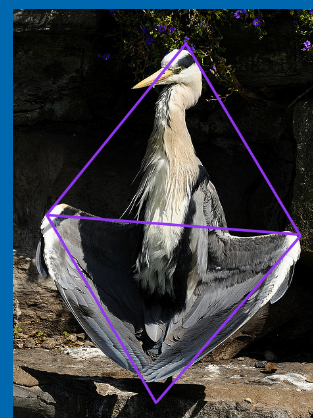
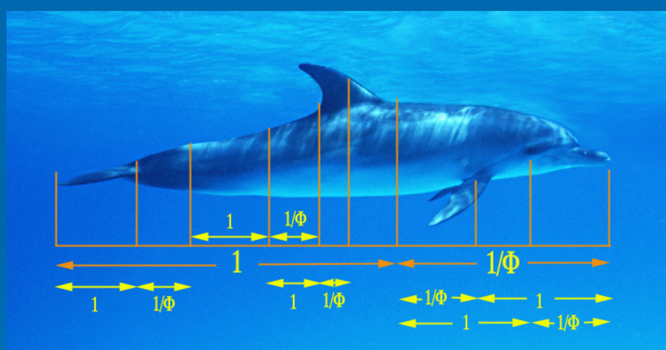
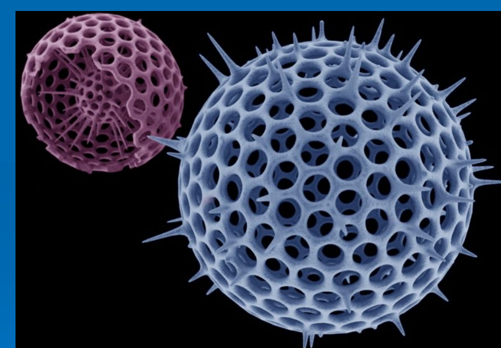
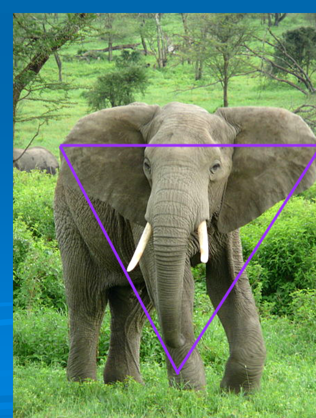
SG205B. Ia The Sacred Geometry of Nature
Part 2: Minerals & Animals

Online Module SG205-B
(Interm V-B)





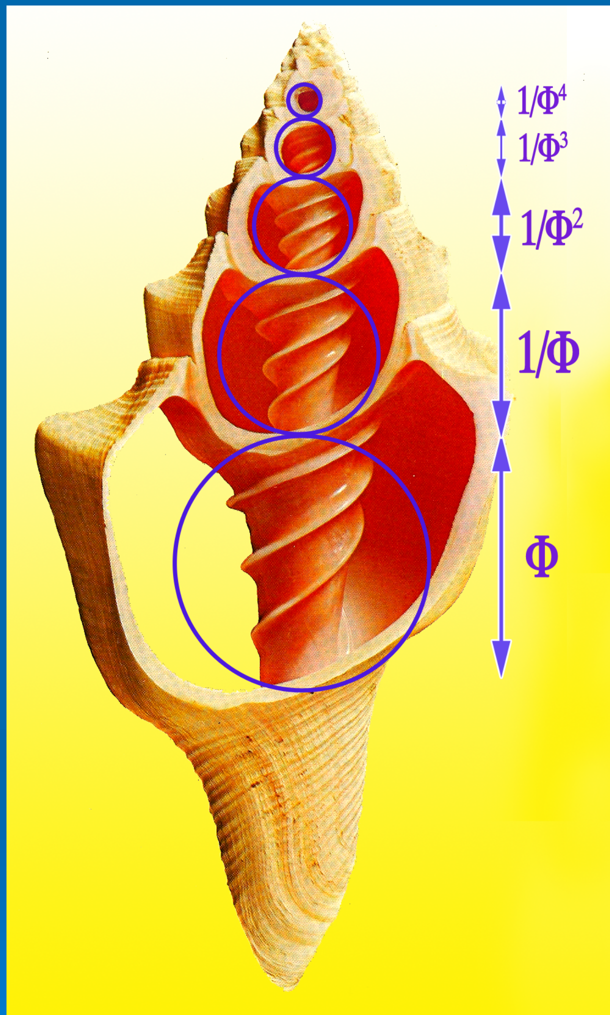




Presented by AYA
& the School of Sacred Geometry
P. O. Box 3714
Sedona, AZ 86340

www.SchoolOfSacredGeometry.org
phi@schoolofsacredgeometry.org
www.starwheels.com

SG205B.Ib The SG of Nature - Part 2 - Contents



SG205B.Ic The Sacred Geometry of Nature - Part 2

We have acknowledged image credits (with hyperlinks) to the best of our ability. Kindly contact us for omissions or corrections.

