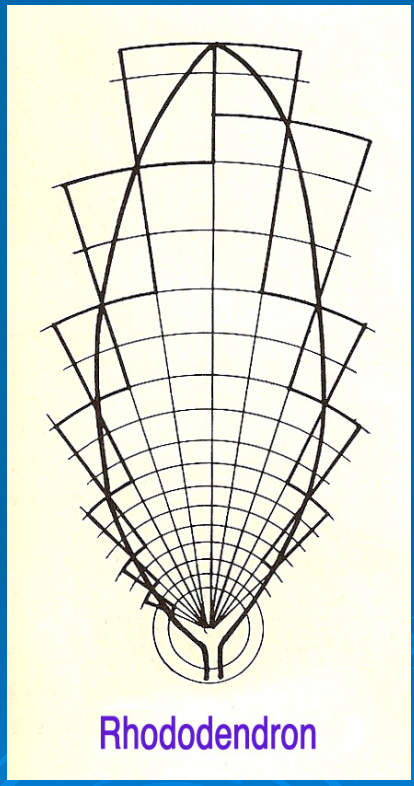

Japanese Maple


Pelargonium


Begonia

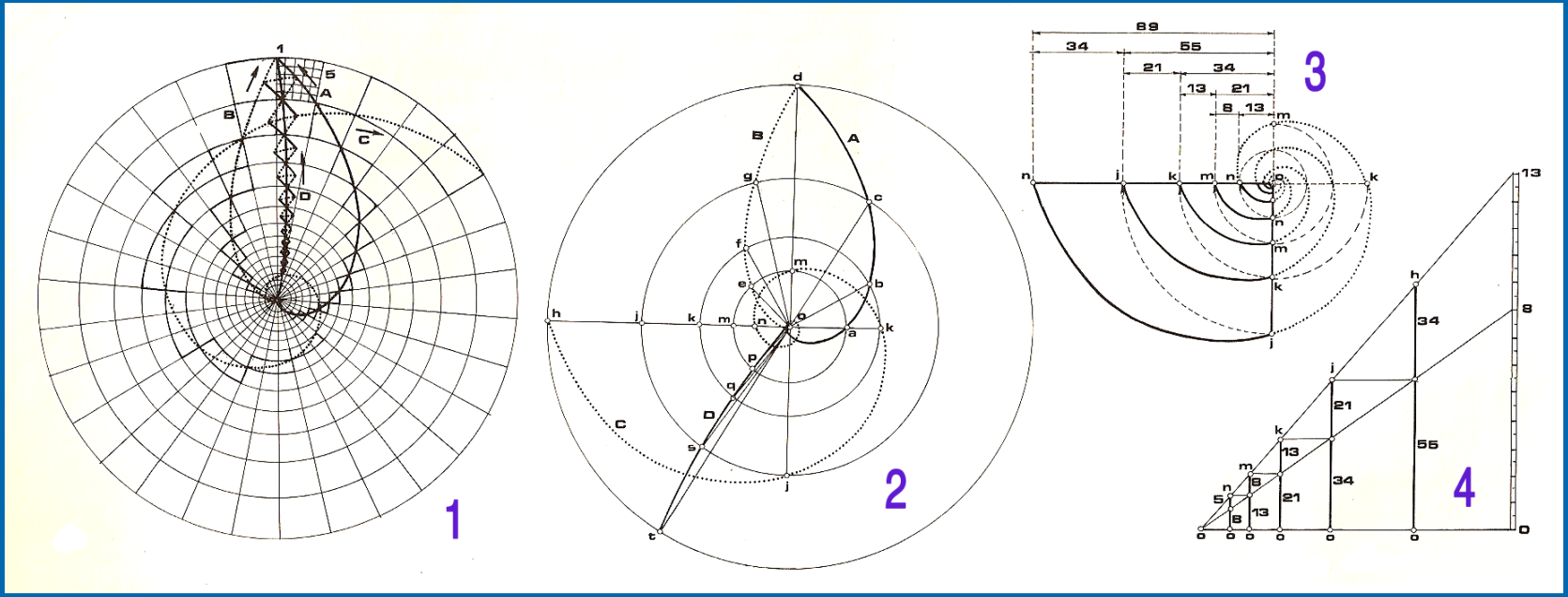

Bloodleaf

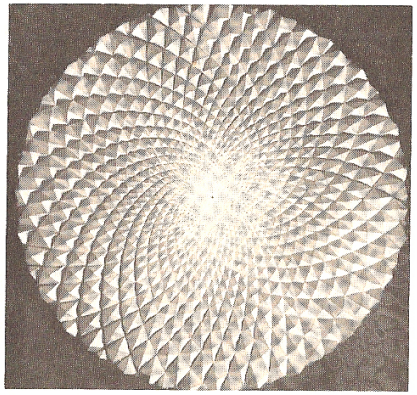
Unknown web image of spiraling leaves.


Rhododendron

SG205A.1.12 Phyllotaxis of the Sunflower

In the Power of Limits, György Doczi gives this description of the golden proportion in the sunflower.





↑ Model of seed pattern

↑ **Figure 1: spirals A and B are the outlines of the seeds. Spirals C and D are their diagonals. The curvatures of these 4 spirals through the squares formed by the radiating and rotating lines are the following:**
Spiral A = curvature 1:1 (moves from one circle to the next and from one radius to the next within a single row of squares). Spiral B = 1:2. Spiral C = 3:1. Spiral D = 5:1.

↑ **Figure 2: these spirals are logarithmic and equiangular through all stages of growth. These stages are marked by lower-case letters on each spiral.**

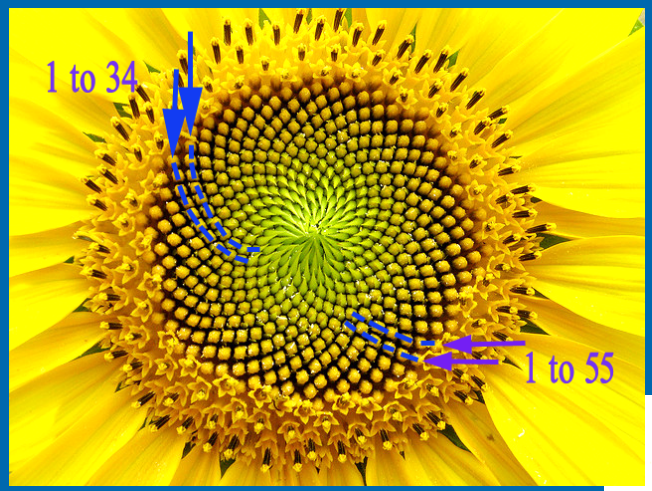
↑ **Figure 3: using the example of spiral C, succeeding segments of growth can be folded upon each other like a fan, thus showing that they share the same proportional rate of growth.**

↑ **Figure 4 shows that the rate of growth is orchestrated by the Golden Ratio. The numbers are Fibonacci numbers.**

(G. Doczi. *The Power of Limits*. 1981)

SG205A.1.13.1 Phyllotaxis of the Daisy (1)

(Diagrams & description from: *The Power of Limits* by G. Doczi.)

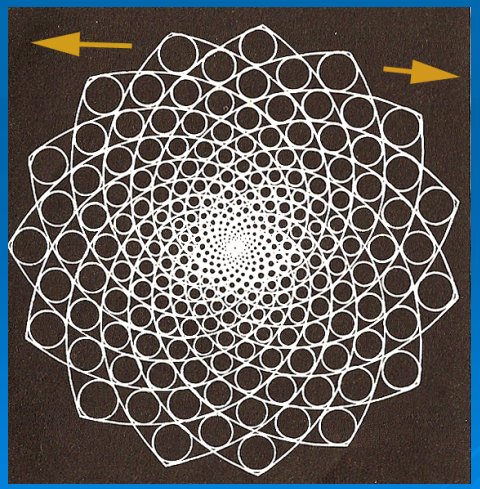


Daisy flower

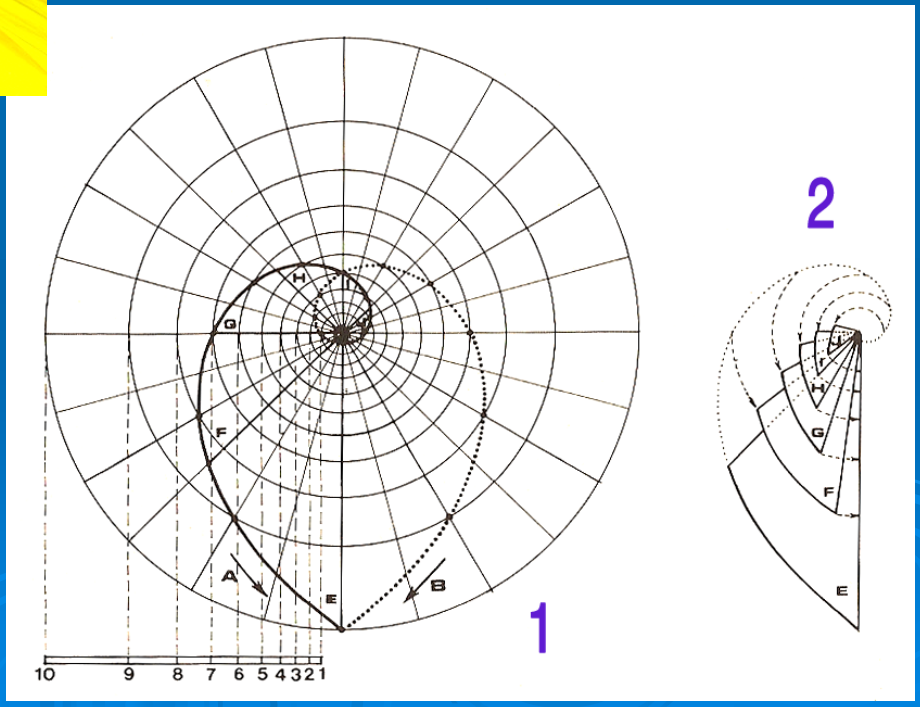
The florets that make up the pattern of the daisy grow at the intersection of two sets of spirals moving in opposite directions (clockwise and counterclockwise).

⬇ Figure 1: two of the spirals are shown on a grid of concentric circles and radiating lines. These spirals are logarithmic.

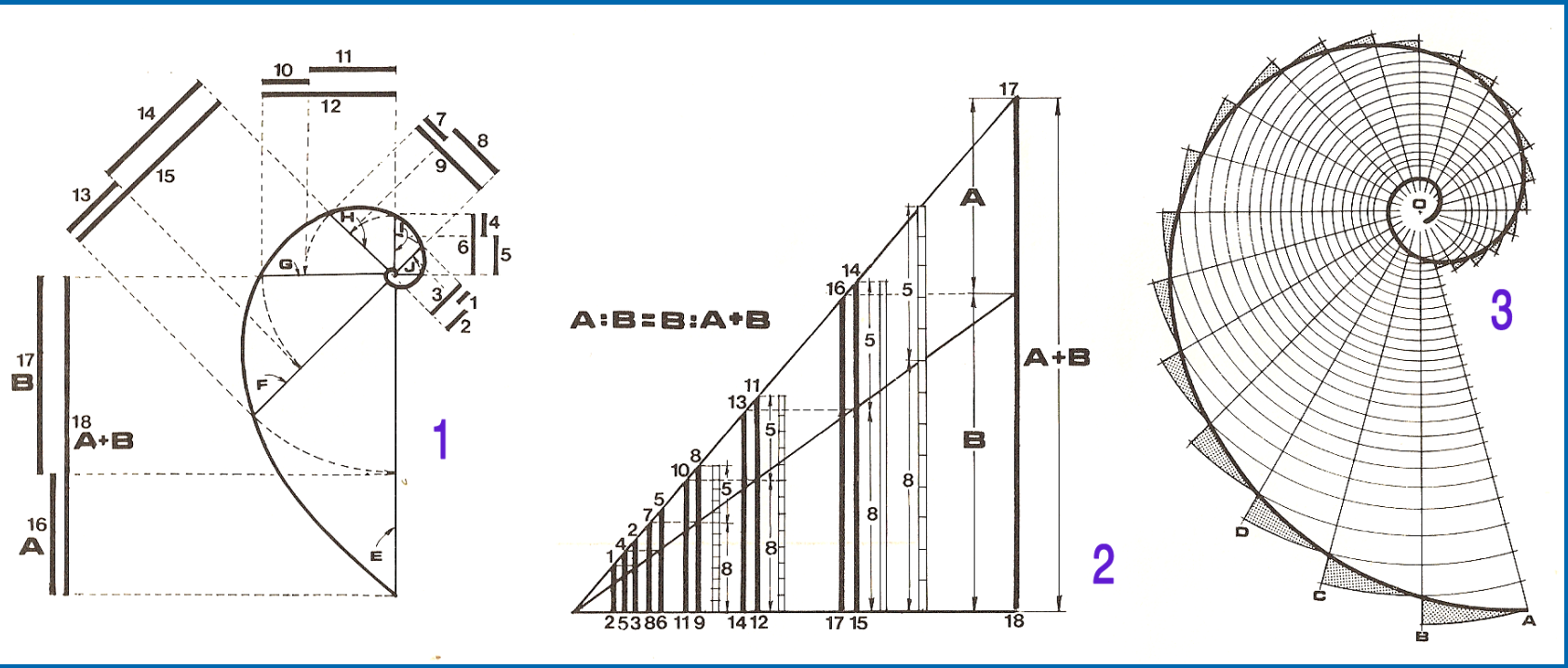
⬇ Figure 2: these spirals are also equiangular - the angle they describe with the radii remains always the same. The segments representing consecutive stages of growth can be rotated around the center until they completely overlap, like a folded fan. This proves that old and new stages of growth all share the same angles and the same proportion.



Daisy: reconstructed diagram.



SG205A.1.13.2 Phyllotaxis of the Daisy (2)



↑ Figure 1: unfolding of one of the spirals in a daisy. As the spiral unfolds from the center, the order of growth, measured along the equidistant radii (E, F, G, H, I, J), increases at the same rate.

↑ Figure 2: parts of old and new growth increments of each stage have been lined up along vertical lines. All points where A's and B's meet in this triangular diagram fall upon the same slanting line which meets the vertical lines at distances measuring 5 and 8 respectively. This is the proportion of the Golden Ratio such as A : B = B : (A + B).

↑ Figure 3: each stage of growth shares the same proportions as shown by the shaded triangles.

(Diagrams & description from: *The Power of Limits* by G. Doczi.)

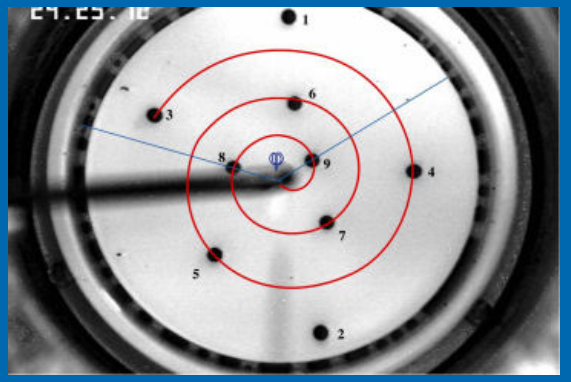
SG205A.1.14 Douady & Couder Experiment

In 1992, Stephane Douady and Yves Couder devised an experiment showing that phyllotactic patterns can result from purely physical mechanisms.

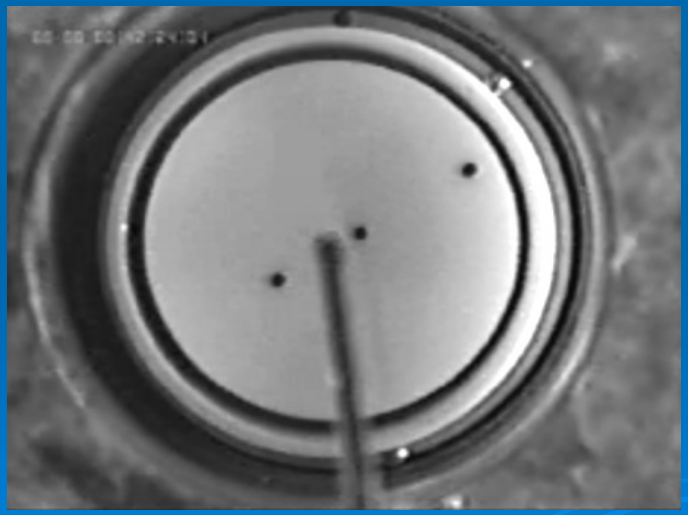
Drops of ferrofluids (which act as tiny bar magnets) were deposited periodically at the center of a circular dish filled with silicone oil. Under the effect of magnets surrounding the dish, the drops repelled each other and were attracted to the edge of the dish. When they fall slowly, the droplets move in precisely opposite directions to one another.

But when the speed increases, they move away from one another at the golden angle, ultimately forming spirals. When the magnetic field was slowly reduced during the process, the drops self-organized into *Fibonacci phyllotactic patterns*.

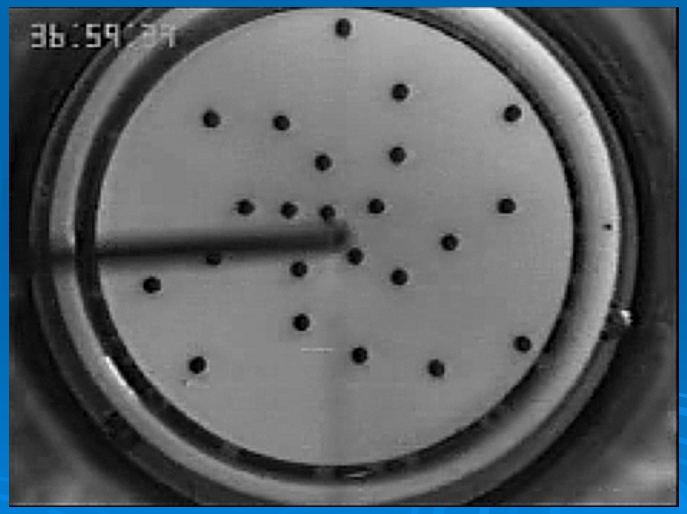
As explained by Mario Livio: *"Physical systems usually settle into states that minimize the energy. The suggestion is therefore that phyllotaxis simply represents a state of minimal energy for a system of mutually repelling buds".* (The Golden Ratio. 2002.)



↑ The Golden Growth angle appearing in the Douady & Couder experiment.



↑ In slow fall, the droplets move in opposite directions to one another.

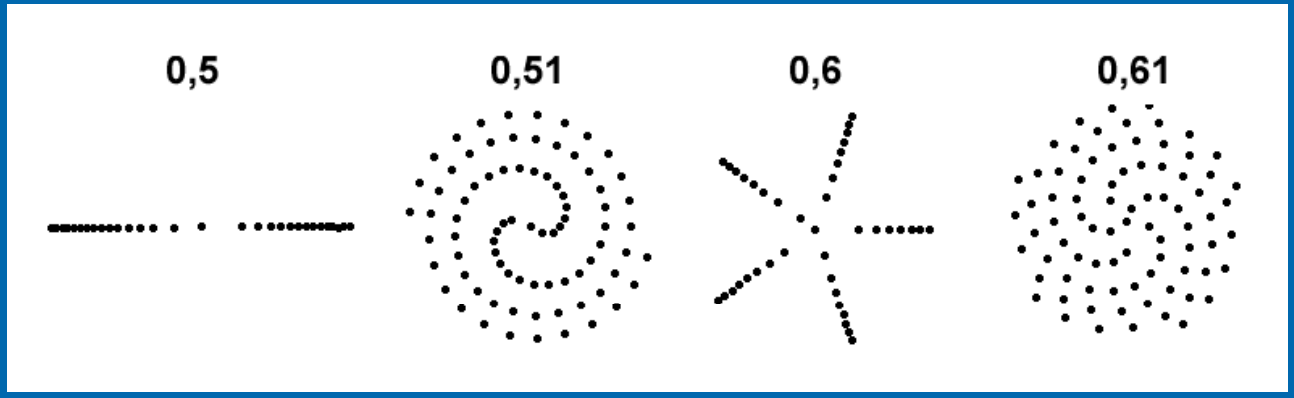


↑ With higher speed and slower magnetic field, the droplets form Fibonacci spirals.

SG205A.1.15.1 Why is PHI the Best Ratio in Plants? (1)

If we use an exact ratio (a rational number) as a turn-per-seed angle we would end up with the seeds placed on straight arms. In terms of seeds - which develop into flowers & fruits - what are the FRUITFUL ratios for the growth angle? For best optimized packing, it turns out that we actually need to use the most irrational number there could possibly be: PHI. Why is it so?

Mathematically speaking, EXACT FRACTIONS DO NOT CREATE AN EFFICIENT USE OF SPACE: they are "fruitless".
For instance, in the following diagram, the two exact ratios of 0.5 and 0.6 (used as divergence angle) create straight lines of "seeds".



← An exact ratio corresponding to an angle of 0.5 (= 1/2) creates a straight line.
An angle of 0.6 (= 3/5) creates 5 lines.
More "inexact" (irrational) ratios like 0.51 or 0.61 create better, rounder packing.

- **Since 0.5 = 1/2, we get just 2 "arms" and the seeds use the space on the seed head very inefficiently: the seed head is long and floppy.**
- **Since 0.6 = 3/5, every 3 turns will create exactly 5 seeds and the sixth seed will be at the same angle as the first, the seventh in the same (angular) position as the second and so on. So we count 3-of-the-5 (3/5) to find the next "arm" where a seed will appear. If we try 1.6 or 2.6 or 3.6 we get the same pattern since the extra whole turn does not affect where the seeds are placed. As explained by Ron Knott in his Fibonacci pages: what is important is just the fractional part of our seeds-per-turn value and we can ignore the whole number part.**
- **If we use 0.51 as the divergence angle (0.51 of a turn between seeds), we get more of a circular and therefore more compact pattern but the seeds seem to be sprayed from two revolving "arms". This is because 0.51 is very close to 0.5 and a half-turn between seeds would mean that they would appear on alternate sides, in an almost straight line.**
- **Now, if we use a value closer to phi ($1/\Phi = 0.6180339\ldots$), like 0.61, it gets better, but there are still large gaps between the seeds near the centre, so the space is not optimized. We actually need more decimals to PHI to optimize the pattern, as in nature: we need 0.618.**

So, the most "fruitful" number is NOT an exact ratio since very large seed heads would eventually end up with seeds in straight lines. Numbers which cannot be expressed exactly as a simple ratio or represented by terminating or repeating decimals are called irrational numbers. Examples of irrational numbers are: Pi (π - the ratio of a circle to its diameter), the natural logarithm (e), $\sqrt{2}$, PHI (Φ) and its reciprocal $1/\Phi$… and any multiple of them.

Next page reviews the efficiency of irrational numbers for space packing.

SG205A.1.15.2 Why is PHI the Best Ratio in Plants? (2)

The most "fruitful" number is the best irrational. How do we find out?

• If we use "e" (natural logarithm = 2.71828…) as the turn-per-seed angle, this creates 7 arms since its turns-per-seed is two whole turns plus 0.71828... of a turn, which is a bit more than 5/7 (= 0.71428…).

• A similar thing happens with "Pi" (π = 3.14159…) since the fraction of a turn left over after 3 whole turns is 0.14159 and is close to 1/7 = 0.142857... It is a little less, so *the "arms" bend in the opposite direction* to that of "e" (which were a bit more than 5/7).

These rational numbers are called *rational approximations* to the real number value. If we take more and more seeds, the spirals alter and we get better and better approximations to the irrational value.

So, what is the "best" irrational number?
What is the most "irrational" of the irrational numbers?

This will be a number that never settles down to a rational approximation. There is only one, namely PHI.
The mathematical theory behind is called CONTINUED FRACTIONS. A rational number can be represented by a simple *finite continued fraction* (below left).
An irrational number can be represented by an *infinite continued fraction* (below right).

$$N = a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{\ddots + \cfrac{1}{a_n}}}}$$

← Finite continued fraction. The iteration is terminated after finitely many steps by using an integer instead of another continued fraction.

Infinite continued fraction for PHI (Φ) →
It never exactly "settles down" but partakes of "infinity".
PHI harmoniously divides One unto itself.

[◆SG104.2]

$$Phi = 1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \ddots}}}}$$

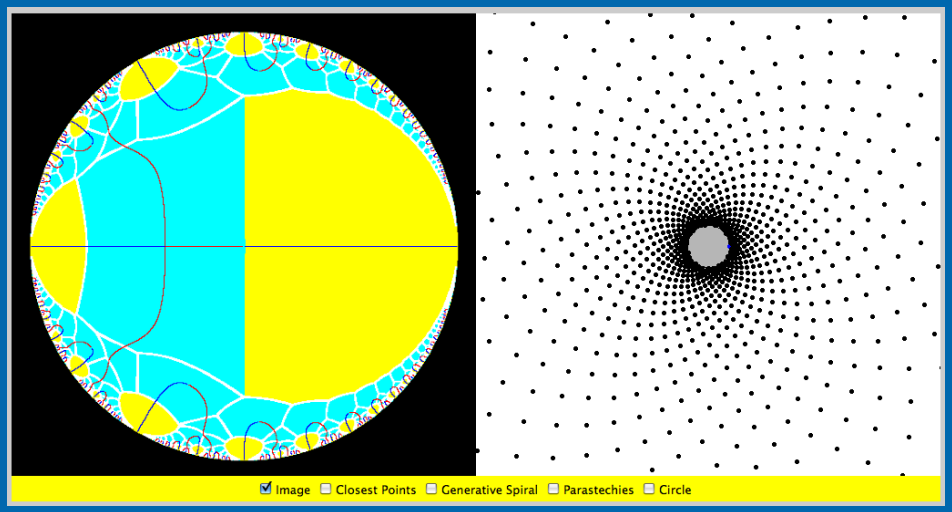
So the "hardest" number to make "rational" would be one with the smallest terms, namely, all 1. This is PHI - the Golden section number! PHI is the solution to the quadratic: $x^2 = x + 1$. Dividing both sides by x, we get: $x = 1 + 1/x$ which leads directly to the continued fraction for PHI.

As exact values: PHI (Φ) = $(\sqrt{5} + 1)/2$ and of its reciprocal Phi (1/Φ) = $(\sqrt{5} - 1)/2$. Both are irrational numbers whose best rational approximations are ratios of successive Fibonacci numbers:... Phi: 1/1, 1/2, 2/3, 3/5, 5/8, 8/13, 13/21, ... PHI: 1/1, 2/1, 3/2, 5/3, 8/5, 13/8, 21/13, ... which is why we see the Fibonacci spirals in the seed heads! No matter how big the seed head gets (scale invariance), the seeds are always optimally packed.

PHI is the SIMPLEST of the infinite continued fractions. So, even though mathematicians call PHI the "most irrational" number, we, as sacred geometers, could call it the "most ratio-nal" because it delivers the best and simplest ratio of harmony between the small, the larger and the whole.

SG205A.1.15.3 Why is PHI the Best Ratio in Plants? (3)

Go here for this interactive applet program about spiral lattices (and therefore Fibonacci parastichies and the Golden Growth Angle):
http://www.math.smith.edu



This applet enables the exploration of all possible spiral lattices and their organization according to their divergence angles, expansion rate, and parastichy numbers. To see the relation between these three entities and visualize the spiral lattices, click the mouse in the Parameter Space. Move the mouse keeping the button pressed. To each point P of the parameter space corresponds a spiral lattice. The divergence angle of the lattice is given by the angle P makes with the x - axis, and expansion rate by the inverse of the distance from P to the center of the parameter space.

- **The option *Parastichies* shows the spirals that you may have perceived mentally by connecting the dots to their nearest neighbors.**
- **The option *Closest Points* shows the 2 closest points to the blue point on the central circle (which represents potentially the newest primordia on the edge of the meristem).**
- **The option *Generative Spiral* joins the points in order of increasing distance from the center. In a plant, this would retrace the chronology of the primordia formation.**
- **The option *Circle* draws the circle centered at the blue point and passing through the second closest point to it. It enables one to visualize the changes of first and second closest points which determine entirely the changes in numbers of parastichies.**
- **The option *Image* shows the partition in the parameter space in regions where the number of parastichies are constant. If you follow the red paths starting from the center of the Parameter Space (the lattice will be distichous at first) with your mouse clicked on, you will see a succession of spiral lattices with Fibonacci phyllotaxis.**

Count the number of spirals you see at the different stages,
and note the angle towards which the paths lead you: 137.5 and 222.5.

SG205A.1.15.4 Why is PHI the Best Ratio in Plants? (4) Summary

Of all irrationals,
PHI is the slowest CONVERGER

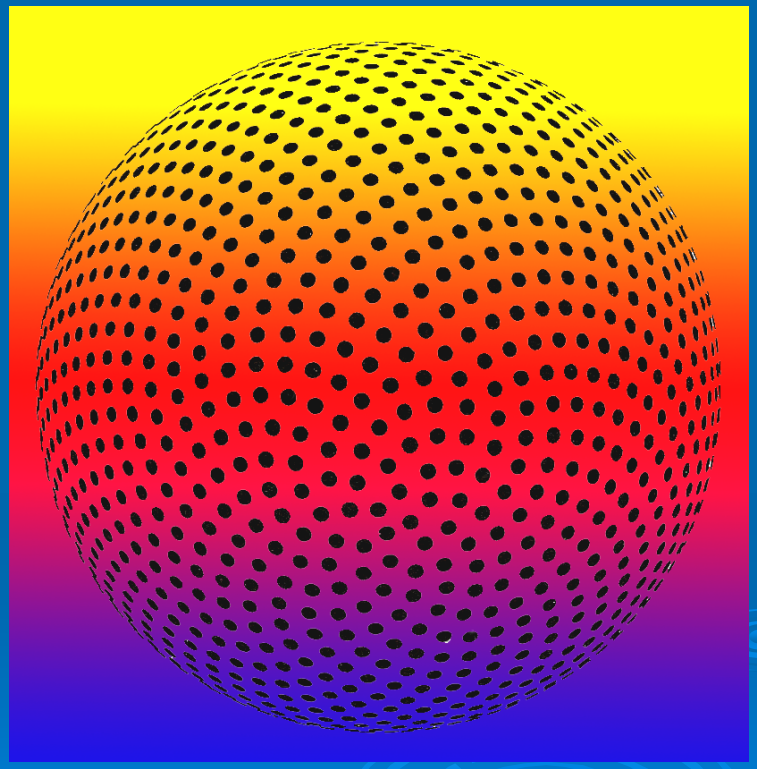
What does that mean?

H. S. M. Coxeter (1907-2003) is regarded as one of the greatest geometers of the 20th century. Professor at the University of Toronto, Coxeter pioneered the study of polyhedra and polytopes (higher-dimensional polyhedra) and brought abstract geometry into the visual domain before computers could give us the stunning graphics we now have. [◆SG107]

Coxeter was an artist as well: an accomplished piano player at age 10, he felt that music and mathematics were intimately related and thus he took his place in the time-honored Pythagorean tradition. He met Maurits Escher and his work on geometric figures helped inspire some of Escher's works, [◆SG208]. Coxeter also inspired some of the inventions of Buckminster Fuller.

In the domain of mathematical phyllotaxis, Coxeter showed in 1972 that PHI is the only irrational without intermediate convergents: it provides the only possible value of divergence (the "Golden Angle of divergent Growth") that can strictly fulfill the condition observed in spiral phyllotaxis. This is called "Tait's condition": the succession of nearest angular neighbors to any given leaf, in the following sequence of leaves, alternates from side to side.

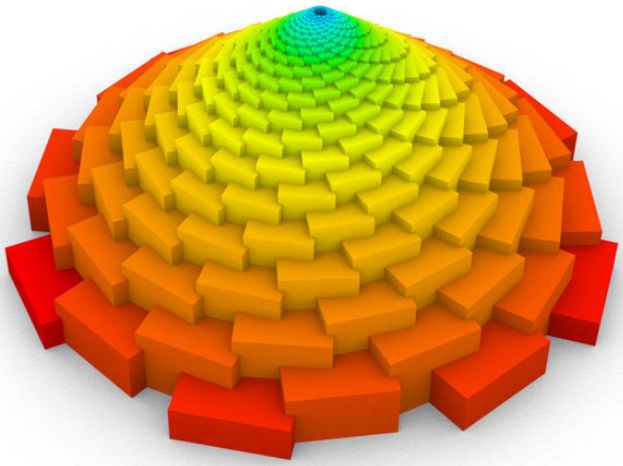
In other words, the plant optimizes the occupation of space and sunlight with utmost efficiency: it delays as long as possible growing leaves in directions close to those already occupied. It is a mathematical (and musical) problem. As explained by Robert Dixon in Spiral Symmetry (Hargittai, 1992): *"Any irrational divergence ensures that no two leaves will exactly superpose, and PHI is the only irrational divergence for which the succession of nearer and nearer approaches from right and left is a strict alternance."* PHI IS THE SLOWEST CONVERGER.

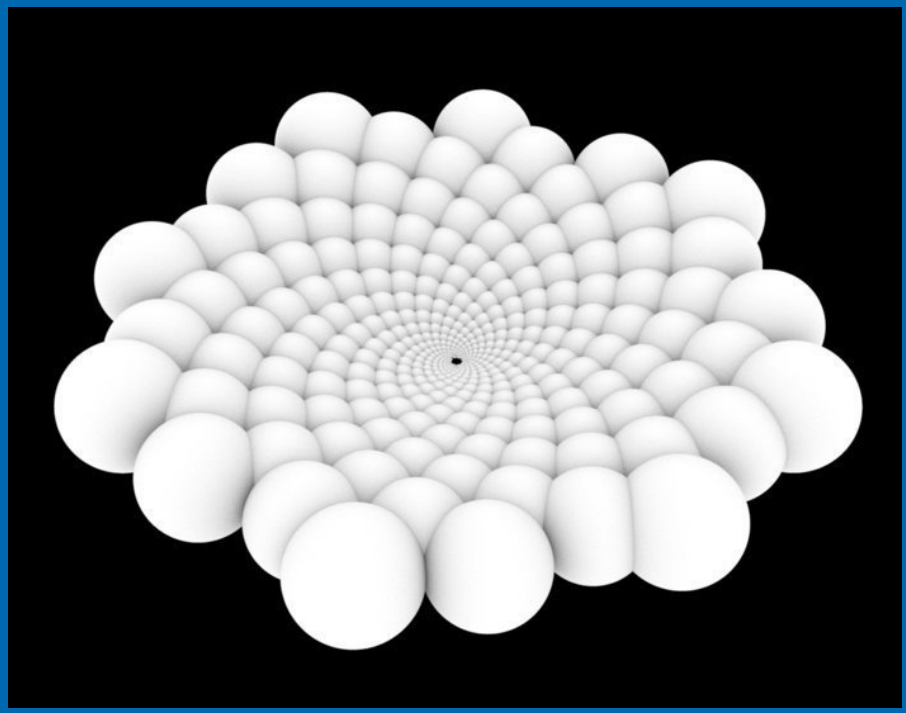


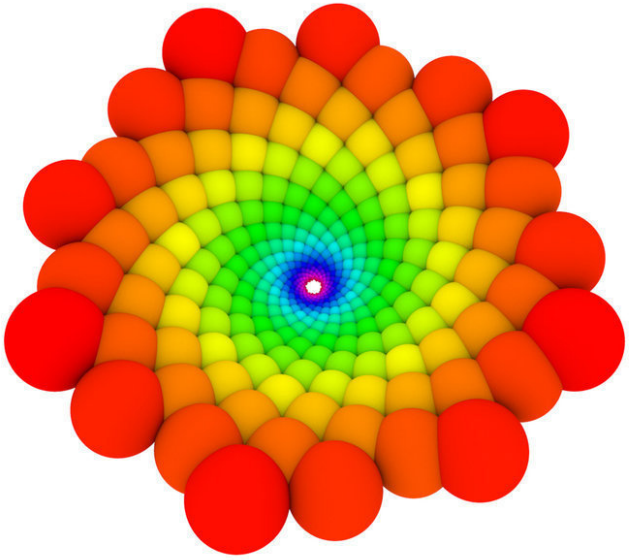
↑ Phyllotaxis sphere pattern.

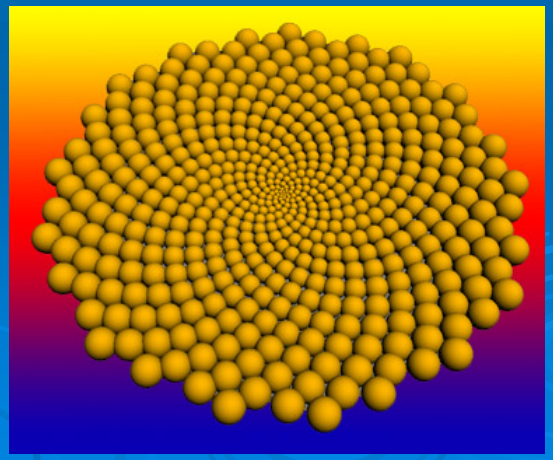
After R. Dixon in Spiral Symmetry.
(Ed. I. Hargittai & C. A. Pickover. 1992)

SG205A.1.16.1 Phyllotaxis Computer Models (1)



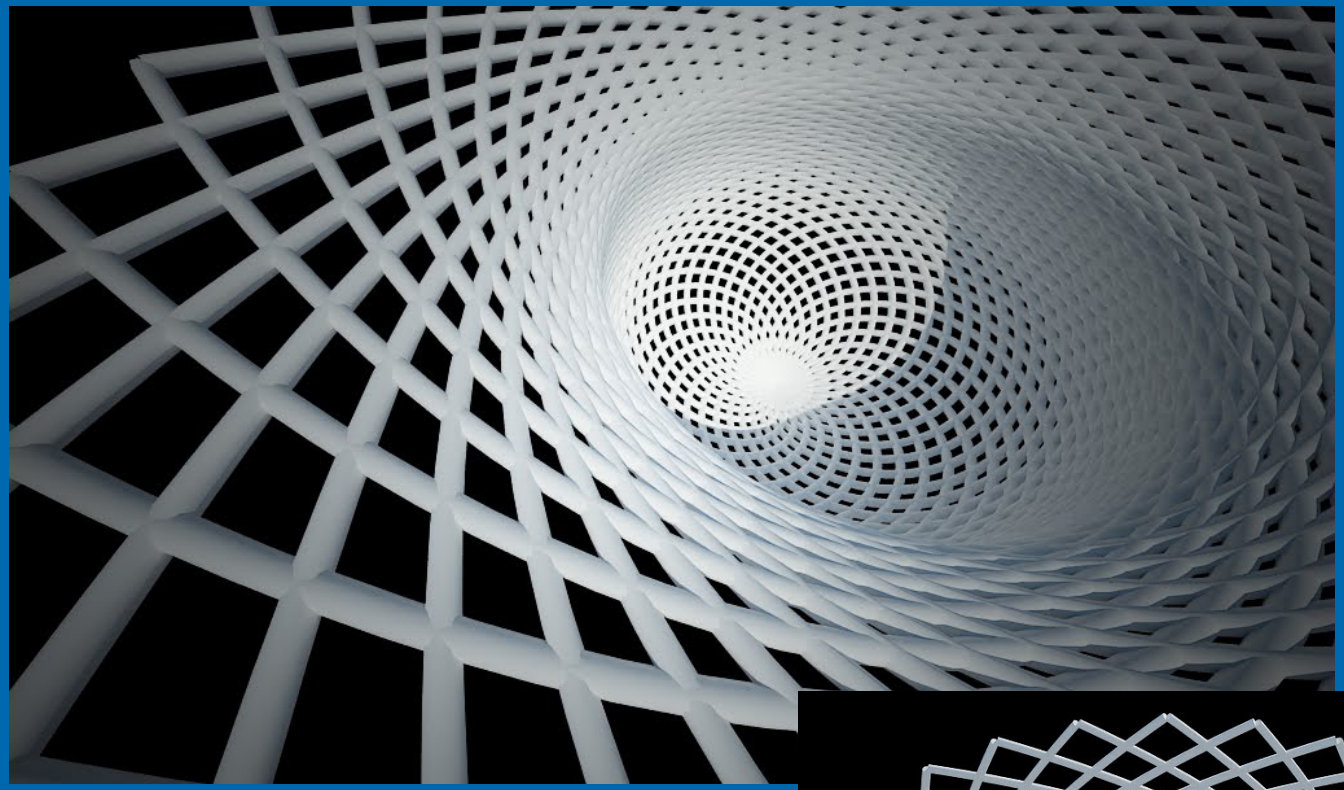


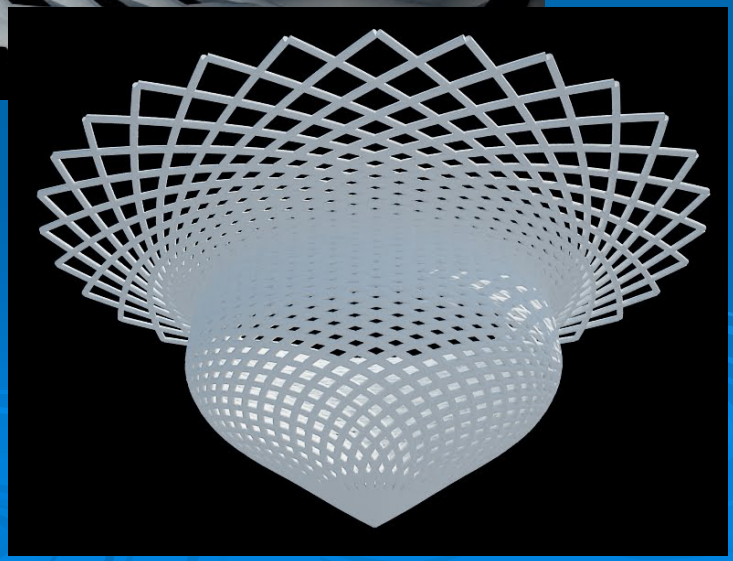




www.pxfactory.eu

SG205A.1.16. 2 Phyllotaxis Computer Models (2)

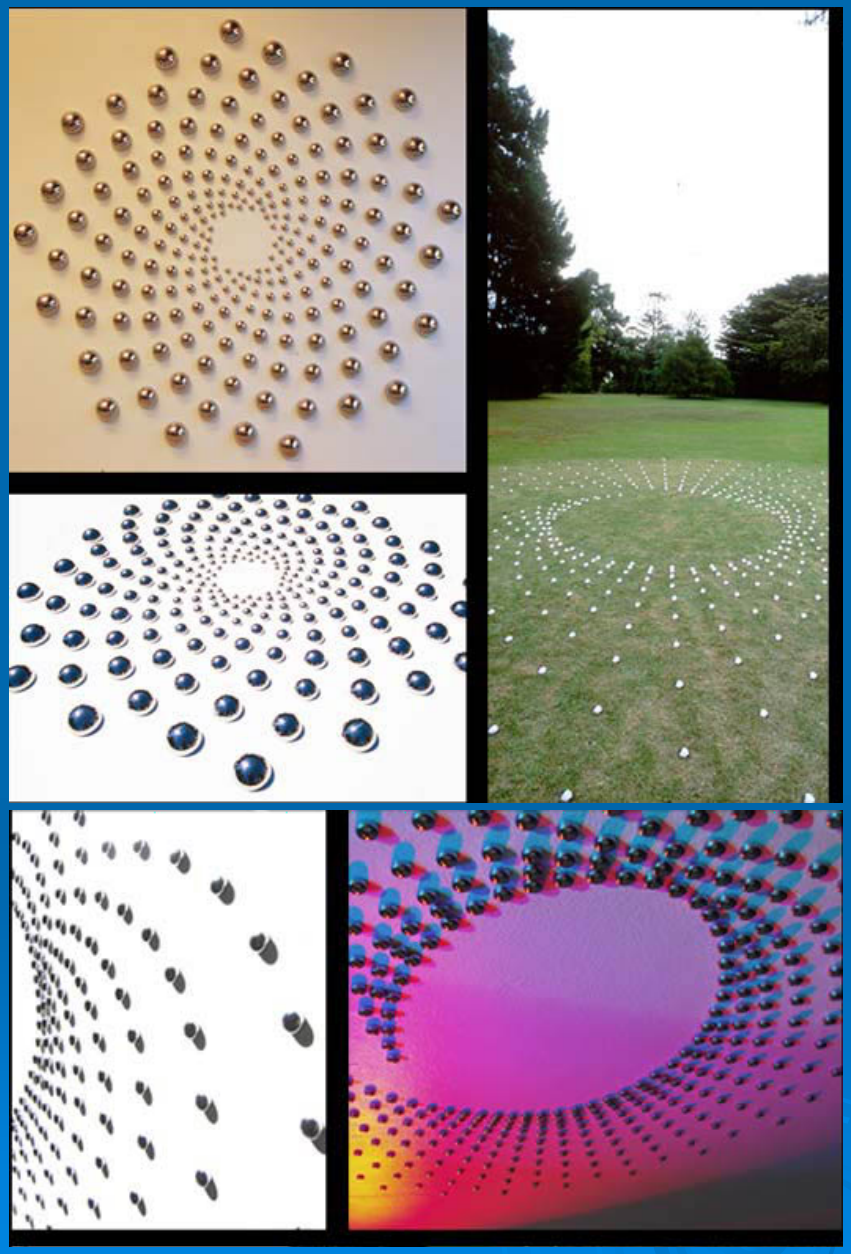


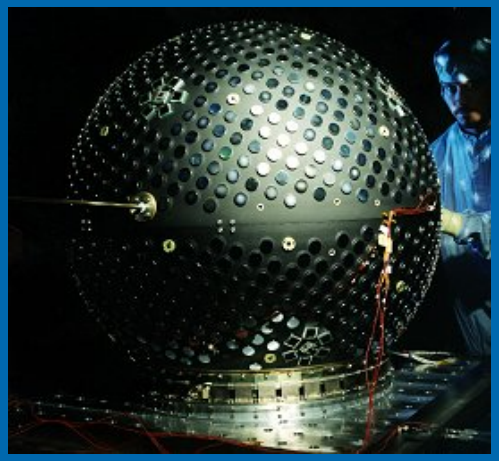


Credit: David del Giudice.

//madeincalifornia.blogspot.com/

SG205A.1.17 Phyllotaxis in Art & Science





↑ The STARSHINE (Student Tracked Atmospheric Research Satellite Heuristic International Networking Experiment) series of satellites were student participatory missions.
Approximately 40,000 students from all parts of the world helped polish the 1,500 distinctive mirrors of Starshine #3.

Note the satellite's "Phyllotaxis".

← Sculptural installations exploring the phyllotactic growth pattern.
Matthew Harding.
//matthewharding.com.au

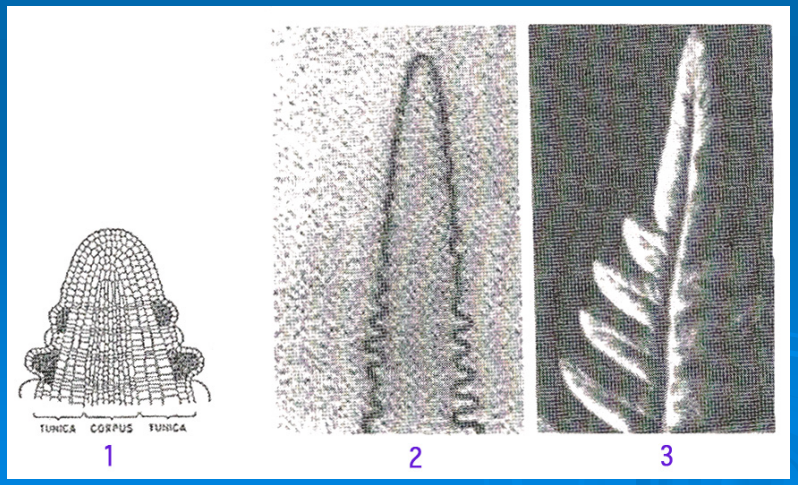
SG205A.1.18.1 Systemic Phyllotaxis (1) Introduction

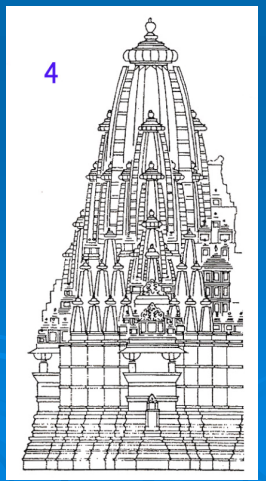
Roger V. Jean has been pioneering the study of *"Systemic Phyllotaxis"* which is an emerging multi-disciplinary area of research within comparative morphology. It proceeds from a synthetic relational approach, and it attributes more importance to resemblances than to differences. In R. Jean's own words:

"Primordial patterns observed in plants can be observed in other areas of nature as well. Pattern formation in plants must therefore transcend (…) the strictly botanical substratum. Consequently, models of pattern generation in phyllotaxis must not be based too much on strictly botanical devices or material, such as diffusion of phytohormones. They must introduce more formal, systemic concepts that are able to explain similar patterns wherever they arise… In order to find the best explanations for phyllotactic patterns, we must take into consideration the fundamental properties of space-time, … the general laws of nature and the structure of the universe."

These words ring true for us, as we have already uncovered the ubiquitous presence of the Fibonacci numbers and the Golden ratio in many aspects of nature, including the quantum level of interacting with the Zero Point Field. Beyond molecular chemistry, there are fundamental mechanisms, such as harmonic proportions, PHI nesting, branching processes, gnomonic growth, fractals hierarchies, global scaling and holographic non-locality which reveal the deeper, universal foundation of phyllotactic patterns. In this sense, "botanical" phyllotaxis has now expanded to a "universal" phyllotaxis set on a vision quest for the causal laws of cosmic harmony. Jean proposes to call it "Primordial Pattern Morphogenesis". He writes: *"What could be needed in order to cope with the challenge of origin… is a bio-philosophy which considers that nature is far richer than usually thought. (…) Maybe more stress should be put on teleology (the science of ends and purposiveness)…"*

Furthermore, the specific phyllotaxis studying the presence of PHI and Fibonacci structures, across the disciplines of science and the scales of nature, can be called Golden or FIBO-PHYLLOTAXIS. And this could well be the new word for Sacred Geometry.





Gnomonic growth [◆203A.1]
or phyllotaxis in nature & culture:

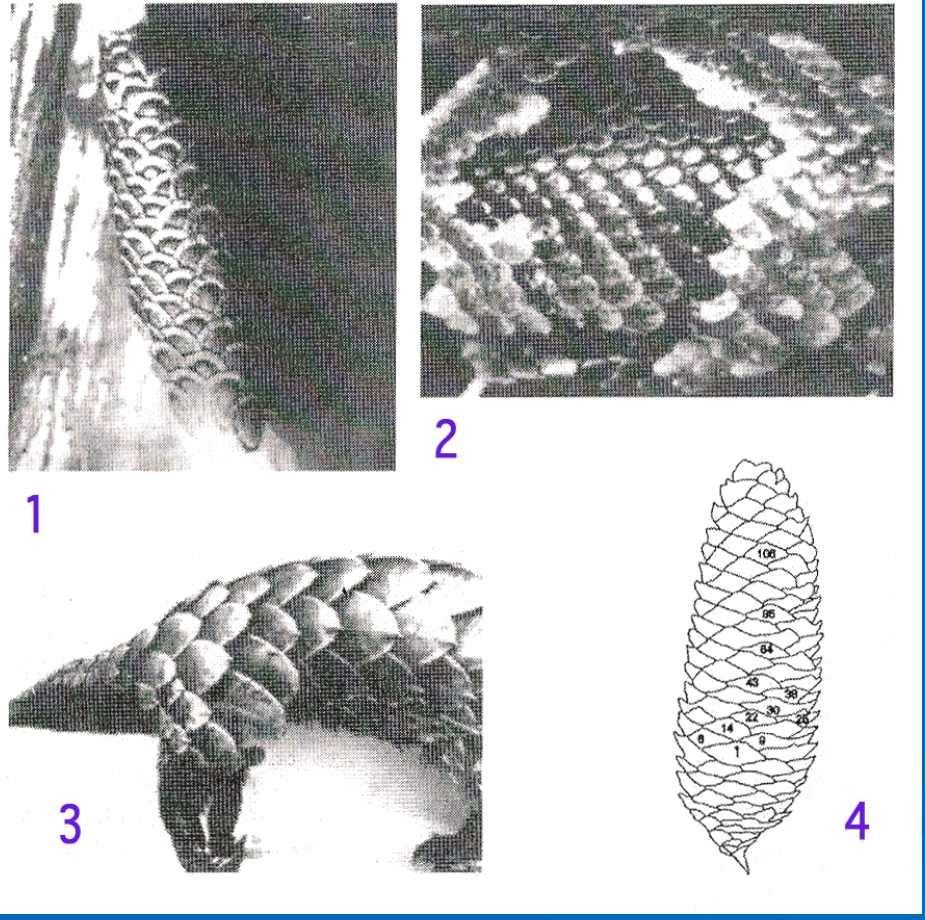
← 1. Longitudinal section of the parabolic shoot apex of *Hippuris vulgaris*, showing the leaf primordia.

← 2. Crystal of ammonium chloride growing in a dendritic way at a parabolic speed.

← 3. Tip of a leaf of *Pteridium aquilinum*, a widespread fern.

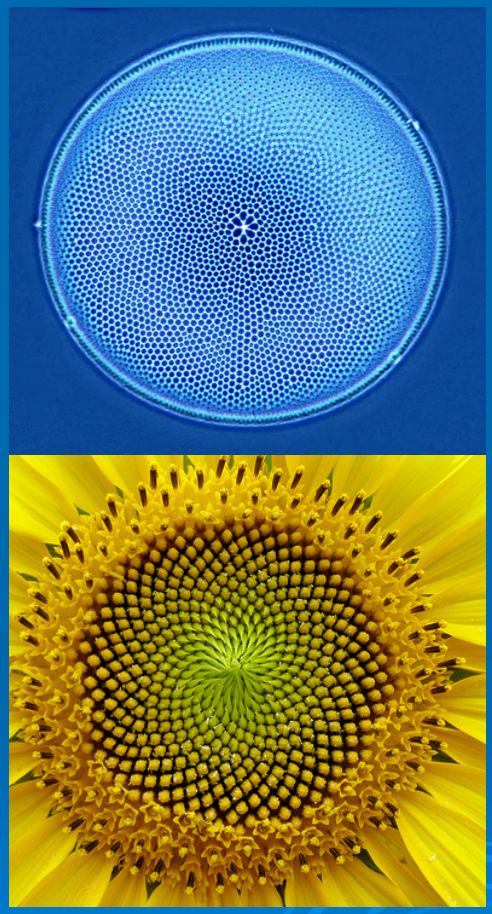
← 4. Elevation plan of a multi-tiered Indian temple.

SG205A.1.18.2 Systemic Phyllotaxis (2) Examples



↑ 1. Scales on an asclepiad seed. 2. Scales on a snake's skin.
3. Pangolin. 4. Spruce cone with 5-8 phyllotaxis. *Picea excelsa*.

(Pictures credit: R. V. Jean. Phyllotaxis.)



← *Coscinodiscus* diatom

← sunflower

"In order to throw more light on the fascinating phenomenon of phyllotaxis, we will have to discover new properties of the primordial substance from which everything is made and of light itself." (R. Jean)

SG205A. Chapter 2. A Gallery of Plants & Flowers

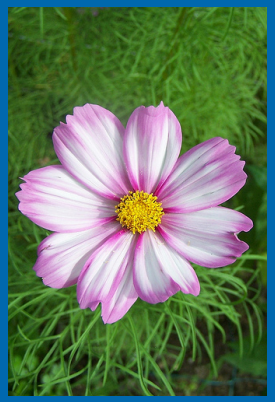
SG205A.2.1.1 Fibonacci Numbers - Flower Petals

Nature has a *"fascinatingly prevalent tendency"* (the expression is from Donald Coxeter, the famous 20th century geometer) to produce flowers with Fibonacci numbers of petals or seeds.

1. White Calla Lilly

2. Euphorbia

3. Wild Iris



8. Picotee Cosmos

13. Black-eyed Susan

5. Columbine

21. Shasta Daisy

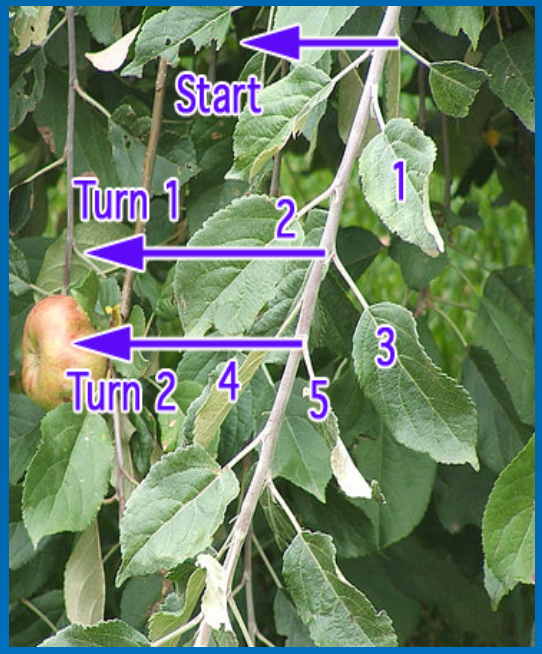
34. Field Daisies

SG205A.2.1.2 Fibonacci Numbers - Leaves per turn

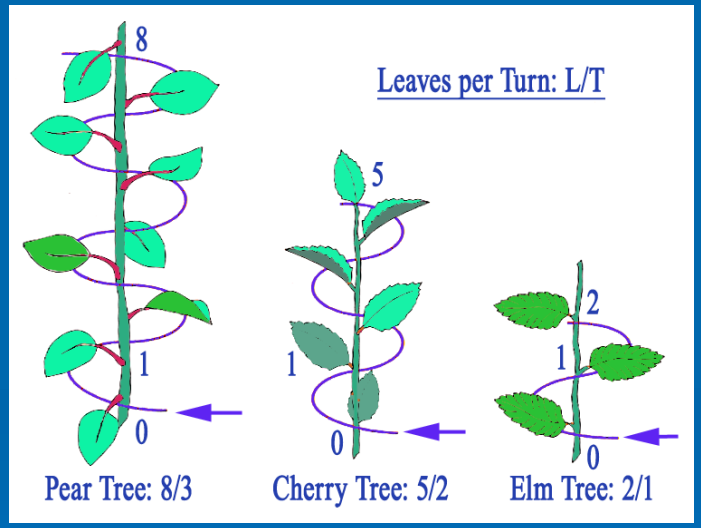
In plants & trees with spiral phyllotaxis pattern, if we count the number of leaves per turn of the spiral, we obtain Fibonacci numbers. This the L/T ratio (leaves per turn).

2/1: Corn - Wheat - Bamboo - Fern - Ivy
Sycamore - Maple - Linden - Lime…
3/1: Hazel - Beech - Blackbery…
3/2: Grasses - Elm…

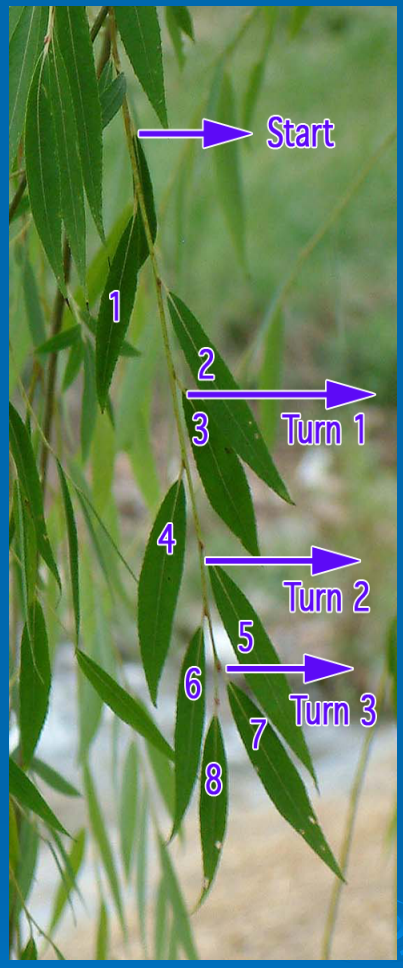
5/2: Mustard - Groundsel - Poplar - Holly
Pepper - Apple - Plum - Cherry - Apricot…
8/3: Weeping Willow - Pear…
13/5: Bottlebrush - Pussy Willow - Almond…



Apple tree branch with a 5/2 phyllotactic pattern.



Ratios of leaves per spiral turn on some trees.

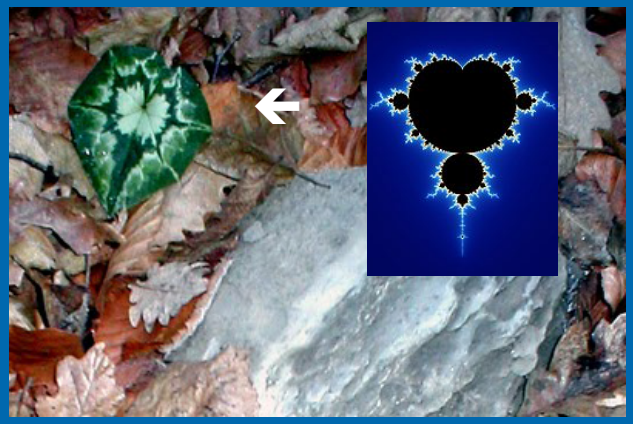


Willow with 8/3 phyllotactic pattern: 8 leaves within 3 turns.

Note. Other numbers also show up in plants but with a much lesser frequency. In other swords, yes, you will find 4-leaves clover but you have to look hard. And some of these other numbers actually belong to the Lucas Series, a mathematical sequence that converges to the Golden Number as well. The Lucas Series is: 2 - 1 - 3 - 4 - 7 - 11 - 18 - 29 - 47…

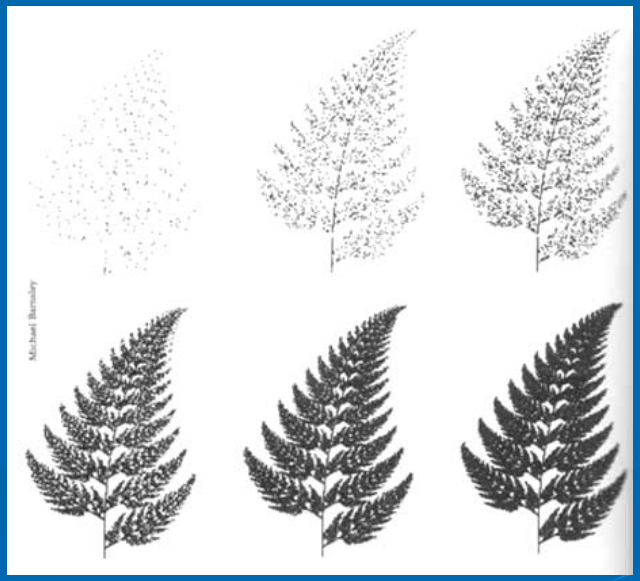
SG205A.2.2.1 Fractals in Nature (1)

The new mathematics and geometry of Fractals pioneered by Benoit Mandelbrot around 1984 [◆SG203-A] gave us a new appreciation for the natural world and the patterns we observe in it. Many natural phenomena and creations previously seen as "chaotic" or "random" are now known to follow subtle and precise fractal laws of coherence and scale-invariance. Fractality and its mathematical relationships (power laws) turns out to be a window into finer levels of cosmic harmony & order. The word "chaos" itself had to be redefined as systems appearing unpredictable yet actually deterministic, following rules based on nonlinear iterative equations expressing specific initial conditions. Fractals are unpredictable in specific details yet deterministic when viewed as a total pattern - this reflects what we observe in the smallest details & larger patterns of nature in all its physical and energy creations…



← The appearance of a Mandelbrot set fractal shape on a cyclamen leaf.

//orso.blogspot.com



➔ <u>Fractal Fern:</u> a simple way to understand fractals and the meaning of "iteration" is to examine the recursive operation that produces a fractal fern through a "chaos game" of generating random numbers and then placing them on a harmonic grid.
After a few dozen repetitions (or iterations), the shape we would recognize as a Perfect Fern appears from the abstract world of fractal math.

Nature always follows the simplest and most efficient way. Fractals are maps of the simplest paths sliding up the scale of dimensions (from 2-D to 3-D and so on); they are the contemporary expression of the old wisdom teaching: "As above, so below".

As put by Miqel: *"It is simply an artifact of nature's elegance that we find exact correspondences between these inherently existing mathematical forms and natural patterns, and even living creatures of many types."*

Fractal Fern
www.miqel.com

SG205A.2.2.2 Fractals in Nature (2) Ferns

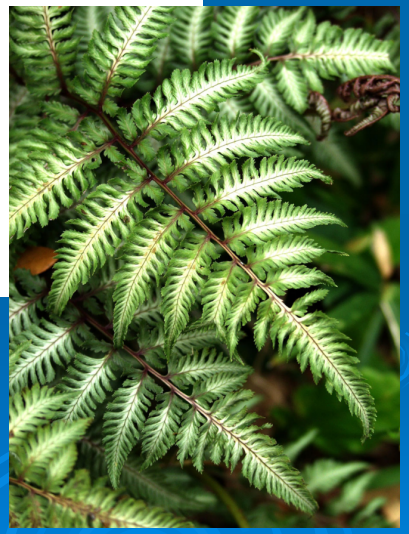
//stilgherrian.com

www.irishviews.com

//desktop-world.info

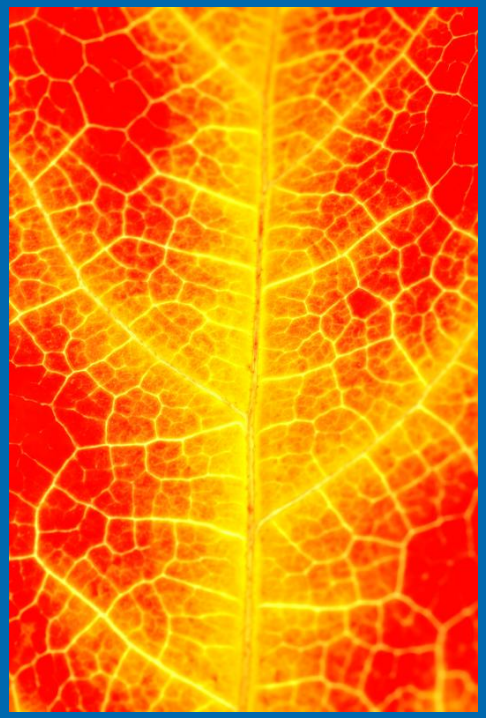
↑ The unfolding of a fern: from Archimedean to logarithmic spiral

← www.inforochester.com



www.extension.iastate.edu

SG205A.2.2.3 Fractals in Nature (3) Leaves



//originalbeauty.files.wordpress.com

A leaf is an above-ground plant organ specialized in the process of photosynthesis.

For this purpose, a leaf is typically flat (laminar) and thin. As an evolutionary trait, the flatness of leaves works to expose the chloroplasts to more light and to increase the absorption of carbon dioxide at the expense of water loss.

↑ Vein skeleton of a Hydrangea leaf

//k43.pbase.com

We are showing here various leaf network structures showing the fractal branching system of the xylem that transports water through a leaf.

← Image: www.esa.org/esablog

SG205A.2.2.4 Fractals in Nature (4) Trees

gaiathelivingearth.blogspot.com

Nature and specially the plant kingdom is an encyclopedia of fractal patterns.
While the term "fractal" was only recently coined and the mathematics formalized, many keen observers of nature have noted these patterns for much longer.
A famous example is Da Vinci's Tree.

↑ The banyan tree in Lahaina, Maui, Hawaii.
This is a SINGLE tree that has fractalized itself.

← Da Vinci's Tree

Leonardo da Vinci speculated about a logical relationship between tree branches at different heights, based on their volumes. He wrote in his notebooks: *"All the branches of a tree at every stage of its height when put together are equal in thickness to the trunk [below them]."* One branch, the trunk, splits in two, which he thought must have 1/2 the cross-sectional area as the trunk. These two branches then split into four, whose area would be one fourth that of the trunk.
This was a logical inference, and has come to be known as "Leonardo's Rule for Branches". This came from the idea that branches act as pipes to move fluid, and the total cross-sectional area must be the same at different levels of the tree. This rule has actually been shown to be not entirely correct but it is a good initial model of a harmonic proportion between parts and whole.

↑ Olive tree

SG205A.2.3 Fractals in Landscapes

Large scale growth & flow systems display fractal structures similar to the fractal symmetries found in trees, plants & leaves.

↑ Fractal Mountain structures in Tibet. www.miqel.com

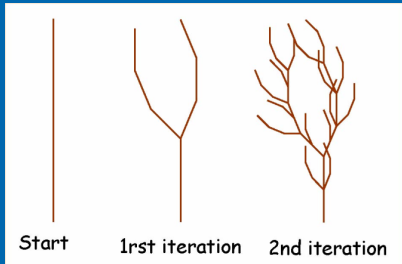
↑ Fractal Cascades in Croatia. //2.bp.blogspot.com

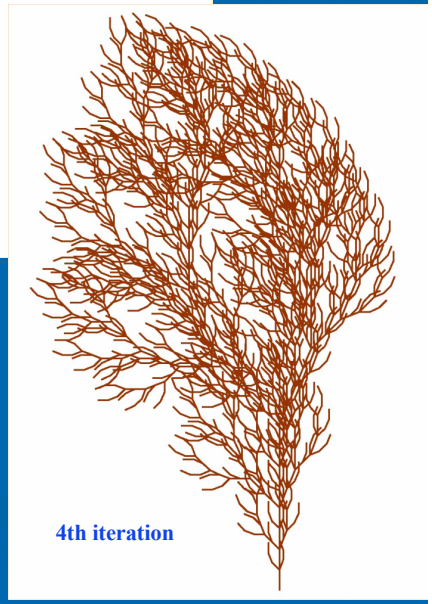
↑ Valleys and river basins display beautiful capillary fractal dendritic branching. www.miqel.com

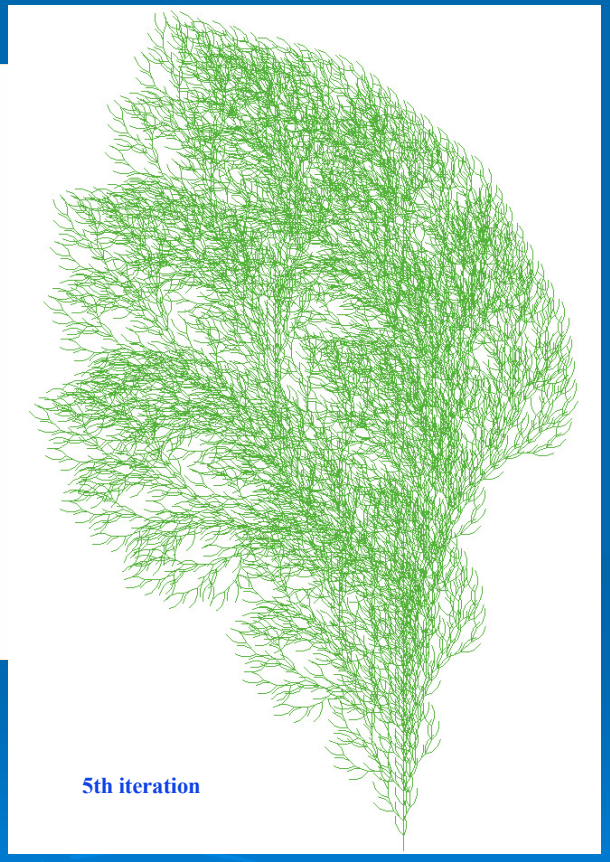
← Fractal Rivers

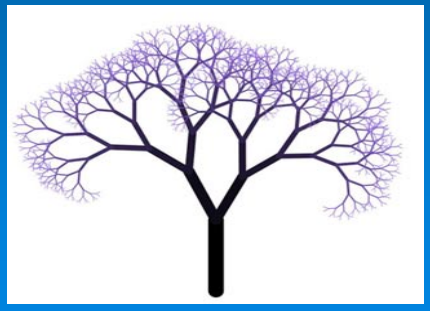
SG205A.2.4 Fractal Plant Simulations

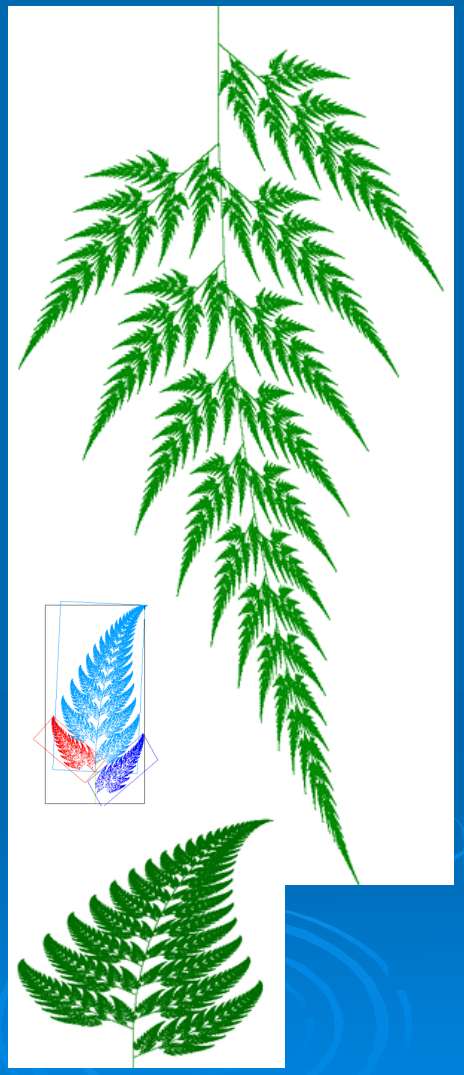
(🡸🡻 Images: Frank Timmes. www.cococubed.com)









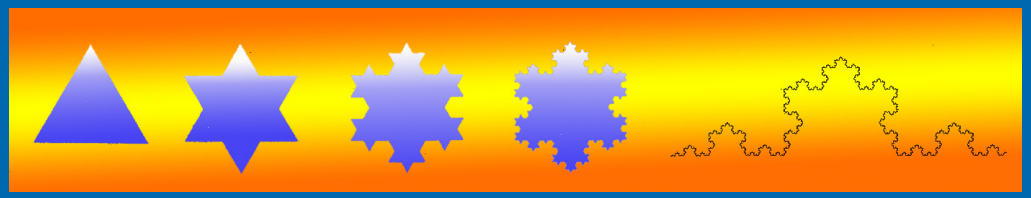


www.miqel.com

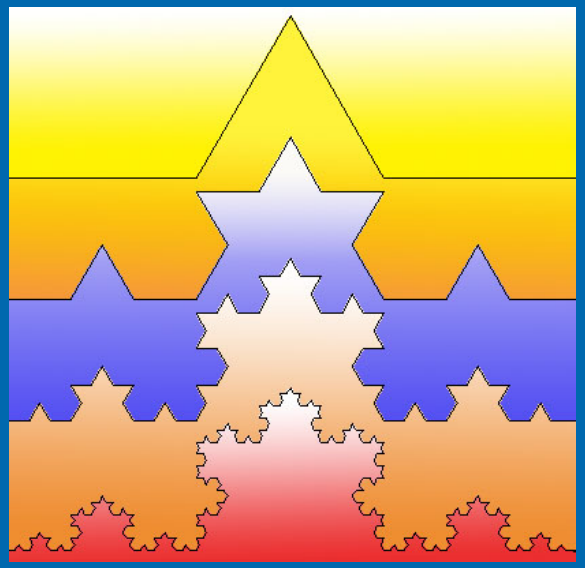
🡹 Fern simulations

SG205A.2.5.1 Golden Reduction Factor (1)

As we have seen in SG203-A (chap. 1), the Golden Reduction factor "f" of 1/Φ (= 0.618) is the precise mathematical ratio allowing for branches or leaves to touch without overlapping. We have already met the famous Koch Snowflake, the result of a simple iterative function. The Koch fractal has a "length reduction factor" (f) of 1/3: the original side of 1 is replaced by 3 x 1/3.



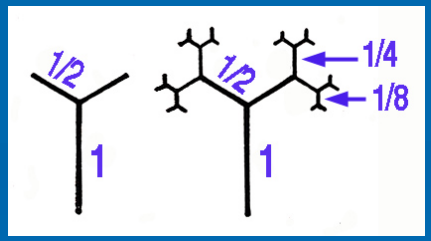
↑ Koch Snowflake Fractal with Reduction Factor 1/3



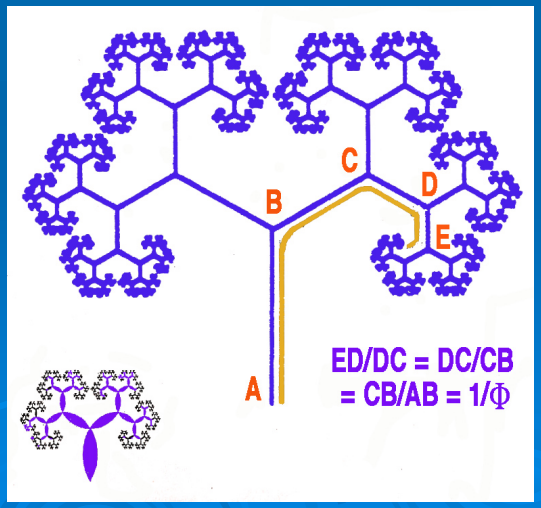
↑ Zoom on Koch Fractal

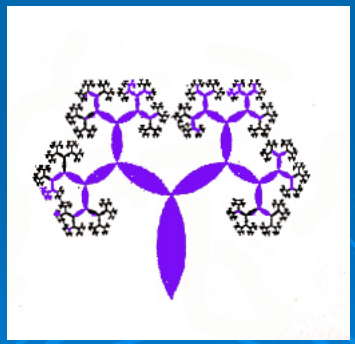
What interests us here is the question: what is happening when we vary the reduction factor "f"? If we use a reduction factor of 1/2, we obtain elements that are still far apart (see left). So the question arises: at what reduction factor f do the elements (branches) perfectly TOUCH but DO NOT OVERLAP?

This happens to be when f is precisely equal to the reciprocal of Phi or Minor Phi = 1/ Φ = .618



↑ If we use a reduction factor of 1/2 (instead of 1/3) and start with a line, we obtain the "f = 1/2" tree. The elements are still far apart.

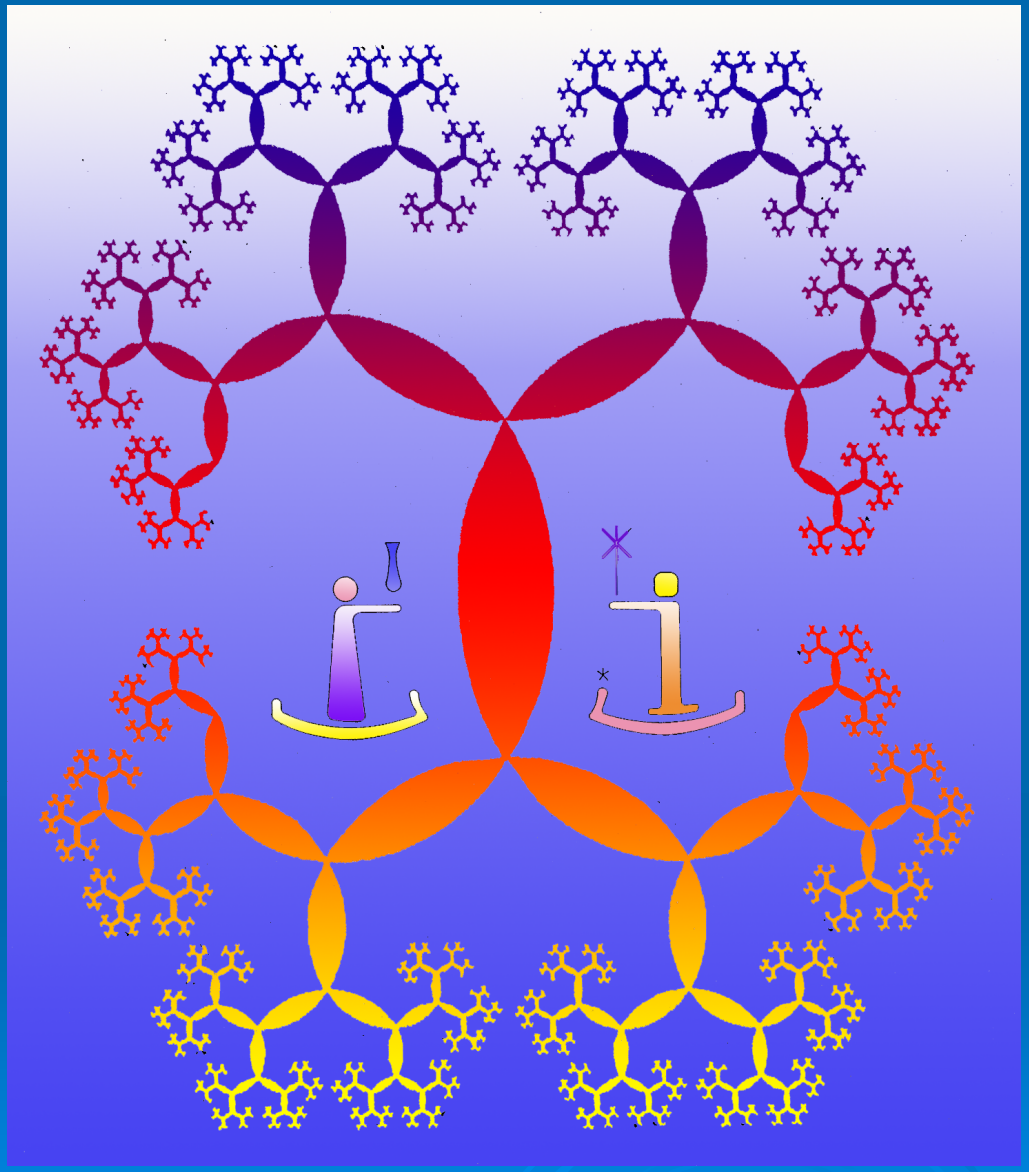




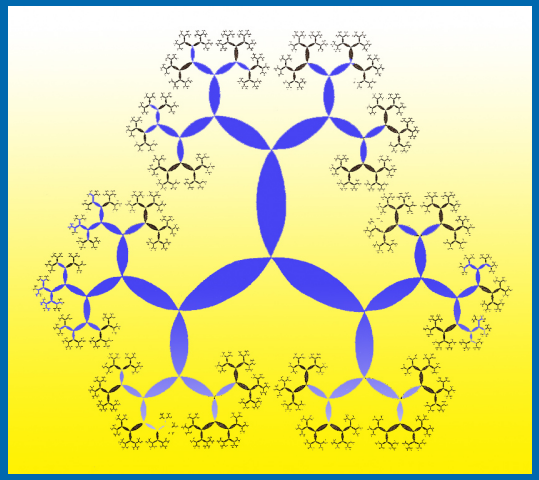
← ↑ Golden Fractal Tree with f = 1/Φ = 0.618 and fractal dimension = 1.44

Note the appearance of the Golden Spiral →
AB : BC :: BC : CD :: CD : DE

SG205A.2.5.2 Golden Reduction Factor (2) Golden Trees



Four Golden Trees



Three Golden Trees

$$1 / \Phi$$

=

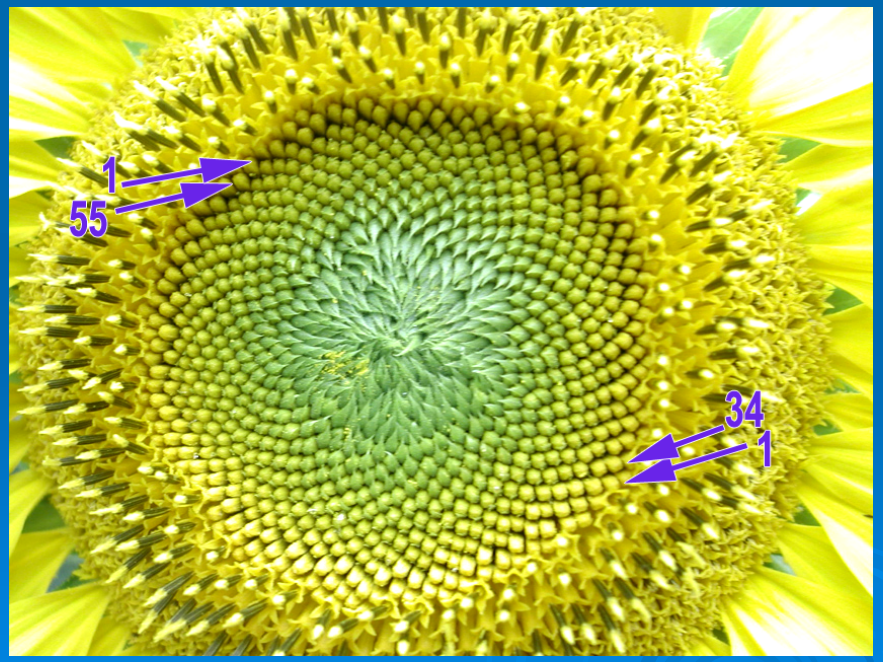
Perfect fractal Reduction Factor

SG205A.2.6.1 The Sunflower (1)

The Sunflower (*Helianthus annuus*) is an annual plant native to the Americas, that possess a large inflorescence or flowering head… What is usually called the "flower" is actually a *flower head* made out of 1,000-2,000 individual florets crowded together… Sunflowers have a type of phototropic response called *heliotropism* (sun turning); the leaves and flower heads of young sunflowers follow the sun and their orientation therefore changes from east to west during the day.

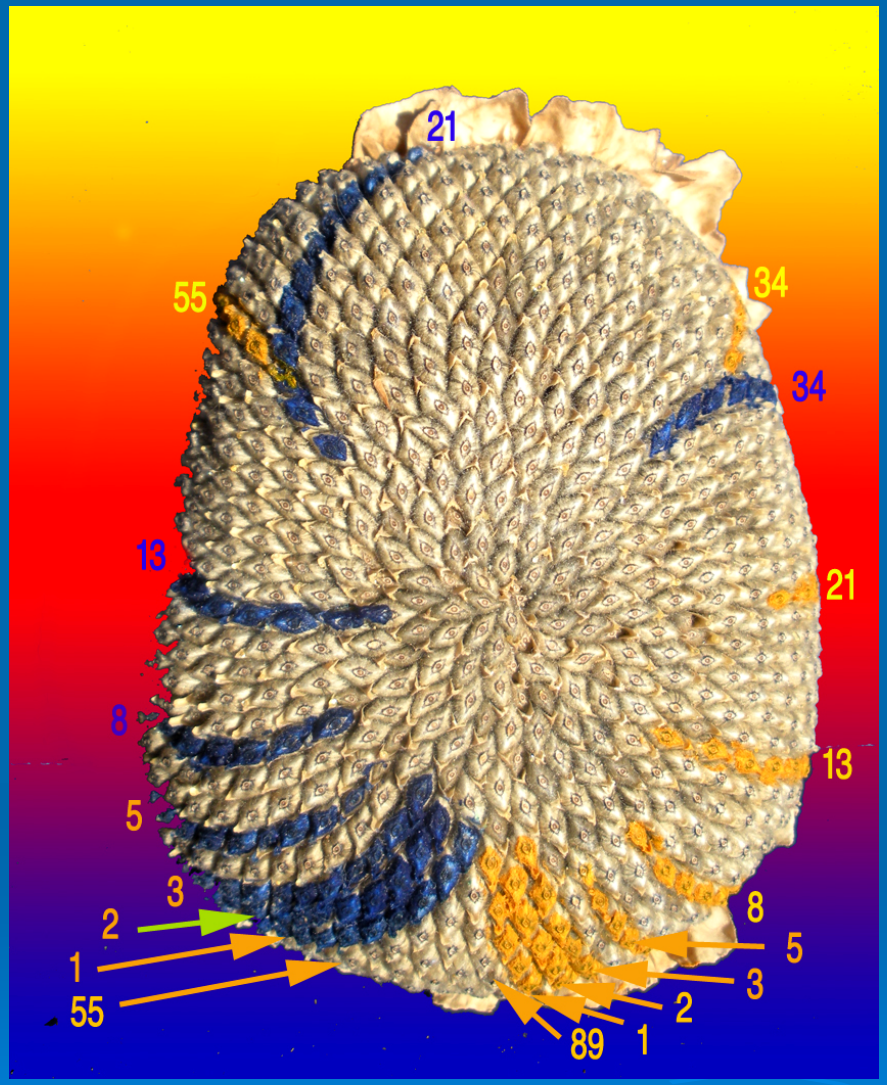
The sunflower has a spiral phyllotaxis. Typically each floret is oriented toward the next by approximately the Golden Angle of 137.5°, producing a pair of *parastichies with successive Fibonacci numbers*. Typically, there are 34 spirals in one direction and 55 in the other; on a very large sunflower there could be 89 in one direction and 144 in the other.

↑ Credit: www.goldenmeangauge.co.uk



← Credit

SG205A.2.6.2 The Sunflower (2)



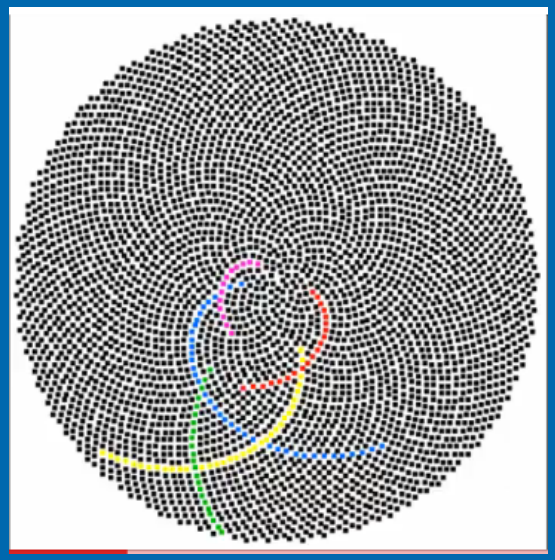
↑ Typical medium size sunflower with 55/89 phyllotaxis:
55 CW (blue) spirals and 89 CCW (yellow) spirals.

(From the garden of ChocolaTree, Sedona, Arizona.)

www.maths.surrey.ac.uk

↑ Detail of the flowering seed head.
Note the pentagram geometries.
Image by Cisca Castelijns. www.visualphotos.com

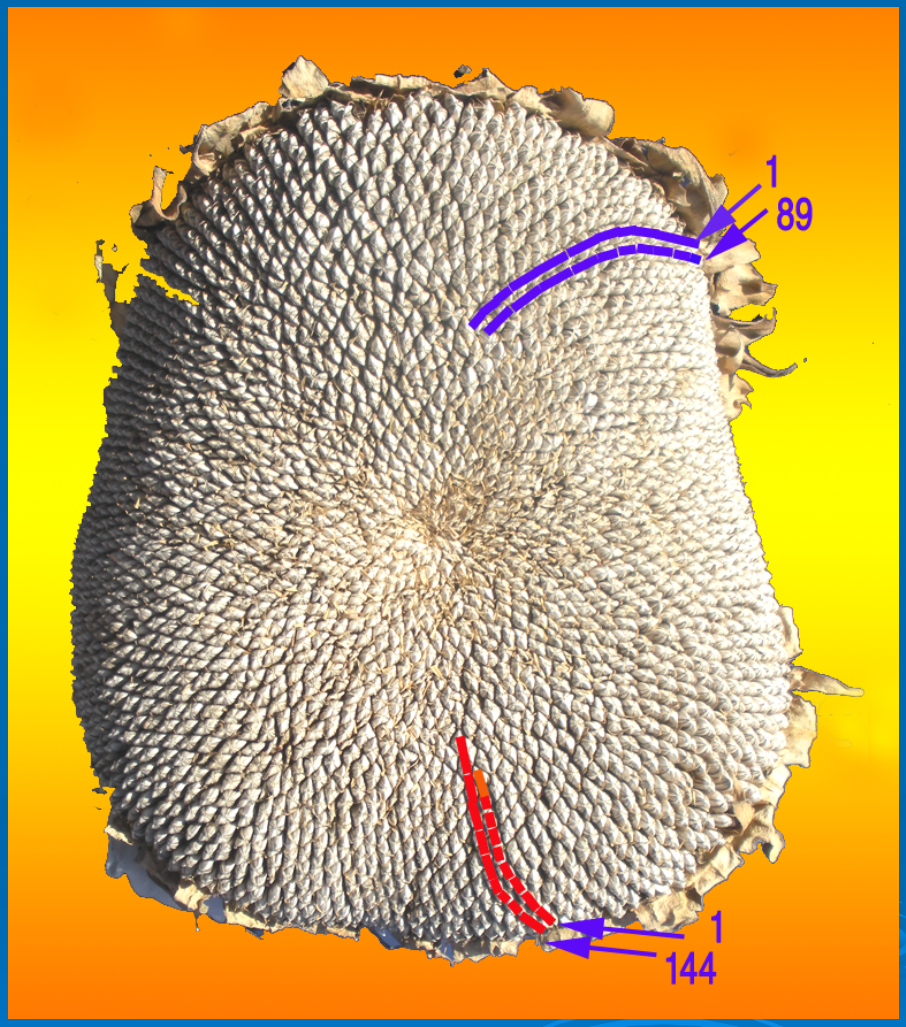
SG205A.2.6.3 The Sunflower (3)



↑ Computer model of sunflower phyllotaxis.
www.mcs.surrey.ac.uk

These two images (the model and the real image) show that there are 3 tiers of spirals with jumbled areas at their boundaries.

As the radius decreases toward the center and the seeds fit into smaller spirals, there is an "organic" re-harmonization of the space packing.



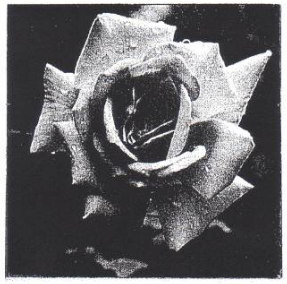
↑ This 10 feet tall sunflower grew up in the Village of Oak Creek, AZ, in the summer of 2010. The seed head was so heavy that it turned down to face the ground, thus preventing the birds to pick up all its seeds.
When the florets dried out, one could see, on the periphery, the 2 parastichies and count the spirals: 89 spirals (blue) going CW and 144 spirals (red) going CCW.

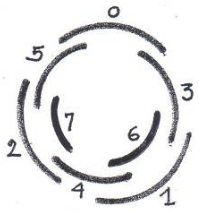
SG205A.2.7.1 The Beautiful Rose (1)

"Die Rose ist ohne warum; sie blühet, weil sie blühet..."
["The Rose is without 'why'; she blooms, because she blooms..."]

So wrote the German physician, priest and mystical poet Angelus Silesius (1624-1677). Yes, the beauty of the rose is devoid of questions… and infuses the senses of the beholder with a mystical communion. We do not need logical reasons to be convinced of beauty. What we need is to open our heart and use the small and great beauty we encounter to recognize the source of beauty within ourselves… thus walking the path of beauty and blossoming just like a rose…

However, it is pleasantly satisfying to the mind to know that the beautifully ordered arrangement of the petals in a rose flower is also based on the Golden Ratio. As explained by Mario Livio in *The Golden Ratio* (2002): "If you dissect a rose (petal by petal), you will discover the positions of its tightly packed petals." The figure below shows a schematic where the petals have been numbered.





The Beautiful Rose

The angles defining the location of the rose petals are the *fractional parts of simple multiples of Phi.*

- Petal #1 is 0.618 (decimal of 1 x 1.618) of a turn from petal #0.
- Petal #2 is 0.236 (decimal of 2 x 1,618) of a turn from petal #1... etc...

Petal:	0	1	2	3	4	5	6	7
Position:	0	.618	.236	.854	.472	.090	.708	.326

By setting a given level of inhibition, a flower can arrange for the total number of petals to be a small Fibonacci number, but not any other number.

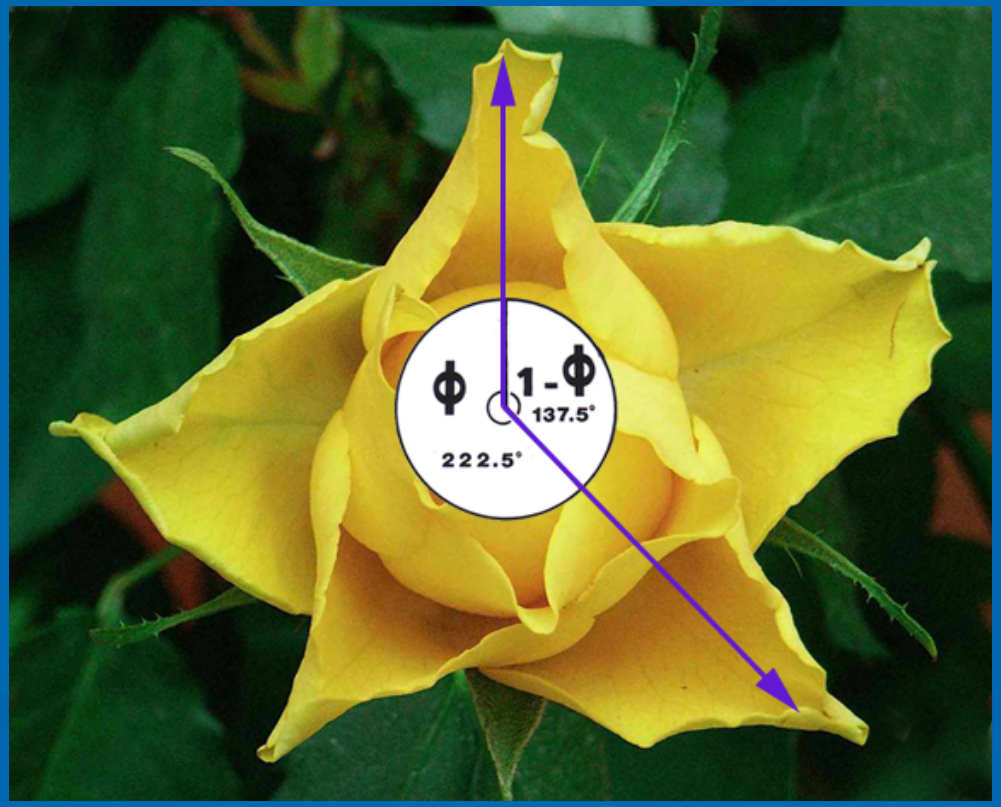
Rose Symbolism

Roses have been long used as symbols of love and beauty. 'Rose' means pink or red in a variety of languages. The rose was sacred to a number of goddesses (including Isis and Aphrodite), and is often used as a symbol of the Virgin Mary.

The ancient Greeks and Romans identified the rose with their goddesses of love, Aphrodite and Venus. In Rome, a wild rose would be placed on the door of a room where secret or confidential matters were discussed. The phrase *sub rosa*, or "under the rose", means to keep a secret and is derived from this ancient Roman practice.

(Wikipedia)

SG205A.2.7.2 The Beautiful Rose (2)

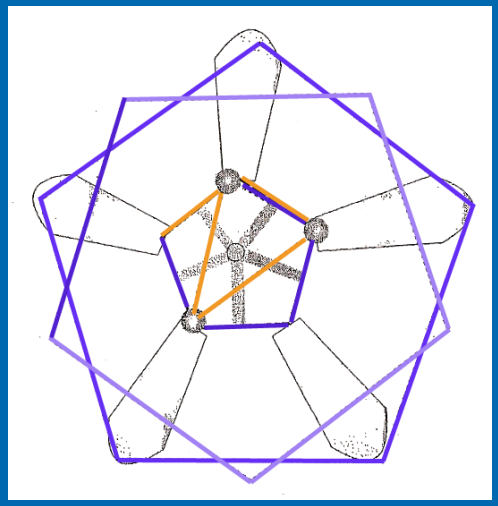


Since the earliest times, the rose has been an emblem of silence:
- In Greek Mythology, Eros presents a rose to the god of silence.
- In a Celtic folk legend, a wandering, howling spirit was silenced by presenting the spirit with a wild rose every new moon.

If a maiden had more than one lover, it is believed in one mythology, she should take rose leaves and write the names of her lovers upon them before casting them into the wind. The last leaf to reach the ground would bear the name of the lover whom she should marry.

↑ Ancient plan of the city of Prague, in the shape of a rose. This is an example of traditional geomancy or "Feng Shui" creating harmonic orientations & connections between the different parts of a whole system (here a city).

SG205A.2.8.1 The Passion Flower (1)



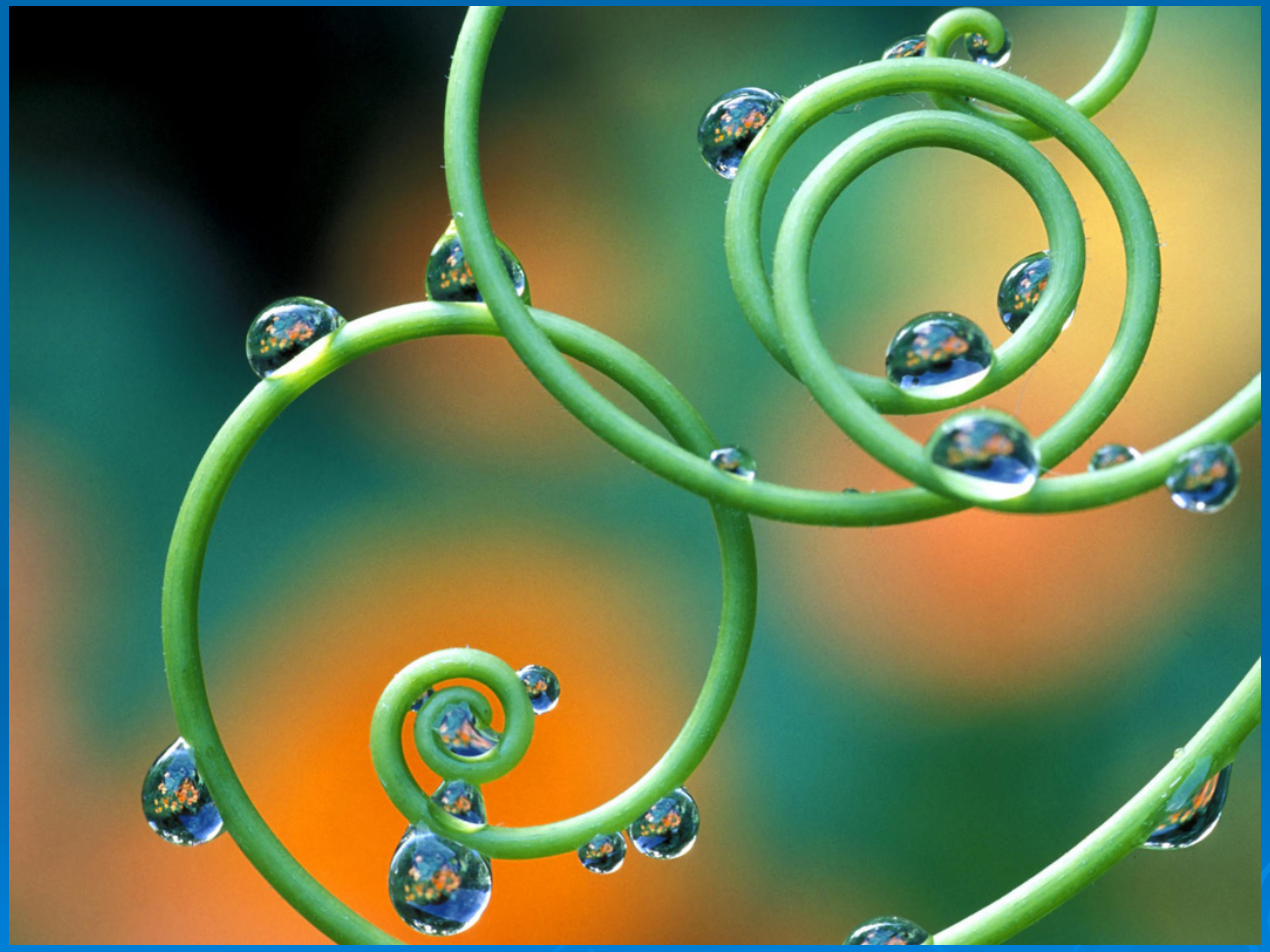
"Passiflora incarnata" **is a magnificent display of penta-symmetries and the Fibonacci numbers 2 - 3 - 5 - 8 - 13**

- **2 sets of 5 green petals.**
- **Array of purple and white stamens**
- **5 T-shaped green stamens forming a pentagon**
- **On top: 3 deep brown carpels. Top parts = 8** **(Image: //i.ehow.com)**

↑ Back view: the 3 sepals that protected the bud are outermost, then 5 outer green petals followed by an inner layer of 5 more paler green petals. Total = 13.

SG205A.2.8.2 The Passion Flower (2)

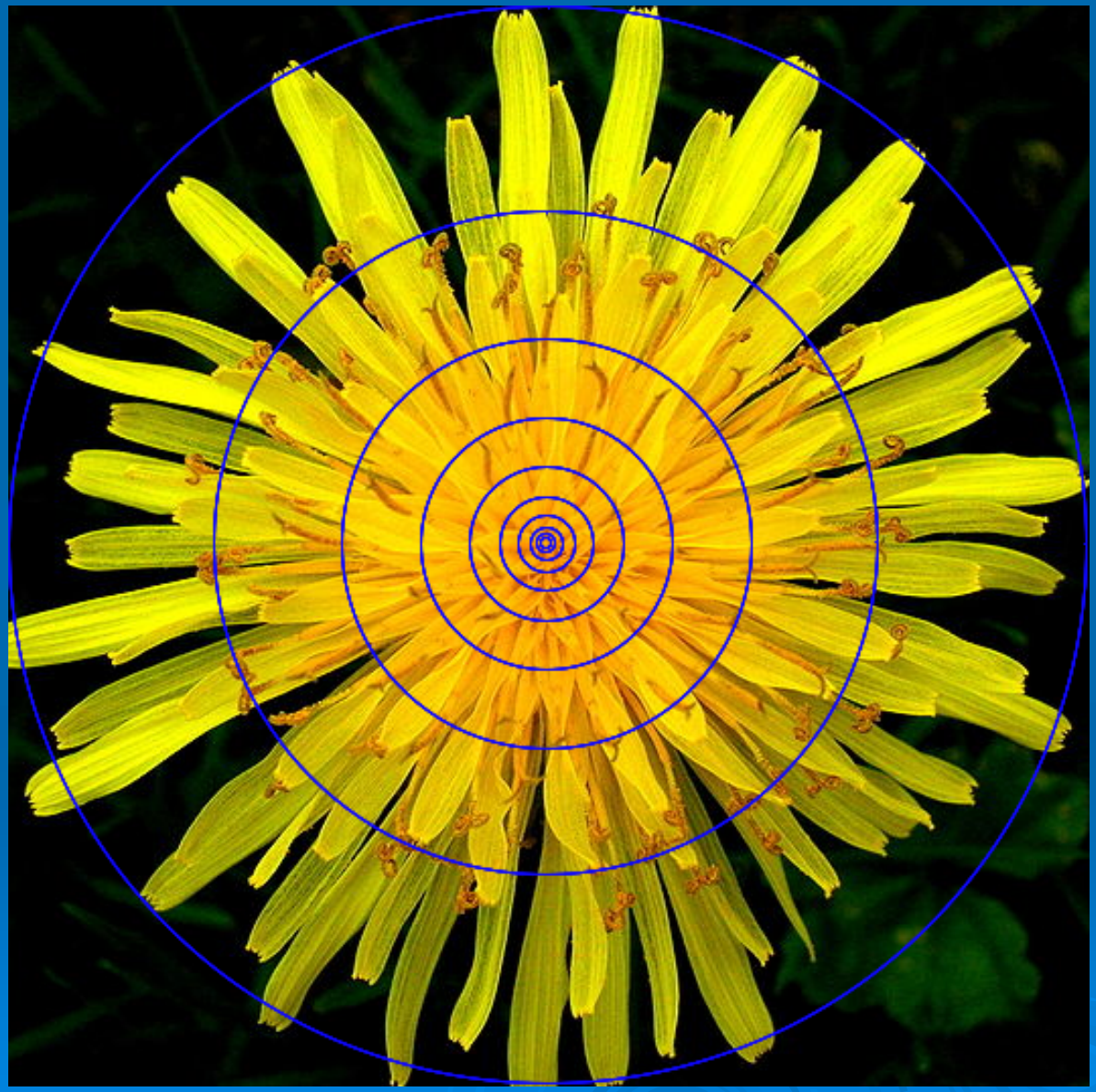
The spirals of the Passion Flower plant.



www.ecardmedia.eu

www.pbase.com

(See *infra* - images of the Passion flower's pollen: ◆SG205.3.6)



SG205A.2.9 The Dandelion

//robinsherbshop.blogspot.com

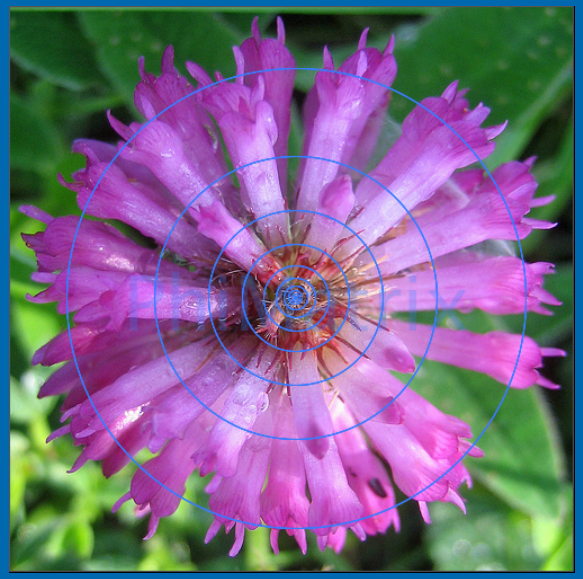
← Dandelion flower
with PHI circles (PhiMatrix™)
www.types-of-flowers.org

SG205A.2.10.1 Flower Beauties (1)

Note: we are using the concentric circles PhiMatrix™ grid on some of the flower pictures.

Images:
www.flickriver.com/photos/steffe

SG205A.2.10.2 Flower Beauties (2)



www.flickriver.com/photos/steffe

SG205A.2.10.3 Flower Beauties (3) Orchids (1)

(Note the penta-symmetries)

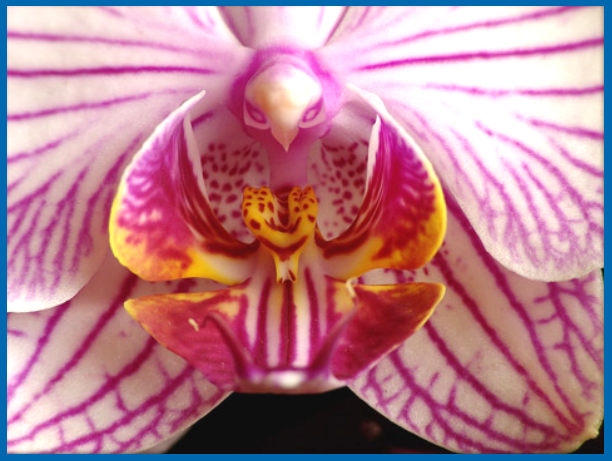
Images: Orchids in Botanical Garden. Iao Valley, Maui, Hawaii.

Perspective: The number of orchid species equals more than twice the number of bird species, and about four times the number of mammal species.

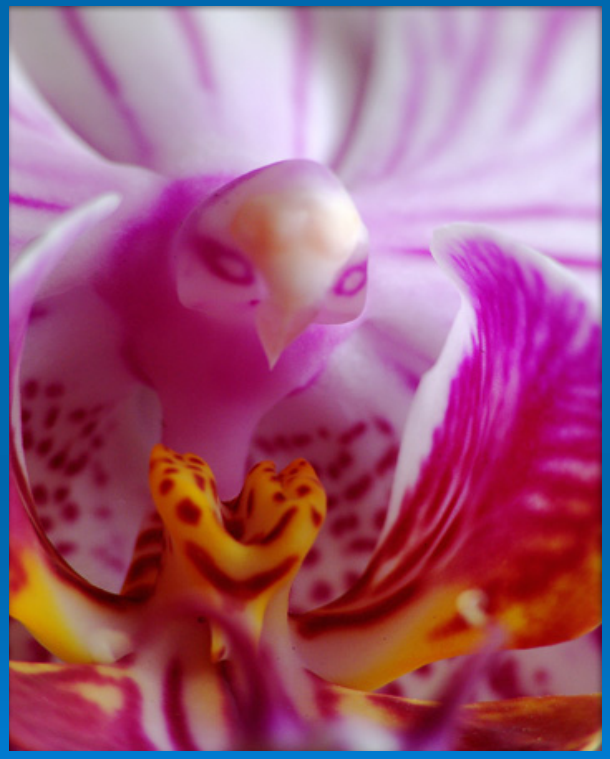
SG205A.2.10.4 Flower Beauties (4) Orchids (2)

The flower of a *phalaenopsis* (Greek *phalaina* = moth + *opsis* = looking like) orchid resembles a moth in flight. Hence the common name: Moth Orchid.
Phalaenopsis orchids are native throughout Southeast Asia, and can be found from the Himalayan mountains to as far south as the Philippines and northern Australia. They tend to grow in the shade below the canopies of moist and humid lowland forests.

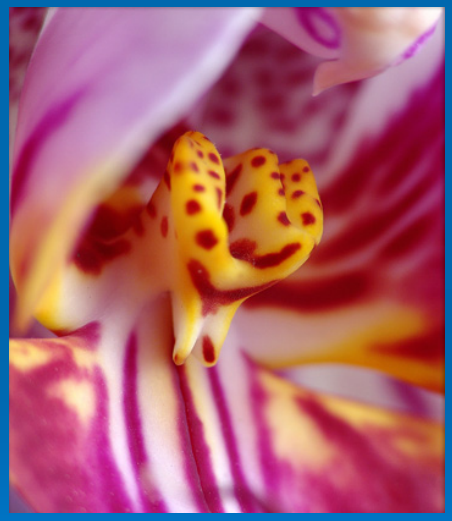
↑ Side view



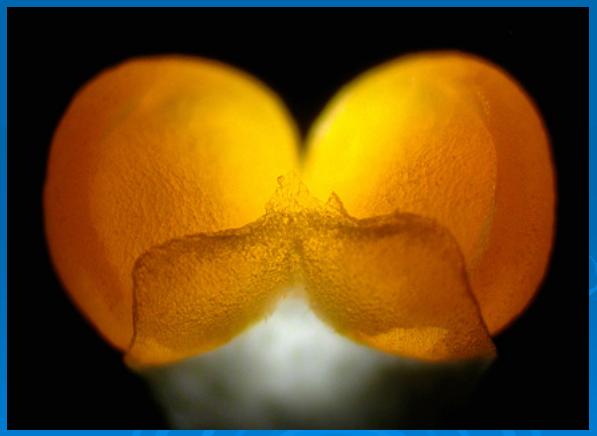
↑ For fertilization to take place, a visiting insect must alight onto the lip, climb into the throat and up onto the strangely shaped, red-spotted yellow platform beneath the anther (looking like a bird's head).



↑ Beneath the white membrane of the "bird's head", one can see two masses of yellow pollen. When the insect backs out, the "beak" breaks up and the pollen masses stick to the bird's back.



↑ The red-spotted yellow "visitor's platform"



↑ The two masses of pollen (*pollinia*) that stick to a visiting insect to be carried away to another orchid flower.

All images: Brian Johnston
www.microscopy-uk.org.uk

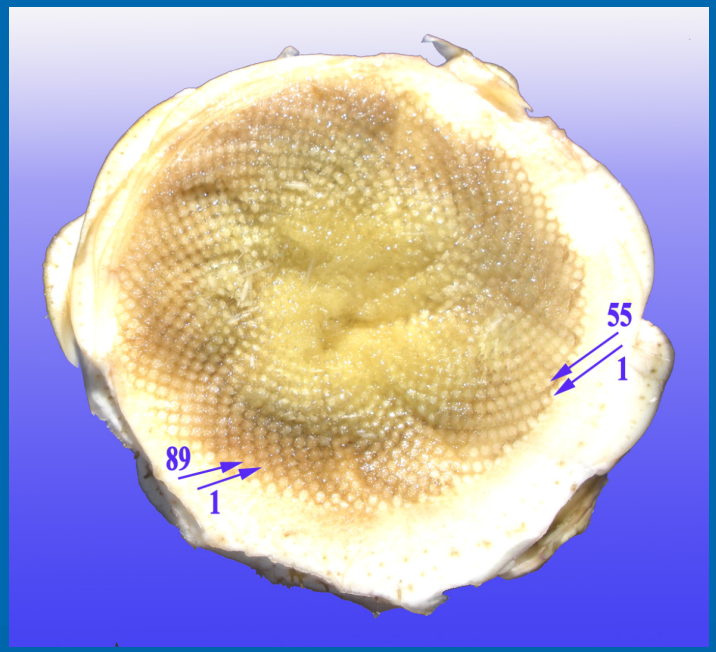
SG205A.2.10.5 Flower Beauties (5) Hawaii Flowers. 2011.

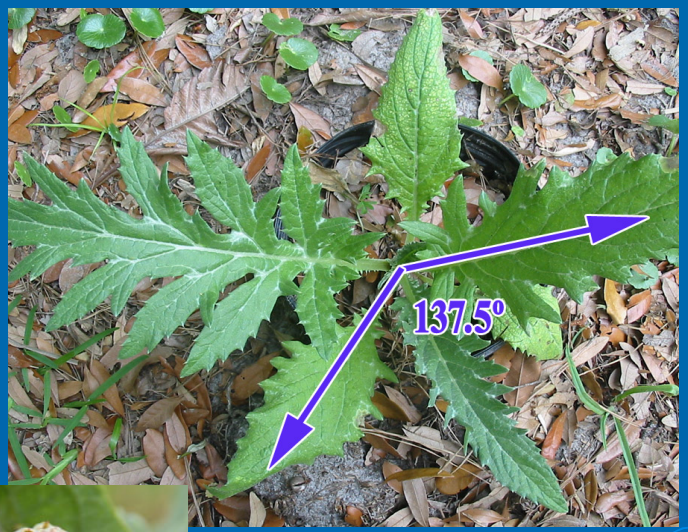
SG205A.2.11.1 Fibo Vegetables - Artichoke (1)

As I was about to eat my raw artichoke, I thought: "Oh I am going to cut a cross section and check the pattern…" Sure enough, there was a perfect sunflower seed head pattern: 55 spirals CW and 89 spirals CCW.

Actually, the whole artichoke (*cynara scolymus*) IS a flower, belonging to the thistle family. A horizontal cross section cut higher up in the artichoke displays the classical spiraling pattern of primordia separated by the Growth Angle of 137.5º. The artichoke plant itself grows long leaves at Growth Angle locations.

Artichoke is a traditional diuretic. It also contains *cynarin*, an agent known to increase the bile flow.



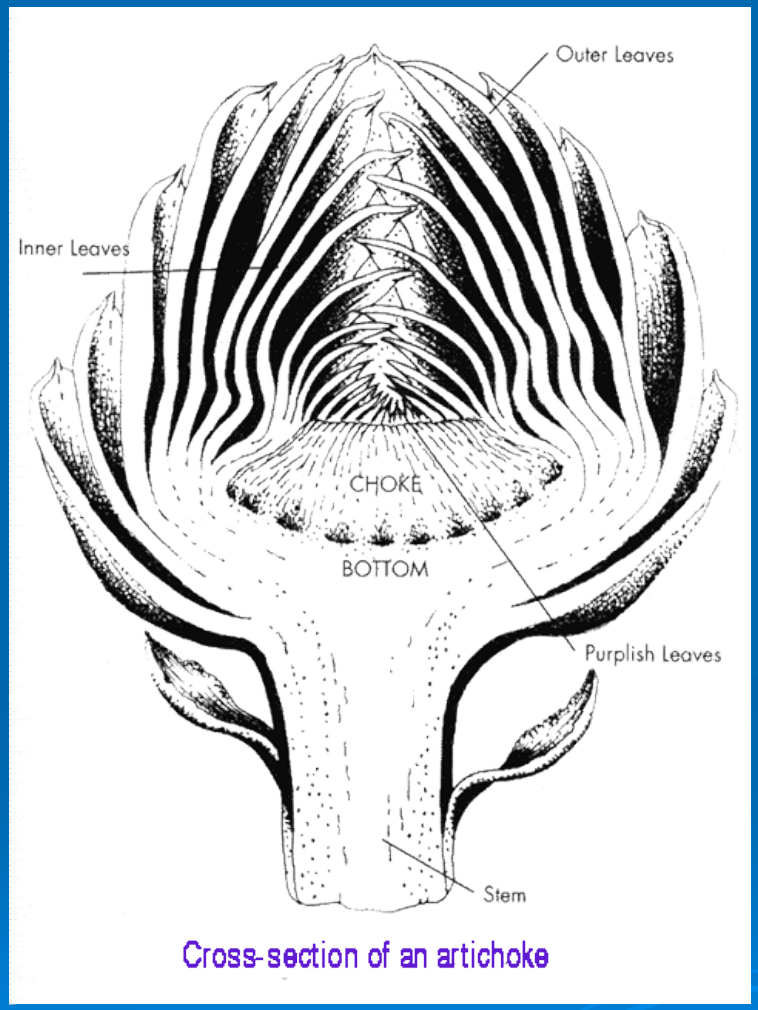


← When the artichoke is blooming, you can see that it is a glorious flower, just like the sunflower.

↑ The artichoke plant itself shows long leaves at Growth Angle locations.

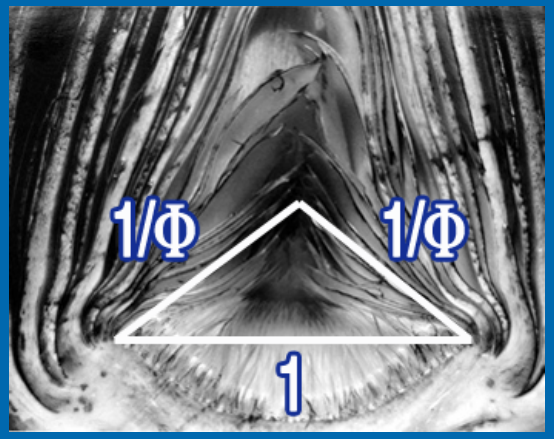
← See the spirals formed by the bracts.

SG205A.2.11.2 Fibo Vegetables - Artichoke (2)



Cross-section of an artichoke

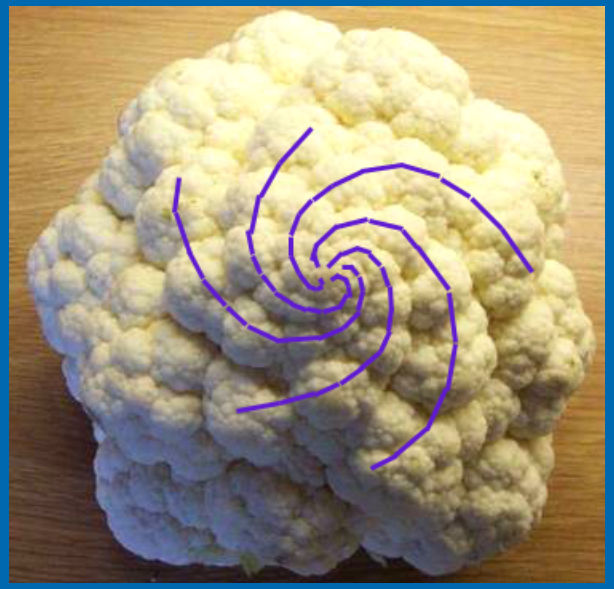
The vertical cross-section of an artichoke is also quite revealing of exquisite symmetries and proportions.



← Golden Gnomon triangle. Overlaid on "Artichoke" by Edward Weston (1930).

//theartichokeblog.com

SG205A.2.11.3 Fibo Vegetables - Cauliflower



From a top-view perspective, there are 5 distinct spirals.

This is your ordinary cauliflower. Note how it is almost a pentagon in outline. Looking carefully, you can see a center point, where the florets are smallest. Look again, and you will see how the florets are organized in spirals around this centre in both directions.

The cross-section of a cauliflower shows the fractal structure.

The numbers (in blue) indicate the fractally decreasing size of the "cauli-trees".

Here is some "cauliflower homework" suggested by Dr. Ron Knot in his famous Fibonacci website:

Take a look at a cauliflower next time you're preparing one.
FIRST, LOOK AT IT:
• Count the number of florets in the spirals on your cauliflower.
The number in one direction and in the other will be Fibonacci numbers, as we've seen here.
• Do you get the same numbers as in the picture?
• Take a closer look at a single floret (break one off near the base of your cauliflower). It is a mini cauliflower with its own little florets all arranged in spirals around a centre. If you can, count the spirals in both directions. How many are there?
THEN, WHEN CUTTING OFF THE FLORETS, TRY THIS:
• Start at the bottom and take off the largest floret, cutting it off parallel to the main "stem".
• Find the next on up the stem. It'll be about 0.618 of a turn round (in one direction). Cut it off in the same way.
• Repeat, as far as you like and…
• Now look at the stem. Where the florets are it looks rather like a pine cone or pineapple.
The florets were arranged in spirals up the stem. Counting them again shows the Fibonacci numbers.

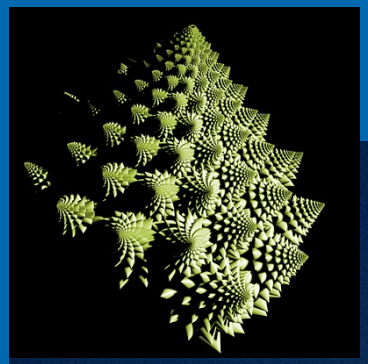
SG205A.2.11.4 Fibo
Vegetables - Cabbage

↑ Vertical cross-section showing the fractal folds.

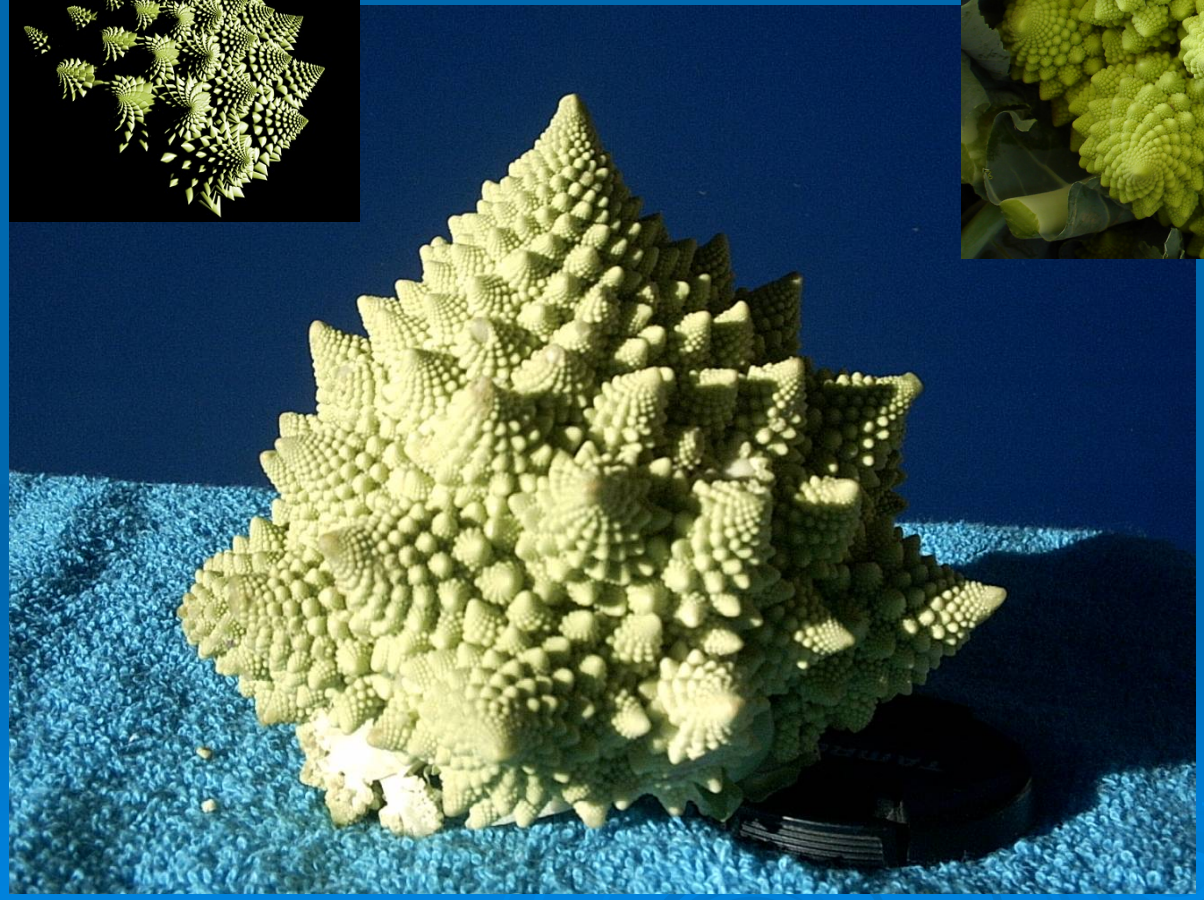
↓ ↑ Horizontal cross-sections showing the spiral structure.

SG205A.2.11.5 Fibo Vegetables - Romanesco

The "Romanesco" cauliflower



… feeding on live, raw,
fractal harmonics…



↑ A fractal forest.
Vertical cross-section
by A2zumac.
www.flickr.com

SG205A.2.11.6 Fibo Vegetables - Lettuce

"Butterhead" lettuce has no proper stem for the leaves. Carefully peeling off the leaves, from the outermost first, notice that they overlap and there is usually only one that is the outermost each time. Find some Fibonacci number connections and admire the creatively packed spirals of golden angles…

← Vertical cross-section of a "romaine" lettuce.

SG205A.2.11.7 Fibo
Vegetables - Onion

↑ Beautiful curves of growth.
Notice how the skin's color seeps through the cracks of the curving layers, like light in caves of crystal ice.

↑ Onion root

↑ Spiral growth at the apical meristem of onion root.
www.nowyteatr.org

Onion "Snow Peaks"
by Angelwhispers
www.mylot.com

← The 9 layers embedded in this → onion.

SG205A.2.12.1 Fibo Fruits - Banana (1)

What about the harmonics of a banana? Count how many "flat" surfaces it is made of - is it 3 or perhaps 5? Cut it sidewise and look again: Fibonacci number.

Banana tree with inflorescence (below), stem with Golden Growth angle spiraling tiers, and banana fruits (top).
//each-one-teach-one.wikidot.com

↑ Transverse section of a banana

↑ Banana trunk. By Detengase

↑ "Banana tree" by Sandie Smith

SG205A.2.12.2 Fibo Fruits - Banana (2)

A banana chalice

Baby banana seedling developing its first leaf. A perfect growth spiral or vortex of life.

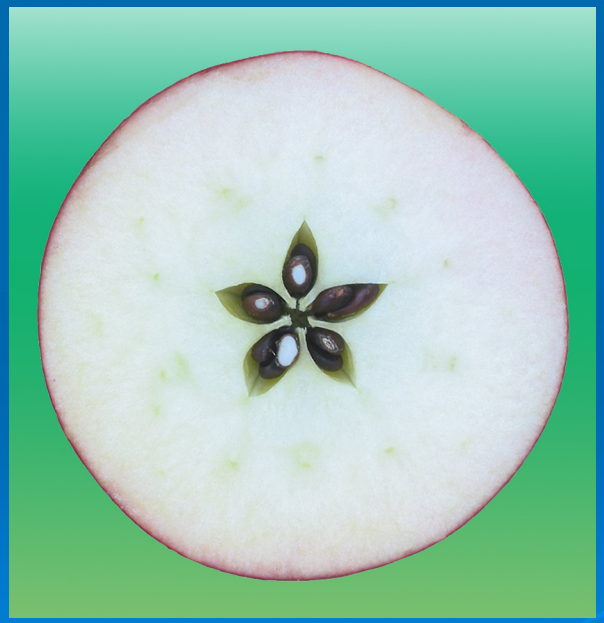
//commons.wikimedia.org

SG205A.2.12.3 Fibo Fruits - Apple

"Why do apples blossoms always have five petals? Only children ask such questions…

When we look deeply into the patterns of an apple blossom, we discover a perfection, an incredible order, that awakens in us a sense of awe that we knew as children. Something reveals itself that is infinitely greater than we are and yet is part of us…."
(Such is the opening sentence of G. Doczi's pioneering book The Power of Limits.)

Instead of cutting an apple from the stalk to the opposite end where the flower was (i.e. from "North pole" to "South pole"), try cutting it along the "Equator". The penta-symmetry appears.



↑ The *gynoecium* of an apple contains five *carpels*, arranged in a penta-star geometry.
(Wikipedia)

↑ Apple 5-petaled blossom

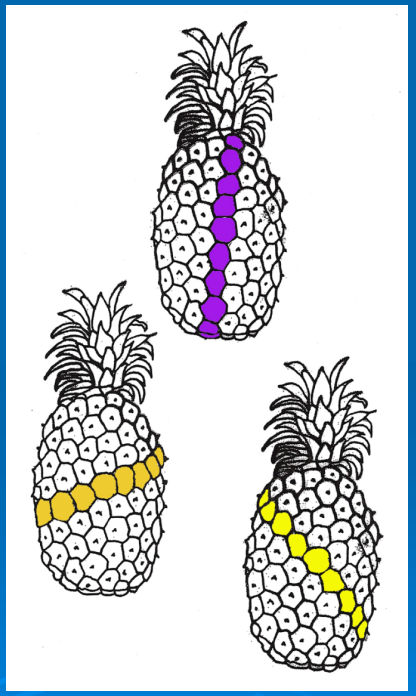
[For the symbolism of the apple: ◆SG305]

SG205A.2.12.4 Fibo
Fruits - The Pineapple

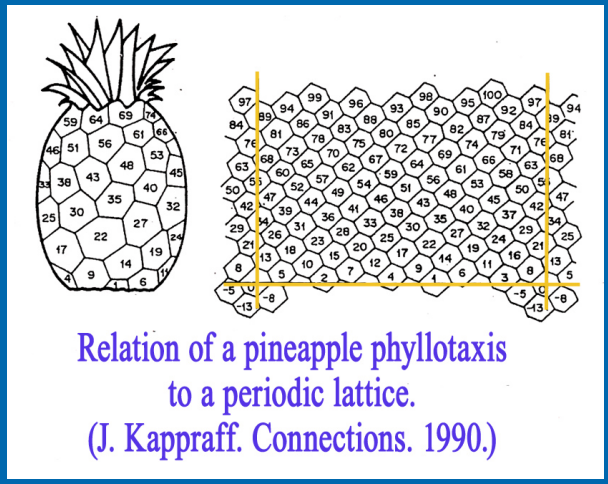
Leaving behind the common pinecone that only shows two sets of Fibonacci-related parastichies (spirals), the pineapple goes further: it exhibits an exquisite lattice of 3 SETS of spirals.

"The fruit of a pineapple is arranged in two interlocking helices, eight in one direction, thirteen in the other, each being a Fibonacci number." **(Wikipedia)**

↑ Pineapple flower



↑ The 3 spirals of the pineapple.

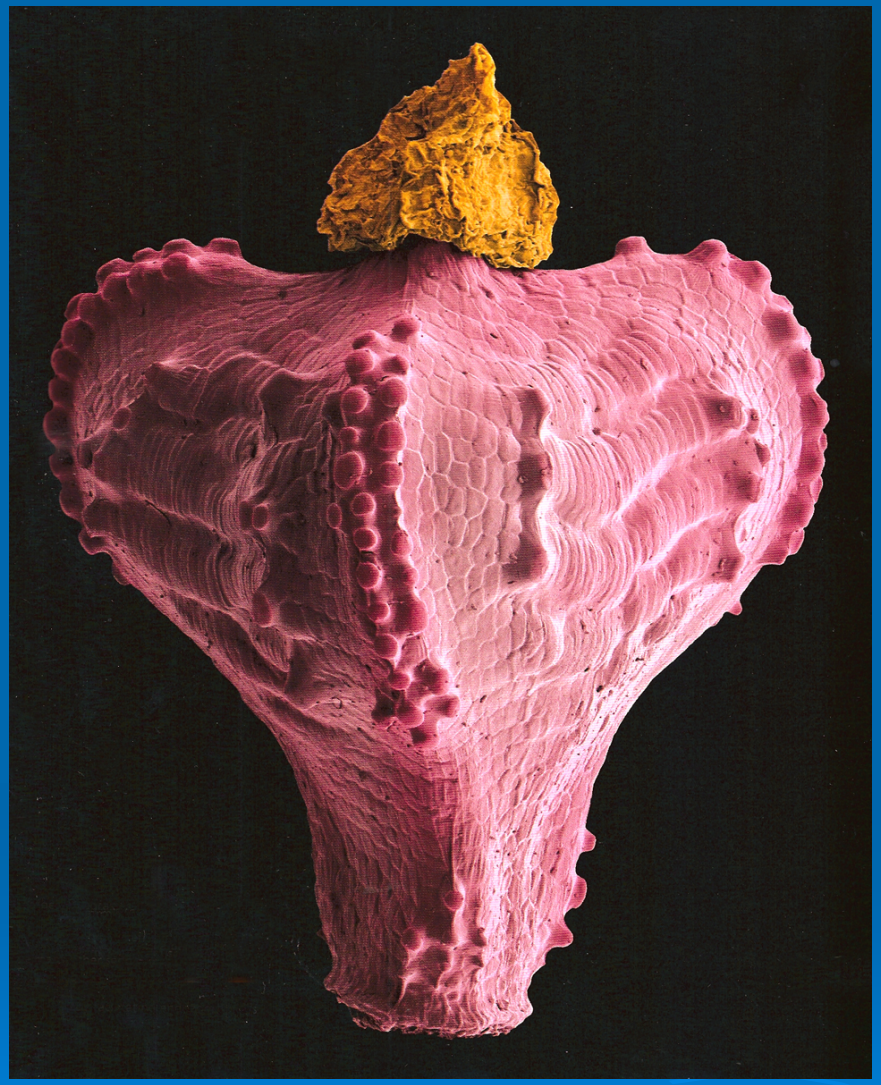


↑ In this model, the initial stalk is adjacent to the 5th, 8th, and 13th stalks, all Fibonacci numbers. These stalks line up with the initial stalk along a series of 5, 8, and 13 diagonal lines of hexagons which represent the number of clockwise and counterclockwise spirals on the surface of the pineapple. (Kappraff)

<u>Pineapples & Hummingbirds</u>

Pollination is required for seed formation, but the presence of seeds negatively affects the quality of the fruit. In Hawaii, where pineapple is cultivated on an agricultural scale, importation of hummingbirds is prohibited for this reason.

SG205A.2.13
Extraordinary Fruits

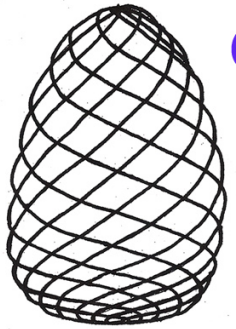


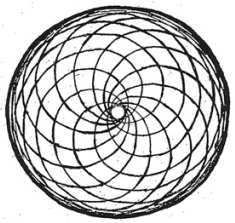
↑ Fruit of *Bulbostylis hispidula.* East Africa.
Fruit. Rob Kesseler. 2008.

↑ Fruit of *Rubus phoenicolasius*. (Japanese Wineberry)
Native to Asia.
Fruit. Rob Kesseler. 2008.

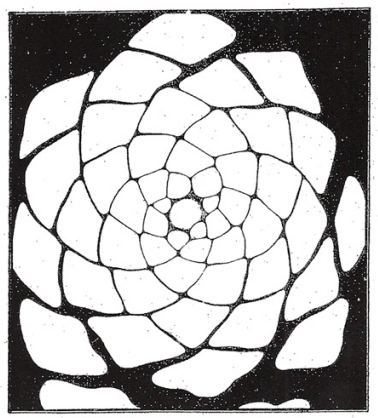
SG205A.2.14.1 Geometries of the Pine Cone (1)

Geometries of the Pine Cone



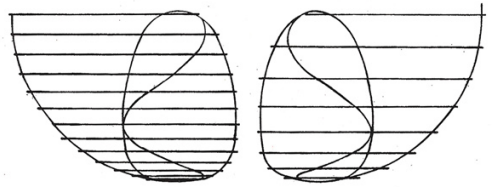


Double spiral pattern (8/13) in a pinecone. (After G. Doczi).

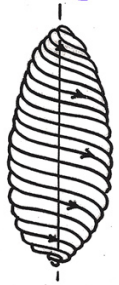


Pineus Pinea...system 5 + 8.
Transverse section of the apex of the young seedling.
(A. H. Church. 1904)

Outlines of two spirals.



The two spiral systems (parastichies) on a pine cone



Left: Descending Yang energy spirals.

Right: Ascending Yin energy spirals.

At the node-points where spirals cross, energy charges fuse together to create new seed and bring forth life. (After Callum Coats. Living Energies.)

SG205A.2.14.2 Geometries of the Pine Cone (2)

↑ Close-up of pinecone's bracts (scales).

← The scales on the cone of a conifer tree are arranged around a central axis where the Fibonacci spirals are clearly visible.

↓ Similarly, the branch of a pine tree, when the needles have been removed, will show the same Fibonacci spirals.

(Two above photographs by J. C. Perez in "L'ADN Decrypté" - 1997.)

SG205A.2.15 Palm & Coco Trees

↑ The trunk of some palm trees show obvious Fibonacci spirals.

In a coconut → tree trunk, the imprints left by the leaves (as they wind around spaced by the Golden Angle of 137.5°) form sine waves of alternating starting polarities marked by Fibonacci numbers.

Image

//coconutshellearrings.com

←↑ Coconuts cluster following the Golden Angle.

SG205A.2.16 The Cycads and their Cones

The Cycads are plants which lay "eggs": an extraordinary curiosity in the vegetable kingdom. They are living fossils from the Mesozoic era (about 200 million years ago). Similar to ferns, palms or conifers, they have separate sexes. Described as "striking architectural plants", the Cycads look like palms but are not. They produce big ovules similar to fruits. They grow very slowly and can change sex. They are an endangered species. Cycads have been known as symbols of immortality in many cultures. Like the pineapple and palm trees, they display "tri-spirals". Some cycads, like the Stangeria or Cycas thouarsii, have stunningly beautiful cones.

↑ *Encephalartos sclavoi*
(Wikipedia)

↑ Female (left) and male (right) cones of *Encephalartos natalensis*.
//nd.edu/~fboze/cycads.shtml

↑ Cones of the *Cycas thouarsii*

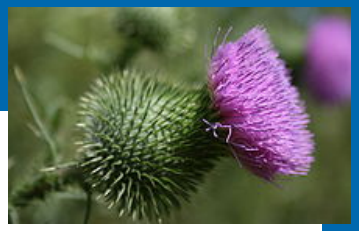
↑ "Eggs" of the *Stangeria*.
www.photomazza.com

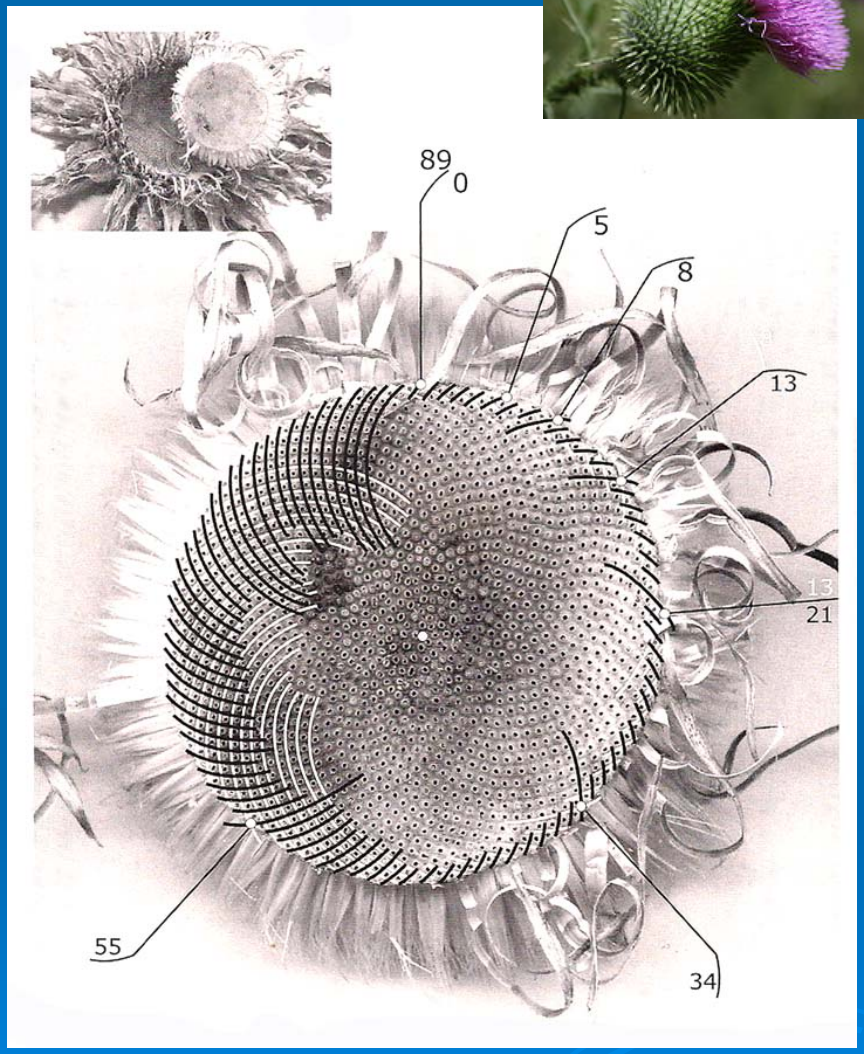
↑ Cones of the *Stangeria eriopus*
//pacificcycad.com

SG205A.2.17 The Thistles

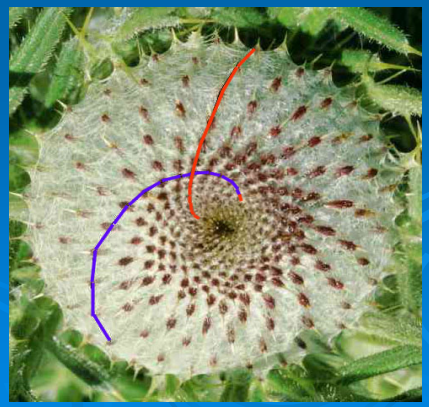
Belonging, like the sunflowers, to the family of Asteraceae, the thistles have a very specific Fibonacci phyllotaxis. Traditionally, thistles are an ancient Celtic symbol of nobility of character as well as of birth.

Bull Thistle. ➔ Note the spiral symmetry of the prickles.





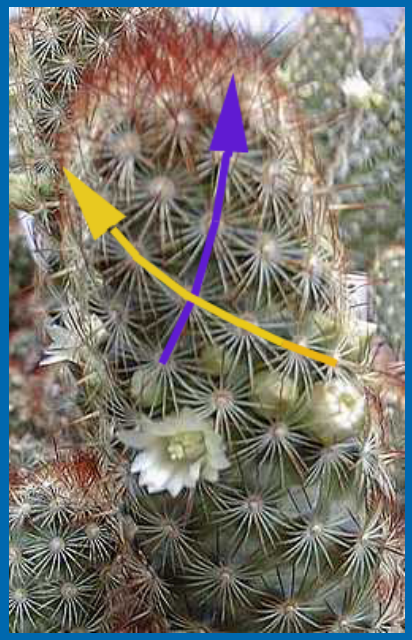
↑ Just like a sunflower, this thistle displays 89 spirals (in black) one way and 55 spirals (in white) the other way.
Image: Robert Chalavoux. *Nombre d'Or*. 2001 www.chalagam.com



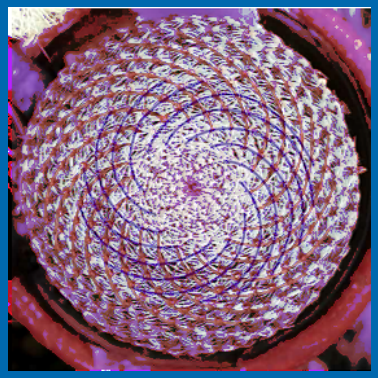
↑ Globe thistle
By Melanie Eclare

← 13/21 pattern
www.branta.connectfree.co.uk

SG205A.2.18
The Cacti



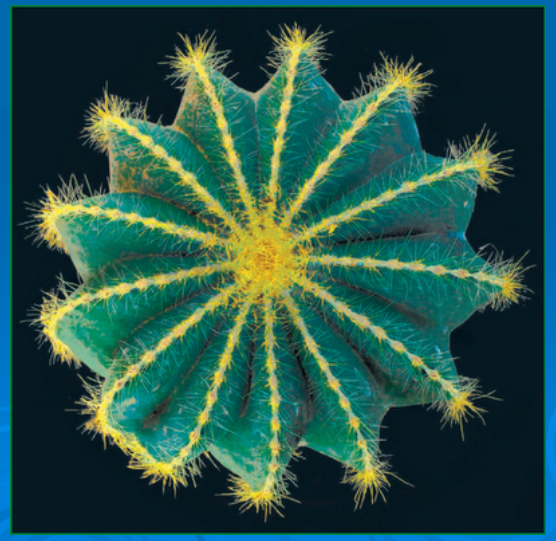
Mammilaria elongata
www.desert-tropicals.com



↑ Superimposing the two spirals (13 blue + 21 red)

Closeup image of a cactus flower (*Echinopsis spachiana*) showing the dancing stamens. (Wikimedia)

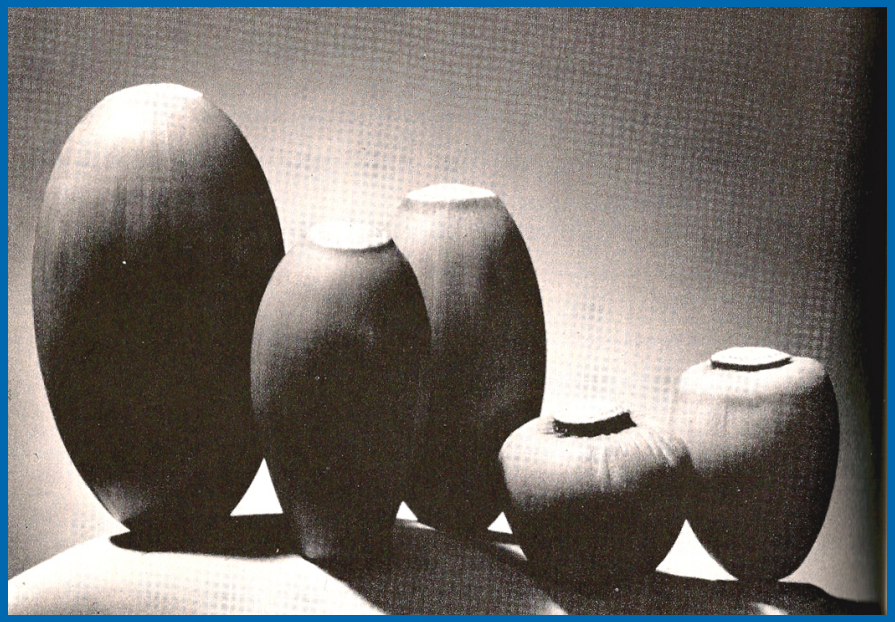
Cactus top view. Fibonacci numbers 13/21. Credit



SG205A.2.19.1 Plant Designs (1)

Nature's designs are stunningly appealing.
Examples from Bertel Bager. *Nature as Designer*. 1976 / 1961.

***Iris germanica*. Also called "sword-lilly".**

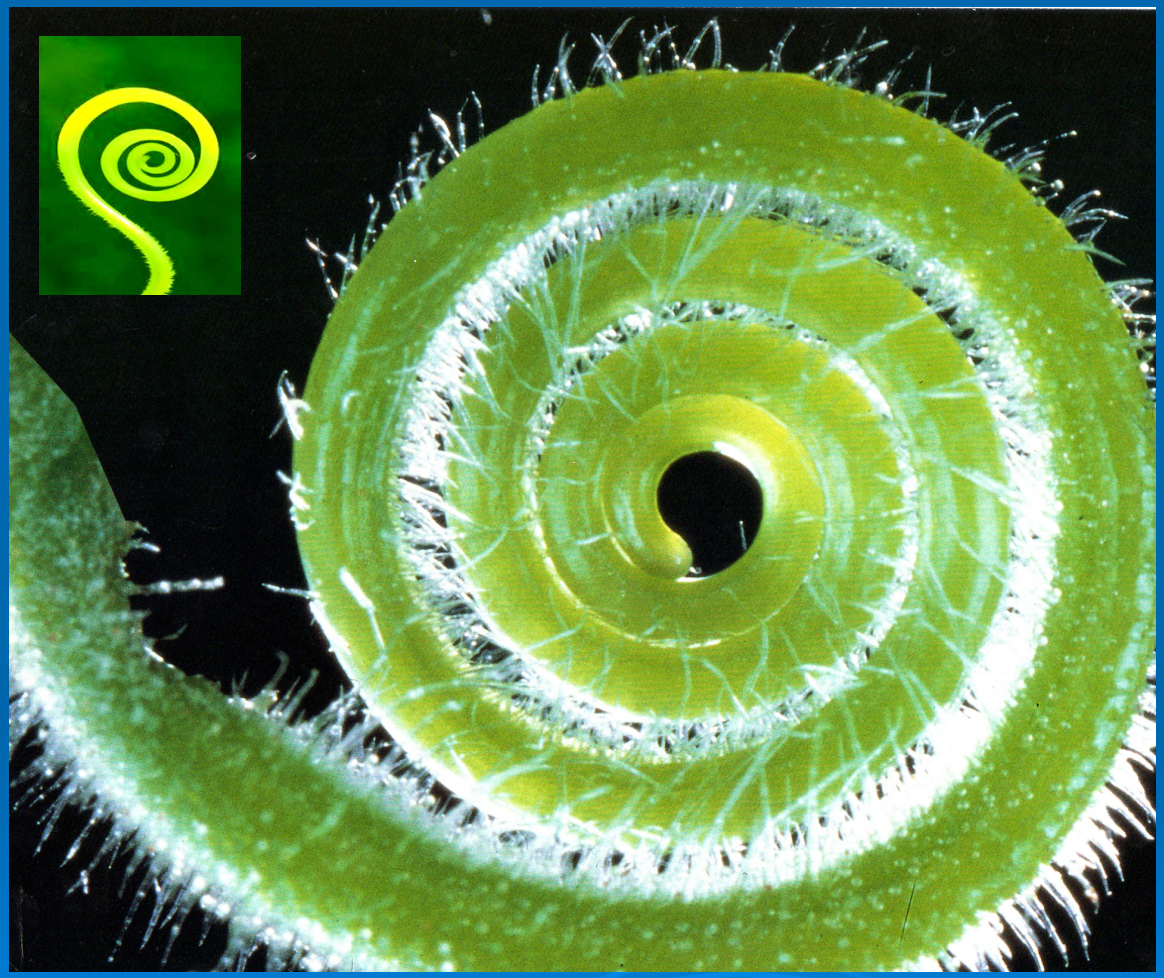


Acorns from oak (*Quercus robur*).

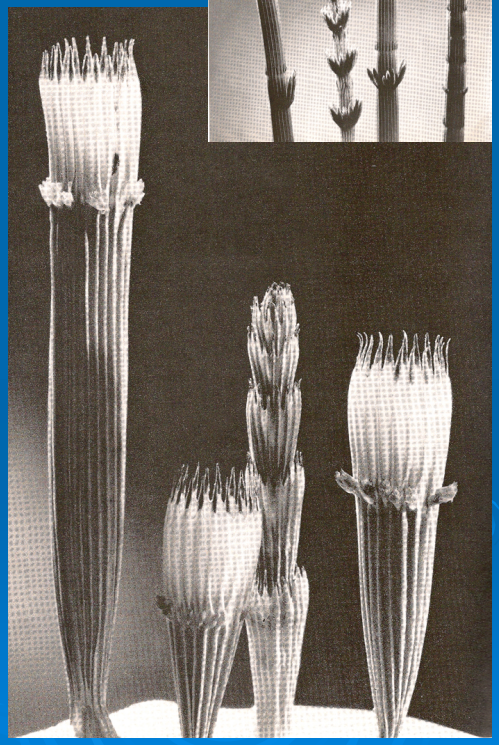
🡸 Spire from hemlock's storkbill (*Erodium gruinalis*).

***"This spiral is a marvel of engineering. It is very sensitive to moisture, untwisting when damp. When the seed reaches the ground, this untwisting movement helps to bury it deeper. Short hairs on the seed and long rigid hairs along the spiral, all backward-pointing, also play a part by braking and holding the seed, and ensuring that the spiral movement assists in deeper burying."* (Bertel Bager).**

SG205A.2.19.2 Plant Designs (2)



➔↓ The fractal elegance of horsetail.



↑ The progressive unfolding of a fern, from an Archimedean spiral to a logarithmic (growth) spiral.

SG205A.2.20.1 Zooming on Plants (1) Macro-Pics

The Sacred Geometry and harmonic symmetry of nature can show up gloriously with dedicated microscopy and SEM (scanning electron microscopy) imaging.

However, using hand-held macro-lenses also allows for stunning macro-photography.

Purple iris petal. www.slrphotographyguide.com

Hoverflight. www.slrphotographyguide.com

The following pages are offered for sacred contemplation. Thanks to the photographers.

SG205A.2.20.2 Zooming on Plants (2) Digital Microscopy

Zooming deeper into the beauty of the plant kingdom requires microscopy techniques. Digital microscopy integrated equipment (digital microscope with screen and built-in camera) is now a very affordable option offering wondrous possibilities.

↑ *Viola prionantha*. By Yangping Wang.
Beijing Planetarium. 2009 Olympus competition.

↑ *Clematis vitalba*. By Viktor Sykora.
Czech Republic. 2010 Olympus Competition.

(Both images: www.olympusbioscapes.com)

SG205A.2.20.3 Zooming on Plants (3) Tomato Trichomes

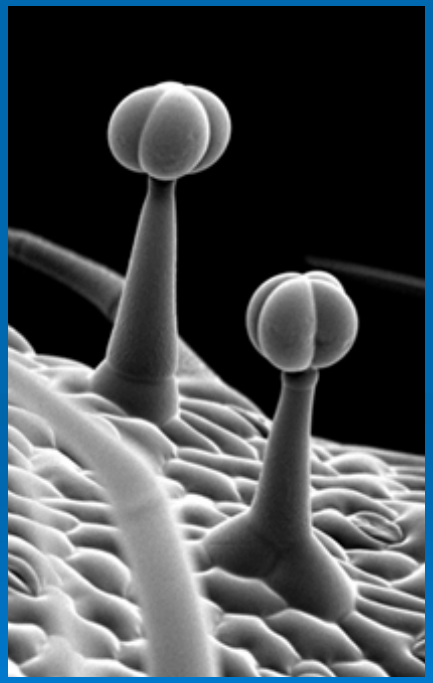
As we are able to peek into the detailed functioning of plants, we find an amazing degree of integrated efficiency tuned to a perfect resonance with all aspects of the environment and with the larger cosmic field. Here is just one example: the glandular *trichomes* in the tomato plant.

Secretory and glandular trichomes (SGTs) are found on the surfaces of above ground plant tissues of approximately 30% of all vascular plant species. Humans are familiar with these structures because they contain the essential oils that give cooking herbs their distinctive smell and taste. In addition to making foods taste better, these uni- and multi-cellular appendages are proposed to play a critical role in plant protection against various environmental stresses including herbivore attack and pathogen infection. (www.trichome.msu.edu)

↑ Stem of a tomato plant (*Lycopersicon esculentum*). www.psmicrographs.co.uk

The surface layer consists of epidermal cells that have thickened outer walls and secrete a waxy coating, or cuticle, which prevents water loss. Gases are exchanged through openings, or stomata, in the epidermal layer (raised openings, lower left corner for example).

The glandular hairs, or trichomes, (vertical spines) bear groups of cells (brown spheres) that secrete oils which are irritating to predatory insects.

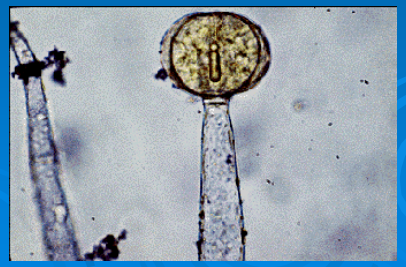


↑ Trichomes on a tomato leaf www.bch.msu.edu Type VI (generally 4-celled glandular head)

Five kinds of glandular trichomes have been found in tomato species, which are Type I, large with multi-cellular base; Type III, intermediate in size with a single basal cell; Type V, short, slender, 1-4 celled; Type VI, short with a 2-4 celled glandular head and Type VII, 0.05-0.1 mm smaller glandular hairs with a 4-8 celled glandular head.

← A close-up on the stem of a tomato plant. Hairs and trichomes are sticking out. They are multi-function antennas interacting with the web of life.

www.dampkring.nl



← Tomato glandular trichomes have been found to contain crystals (calcium oxalate and cadmium oxalate). www-plb.ucdavis.edu

SG205A.2.21 Reflections on Fibonacci/Lucas in Plants

As human consciousness evolves, we are peeling off the first layers of appearances in the 3D realm and we are already uncovering the extensive presence of the Fibonacci lattice structure. Soon new comprehensive explanations will provide a larger understanding, possibly related to the Zero Point Vacuum Field, as the human perception mechanisms change to increasingly reflect an expanded awareness of cosmic harmony.

The Fibonacci Series and its limiting convergence to PHI is only the visible expression of a much more complex and universal dynamics of cascading harmonic organization of the cosmos. These are exciting times, on the cusp of two paradigms. Could it be that these sequential paradigms are related by a Fibonacci factor in terms of their expansion? There is evidence that consciousness itself follows quantum, fractal steps of evolutionary expansion, moving along a spiral pattern that could well be the PHI Proportion…

To be sure, the Fibonacci patterns in nature were established way before Leonardo da Pisa aka Fibonacci was born or the Fibonacci Association was created in 1963. Yet it is interesting to note that human perception seems to only be progressively attuned to the natural harmonic order represented by the Fibonacci Series. It is as if human consciousness, as it evolves & expands, is becoming more able to consciously look through the superficial randomness and suddenly SEE underlying patterns of order never perceived before. As an example: older herbal books present drawings of the *Sunflower* along with some of its medicinal properties, but if you look closely at the drawings, the center of the sunflower is a collection of circular rings with random points, completely missing the Fibonacci-based exact number of spirals of the florets (seeds) that are now so obvious to us.

My conclusion is that we are just WAKING UP to perceive the entire universe as a gigantic HARMONIC ORCHESTRATION of wave forms, all inter-connected in multi-simultaneous ways: a grand play indeed to be born into.
The journey of cosmic consciousness has begun: welcome!

← Copperplate engraving of a sunflower (*Helianthus Annuus*) from *Hortus Floridus* by Crispian van de Passe. Published in Arnheim in 1614-1617.

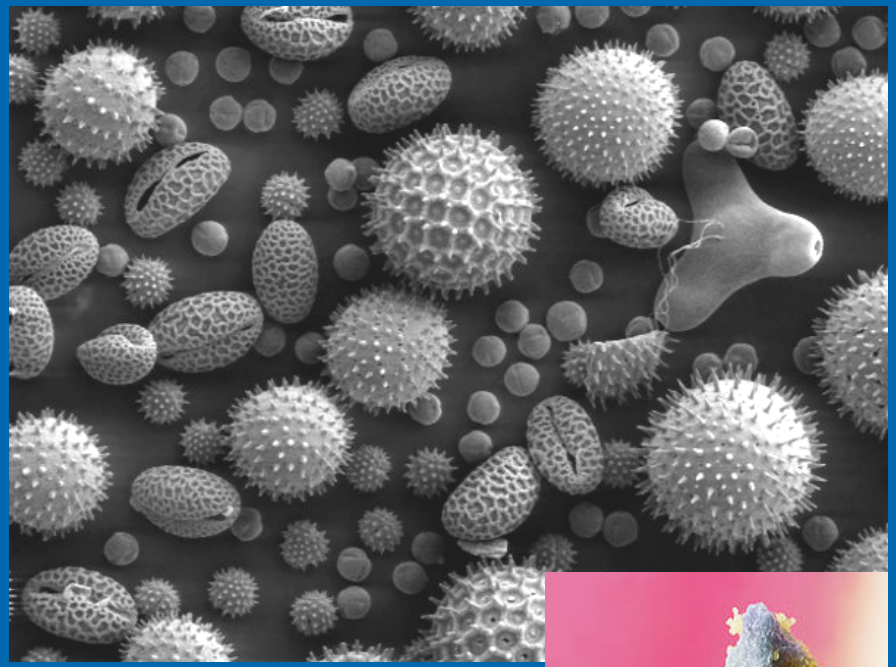
(From Richard G. Hatton. *Handbook of Plant and Floral Ornament from Early Herbals.* Dover. 1960)

The way ➔ most people see sunflowers.

But oftentimes, the spirals had to be pointed out before the person suddenly SAW them…
… just like one suddenly SEES the 3D effect of a stereogram.

SG205A. Chapter 3. Geometries of Pollen

SG205A.3.1.1 The Pollination Process (1)



↑ Pollen grains from a variety of common plants. Note the geodesic ("buckminsterfullerene") structure of some pollen grains. www.microbehunter.com

↑ Bee collecting pollen.

↑ Pollen grains on a tulip stamen. (Wikipedia)

The website http://www.geo.arizona.edu states: *"Pollen grains* are an outrageous invention of the seed plants, which first appeared over 300 million years ago. Pollen frees the seed plants from dependence on standing water for *fertilization*, which is needed by the spore-reproducing plants like ferns. The distinction is similar to the difference between amphibians *vs.* reptiles".

Pollen is a fine to coarse powder produced in the male organs of the flowers - *anthers*. (See next page).

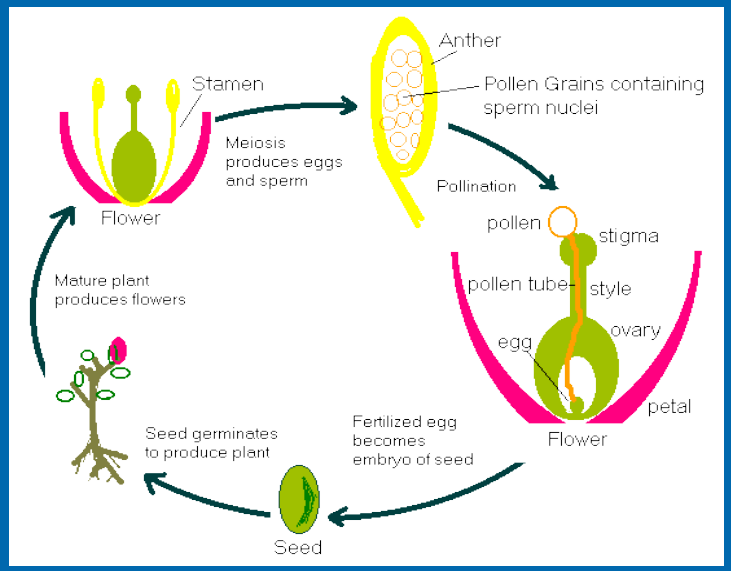
Simple description (case of the sunflower)

Most plants rely heavily on pollen movement between plants, via insects and bee colonies. These organisms benefit the plant because they carry pollen from plant to plant, allowing cross-fertilization to take place.

Flowers contain both male and female producing parts. In order for reproduction to take place, the pollen (which will produce the sperm) has to come into contact with the stigma of the pistil (which contains the ovule with the egg). Pollen is pushed out the top of the style and is then ready to be picked up by any insects that happen to visit the flower in search of pollen or nectar. Bees are most common visitors. Once the style has pushed the pollen out by its piston-like action, it splits open, exposing the stigmatic surface, which thus far has remained virgin but is now ready to receive pollen.

The pollen then descends down the style, and in a short time sperms are discharged, one of which will fuse with the egg and thereby initiate the development of a new seed. However if by chance the flower does not receive any pollen from an outside source, the stigma curves around and eventually contacts its own pollen so that self-pollination may then take place, thus ensuring seeds. And the growth process starts once again. http://bioweb.uwlax.edu

SG205A.3.1.2 The Pollination Process (2)



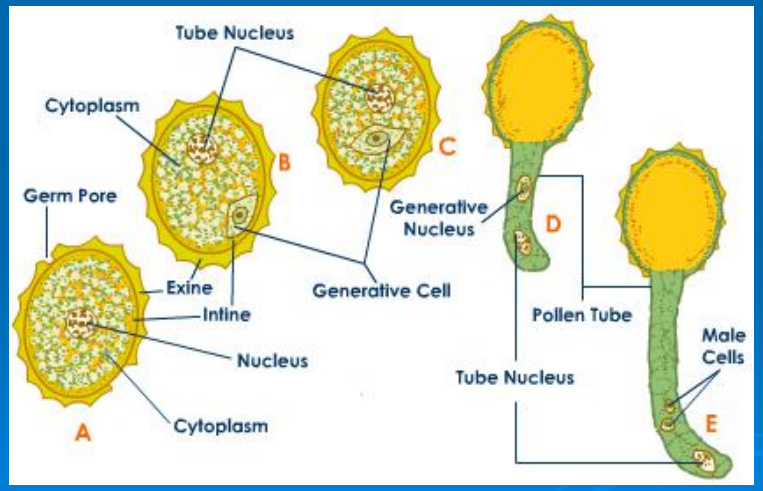
The cycle of pollination & fertilization. www.geo.arizona.edu

The pollen grains which reach the sticky stigma, absorb these secretions, swell up and rupture at one of the germ pores. The thin *intine* emerges out in the form of a pollen tube which continues to grow and penetrates deep into the style.

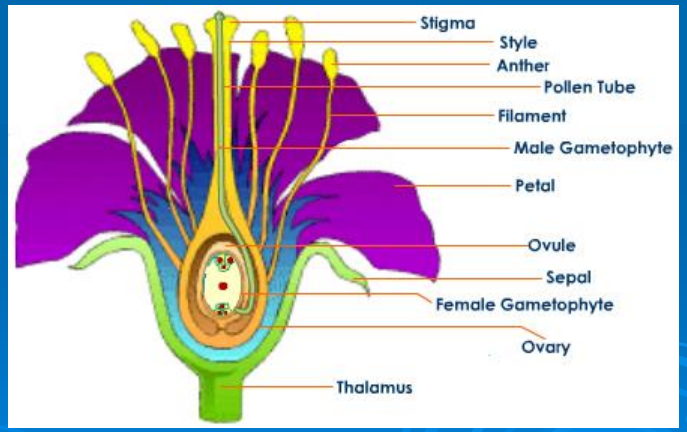
The contents of the pollen grain move into the pollen tube. The tube nucleus moves first and comes to lie at the tip of the pollen tube. This is followed by the migration of the generative cell or the two male gametes if they have already formed.

The pollen tube enters into the ovule, through the *micropyle*. Inside the embryo sac, the tip of the pollen tube ruptures and the 2 male gametes are set free near the egg apparatus. This entire phenomenon of fertilization involving the fusion of the egg and one of the male gametes, together with the union of the second male gamete with the secondary nucleus or the polar nuclei is called a double fertilization.

Images & text: www.tutorvista.com



Stages in the germination of a pollen grain. Note the growth of the pollen tube.



Longitudinal section of a flower showing germination of pollen grains and the phenomenon of fertilization. One pollen tube has grown through the style and has entered the embryo sac.

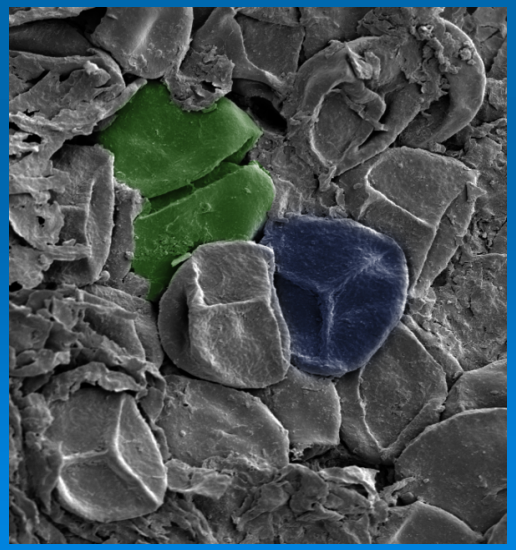
SG205A.3.2.1 The Science of Pollen - Palynology

The study of pollen is called *palynology*, a branch of science concerned with contemporary or fossil palynomorphs (pollen shapes). Palynology can be applied to problems in many fields including geology, botany, paleontology, archaeology, pedology (soil study), and geography.

Pollen are decay-resistant and keep for a long time, up to geological times. Therefore the importance of fossil palynomorphs (organic-walled microfossils between 5 and 500 micrometers in size) in geology and archeology.

Here we are concerned with what could be called "phyllotactic palynology": the geometrical arrangement of pollen geometries in harmonic patterns.

We will also note examples of the resonant correspondences between pollen and their plant, as if some common "personality" was expressed in the various aspects/phases of the plant life and its unique contribution to the orchestra of life.



← A late Silurian (443 - 416 Mya - million years ago) sporangium bearing *trilete* spores. Such spores are the earliest evidence of life on land.

Green: A spore tetrad.
Blue: A spore bearing a trilete mark (the *Y*-shaped scar).
The spores are about 30-35 µm across.

(Wikipedia)

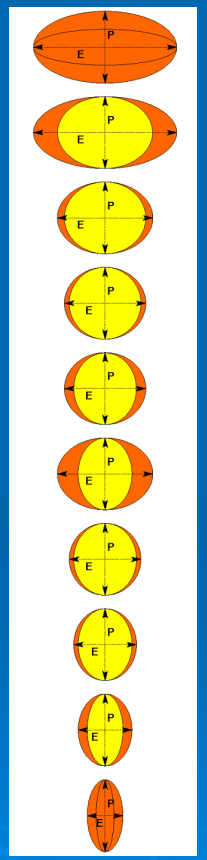
↑ Year 2008 (Vol. 32) publication of the Palynological Society, founded in 1967.
The pollen image on this cover is *Helianthus annuus* or common Sunflower, here shown as a cluster of pollen grains arranged in a 6 + 1 packing. Normally each pollen grain is separate.
One can already see here the start of the spiral phyllotaxis on the spherical pollen grain.
Also, note the interesting tri-lobe design of the logo.

SG205A.3.2.2 The Science of Pollen - Classification (1)

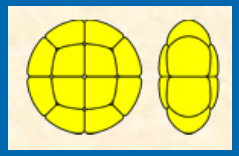
Pollen grains are distinguished primarily by their form and their surface sculptures.

A. Pollen in groups of four grains..TETRADS
AA. Pollen in groups of more than four grains..POLYADS
AAA. Pollen grains free
 BB. Aperture one or grain without apertures
  C. With bladders or meridional ridges
   D. With bladders.....VESICULATE
   DD. With deep meridional ridges.....POLYPLICATE
  CC. Without bladders or meridional ridges
   D. No distinct apertures.....INAPERTURATE
   DD. One aperture
    E. Aperture elongate.....MONOCOLPATE
    EE. Aperture +/- circular.....MONOPORATE
 BB. More than one aperture
  C. Without lacunae in a fixed geometrical pattern
   D. Apertures not fused
    E. Furrows present, no free pores
     F. Furrows without distinct pores or transverse furrows
      G. Three furrows.....TRICOLPATE
      GG. More than three furrows
       H. All furrows meridional....STEPHANOCOLPATE
       HH. Furrows not meridional....PERICOLPATE
     FF. Furrows with distinct pores or transverse
      G. Three furrows.....TRICOLPORATE
    EE. Three pores present, no furrows
     F. Three pores.....TRIPORATE
     FF. More than three pores
      G. Pores in an equatorial zone....STEPHANOPORATE
      GG. Pores evenly distributed.....PERIPORATE
   DD. Apertures fuses to rings etc. .....SYNCOLPATE
  CC. With lacunae in a fixed geometric pattern
   D. Lacunae elongate (pseudocolpi).....HETEROCOLPATE
   DD. Lacunae not elongate.....FENESTRATE

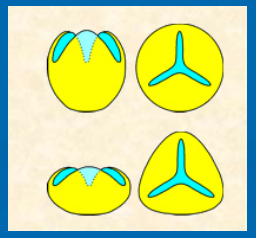
Pollen grains and spores develop a wide variety of complex shapes and surface structures. These characteristics are used to identify grains through side by side comparison with known samples. Because of the complexity of grain surfaces, a comprehensive system of morphological designations has been established.



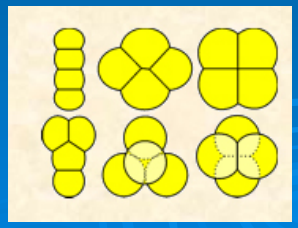
← Compound Aperture.



← Polyads



← Tricotomocolpate & tricotomosulcate

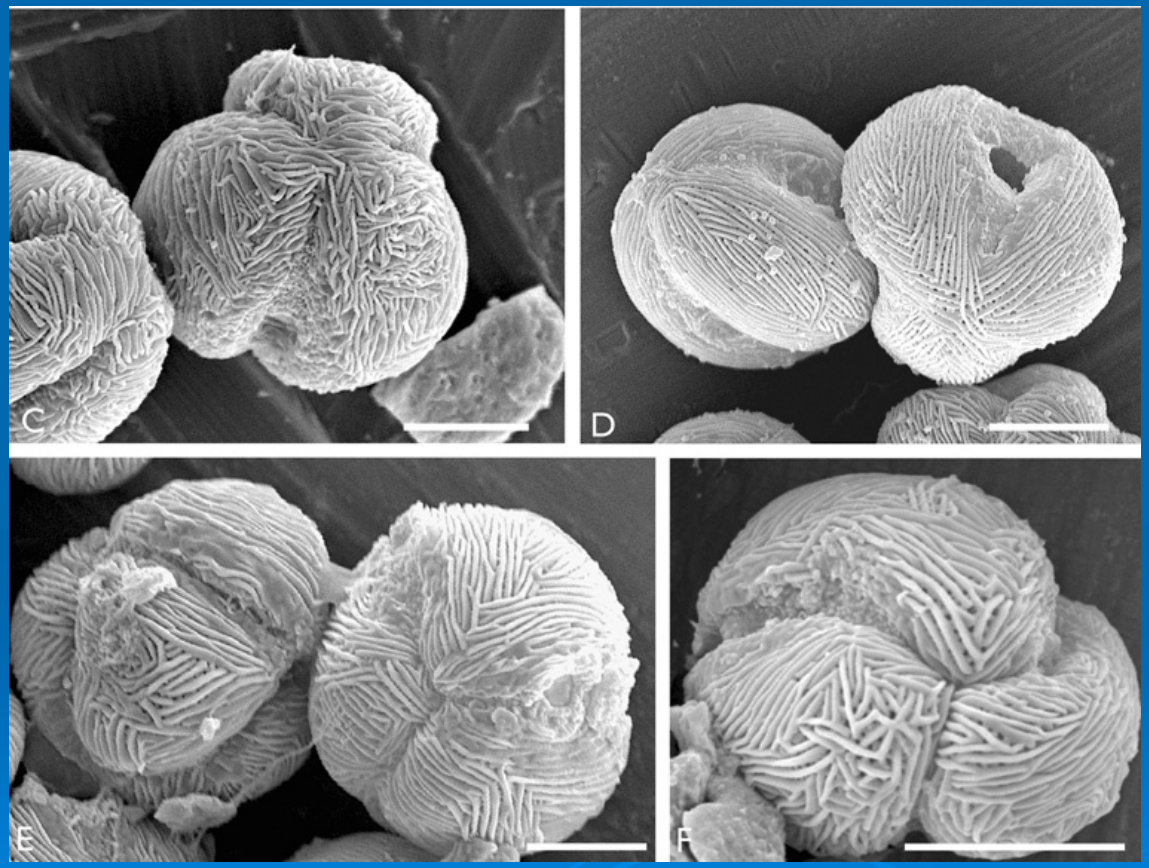


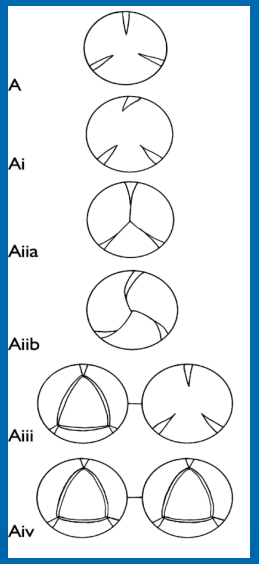
← Tetrads

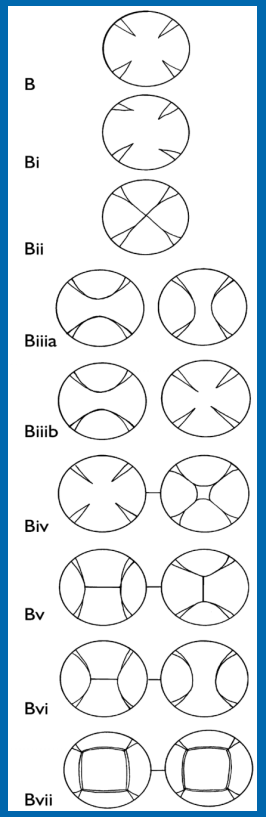
← ↑ A selection of interesting pollen geometries.
Glossary of Pollen & Spore Terminology. www3.bio.uu.nl

SG205A.3.2.3 The Science of Pollen - Classification (2)

A 2007 paper in the palynological magazine *Grana* gives an idea of the frequent phenomenon of morphological variability in pollen. Variation in the number and arrangement of apertures appears to be the most common type of variation. Pollen diversity can occur between individuals of a population (polymorphism) or within the same plant (heteromorphism). The example used by researchers is the *Centaurium pulchellum*.







↑ Diagrams in polar view of the two typical and 13 atypical aperture configurations observed in *Centaurium pulchellum*.

↑ The unique "signature" of pollen grains within the same species.

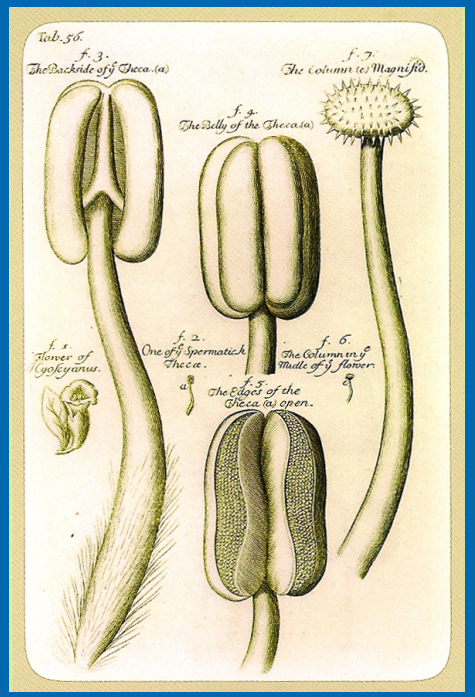
Images & diagrams: Pire, Stella Maris and Dematteis, Massimiliano (2007) 'Pollen aperture heteromorphism in *Centaurium pulchellum* (Gentianaceae)', Grana, 46:1, 1 - 12 www.informaworld.com

← The flowers of *Centaurium pulchellum*. (Wikipedia)

SG205A.3.2.4 The Science of Pollen - Ancient Pollen Art (1)

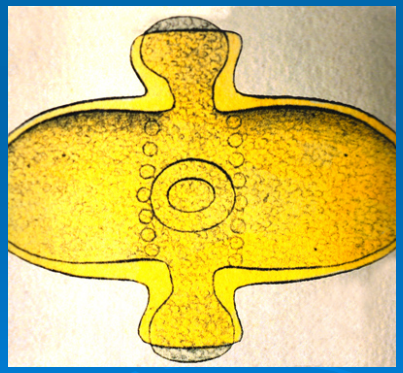
Ever since Robert Hooke's seminal book *Micrographia* (published in 1665), the use of the microscope opened the way to the microworlds in nature. Artists & scientists have been forever fascinated by the exquisitely minute symmetries and geometric structures to be seen, under the microscope, in plant elements such as pollen, seeds, flowers or fruits. Among the early plant anatomists & physiologists (who were also artists) we can cite the following:

- **Robert Hooke (1635 - 1703) was an English natural philosopher and polymath (sort of an England's Da Vinci). Micrographia (1665) describes Hooke's microscopic & telescopic observations and illustrations as well as some original work in biology (Hooke coined the term "cell" by analogy with a monk's cell).**
- **Nehemiah Grew (1641 - 1712) was an English vegetable anatomist and physiologist, very famously known as the *"Father of Plant Physiology"*. Grew pioneered work with the microscope.**
- **Carl Linneaus (1707 - 1778). The first use of "pollen" as a scientific word describing the male sperm carrying units of flowering plants is credited to Linneaus in *Sponsalia Plantarum* (The Bethrothals of Plants) in 1747.**
- **Francis Bauer (1758 - 1840) was an Austrian microscopist and botanical artist. He was the first botanical illustrator at the Royal Botanic Gardens, Kew and Museum and was later appointed *Botanick Painter to His Majesty* King George III. His legacy is to be found in sumptuous botanical illustrations.**
- **Julius von Fritzsche (1808 - 1871) was a German chemist and botanist who published, in 1837, a landmark book on pollen (*"Ueber den Pollen"*).**



↑ **A page from Nehemiah Grew. *The Anatomy of Flowers, prosecuted with the bare Eye, and with the Microscope.* 1682.**

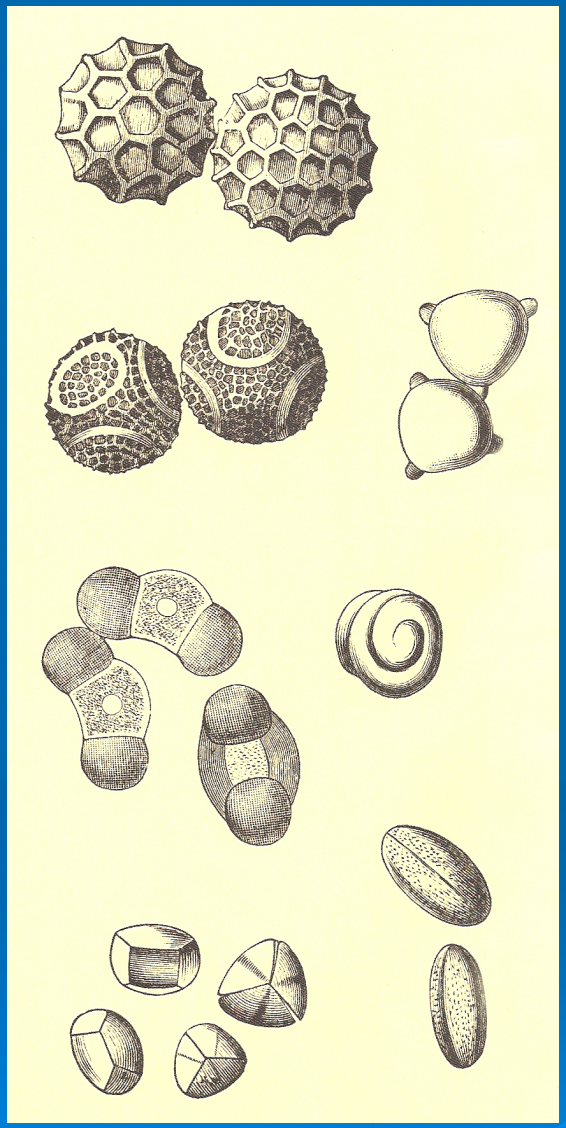
↑ **Robert Hooke. Note the ammonite on the desk.**



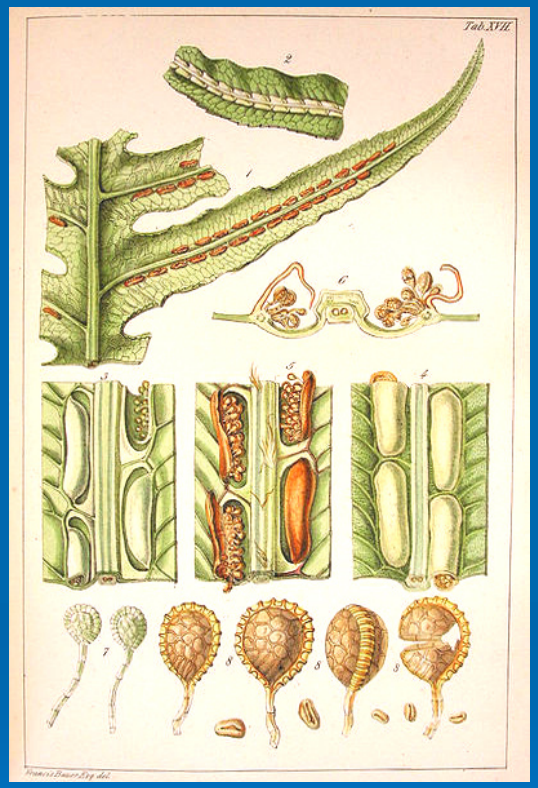
↑ **Julius von Fritzsche. Pollen of *Morina longifolia*. *Ueber den Pollen*. 1837.**

← **Scanning electron micrograph of *Morina longifolia* (Common Mallow).**

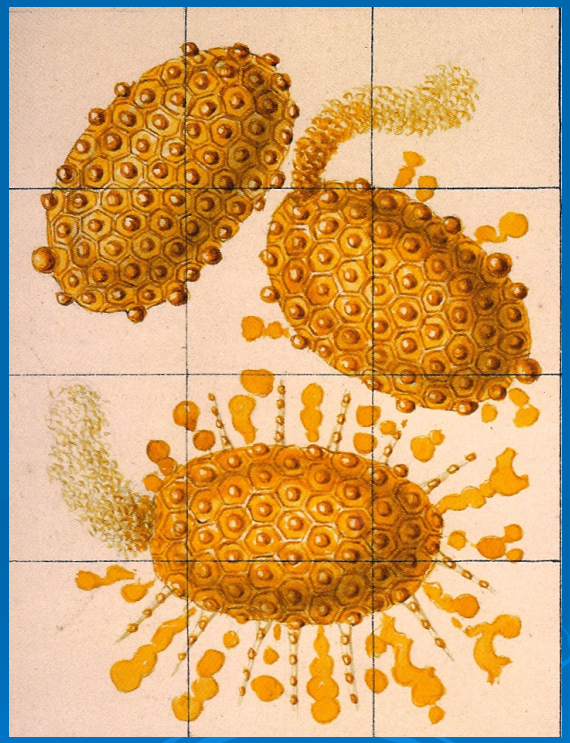
SG205A.3.2.5 The Science of Pollen - Ancient Pollen Art (2)



Page from *The Natural History of Plants.* A. Kerner & F. W. Oliver. 1903.



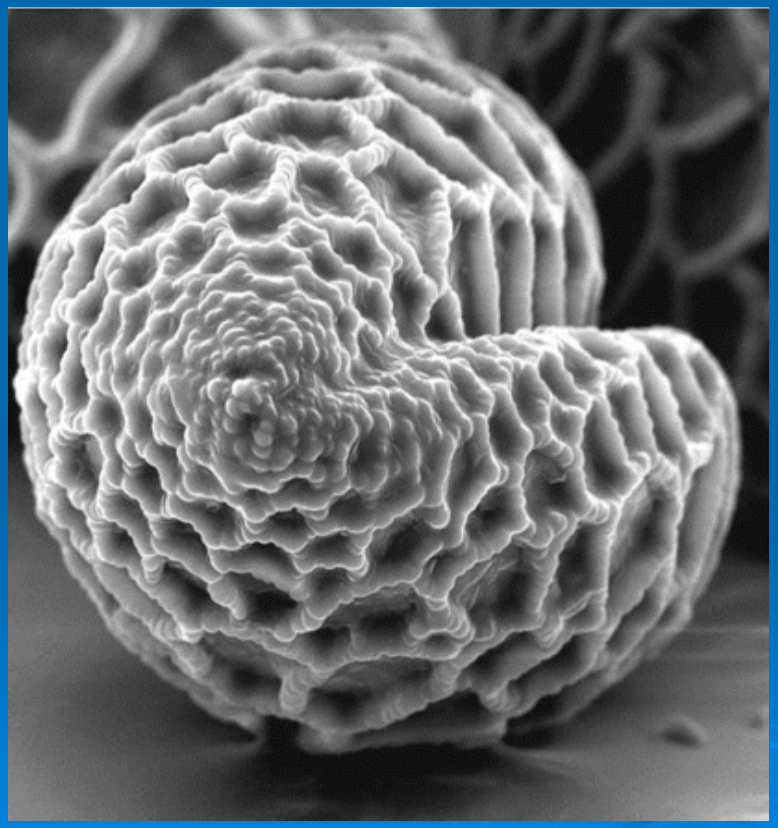
Francis Bauer. Illustration of *Woowardia radicans.*



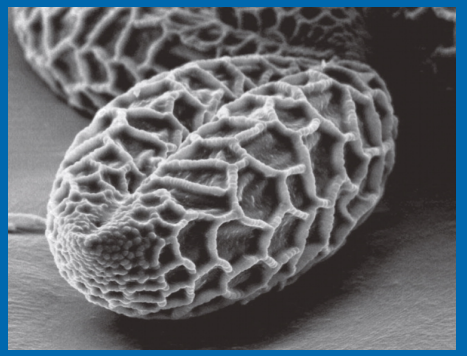
Francis Bauer. Illustration of pollen grains from *Lilium tigrinum* (Tiger lily).

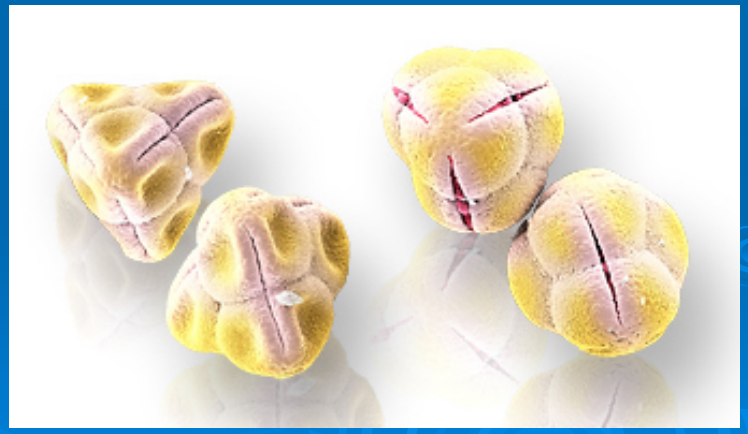
SG205A.3.3 Pollen - Geometries of Dried Pollen

All pollen grains have a cellular wall consisting of an impermeable outer layer called the *exine*, interrupted by permeable apertures that provide routes of exchange with the external environment. Pollen oftentimes have to travel long distances after leaving a plant and are thus exposed to dry conditions that can desiccate and potentially destroy the miniscule grains. To prevent desiccation, the pollen surface undergoes a folding process called *harmomegathy*, which results in a sealed pollen grain with the permeable apertures tucked inside the exine.
Based on aperture number and geometry, a variety of surface folds can form. Here are some examples of desiccated pollen grains found in the Proceedings of the National Academy of Sciences. (www.pnas.org)



← → Scanning electron micrograph of a dehydrated lily pollen grain.





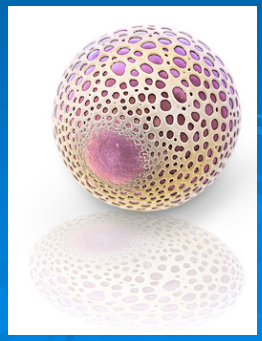
↑ Dry and hydrated *Erica* pollen. By Martin Oeggerli. Note the tetrahedral shapes.

SG205A.3.4 Pollen - Micronaut Artist Oeggerli

It is a gift to experience the beautiful micro-pictures of pollen crafted by Swiss scientist Martin Oeggerli. Oeggerli (who uses the name Micronaut for his art), uses a Scanning Electron Microscope to capture images of pollen grains and then artfully colorize them in graphic programs. The result is an open window into the amazing world of pollen shapes.

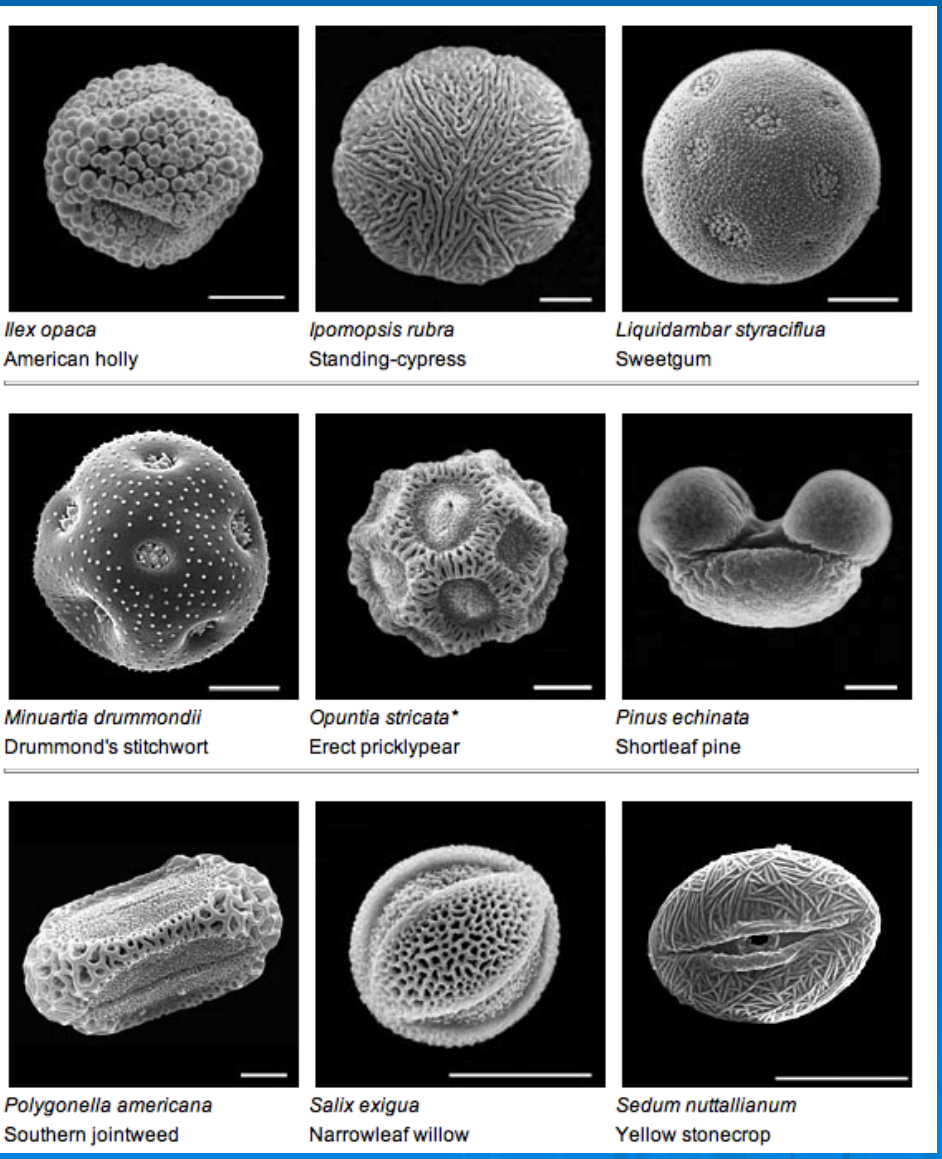
Visit Martin Oeggerli's website:
www.micronaut.ch

We show some of Oeggerli's images in the following pages.
You can also go to the following site to view all the pollen images (in the left mandala image) in a zoom program:
//morrisonworldnews.com



← Bromeliad.

SG205A.3.5.1 Pollen Shapes - Common Plants (1)



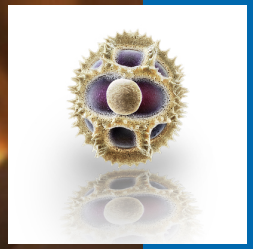
Pine tree.
Martin Oeggerli

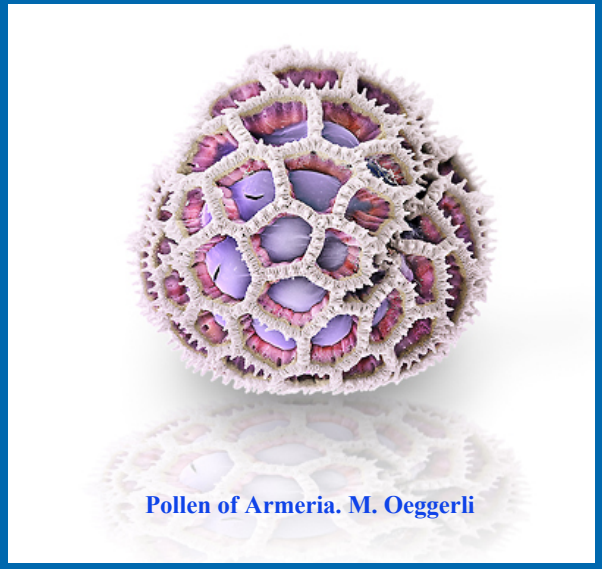
Pollen of Acanthus.
Martin Oeggerli.

A gallery of pollen. //askabiologist.asu.edu
The white scale bar represents 10 micrometers.
(A micrometer is 1 millionth of a meter).

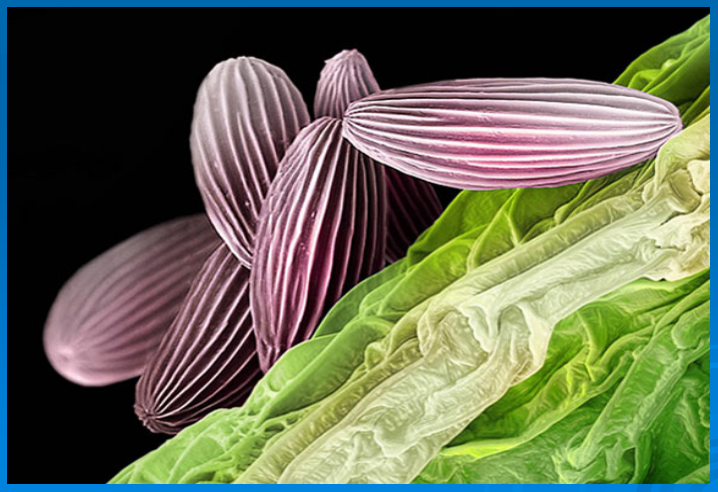
SG205A.3.5.2 Pollen Shapes - Common Plants (2)

↑ White clover





Pollen of Armeria. M. Oeggerli



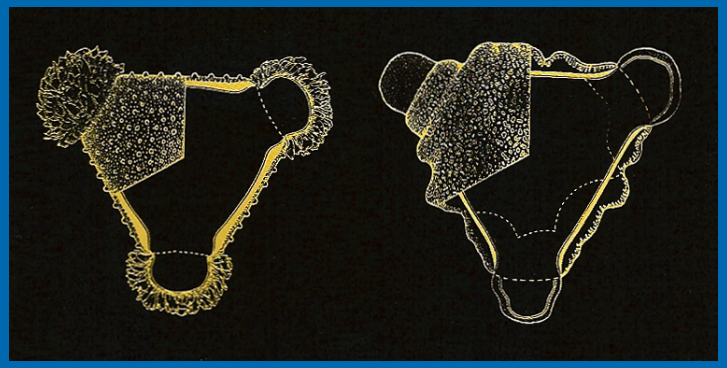
← Pollen from a Pistia (water lettuce)

↑ Snowball plant

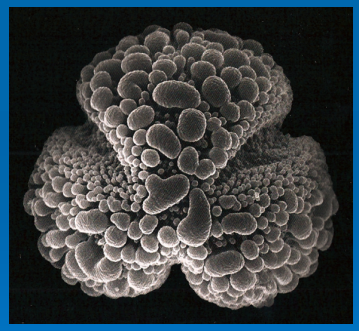
All images by Martin Oeggerli //1dak.com

SG205A.3.5.3 Pollen Shapes - Geometric Pollen (1)

SEM image of pollen of Prickley Pear cactus. Dodecahedral shape.
//sciencephoto.com Search "Prickley Pear pollen".



↑ Pollen geometries by Gunnar Erdtman.
Left: *Xylomelum angustifiolium*
Right: *Hakea ruscifolia*
(*Plant Morphology and Plant Taxonomy*. 1952.)

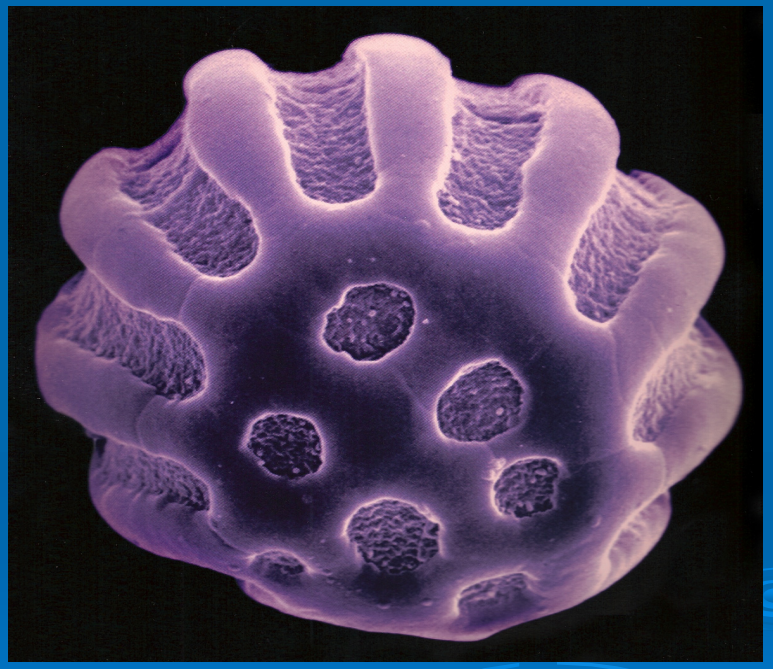


↑ Polar view of pollen.
Pollex aquifolium.
Pollen. Rob Kesseler.
2006.

↑ Pollen of *Hymenea courbaril*.
www.nybg.org

SG205A.3.5.4 Pollen Shapes - Geometric Pollen (2)

**Sculptural creations of nature,
best designed for optimum dispersal
in specific ecological niches.**

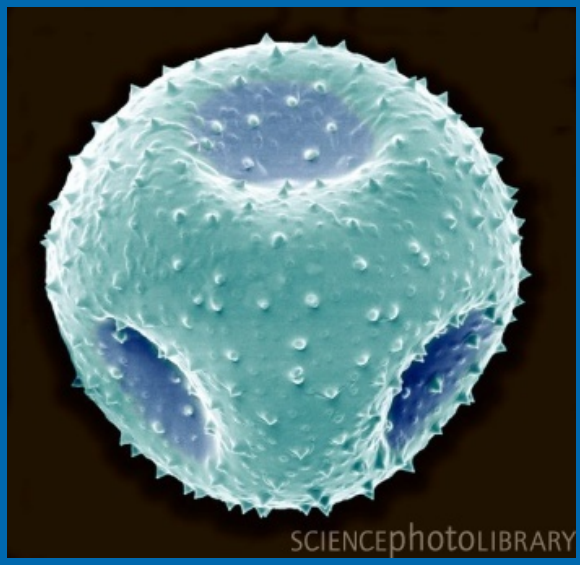


↑ Pollen of *Polygala vulgaris*. *Pollen*. Rob Kesseler. 2006.

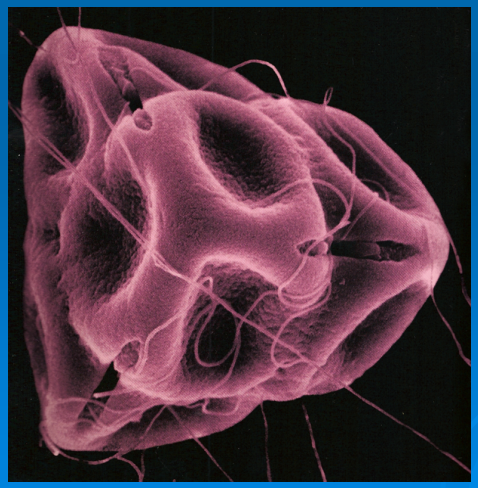
**← Pollen of *Tussilago farfara* (Coltsfoot).
Pollen. Rob Kesseler. 2006.**

SG205A.3.5. 5 Pollen Shapes - Platonic Pollen

← DODECAHEDRON - Pollen of *Stellaria holostea* (Greater Stitchwort). *Pollen*. Rob Kesseler. 2006.



↑ CUBE - Pollen of the "Christmas cactus" (genus *Schlumbergera).*
http://www.sciencephoto.com

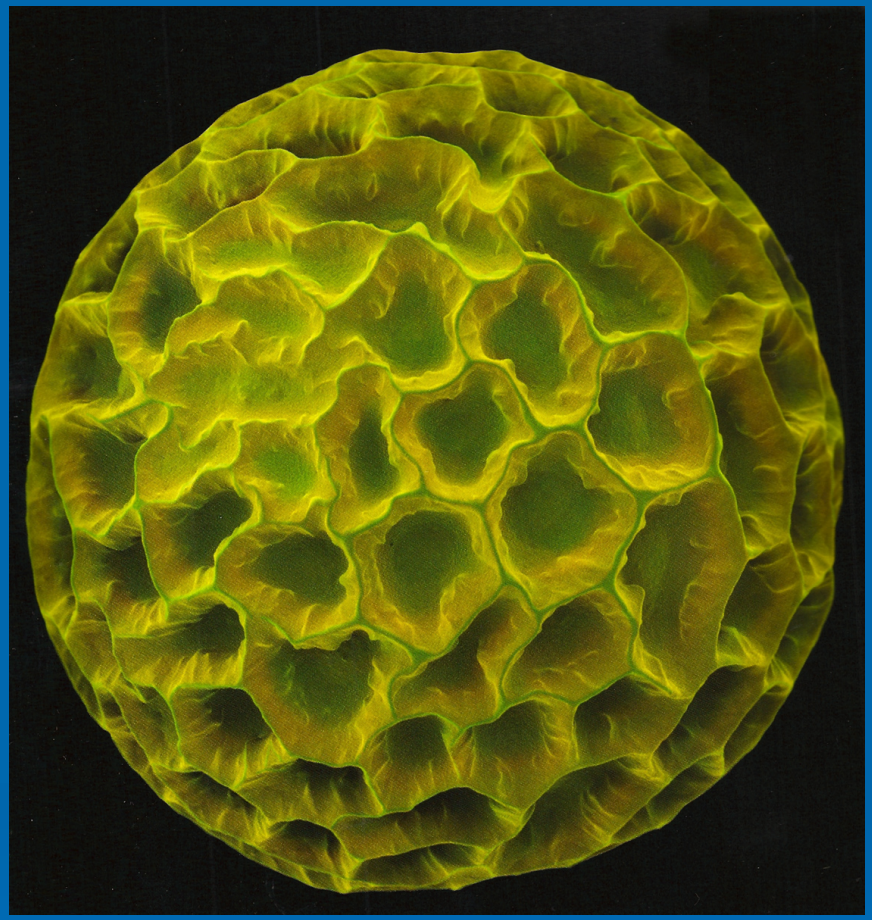


← Pollen tetrad from *Rhododendron* (Naomi Glow). *Pollen*. Rob Kesseler. 2006.

↑ Dandelion pollen.
//usda-apmru.tamu.edu

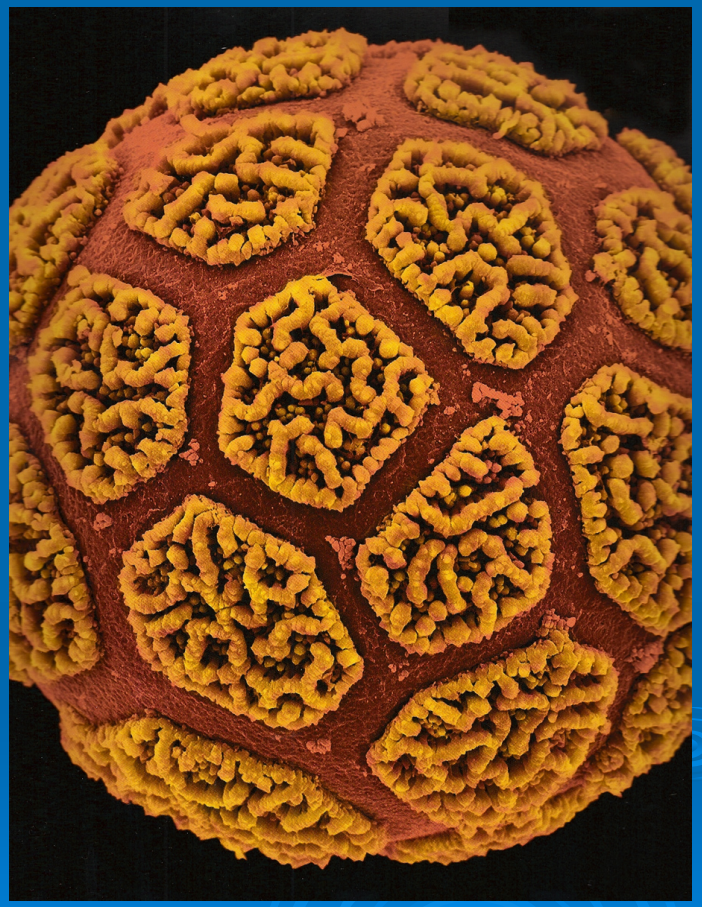
↑ TETRAHEDRON - *Erica* Pollen
www.sciencephoto.com

SG205A.3.5.6 Pollen Shapes - Geodesic Pollen (1)



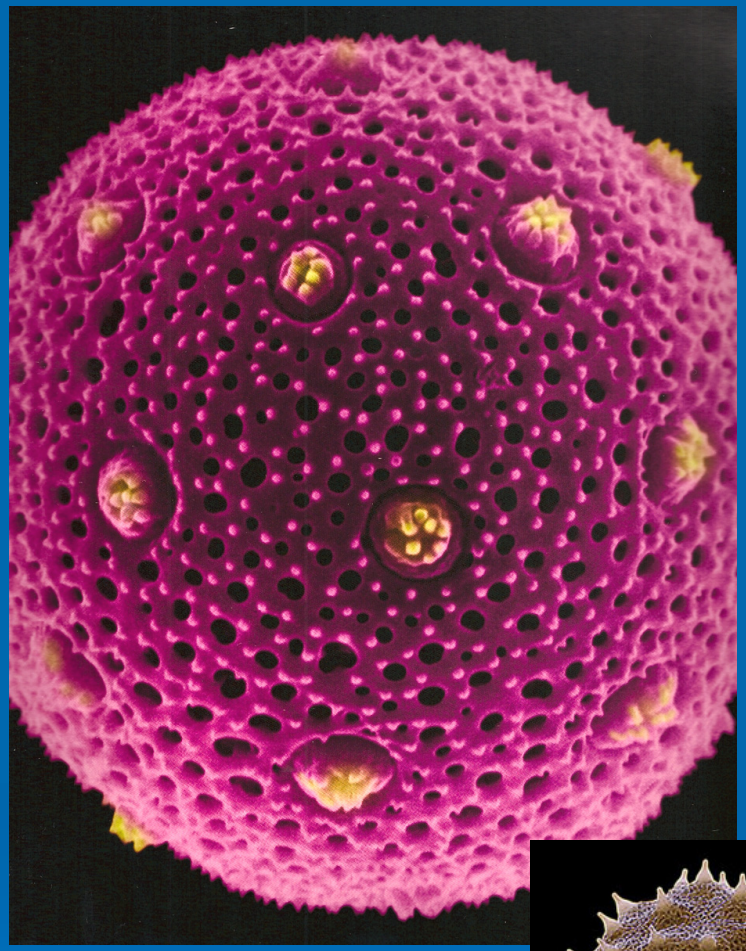
↑ Pollen of *Bulbine latifolia* (Rooiwortel).
Pollen. Rob Kesseler. 2006.

Pollen of *Cydista aequinoctialis* →
www.nybg.org

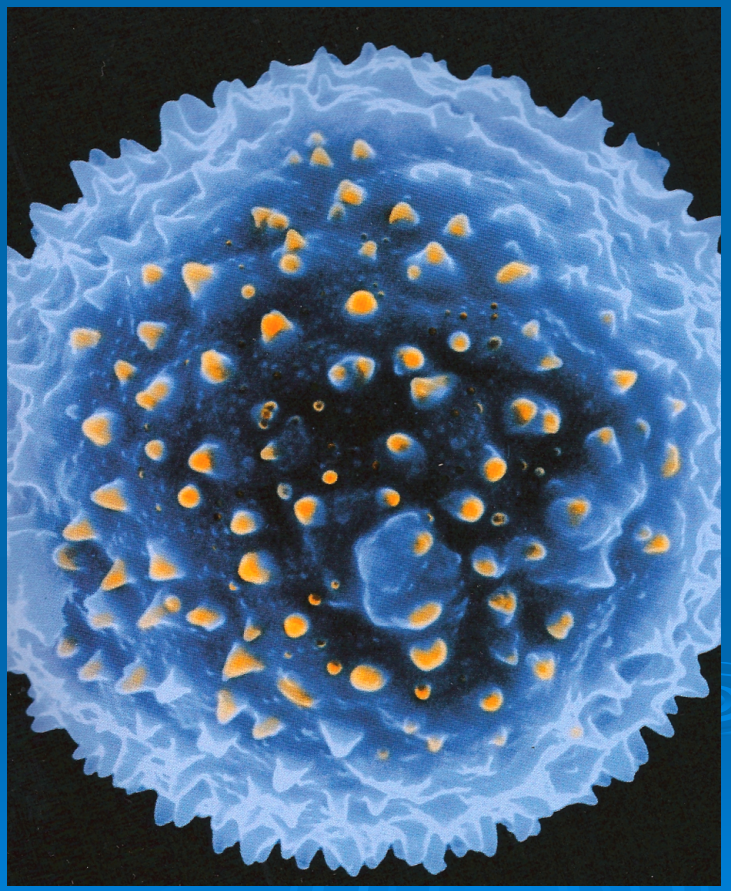


↑ Pollen of *Iris decora* .
Pollen. Rob Kesseler. 2006.

SG205A.3.5.7 Pollen Shapes - Geodesic Pollen (2)



← Pollen of *Sileni dioica* (Red Campion). *Pollen*. Rob Kesseler. 2006.



↑ Pollen of *Meconopsis grandis* (Himalaya Blue Poppy). *Pollen*. Rob Kesseler. 2006.

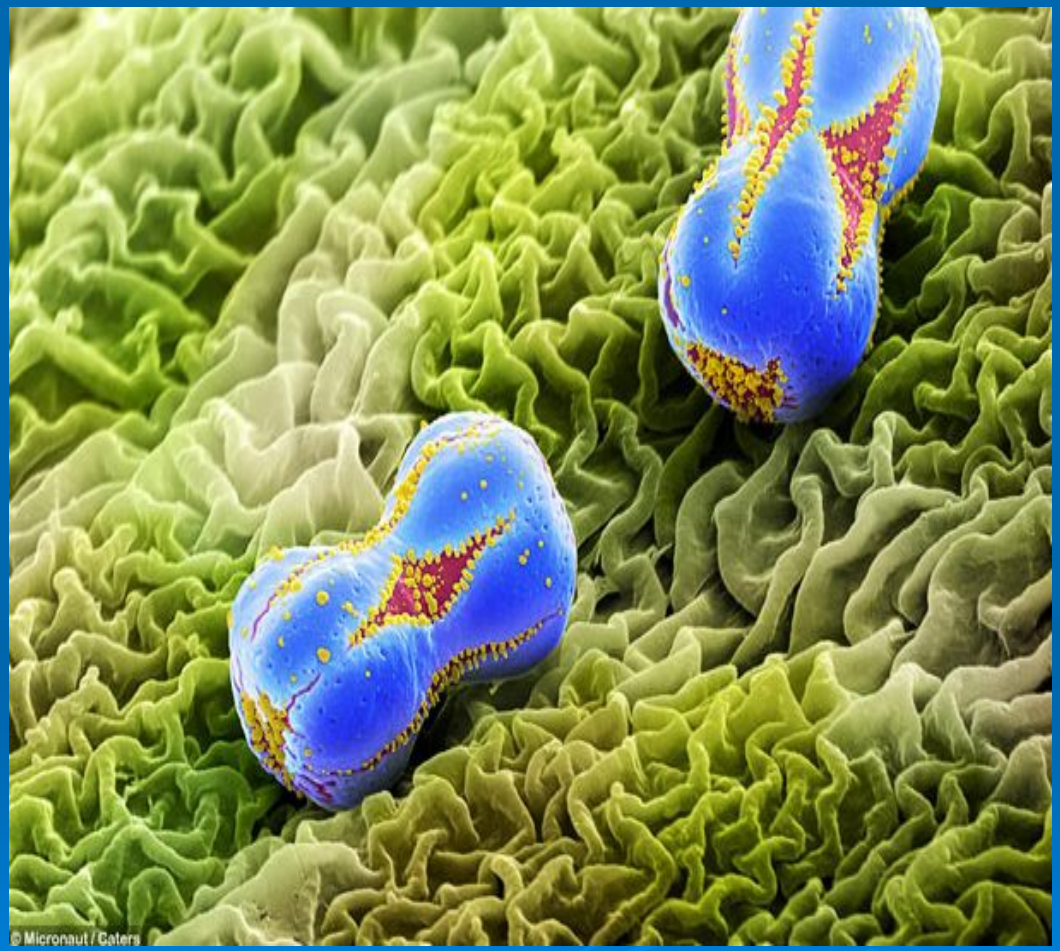
The pollen from a Mallow flower ➔
Its spines help it cling to birds' feathers.
M. Oeggerli.
www.telegraph.co.uk

SG205A.3.6.1 Pollen & Flower (1)
Evening Primrose

Evening primrose pollen. Colored scanning electron micrograph (SEM) of evening primrose (*Oenothera biennis*) pollen grains. www.psmicrographs.co.uk

//greennature.com

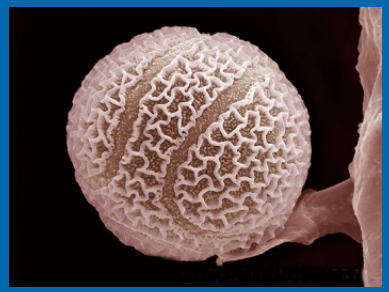
SG205A.3.6.2 Pollen & Flower
(2) Forget-Me-Not

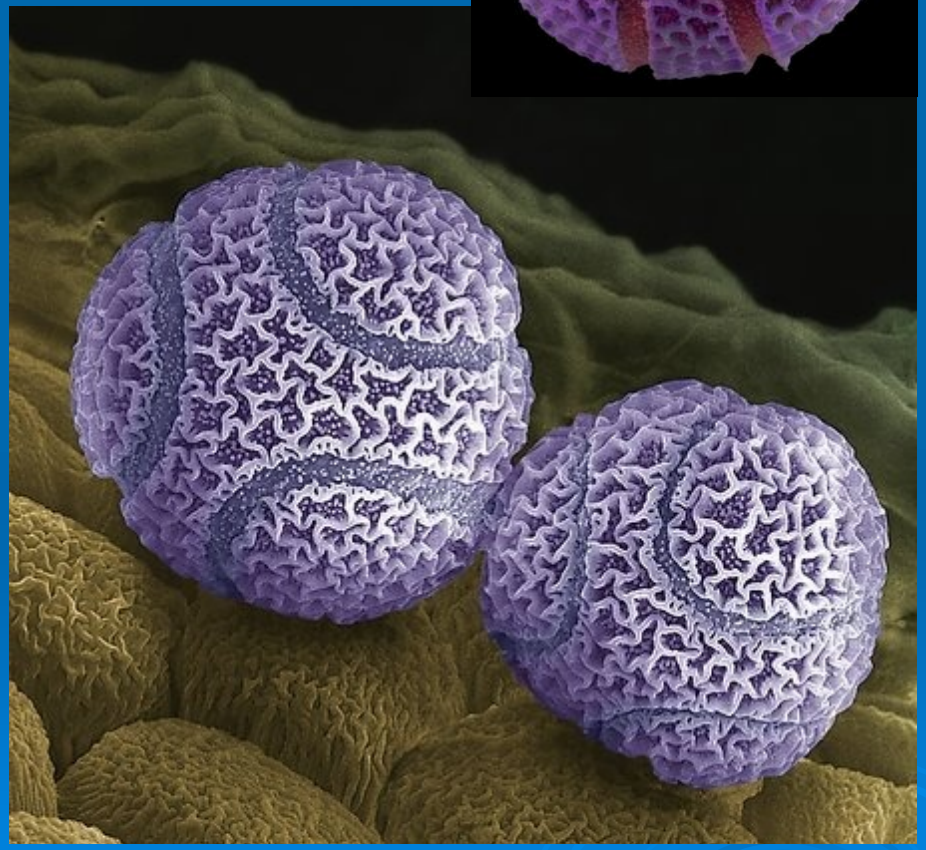


↑ Jewel-looking pollen of "Forget-Me-Not"
By Martin Oeggerli.

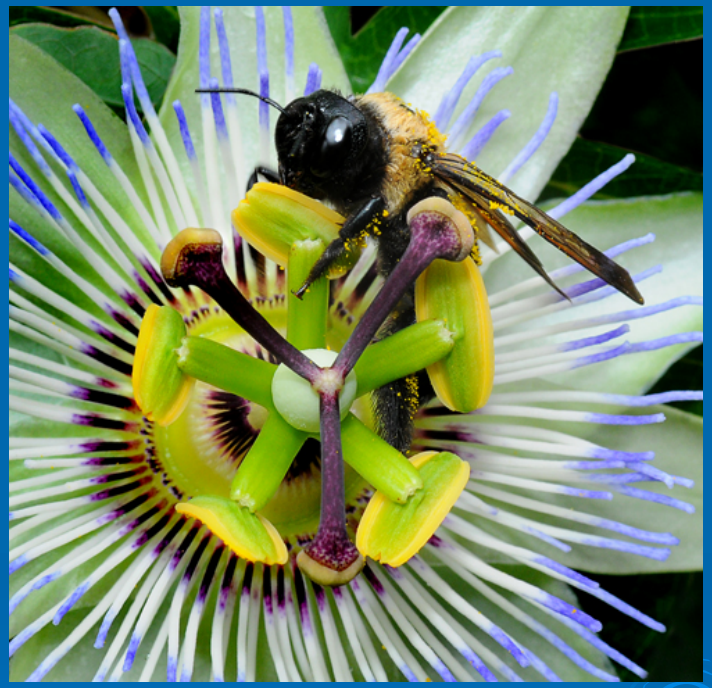
↓↑ "Forget-Me-Not" (genus Myosotis)
is the state flower of Alaska.

SG205A.3.6.3 Pollen & Flower
(3) Passion Flower (1)





↑ Pollen grains of the Passion Flower www.sciencephoto.com

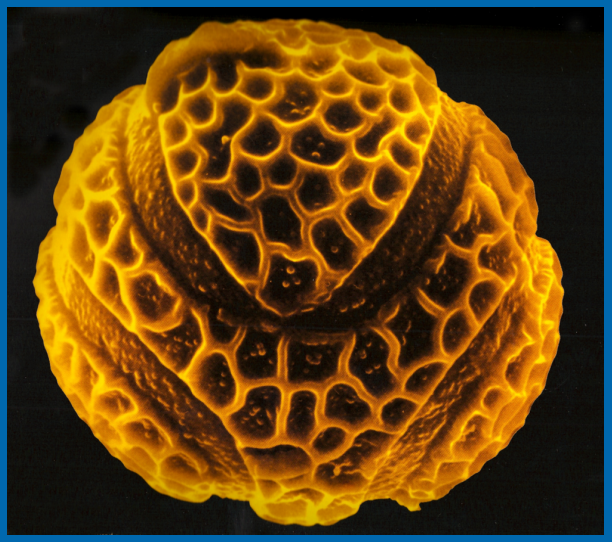


//cindydyer.files.wordpress.com

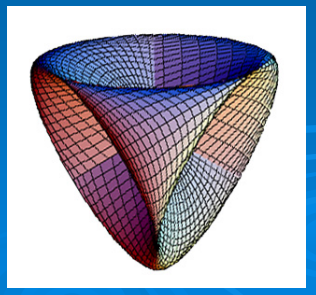
Look at the precious gems the bee is collecting!

SG205A.3.6.4 Pollen & Flower (4) Passion Flower (2)

↑ Engraving of pollen grain from *Passiflora*. Carl Julius von Fritzsche. *Ueber den Pollen*. 1827.

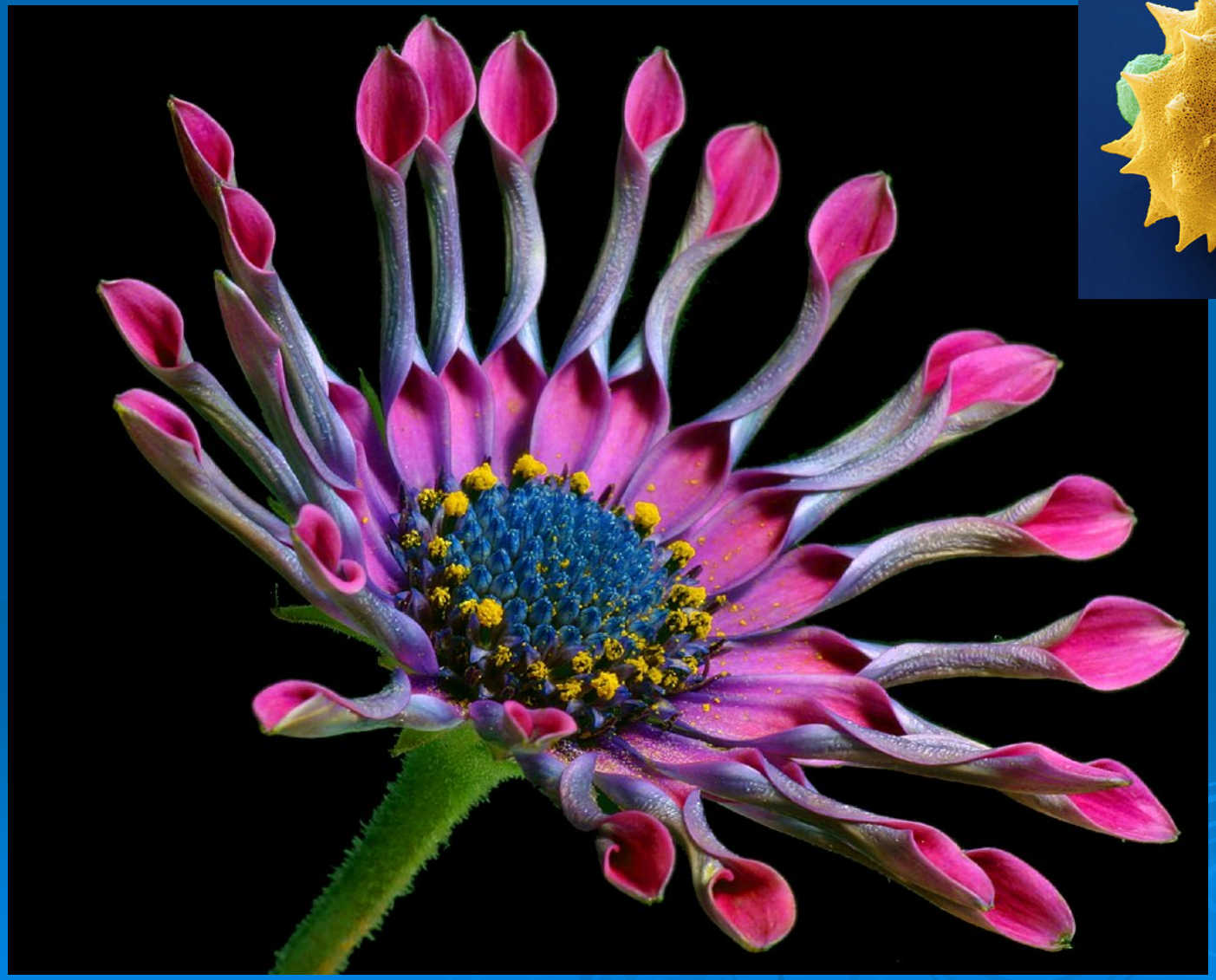


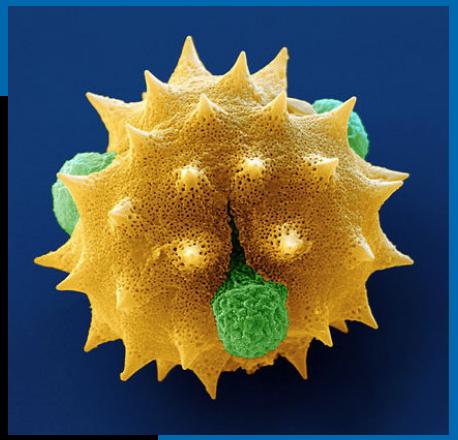
↑ Pollen of *Passiflora caerulea*. SEM micrograph. *Pollen*. Rob Kesseler. 2006.



//knol.google.com

SG205A.3.6.5 Pollen & Flower (5) Daisy Flower





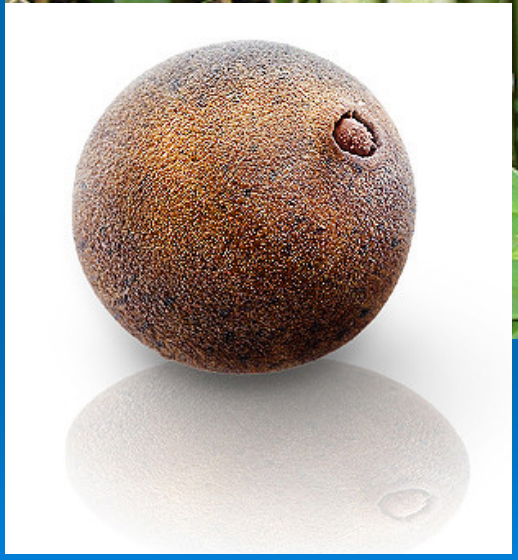
↑ Pollen grain of the daisy flower.

← A magnificent Daisy flower with bursting pollen. (Jon Sullivan).

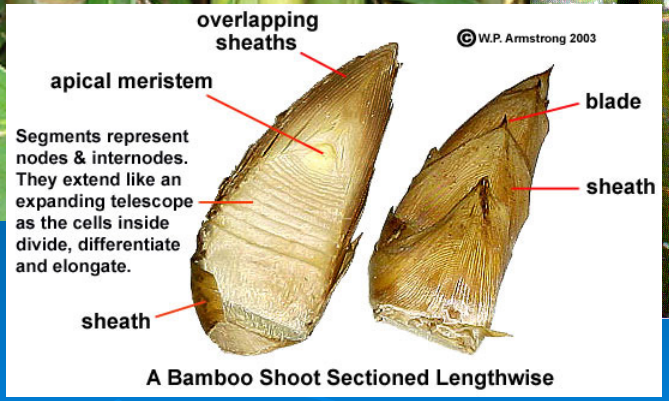
www.public-domain-image.com

Note: we have here a non-Fibonacci, non-Lucas phyllotaxis (24 petals), but the overall proportions are stunningly harmonious. (See supra ◆SG205.2.10)

SG205A.3.7.1 Pollen, Plant & Tree (1) Bamboo



↑ Pollen of bamboo. M. Oeggerli.
Note the smoothness of the pollen grain.



↑ Section of Bamboo shoot.
Note the fractal geometry.
//waynesword.palomar.edu

↑ Giant bamboo.
//prettybrilliant.tumblr.com

SG205A.3.7.2 Pollen, Plant & Tree (2) Olive

↑ Olive tree pollen www.bsip.com/en

↑ Olives www.importpeace.org

↑ Olive tree

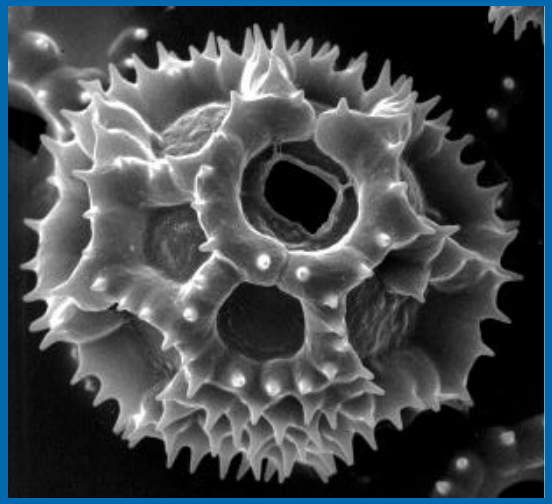
↑ The extraordinary sun-umbrella scales on the surface of an olive tree leaf. These scales protect the tree from heat in a semi-arid climate. The scales trap still, moist air, close to the leaf's surface, slowing the rate of water loss. (*Heaven & Earth*. Phaedon. 2002.)

SG205A.3.7.3 Pollen, Plant & Tree (3) Silk Tree

↑ Pollen of Silk Tree.
SEM image: M. Oeggerli

The Silk Tree (*Albizia julibrissin*) is also known as Persian Silk Tree, Pink Siris or "Night Sleeper" (because the leaves close at night). The small flowers make bundles, with showy stamens much longer than the petals.The flowers are produced throughout the summer in dense clusters of pink stamens with a white base, looking like silky threads.
They are attractive to bees, butterflies and hummingbirds.

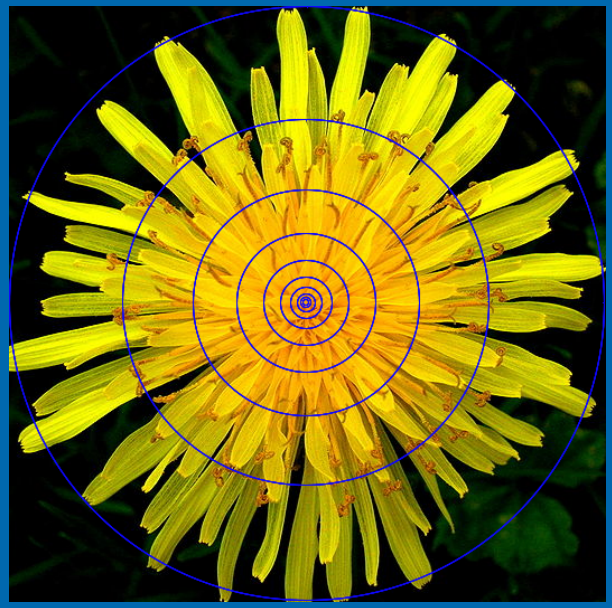
SG205A.3.8 Pollen, Seed & Flower - Dandelion



Dandelion pollen ↑ and seed ↓
//eve.kean.edu

www.your-cup
-of-tea.com

The many faces of one plant



www.types-of-flowers.org →

Make a wish…

↑ Dandelion seed.
Note the Fibonacci spirals.
commons.wikimedia.org

↑ //stealsanddealsforkids.com

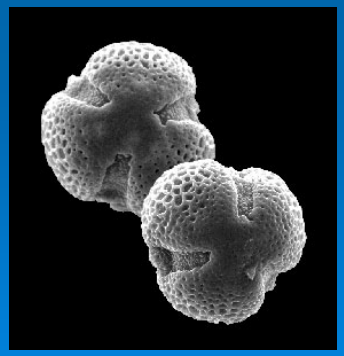
SG205A.3.9 Pollen by Location - French Guiana

Below are some amazing shapes of pollen taken from the Pollen Atlas of bat-pollinated plants of central French Guiana.
By Vanessa Hequet, the New York Botanical Garden. Scanning Electron Microscope. Average size = 10-20 micrometers (one-millionth of a meter).
www.nybg.org/botany/tlobova/hequet/pollen_atlas.html

Crescentia cujete

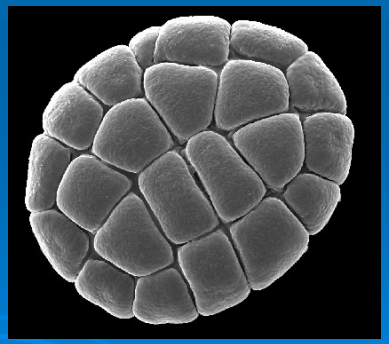
Cydista equinoctialis

Hymenea courbaril



Hillia illustris

Pachira aquatica



Inga cayennensis

Caryocar villosum

SG205A. Chapter 4. Geometries of Seeds

www.eyefetch.com

In this chapter, we are briefly visiting the magical realm of seeds:

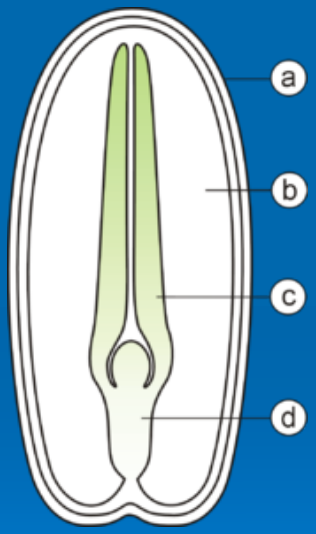
- Their geometries & symmetries.
- Their compact, resilient and aerodynamic efficiency to survive and propagate.
- Their symbolism & sacredness.
- Global initiatives to preserve seeds for a sustainable future.
- Their beauty and the cosmic intelligence they contain.

SG205A.4.1 The Seed - A Vortex of Life Force

Seeds have been an important development in the reproduction and spread of flowering plants, relative to more primitive plants like mosses, ferns and liverworts, which do not have seeds and use other means to propagate themselves. This can be seen by the success of seed plants (both gymnosperms and angiosperms) in dominating biological niches on land, from forests to grasslands both in hot and cold climates. Humans are a seed organism as well.

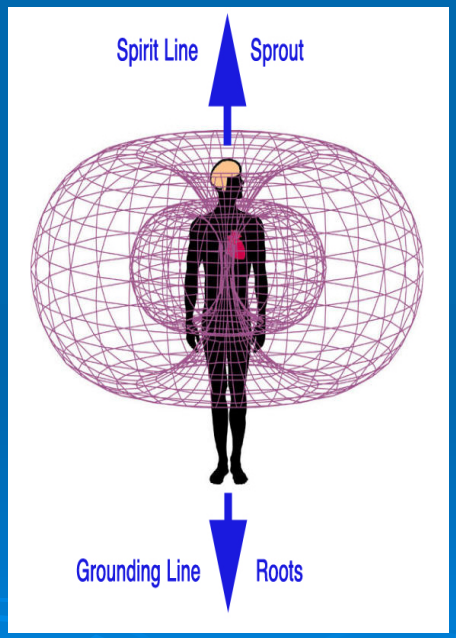
A seed is a small embryonic plant enclosed in a covering called the *seed coat*, usually with some stored food. The formation of the seed completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule. The seed of *dicotyledons* (about 200,000 species with two embryonic arms) have two "cotyledons" (embryonic leaves) within the seed: these show up as the two visible leaves starting any sprout. They look like arms reaching up. Similarly, the development of the root system in a plant is analogous to the feet in a human being. The entire process of growth happens in a vortex dynamics, regardless of scale: seed, human, planet…

In flowering plants, all seeds are enclosed within a fruit. Fruits protect seeds and aid in their dispersal: winged dry fruits (i.e. maple tree) are adapted to distribution by the wind while fleshy fruits (i.e. cherry) are eaten by birds and their seeds are deposited some distance away.



↑ Diagram of the internal structure of a *dicot* seed.
(a) Seed coat (protective layer)
(b) Endosperm (nutrition tissue)
(c) Cotyledon (embryonic leaves)
(d) Hypocotyl (embryonic stem)

↑ *Tadasana* yoga position: reaching for Heaven. Note the similarity with the 2 embryonic leaves.

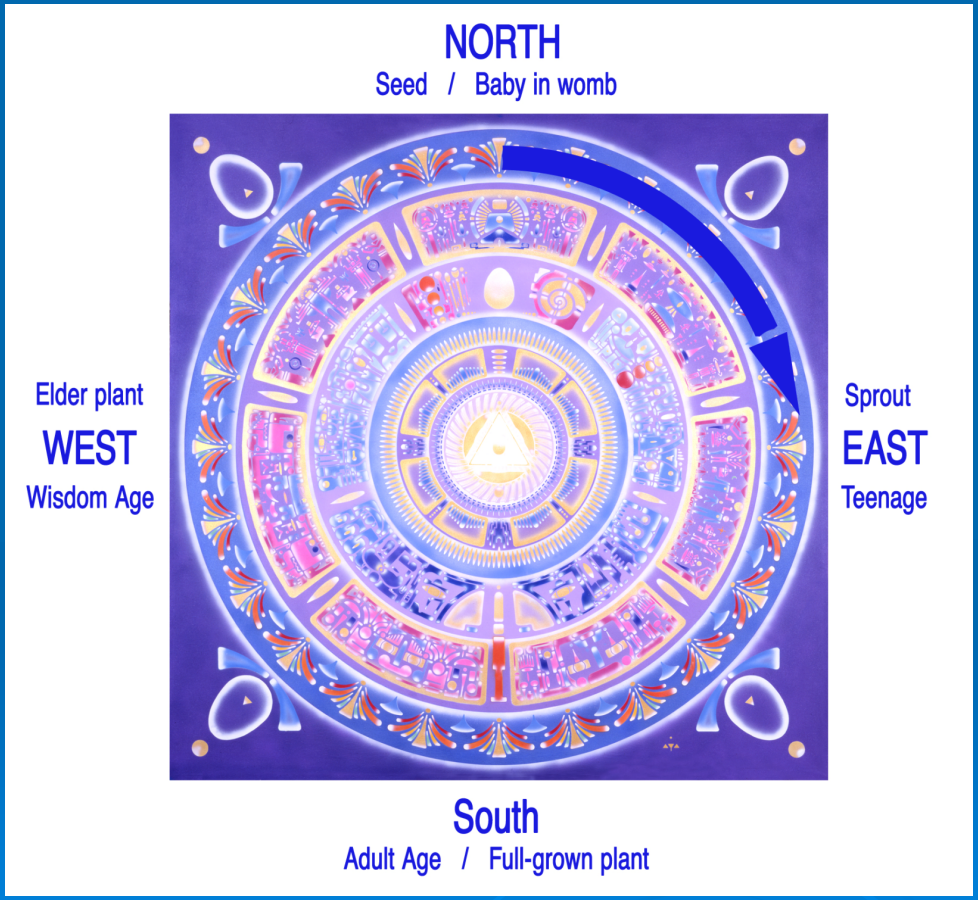


↑ Humans are a seed, reaching up & down

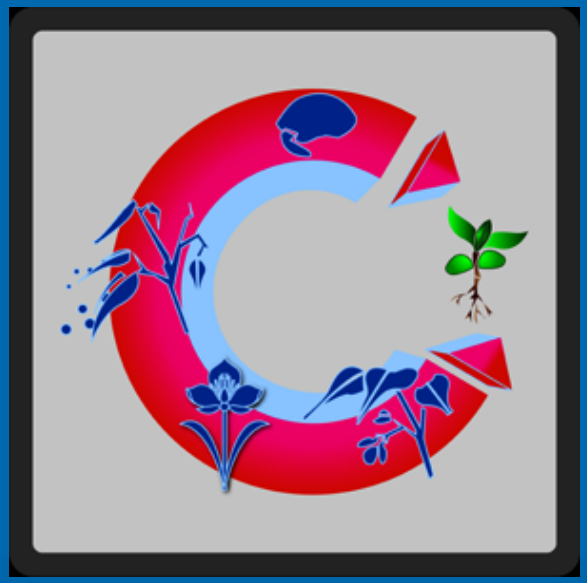
↑ Sprouting wings and growing roots.

SG205A.4.2 The Seed - A Cycle of Growth

The seed is a symbol and direct actor of growth. **It is at the beginning of a cycle of growth on the Wheel of Life. Moving out of the safe (mummy) enclosure of the seed shell (the womb - symbolized by the North direction), the seed initiates its second phase and** begins to grow roots and to sprout leaves around a stem (its spinal column). All plants have stems. The main stem holds up the plant and carries water throughout the plant. Secondary stems grow out from the main stem and leaves grow out of the secondary stems.



SW #48 ("Wheel of Life") expressing the Medicine Wheel of the archetypal Life Cycle that all living organisms go through, whether plant, human or galaxy.



www2.yk.psu.edu

Stages of seed growth

SG205A.4.3 Seeds, Biodiversity & Biopiracy

Why are seeds so essential?
Because seeds store the potential and information of *biodiversity*
(the variety of life forms that exist on the planet).

It is estimated that there are over 270,000 plant species on Earth, some of them fast disappearing. More than 30,000 species of plant are edible, but we use only a tiny fraction of these in commercial agriculture. In the future we may well need a much greater range of species, particularly if climate change alters growing seasons or the world population continues to increase and we run out of prime agricultural land. Plants are also vital for medicine. About 70% of the world population relies on traditional plant remedies for medicine. Only one in five plant species have been screened for use in medicine. Cures for diseases could lie in many of these unscreened species. We can't afford to let these plants, and the potential they hold, die out.

All of these species are the products of billions of years of evolution, and each has adapted to fill a special niche in its own ecosystem. This wealth of unique and fascinating life forms is a massive global treasure (a Library of Life) and constitute the overall WEB of LIFE. All of these life forms make up functioning ecosystems, and these provide *ecosystem services* that support our own human lives. Ecosystem services include purification of water and air, generation and maintenance of soils, regulation of the climate, control of pests, protection from floods and droughts, and much more…

For most plant species, life starts with a seed. The seed population on earth constitutes the basic genetic pool of life creating biodiversity. This is why the threats of wide-spread seed extinction (part of the man-caused *"Sixth Extinction"*) and corporate bio-piracy are so alarming. The estimation is that by 2050, one quarter of the world's remaining 270,000 plant species will be extinct.

Replanting heirloom seeds is increasing regional adaptability and true sustainability. This is diversity at its best.
The strength of any ecosystem is a function of its diversity.

BioPiracy. **Some international corporations are now using patents to gain monopoly control of products that have been used by traditional societies for hundreds of years. These patent abuses are particularly alarming in the areas of medicine and food, the things necessary to sustain life. When a large corporation controls the supply of medicine or food for entire populations, this is intentional enslavement of humanity for the sake of greed.**

Monsanto has been getting great scrutiny recently. They are gaining a virtual monopoly on the world's food supply by controlling the market on seeds. In the US, Monsanto owns 90 percent of soy, 85 percent of corn, and 95 percent of sugar beets, all genetically modified. When Monsanto purchased Semenis, just one of its many subsidiary seed companies, it gained control of an estimated 40 percent of the US vegetable seed market in one go from peppers to peas, lettuce to lima beans. The company's seed stock dominates the market so much that American farmers, even organic farmers, have little choice but to buy from them. Organic (non-transgenic) farmers are even being sued for growing seeds pollinated by Monsanto seeds from neighboring GMO (transgenic) farms.

The nature of pollination, which is spread by wind and insects, is one of continual mixing of varieties of crops. The wide use of genetically engineered corn and other crops has raised alarm that traditional varieties of grains and vegetables may go extinct.

SG205A.4.4 Heirlooms & Seed Banks

What are Heirloom Seeds? Before the spread of agro-business and its life-threatening monocultures, a much wider variety of plant foods was grown for human consumption, thus keeping a large plant gene pool available and growing. Seeds were preciously harvested, kept and passed on as an inheritance. These cultivars are called the *heirloom seeds*. Many heirloom vegetables have kept their traits through the freedom of open pollination: they are unique individuals with endlessly beautiful seed shapes and geometries. They are a needed part of the web of life.

Many gardeners today are using the word heirloom when they really mean non-hybrid. Heirlooms are treasures. Heirloom seeds are the seeds for open-pollinated varieties with histories, with stories. At one time, someone, somewhere thought each heirloom was a treasure and passed it on.

Heirloom Seeds are open-pollinated. "Open-pollinated" seeds come from relatively stable varieties resulting from pollination between genetically similar parents. By saving seeds from the best open-pollinated plants, mankind has taken advantage of natural genetic recombination and mutation to improve agriculture for the past 10,000 years. Gardeners can save seeds from open-pollinated varieties and be reasonably sure of growing plants similar to the original parents. On the other hand, seeds saved from hybrid and genetically modified varieties present a complicated challenge for seed savers. Only a small percentage of will resemble the original parents. Some will be sterile. Most are patented and saving seeds from some is now illegal. Modern home gardeners have begun to rediscover the advantages of growing open-pollinated varieties. Because they have been saved by gardeners and small farmers, the characteristics most desired by gardeners like regional adaptability, local disease and insect resistance, fresh-picked flavor, nutrition and longer harvesting periods are the ones that survived.

When gardeners improve a seed stock from year to year by selecting seeds from their best varieties, they are taking the best of their garden into the future.

http://beginningfarmers.org/seeds/ This link provides a list of heirloom, organic, open pollinated and non-GMO seed sources.

Global Seed Banks. At the turn of the 209th century, the survival importance of *seed banks* became obvious. Seed banks provide insurance against the loss of plant species in the wild as well as options for the future use of plants. Seed banks also provide a source of high quality seed material for use in the recovery and restoration of threatened plants and habitats. Of course, far-sighted people had already worked on gathering heirloom and wild species seeds on a community, regional or national level, but the appearance of global seed banks is most recent. The next 2 pages illustrate the two global seed banks we now have.

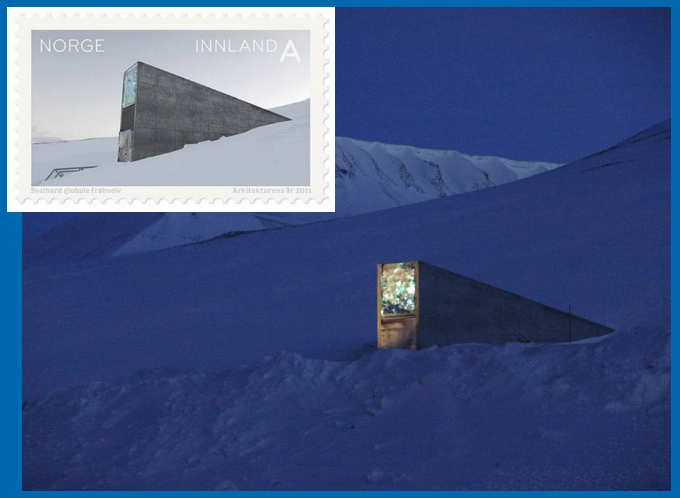
Note by Aya: the success of the human "seed", like any other seed, depends on biodiversity and, harmonically, on a complex interconnectedness with all the other elements of the web of life and the cosmic quantum field.

SG205A.4.5 Norway:
Svalbard Global Seed Vault

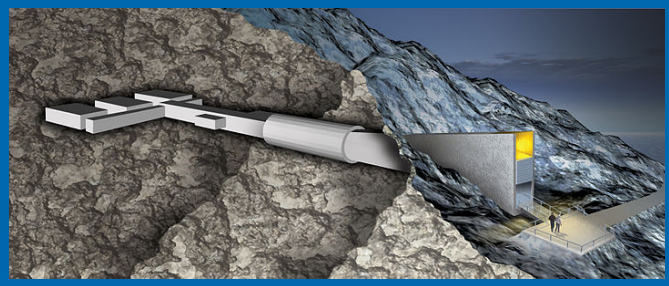
The *Svalbard Global Seed Vault* is a secure seedbank located on a Norwegian island of the remote Arctic Svalbard archipelago, about 1,300 kilometers (810 miles) from the North Pole. The facility preserves a wide variety of plant seeds in an underground cavern. The seeds are duplicate samples, or "spare" copies, of seeds held in genebanks worldwide. The seed vault will provide insurance against accidental loss of seeds, as well as a refuge for seeds in the case of large scale regional or global crises. The seed vault is managed under terms spelled out in a tripartite agreement between the Norwegian government, the Global Crop Diversity Trust (GCDT) and the Nordic Genetic Resource Center.
The seed Vault will contribute to the FAO Global System for Plant Genetic Resources.

The Seed Vault receives seed duplicates for security storage from all over the world. It is built to withstand attacks as well as any of the predicted global changes. Every reasonable effort has been made to safeguard these seeds.

The Svalbard Seed Vault is an inspiration about the vital importance of crop diversity. More than four hundred thousand seeds samples have been deposited in the Svalbard Global Seed Vault during its first years of operation. A great part of the crop diversity, the seeds from our most important food crops has by this found a safe harbor inside the frozen mountains. So far, seeds from more than 3200 species, and of these more than 70,000 varieties of rice, and more than 60,000 varieties of wheat have been packed in aluminum bags, placed in sealed boxes and shipped to Svalbard.
These seeds may be retrieved from their frozen hibernation inside the mountains of Svalbard and be sent back to their original locations if needed.



The entrance to the Svalbard seed Vault, looking like a rock outcropping.



Cutaway of the Seed Vault.

" The Seed Vault will act as the ultimate safety net for the various seed banks around the world. No country is entirely self-sufficient when it comes to genetic resources. Food security in every country depends on food crops that originate from other continents. Global collaboration is therefore essential to ensure correct storage and fair distribution of the value generated by their use in research and development. Safeguarding the genetic diversity of food plants is also fundamental to our ability to adapt to climate change. The Svalbard Global Seed Vault is a concrete and important step in this kind of global collaboration, and the initiative is supported by the United Nations."

Ola Westengen, Operation Manager at Svalbard.

SG205A.4.6 The UK Millenium Seed Bank Project

Scientists at Kew first thought about seed storage in 1898, and there has been a formal seed bank for over 40 years.
Extensive research into seed physiology and storage has been undertaken since the mid 1960s.

1996: Millennium Seed Bank Appeal launched on 31 May by HRH The Prince of Wales with Sir David Attenborough as patron.
2000: Second phase of the Seed Conservation Project begins, involving partner organizations around the globe.
Trust Millennium Building completed and opened by HRH the Prince of Wales on November 20th.
2004: European Seed Conservation Network (ENSCONET) funded for five years by an EU grant.
2006: Species intake for international phase of Project exceeds 10,000. Formal partnerships with 47 organizations in 17 countries. Kew's Millennium Seed Bank partnership is built on a network of organizations around the world that share a common interest in the conservation of wild plant diversity.
2007: The project's billionth seed is collected.
2010: MSB and its partners in more than 50 countries achieved their first major milestone of collecting and conserving seeds from 10% of the world plants.
2010: In conjunction with Kew MSB, the hugely successful "Seed Cathedral" UK pavilion is offered at the Shanghai World Fair. [See next page].
March 2011: 30,402 species saved for the future in Kew's Millennium Seed Bank with 1,845,831,357 seeds in storage.
Over the next 10 years: Kew's Millennium Seed Bank is building upon its current global partnership to save 25% of the world species by 2020.

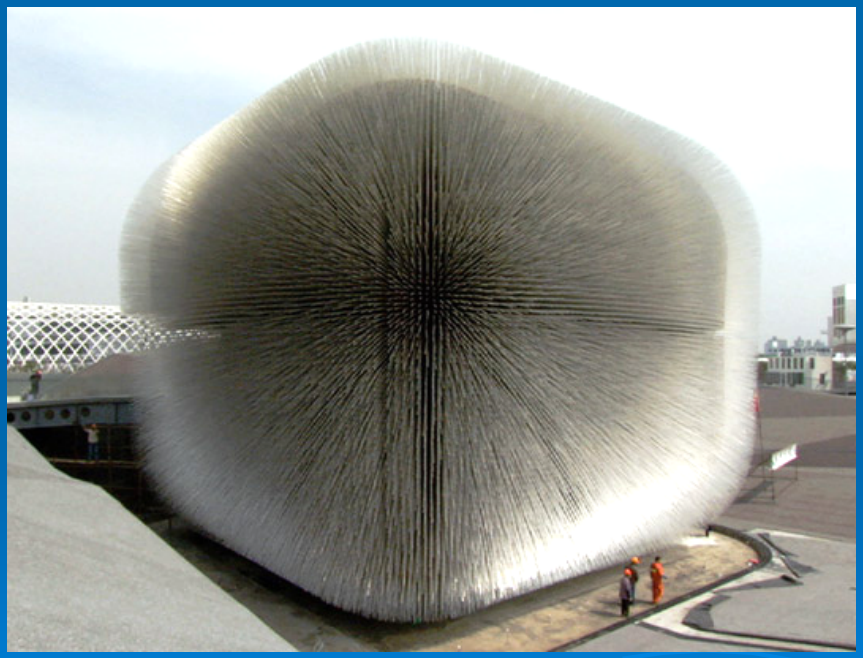
↑ A view of the Kew Millenium Seedbank, with 3 enlarged "seeds". (Note the geometry of the patterns: 3, 4 and 5)

↑ Kew Millenium Seed Bank (MSB). Kew's Millennium Seed Bank has the capacity to store all of the world's rare, threatened and useful plant species. Note the 10% mark goal already attained.
www.kew.org

SG205A.4.7.1 The Seed Cathedral (1)

The 2010 World fair in Shanghai was the largest World Fair ever, with over 190 countries participating. For nature's lovers, the UK pavilion, known as the "Seed Cathedral", was the most extraordinary sight & experience as well as an auspicious omen for the future of Mother Earth. Yes, seeds are so magnificent that they deserve a cathedral on their own.

Themed "Building on the Past, Shaping our future", the 6000-square-meter pavilion or "Seed Cathedral" and the area around it was designed like a wrapping paper, making it seem as if the wrappers have fallen open to reveal a sparkling jewel of life. Over 60,000 slim and transparent acrylic rods contain the seeds of many plants and are displayed in a spherical geometry looking like a dandelion head with its umbrella seeds ready to fly off in the wind. Visitors can relax around the open space or enter the "Seed Cathedral" to admire the seeds in the spines, marveling how such tiny seeds can produce wonders of nature and life. The UK pavilion hopes to raise awareness for the Millennium Seed Bank Project, the international conservation project launched by the Royal Botanic Gardens in 2000.



↑ The "Seed Cathedral".
Final phase of the construction.
www.inhabitat.com

↑ A dandelion seed head.

SG205A.4.7.2 The Seed Cathedral (2)

Conceived by British designer Thomas Heatherwick, the huge structure is almost like a living being, with its undulating hairs and the promise of life encapsulated in each one. The fiber-optic rods sway in the breeze, conjuring images of tall stalks of grass waving in the wind or the seed heads of plants like the Dandelion. Heatherwick's purpose was to create a structure that was a direct reflection of its contents and purpose.

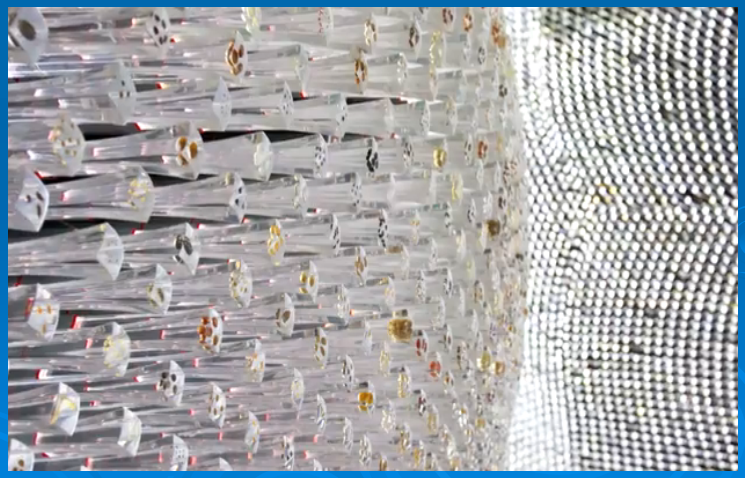
At the end of each of the 60,000 clear acrylic rods are embedded real seeds donated by China Kunming Institute of Botany in cooperation with the UK Kew Royal Botanic Gardens Millennium Seed Bank Project - which aims to stockpile seeds from a quarter of the world's total plant species by 2020 (see *supra*). The potential for life and the future of the planet are showcased in each of these tiny seeds, an awareness that becomes globally potent when you are surrounded by thousands of them in this live earth repository that many millions of people have entered.

During the day, the interior of the Seed Cathedral is illuminated with external light that trickles down the rods as they funnel light within. Inside the Cathedral, the seeds are all illuminated individually to highlight their form and structure.

At night, the structure glows from within: light sources in each rod allow light to travel outward, creating an ethereal sight for passers-by. The fiber optic rods were designed to be sensitive to fluctuating exterior light changes, so even clouds passing overhead are experienced within the Seed Cathedral as subtle flickers of light and shadow. Viewed from inside, the movement of the clouds above and the swaying of the fibers can give the sensation that cathedral is pulsating, or even breathing. The overall effect is one of tranquility and a fundamental connection with nature and her cycles.

The pavilion is a testament to the power and beauty of life, and it grandly echoes the grace of nature and the beauty of plants. It also stands out among the other pavilions at the Expo, most of which are technology-based and filled with flickering images and booming sounds. The Seed Cathedral, by contrast, is a peaceful and almost meditative space where one can quietly enjoy the diversity of nature promise.

↑ The fiber-optics rods pulsating in the wind.



↑ Close-up on the acrylic rods encasing live seeds.

SG205A.4.7.3 The Seed Cathedral (3) After-Life

Reports show that the Seed Cathedral has found great favor with the Chinese public, who have nick-named the pavilion 'Pu Gong Ying', which translates as 'The Dandelion'. The question was asked: what about the after-life of the Seed Cathedral?

Once the Expo was over in October 2010, the seeds did continue life in a new role. In the words of Heatherwick Studio: "After the Expo, just as dandelion seeds are blown away and disperse on the breeze, the Seed Cathedral's 60,000 optic hairs, each one containing the huge potential of life, were distributed across China and the UK to hundreds of schools as a special legacy of the UK Pavilion at the 2010 Shanghai Expo." Each rod with its seeds is a special piece of history marking the collaboration between China and the UK to create this display of the inter-connectedness of humanity and Mother Earth. Each rod, in each school, is a conscious commitment of green sustainability linking local and global responsibility to ensure the survival and expansion of nature's treasures for many next generations.

The Seed Cathedral is a promise to and from the young generations of humans
to honor the magnificent sacredness of Life encapsulated in the symbolic seeds their school has received.

↑ An image showing that seeds gathered from all over the world are redistributed internationally in a global educational drive towards co-creating a web of green sustainability for planet Earth. Credit: www.youtube.com

Website visual references:

www.youtube.com/watch?v=kq_GVcApKDQ
http://www.youtube.com/watch?v=N7JpJVmsBgU&NR=1
http://www.youtube.com/watch?v=xdlL9d0SUQU&feature=related

↑ After dismantling the structure, each rod with its real seeds was forwarded to a school in China and the UK.

SG205A.4.8.1 Seed Sizes

Seeds are very diverse in size: the dust-like orchid seeds are the smallest with about one million seeds per gram, while, at over 20 kg, the largest seed is the *Coco de Mer* (see next page).

The seeds of some plants are so small that they have been called "Dust Seeds". These are distributed by slight air currents. Plants that produce smaller seeds can generate many more seeds per flower, while plants with larger seeds invest more resources into those seeds and normally produce fewer seeds. Small seeds are quicker to ripen and can be dispersed sooner, so fall blooming plants often have small seeds. Many annual plants produce great quantities of smaller seeds - this helps to ensure that at least a few will end in a favorable place for growth. Herbaceous perennials and woody plants often have larger seeds, they can produce seeds over many years, and larger seeds have more energy reserves for germination and seedling growth and produce larger, more established seedlings after germination. (Wikipedia)

www.botany.hawaii.edu

The smallest seeds: orchid seeds.

Certain epiphytic orchids of the tropical rain forest produce the world's smallest seeds weighing only 35 millionths of an ounce. They are dispersed into the air like minute dust particles or single-celled spores, eventually coming to rest in the upper canopy of rain forest trees.
Because Orchid seeds are miniscule they have the aerodynamic properties of pollen. Orchids and a few other groups of plants depend on fungi for nutrition during germination and the early growth of the seedling.

The largest seed: Coco de Mer

www.mysafari.com

SG205A.4.8.2 The Largest Seed: Coco de Mer

The fruit, which requires 67 years to mature and a further two years to germinate, is sometimes also referred to as the Sea Coconut, Bum Seed, Love Nut, double coconut, or Seychelles Nut. Formerly the *Coco de Mer* was known as Maldive Coconut. Its scientific name, *Lodoicea maldivica*, originated before the 18th century when the Seychelles were uninhabited and is derived from *Lodoicus*, the Latinized form of *Louis*, in honor of King Louis XV of France.

In centuries past the coconuts that fell from the trees and ended up in the sea would be carried away eastwards by the prevailing sea currents. The nuts can only float after the germination process, when they are hollow. In this way many drifted to the Maldives where they were gathered from the beaches and valued as an important trade and medicinal item (the fruit is used in Ayurvedic and Chinese medicine).

Until the true origin of the nut was discovered in the 18th century, it was believed by many to grow on a mythical tree at the bottom of the sea. The European nobility in the 16th century would often have these nuts polished and decorated with valuable jewels as collectibles for their private galleries. The Coco de Mer tree is now a rare and protected species.

The Coco de Mer holds three botanical records: the largest fruit so far recorded weighed 42 kg; the mature seeds weighing up to 17.6 kg are the world's heaviest; and the female flowers are the largest of any palm.

www.one-world-trading.com

← ↑ **Some varieties of *Coco de Mer* show a Vesica-type of geometry.**

↑ **Fruit of the *Coco de Mer*. Each fruit contains 1 to 3 seeds.** //cache2.artprintimages.com

↑ **Male inflorescence. (Wikipedia)**

SG205A.4.9.1 Seed Shapes (1)

//beginningfarmers.org

Looking at and touching a handful of mixed seeds is a feast for the eye, for the fingers and for the soul. It is as precious as holding a bunch of gemstones or jewels - in fact even more precious, if we only realize it: the seeds will create more life, whereas the diamonds and rubies will not.

Home Practice: learn how to harvest seeds and start collecting them for their beauty and their survival utility. Show them to your friends and start a *seed exchange group*. They are your "jewels". Start a community seed bank and learn how to see and feel the beauty, harmony and power of these seeds you find and exchange.

**Each seed is as unique as a human being.
Their shapes, patterns & proportions are in direct (holographic) resonance with the flower, plant or tree that will evolve out of them.
What a magnificence!**

↑ Heirloom corn

← Wildflower seeds. By Yanping Wang (Beijing Planetarium).

2010 Olympus BioScapes competition. //30hours.com

http://beginningfarmers.org/seeds/ This link provides a list of heirloom, organic, open pollinated and non-GMO seed sources.

SG205A.4.9.2 Seed Shapes (2)

The dry fruit of the dandelion uses a "parachute" system to navigate away from the mother plant and land in a new "home". www.picturescraze.com

The shape of a seed is primarily functional. In flowering plants, all seeds are enclosed within a fruit. Fruits protect seeds and aid in their dispersal: winged dry fruits (i.e. maple tree) are designed for distribution by the wind while fleshy fruits (i.e. apple or berries) are designed to be eaten by birds so that their seeds are deposited some distance away.

The ovules after fertilization develop into the seeds. The shape of the ovules as they develop often affects the finale shape of the seeds. Plants generally produce ovules of four shapes:

- the most common shape is called *anatropous*, with a curved shape.
- *Orthotropous* ovules are straight with all the parts of the ovule lined up in a long row producing an uncurved seed.
- *Campylotropous* ovules have a curved embryo sac often giving the seed a tight shape.
- The last ovule shape is called *amphitropous*, where the ovule is partly inverted and turned back 90 degrees on its stalk.

The dandelion seed is adapted to burrowing into the ground. Note the tapered shape, the ridges and the rear stabilizing "fins": all elements optimize the function.
www.sciencebuzz.org

The maple seed is adapted to distribution by the wind.
www.starlingphotography.net

The fleshy cherry fruit is eaten by birds who deposit the seed some distance away.

SG205A.4.9.3 Seed Shapes (3)

"You have to trust the seeds
They know the right time
and the perfect dance.

They are in the hands
of the Seed Maker".

Seedlings hugging & supporting each other

Fun Home assignment:

What are the shapes of
the seeds of hope,
the seeds of peace,
the seeds of inspiration,
and the seeds of wisdom?

And how to best help them
to germinate & flower?

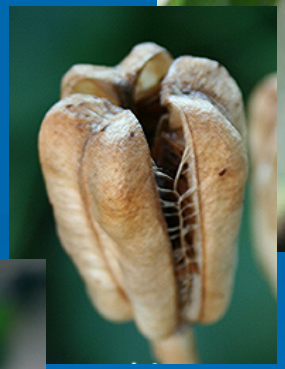
A site entirely devoted to seeds: galleries, seed harvesting, germination, seedlings…
http://theseedsite.co.uk

SG205A.4.10 Geometries of Seed pods

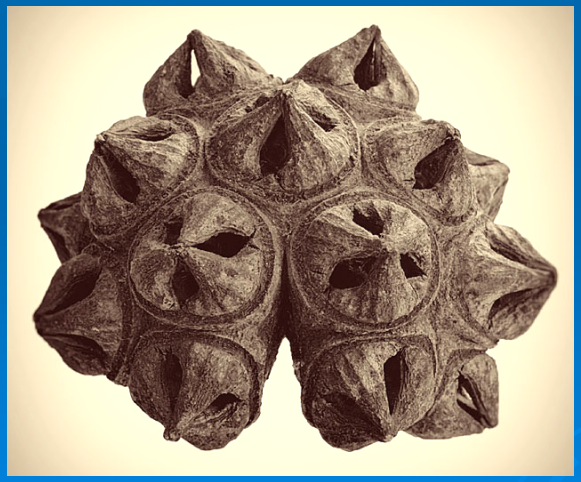
Orchid pod. //orchidlady.com

↑ Rattan seeds in pods

↑ Orchid seed pod. //sharynmunro.com



➔ Oriental Lily seed pod



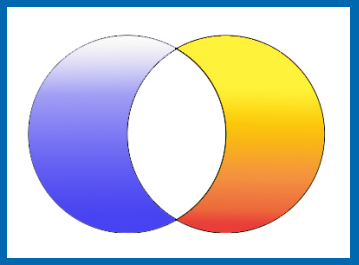
Eucalyptus seed pods. www.kern-photo.com

← Unknown penta-symmetric seed pods from a vine. //messersmith.name

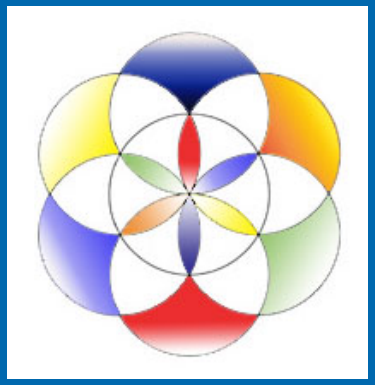
↑ Papaya fruit.

SG205A.4.11.1 The Seed of Life (1)

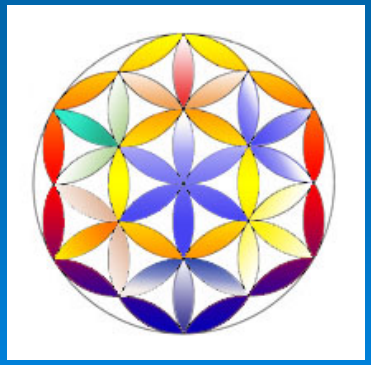
In SG208.3, we explored the *Vesica Piscis*, a classical Sacred Geometry figure generating the Flower of Life (FOL) family of designs. Let us review a progression of adding additional circles to the Vesica figure and passing through the stages of the "Egg of Life" (or shall we call it the *Pollen of Life*?) and the "Seed of Life".



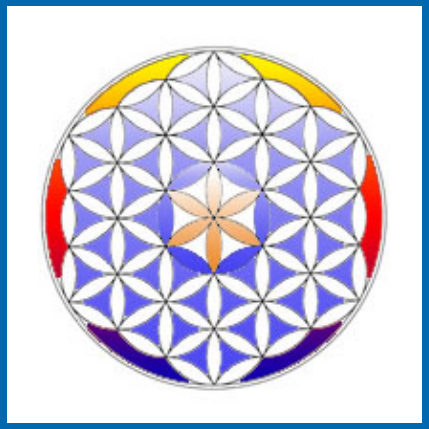
Step 1: the Vesica Piscis



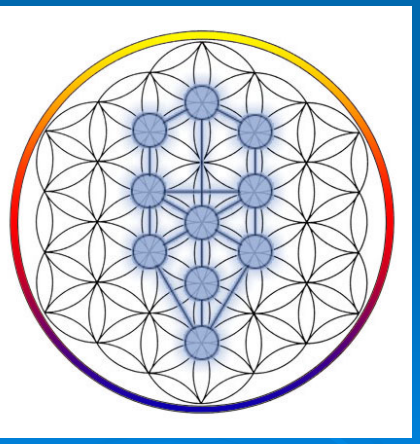
Step 2: the Pollen of Life



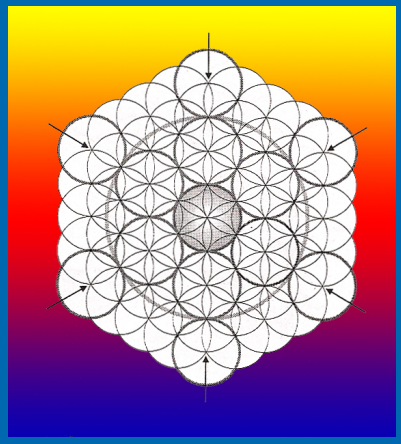
Step 3: the Seed of Life



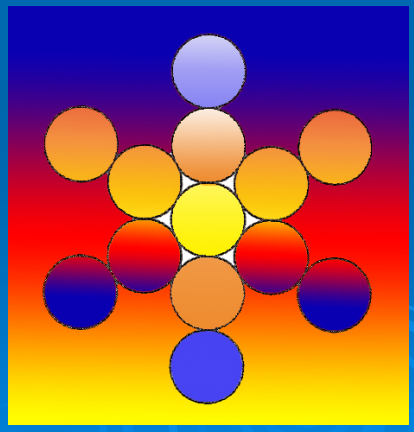
Step 4: the Flower of Life



Step 5: the Tree of Life



Step 6: the Garden of Life



Step 7: the Star of Life ("Metatron's Cube")

SG205A.4.11.2 The Seed of Life (2)

The question can and should be asked: does the geometry of the "Egg of Life", the "Seed of Life" or the "Flower of Life" really expresses the mathematics of growth in a seed, in a plant or a flower?

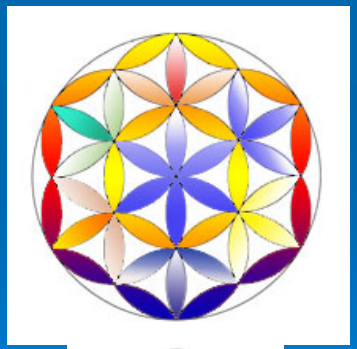
- **First of all, the FOL designs are flat and 2D. They express an equidistant fractality (where the proportional distances are always the same). Higher level fractality in nature mostly follows the Phi ratio spacing based on the Fibonacci numbers, the Golden Growth angle of 137.5º and the Golden Spiral.**

- **We now know that life & life force require an optimum NESTING (recursivenes) of implosive fractal compression/focus (the eye of the hurricane). The maths of this most efficient evolutionary strategy of nature are the SCALING HARMONICS of the Golden Ratio (multiples & submultiples or overtones & undertones). The Golden Number (1.618…) has the unique ability to simultaneously create addition and multiplication, thus opening a universal highway of superconductive energy transmission between dimensions.**

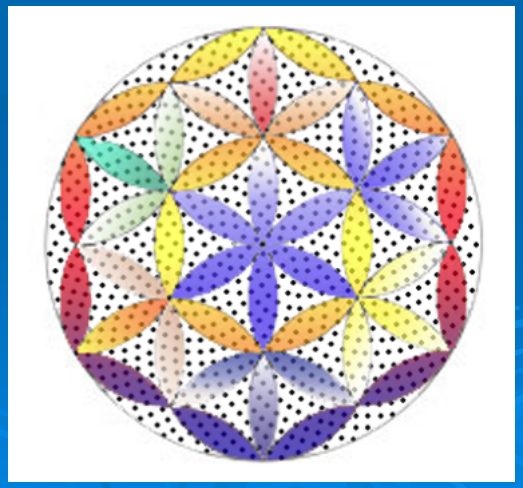
- **Let us remember here that the Vesica Piscis is less than directly related to PHI. While there IS a Golden Vesica, it is not involved in the FOL designs.**

- **One can rotate the FOL design as many times as one wants, this will never create an inter-dimensional portal. Whereas any seed, by the nature of its embedded geometric antennas, spirals into immediate resonance with higher matrices of harmonic growth.**

The FOL designs are wonderful tools for organizing data & figures such as the Platonic Solids. They are great metaphors for processes based on repetitive multiplication and cubic progressions and they provide fascinating templates for mosaic & tile artwork. However, they are not truly *creative* because they lack the intercourse with the FIVENESS of PHI. They fail at representing the GOLDEN FRACTAL VORTEXING of life & consciousness at play in the cosmos. The name "Seed of Life" is a partial misnomer.



↑ When spherized, the Seed of Life design is seen as basically a snow flake geometry (equilateral triangle grid).

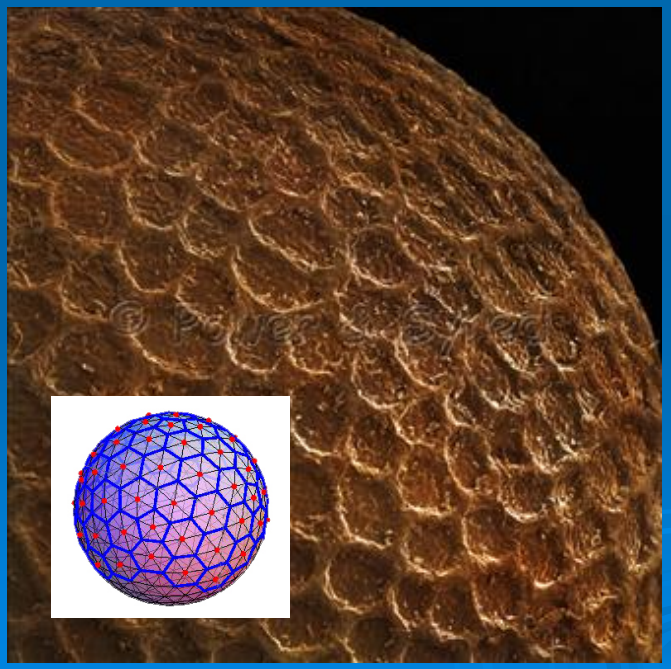


← The "Seed of Life" overlaid on a the phyllotactic pattern of a sunflower's seed head.

The FOL Seed of Life does not match the Fibonacci spirals of the sunflower's seed head.

SG205A.4.12.1 Famous Seeds (1) Mustard Seed

www.psmicrographs.co.uk



Mustard seeds are the small round seeds of various mustard plants. They have been used, in various cultures, as a symbol of smallness and yet infinity.
The perfectly spherical ones look like geodesic domes.

The earliest reference to mustard in India (5th century BCE) is the story told by Gautama Buddha about the grieving mother and the mustard seed. When the mother loses her only son, she takes his body to the Buddha to find a cure. The Buddha asks her to bring a handful of mustard seeds from a family that has never lost a child, husband, parent or friend. When the mother is unable to find such a house in her village, she realizes that death is common to all, and she cannot be selfish in her grief.

The Buddha also stated that if an individual were to pick a single mustard seed, every hundred years from a seven-mile cube worth of mustard seeds, then by the time the last seed is picked, the age of the world cycle would still continue. If a mustard seed is 3mm in diameter, then taking one seed every 100 years from a seven-mile cube of seeds, would take 936 quintillion years, 68 billion times the age of the universe given by science.

In the Quran, Allah stated that, on the Day of Judgment, even the equivalent of a mustard seed will be accounted for because the scales will be established.

Jewish texts compare the knowable universe to the size of a mustard seed to demonstrate the world's insignificance and to teach humility. The great Jewish philosopher, Nahmanides, mentions that the universe expanded from the onset of its creation, in which time it was the size of a mustard seed.

In the Christian New Testament, the mustard seed is used in a parable as a model for the kingdom of God which initially starts small but grows to be the biggest of all garden plants. Faith is also spoken about in the context of a mustard seed.

[More on the symbolism of the mustard seed
will be explored in ◆SG305]

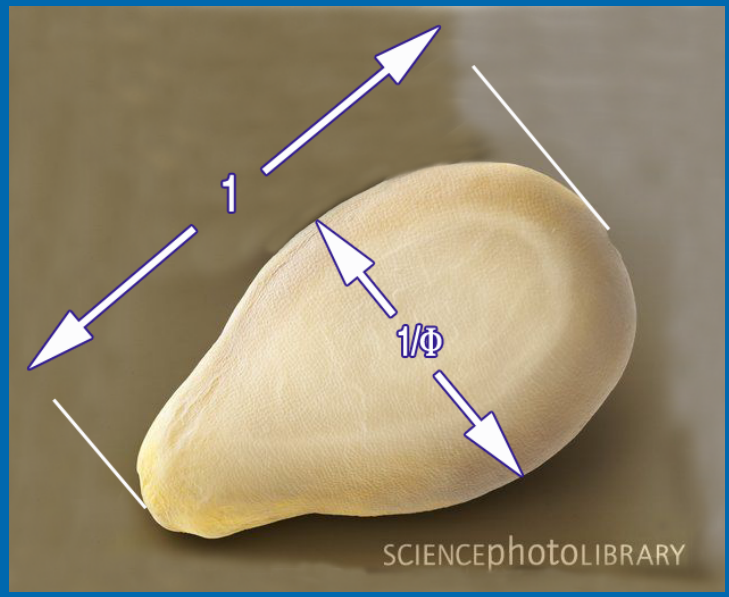
(Geodesic dome: stephenluttrell.blogspot.com

SG205A.4.12.2 Famous Seeds (2) Sesame Seed

The sesame seed is another traditionally illustrious seed.

In Hindu legends and beliefs, tales are told in which sesame seeds represent a symbol of immortality. The God Maha Vishnu's consort Maha Sri Devi herself represents the properties of the sesame seed. With such a sacred background, the sesame seed oil is considered the most auspicious oil next to Ghee used in Hindu rituals and prayers. "Open sesame", the phrase from Arabian Nights, reflects the distinguishing feature of the sesame seed pod, which bursts open when it reaches maturity.

↑ **Electron micrograph of a sesame seed.**
www.psmicrographs.co.uk



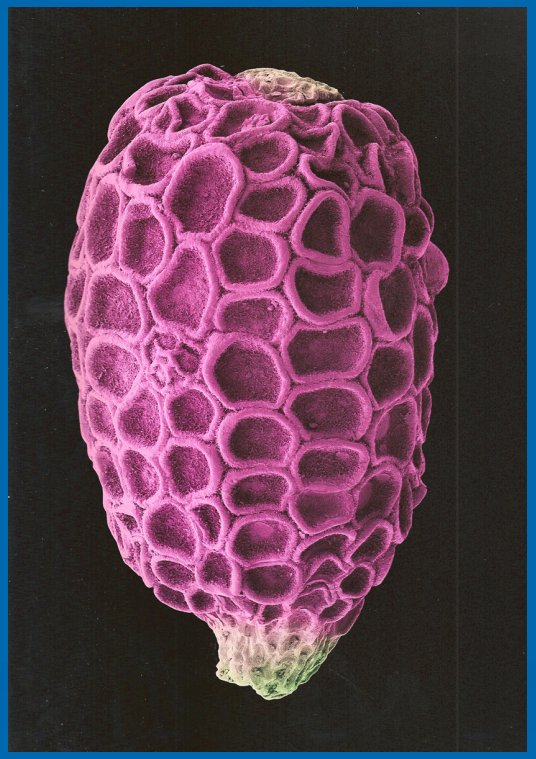
The sesame seed shows the basic harmonic proportion of life, as embodied in the Golden Rectangle.
The sesame seed has the shape of a Golden Gourd.

← **The sesame plant.**
(*Sesamum indicum*)

SG205A.4.13.1 The Seed as Beauty & Harmony (1)

↑ Seed of *Castilleja* flower

(popularly known as Indian paintbrush or prairie fire)



↑ Seed of *Drosera cistiflora*

(Polygalaceae)

(or cistus-flowered sundew)

Seed images by Rob Kesseler. Pollen - The Hidden Sexuality of Flowers. 2009 www.guardian.co.uk
Seeds. 2006

SG205A.4.13.2 The Seed as Beauty & Harmony (2)

↑ Seed of *Polygala arenaria*
(Polygalaceae)
(or Sand Milkwort)

↑ Seed of *Centaurea cyanus*
(Asteraceae)
(or Cornflower)

(Seed images by Rob Kesseler. Pollen - The Hidden Sexuality of Flowers. 2009 www.guardian.co.uk Seeds. 2006.)

SG205A.4.13.3 The Seed as Beauty & Harmony (3)

↑ Seed of *Cleome gynandra*
(Wild Spider flower
or Spider Wisp)

↑ Seed of *Delphinium requientii*
(Ranunculaceae)
(or larkspur)

(Seed images by Rob Kesseler. www.guardian.co.uk Seeds. 2006.

SG205A.4.13.4 The Seed as Beauty & Harmony (4)

↑ Seed of *Lychnis cuculi*

(Ragged Robin)

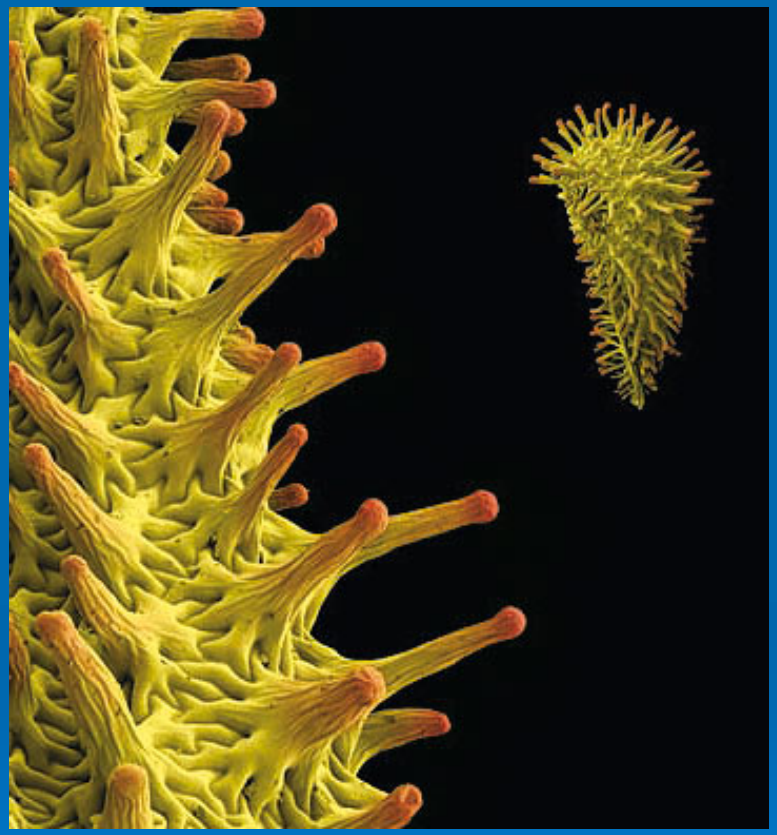
(Seed images by Rob Kesseler. The Hidden Sexuality of Flowers. 2009
www.guardian.co.uk Seeds. 2006)

SG205A.4.13.5 The Seed as Beauty & Harmony (5)

↑ Seed of the Pauwlonia tree

(Seed image by Rob Kesseler. Seeds. 2006. www.guardian.co.uk)

SG205A.4.13.6 The Seed as Beauty & Harmony (6)



↑ Seed of *Ornithogalum dubium*
(Hyacinthaceae)
(or Sun Star)

↑ Seed of *Stellaria holostea*
(Polygalaceae)
(or Greater Stitchwort)

(Seed image by Rob Kesseler. Seeds. 2006. www.guardian.co.uk)

SG205A.4.13.7 The Seed as Beauty & Harmony (7)

← Seed of Acacia cyclops (Fabacea).

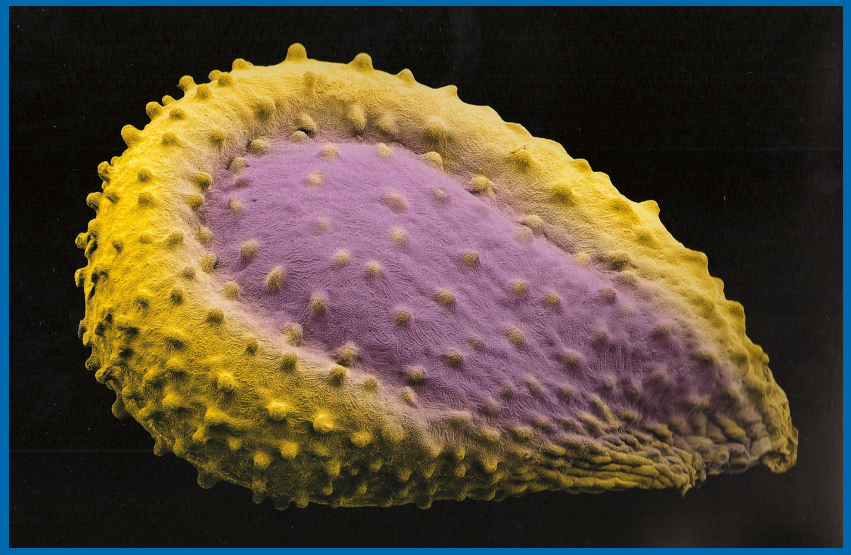
(Seed image by Rob Kesseler. Fruit - Edible, Inedible, Incredible. 2009 www.telegraph.co.uk)

SG205A.4.13.8 The Seed as Beauty & Harmony (8)

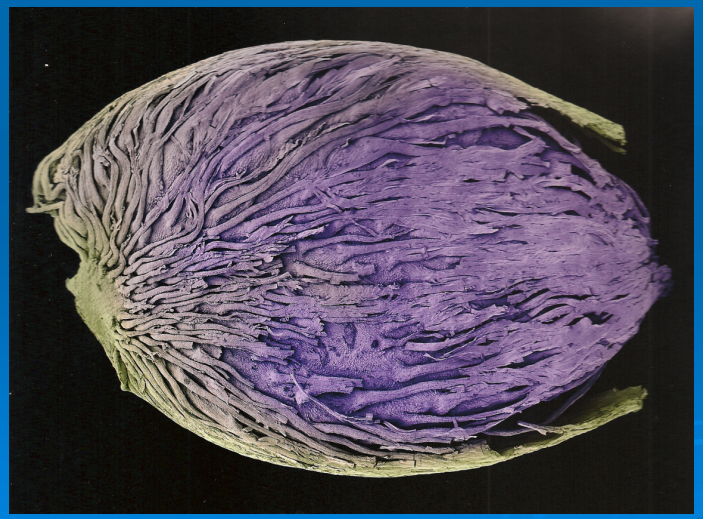
← Seed of *Nemesia versicolor*
(Plantaginaceae)
(or Leeubekkie)

(Image from: *Seeds*. 2006. Rob Kesseler.)

SG205A.4.13.9 The Seed as Beauty & Harmony (9)



↑ Seed of *Spergularia rupicola* (Caryophyllaceae)
(or Rock Sea-spurrey)



(Images from:
Seeds. 2006.
Rob Kesseler.)

← Seed of *Blepharis mitrata*
(Acanthaceae)
(or Larkspur)

↑ Seed of *Setaria viridis*
(Poaceae)
(or Green Bristlegrass)

SG205A.4.14.1 Seeds and Spirals (1)
Pelagornium

When the *Pelagornium* (the common Geranium) seed (the common Geranium) is released, it is straight, but soon it starts to corkscrew to bore into the ground, eventually forming elegant spirals.

↑ Corkscrewing *Pelargonium* seed.
www.scentedleaf.blogspot.com

← www.alvaroviljoen.com

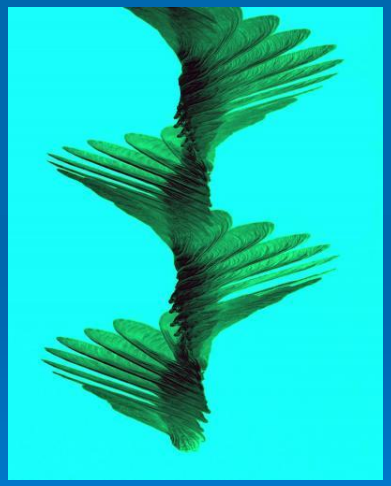
↑ A beautiful picture of a spiraling *Pelargonium* seed.
www.marksgardenplants.com

SG205A.4.14.2 Seeds and Spirals (2) Maple

Maple tree seeds (Samara fruit) and the spiraling pattern in which they glide to the ground have delighted children for ages and perplexed engineers for decades.

Maple seeds display a highly sophisticated flying technology. Filming maple seeds with high-speed video has revealed that maple seed pods remain airborne for miles by harnessing the power of tornado-like vortexes generated as they spin. The flat, elongated pods are densest at their seed-containing ends, a configuration that causes them to rotate while falling. Rotation produces the pods nickname "whirlybirds" and creates tiny vortexes above their leading edges. Because the spinning, helicopter-like, motion of the maple seeds arises automatically, it is called *autorotation.*

It was also found that a spiral of air develops on top of each falling seed wing. That vortex lowers air pressure and generates lift, acting like a miniature tornado that sucks the seed up.



↑ Model of maple seed's autorotation.
www.sciencedaily.com

↑ There is even a maple seed copter kite.
rudystoys.com

SG205A.4.14.3 Seeds and Spirals (3) Indian Mahagony

Mahogany seeds are another instance of efficient fliers. The West Indian Mahagony tree (*Swietenia mahagoni)* produces a pod containing tight-fitting winged seeds.

The structure of these seeds as rotary wings enables them to spiral through the air as they fall, just like a helicopter. They have to because they need to get as far away from their parent tree, or else they can't grow into a healthy plant from all that competition with the parent for sunlight, nutrients, etc…

↑ A mahagony seed pod with its many rotary wing seeds fitted like an elegant jigsaw puzzle in 3D. toyspedia.blogspot.com

↑ Some of the many flying seeds in a Mahagony seed pod.

← When the pod is ripe, it falls off the tree and sends out the flyers rotary seeds in the wind.

//herbalmiracles.blogspot.com

SG205A.4.14.4 Seeds and Spirals (4) The Mountain Mahagony

The mountain mahogany's spiraling seeds are designed for flight. Affixed with a silver-haired coiled plume, they remain nested in their dried tubular calyx until the suggestion of wind exhorts an inclination to

Appropriately, it is from these signature seeds that the mountain mahogany (*Cercocarpus ledifolius*) derives its name. Cercocarpus comes from the Greek *kerkos*, for tail, and *carpos*, or fruit.

When the spiraled plume lands, it is poised literally to nestle into the earth. Autumn adjusting humidity causes the tail to alternately straighten and recoil (a response to moisture and a lack thereof, respectively). This movement drives the seed deeper and deeper. Once lodged in the soil, it releases the tail and begins to grow roots for another mountain mahogany.

(Images & text: //imprint.printmag.com)

SG205A.4.15 Green Singing & Navoti

Kokopelli ➔ is the Hopi spiritual being most closely associated with plant fertility and seed germination.

Plants & seeds respond wonderfully to musical harmonies. This was an integral part of ancient farming & gardening traditions. In many sacred cultures, even the seed preparation & germination was a highly ceremonial protocol involving prayers to the spiritual spirits of nature and dedicated chants of auspiciousness. Viktor Schauberger describes his encounter with a farmer singing to the liquid compost he used to improve the yield of his crops [◆SG203.5]. Nowadays, this is revived by new gardening techniques like "Sonic Bloom" which use bird singing and Indian ragas recordings [◆SG201.6] .

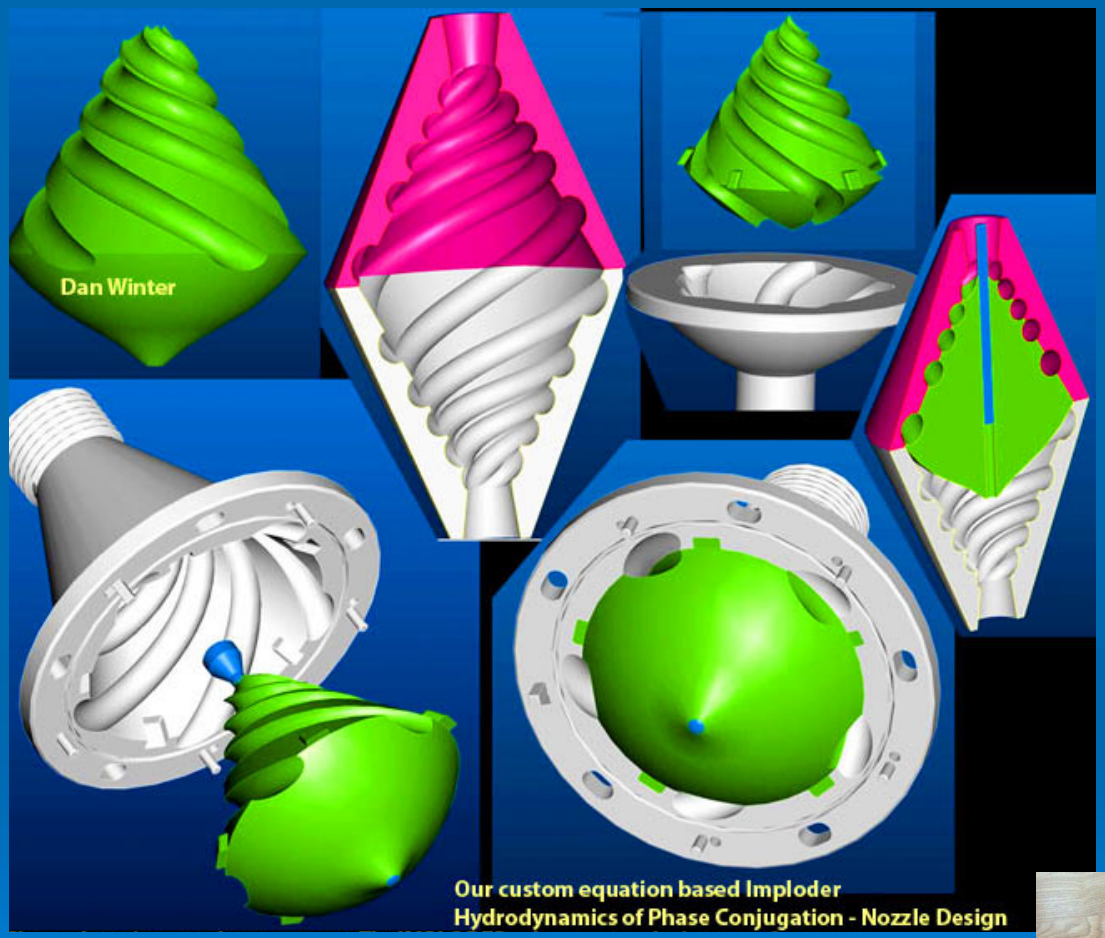
In their landmark study about the "*Secrets of the Soil*" (1989), C. Bird & P. Tompkins give the following account:

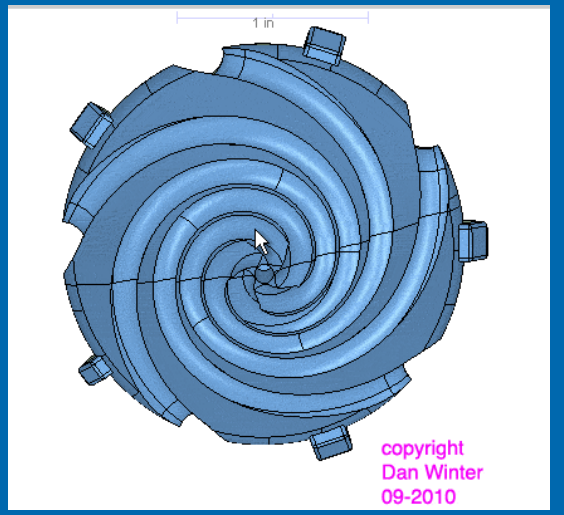
"John Kimmey was a guest of David Monongye, a traditional religious leader and elder of the Hopis… Drawn by an urge for which he could not account, Kimmey ambled to the edge of the Third Mesa and down a dusty trail… Kimmey became aware of an eerie song wafting through the arid surroundings. Beyond the last rock outcropping, he gazed upon an expanse of planted corn so vast it didn't seem Hopi. The singing became clearer, coming from a soft, powerful voice… To his astonishment he noticed that every one of the thousand or more clumps of waist-high Hopi cornstalks, each with a dozen or more ripening ears, was growing as lushly as if it had been planted in rain-blessed Iowa… Tiptoeing through the cornstalks, Kimmey spotted an old Indian seated on the ground, his eyes closed and impervious to the presence of any passing creature, including Kimmey, the atmosphere around him indicative of deep communication with the cosmos.
Gingerly moving away, Kimmey returned to his quarters, where his Hopi host smiled: "So you came upon old Titus! He still keeps the ancient Hopi way, which unfortunately has all but died out among the present generation. It's not the water, it's the NAVOTI that keeps his plants alive. He knows by heart the right airs to chant to his corn children, for whom he offers prayers at planting time… He goes to his children in the high heat of noon to impart courage to them with his generations-old songs".
"Surely," Kimmey protested, "all the other corn farmers must see what a difference the songs make to his crop. Why don't they sing to theirs too?"
Hopi elder David sighed: "It's too late. NAVOTI is no longer alive in other men's seeds."

Note: this maybe the hidden secret of some heirloom seeds that have preserved essential PHI-based musical harmonies in their DNA - we now know that the Fibonacci fractal resonance of nucleotides is directly connected to the increase of life force and consciousness [◆SG204.4 and ◆SG305]. The *Navoti* in the seeds might well be signatures of golden sacred harmonics which can be reactivated with precisely attuned singing frequencies, dancing Qigong moves and spiritual oneness.

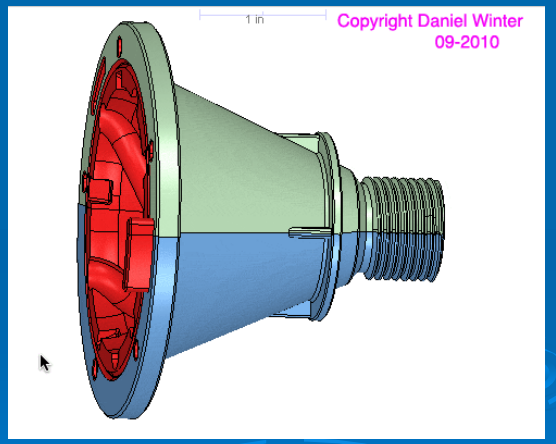
SG205A.4.16.1 PHI Technologies for Seeds (1)

Living Water





↑↓ Animations



Imploder water treatment device based on the Phi fractal vortex.
See the 5-pointed spiraling star at the center of top right image.

www.theimploder.com www.fractalfield.com

9 days

23 days

29 days

SG205A.4.16.2
PHI Technologies for Seeds (2)

Many techniques for improving seed germination and growth have been recently explored: negative ion wind, static electric field, harmonic music etc…

However the enhancement of the water feeding the seeds through the *Imploder* is the most promising: it combines the benefits of Golden Spiral geometry (used in the centripetal nozzle and creating an implosion vortex [◆SG203B.5]) with the coherent action of phase-conjugate magnetics.
The Imploder device creates a super ordered fractal geometry in the water making it BIO-ACTIVE. Highly successful results have been shown in terms of seed germination, plant growth and biomass yield.

PHI (the golden mean proportion) defines beauty, the geometry of all living proteins and plants, and is used by nature for perfect constructive wave interference and phase conjugation. Seeds - and all of nature - respond best to Phi-based Fractal Nesting. This is the penta-symmetric ("golden") pulse within the web of life.

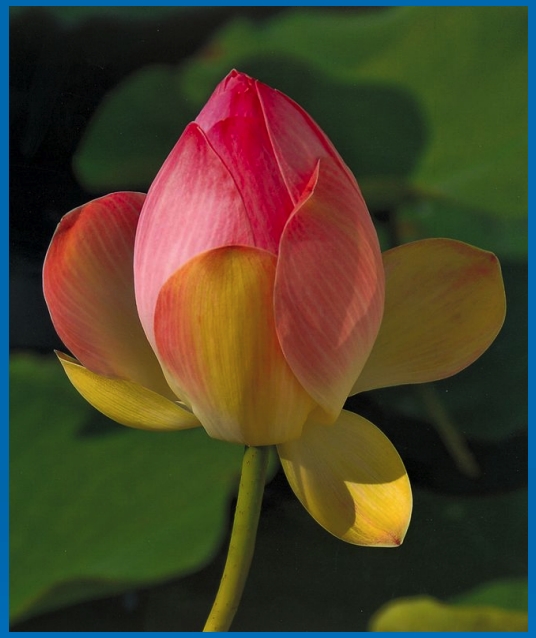
See explanations by Dan Winter:
www.the imploder.com

↑ Left: imploded water plants
Right: Regular tap water

← Growth Experiments with Imploded Water. A growth experiment compared the growth of white mustard seeds in a tap watered control group with an identical setup using tap water put through the implosion device. The Imploder watered group demonstrated an increase in germination rate from 63% to 83% (a 20% increase), and yielded a 328% increase in biomass over a period of 31 days as compared to the control group.

SG205A.4.17 Earthlings as Seedlings

Earthlings
are Seeds & Seedlings
in the
Earth Paradise Garden

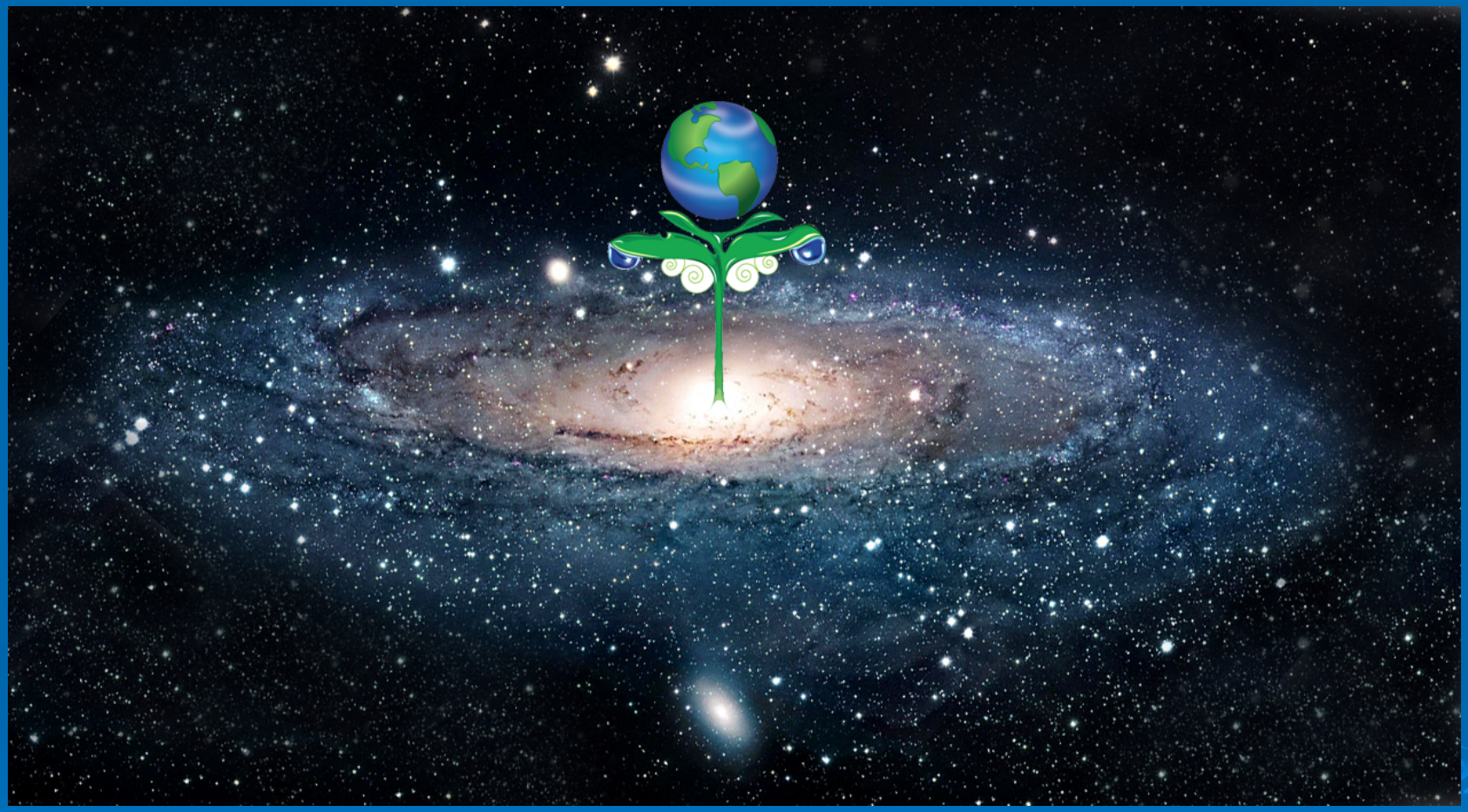


A lotus bud

SG205A.4.18
The Same Flowering

A Buddha seed

We are little seeds in the big garden
We are little sounds in the big silence



SG205A.4.19 The Earth as a Galactic Sprout

SG205A.Ca Conclusion to SG205A - Part 1.

In the first chapters of SG205-A, we have been exploring the plant kingdom (or shall we call it a "queendom"?) in terms of its patterns of harmony & fractal proportions.

We have looked into the spiral architecture of most plants - which is based on the Golden Angle of Growth (137.5°). Phyllotaxis, once an obscure science, is now merging with mathematical physics and many other areas of scientific enquiry as similar patterns of growth can be observed at all scales of nature and also in many manifestations of culture.

We have admired magnificent examples of flowers & plants that touch upon subtle aspects of the human body and spirit. And we have peered into the mini-scale levels of seeds & pollen and their extraordinary micro-sculptures.

A deeper understanding of nature is arising: plants are not only displaying harmonic geometries out of functional efficiency, but also (and maybe essentially) because they are the expression of a cosmic presence of unity & beauty. Plants (and all of nature) are holographically echoing the source of the universe and consciousness. They are primarily soul experiences.

Through the forms of harmonic geometry and golden fractal nesting, plants invite us to engage our own human unity and beauty as a cosmic presence.

The story of Sacred Geometry in Nature, as re-learning how to be enchanted by the ways of nature, is continued in Part 2 of the SG205 module:

Chapter 5: Sacred Geometries in Minerals
Chapter 6: Sacred Geometry in Animals
Chapter 7: The Animal Micro-World
Chapter 8: A Gallery of Shells
Chapter 9: A Gallery of Radiolarians & Diatoms

SG205A.Cb Concluding Quote

"The consistent occurrence of five-fold (pentagonal) symmetry in wild flowers and seeds is a reminder of the intimate connection between the golden ratio, or golden mean, and the power of life and harmony."

Charles, Prince of Wales.

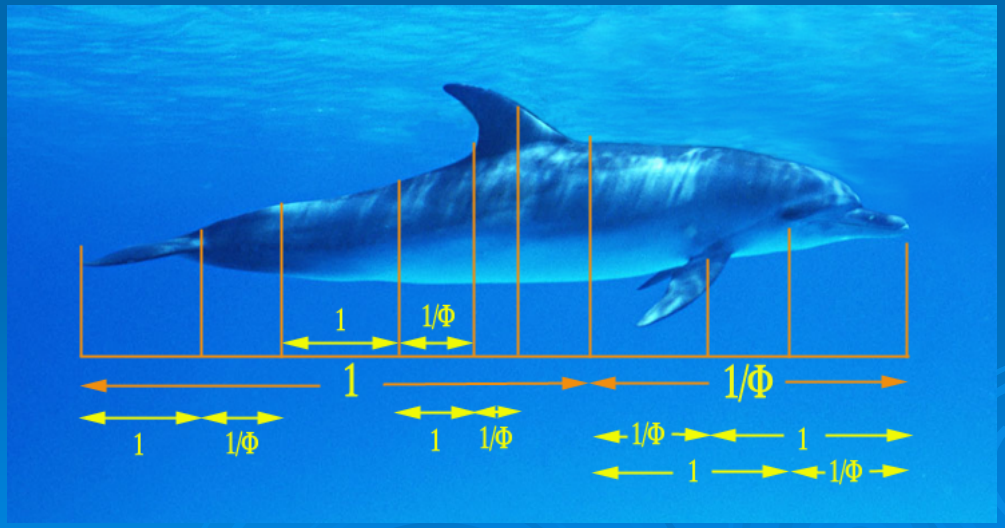
Preface to *Seeds* by Rob Kesseler & Wolfgang Stuppy.
Firefly Books, New York. 2006.

SG205A.Cc To Be Continued in SG205B - Part 2

The review of Sacred Geometry in Nature will be continued in SG205B - Part 2: Minerals & Animals.

PART 2:

Chapter 5:
Geometries in Minerals
Chapter 6: SG in Animals
Chapter 7: The Animal Micro-World
Chapter 8: A Gallery of Shells
Chapter 9: Mini Jewels of the Sea



SG205A.Cd Online SG School Curriculum: Intro & Intermediate

Sacred Geometry Introductory Level: 8 Modules

SG 101	Intro I	Sacred Geometry: Universal Order & Beauty
SG 102	Intro II	History & Traditions of Sacred Geometry
SG 103	Intro III	Sacred Geometry: A Grand Tour
SG 104	Intro IV	PHI: the Golden Ratio & the Fibonacci Series
SG 105	Intro V	The Golden Rectangle & Golden Spiral
SG 106	Intro VI	Pentagons, Pentagrams & the Penta-Modules
SG 107	Intro VII	The Five Platonic & 13 Archimedean Solids
SG 108	Intro VIII	The Vesica Piscis: Cosmic Womb of Creation

Sacred Geometry Intermediate Level: 8 modules

SG 201	Interm I	The Monochord, Music & Cymatics
SG 202	Interm II	The Power of Archetypal Numbers
SG 203A	Interm IIIA	Sacred Geometry Resurgence in Science - Part 1
SG 203B	Interm IIIB	Sacred Geometry Resurgence in Science - Part 2
SG 204	Interm IV	PHI in the Human Body, Biology & DNA
SG 205A	Interm VA	The SG of Nature - Part 1: Plants & Phyllotaxis
SG 205B	Interm VB	The SG of Nature - Part 2: Animals & Minerals
SG 207	Interm VII	SG in Architecture, Sacred Sites & Green Design

SG205A.Ce Online SG School Curriculum: Advanced

Sacred Geometry Advanced Level: 8 modules

SG 301	Adv I	Golden Cosmos: Planets, Stars & Cosmology
SG 302	Adv II	SG in Art, Culture & Creativity
SG 303	Adv III	Universal Symbols: Primordial Knowledge
SG 304	Adv IV	Labyrinths: a Mini-Pilgrimage to Self
SG 305	Adv V	Mandalas & Yantras: Sacred Vortices
SG 306	Adv VI	Languages & Gematrias: Sacred Communication
SG 307	Adv VII	Sacred Geometry in the Healing Arts
SG 308	Adv VIII	Harmony on Earth: Science & Consciousness of Harmony

Upon completion of each level (Introductory, Intermediate & Advanced), a Certificate of Graduation from the Sedona School of Sacred Geometry will be presented to Certification Students.

Postgraduate seminars on current Sacred Geometry research, discoveries & updates will be organized in harmonic time.

Questions: phi@schoolofsacredgeometry.org

SG205A.Cf StarWheel Blessing

SW#93. Phi Vajra". www.starwheels.com

SG205A.Cg
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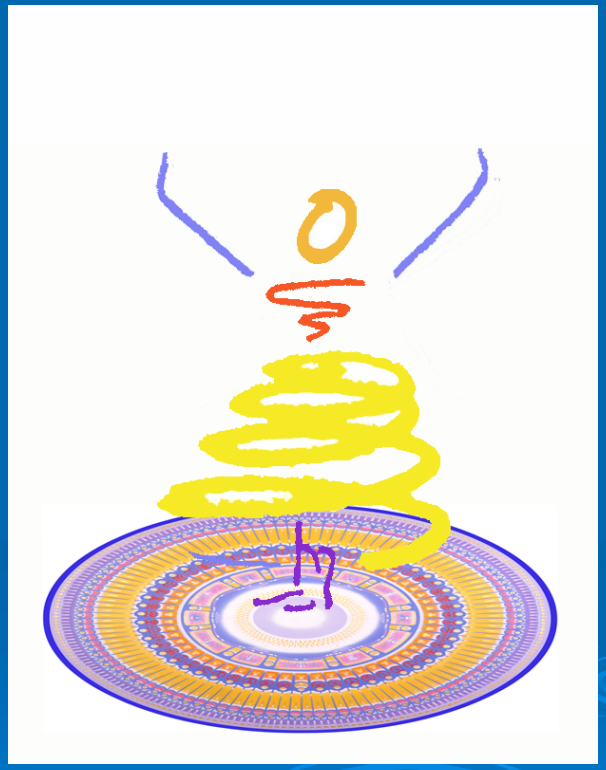
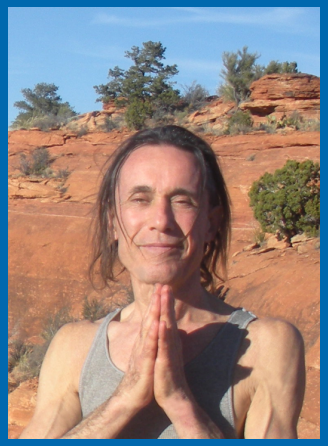
On Facebook: Aya Sheevaya
FB Group: Sedona School of Sacred Geometry



Φ celebration



SG205A.Ch About Aya

A native of France, Aya is a visionary artist and celebration yogi who has dedicated his life to serve humanity and to develop sacred arts education. In his late 20's, Aya realized that his professional life in the French diplomatic service was not fulfilling his heart's desires; he quit everything to go on an extended vision quest. His path took him around the world to visit a variety of sacred sites & cultures and to receive inspiration from many teachers.

In 1985, in Santa Monica, CA, Aya was gifted with a spiritual vision prompting him to create a series of 108 airbrushed neo-mandala paintings: the "StarWheels". The StarWheels, a happy family of vibratory flowers for the Earth, are looking for sacred spaces to be graced with their presence... (www.starwheels.com / www.starwheelmandalas.com)

Moving to Sedona, Arizona, in 1997, Aya has been involved with sacred arts classes & events, mandala creation, Sedona guided tours, labyrinth making and Sacred Geometry teaching. Aya has presented several StarWheel art exhibits, has sponsored community awareness events at the Sedona Library, has developed, in collaboration with Gardens for Humanity, the Peace Garden arboretum at the Sedona Creative Life Center, was a speaker at the Sacred Geometry Conference (Sedona, 2004), co-designed several labyrinth sites (The Lodge at Sedona, Mago's Ranch...), and was on the management team of the Raw Spirit Festival in 2006 - 2008.

Realizing that Sedona was progressively becoming a global spiritual university for many seekers from around the world, Aya founded in 2005 the Sedona School of Sacred Geometry. The school is offering online access to Sacred Geometry PDF modules, with 17 modules completed so far. In the school's website, Aya states: *"We are living at the extraordinary and exciting times of a global transformation to a higher order of human consciousness... Sacred Geometry is the expression and resurrection of our deep innate wisdom, now awakening from a long sleep: seeing again the all-encompassing, fractal-holographic unity of nature, life and spirit... The keyword is HARMONY."* (www.schoolofsacredgeometry.org)

Aya's visionary dream, supported by his non-profit educational organization, the StarWheel Foundation, is the co-creation of an international eco-village "The School of Celebratory Arts" - a green, tropical environment encouraging young people of all nations to develop their creative consciousness and thus contribute to a renewed, spirited, life-respecting global civilization on Earth. (www.starwheelfoundation.org).

Since 2012, Aya is dancing the body divine, after his re-discovery of Yoga, Partner Yoga and AcroYoga. Aya is currently the AcroYoga.org Jam coordinator for Sedona and a teacher of yoga swing asanas.

Blessings in Anjali!