phi@schoolofsacredgeometry.org

SG205B Interlude 1a. Measuring Nature - Methodology

How do we study harmonic patterns in nature? Can we tell if crystals, plants, land animals, birds, shells display harmonic proportions? How to measure the presence or absence of the Golden ratio, the Golden progression or a Fibonacci-based sequence? Plants (as we have seen in SG205A), crystals & shells turn out to be the easiest to measure. Animals, on the other hand, are more elusive as comparative studies of proportions are almost inexistent. There is a great need to gather data on statistically large samples so we can assess prevalent tendencies. We are at the very beginning of a new 'scientific wisdom' of nature.

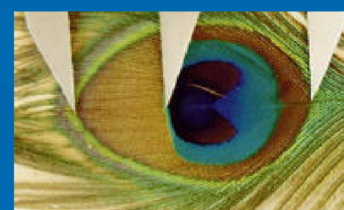
- **First (and underlying more objective methods), there is a subtle sense of inner resonance that triggers our body-mind to a feeling of harmonic kinship with a natural form. We sense there is a musical chord we share with this flower or this animal so that we can dance together, partake of the plant or communicate with the animal. This certainly is a subjective approach but has been used all along by people attuned to nature and by shamanic-type, sensitive humans.**

- **The importance of Scale Variation & Scaling. Scientific tools of magnification or reduction (macro & micro zooming) reveal that, at different scales, patterns of symmetry & harmony are obvious whereas the naked eye may only see random chaos. An obvious example is X-ray diffraction patterns showing the exquisite atomic symmetries of crystals or other substances. We need to learn how to find the proper scale at which nature will reveal its matrix of coherence: it is not necessarily at the scale of our physical vision. Harmonies in nature are nested within each other, they form cascades of progressions (larger & smaller), they group by certain affinities. We need to practice how to be flexible in our perception of nature, how to gaze between defined forms and see the energy field lines connecting elements of nature. We need to re-learn how to listen to other scales/dimensions of a natural object. Science-oriented people use the great technological instruments we now have, and yoga-oriented people, using the instrument of their body-energy system, learn how to fine-tune and attune the senses we have in order to expand their perception into larger levels. There is no opposition or incompatibility between "physical" and "psychic" perception - only many shades of overtones… The new understanding of "fractal scaling" helps to continue a form into "infinity up" and "infinity down"…**

- **The methodology of Sacred Geometry is a *systems' view* whereby the parts are seen in their relationship to other parts and the whole. The old isolation is now impossible. In this integrative approach, each organism has its own harmonic inner coherence that is goldenly fractal to larger systems. So, taking a few body measurements is gross: the whole skeleton has to be precisely studied in terms of its relative fractal proportions and its holographic harmony. It is "music"!**

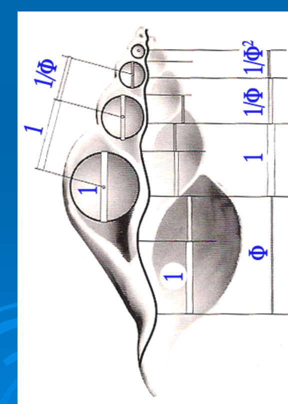
Various researchers have created first-generation tools to assess the presence of the PHI ratio in aspects of nature:

- **Rough measurements with a simple ruler/tape measure. This involves measuring a whole unit and some of its subunits to test if there is a clearly defined Phi ratio. We have done that with the human body [◆SG204].**
- **Using a Phi Gauge or Phi compass allows to directly see if an object (nature or art) has an inherent Phi proportion. (See image next right).**
- **Geometric constructions: overlaying pentagons, golden rectangles or golden spirals to test correlations with main features of an object. This is usually done on pictures and so can be open to discussion.**
- **The Chalavoux method of volumetric circles. (See image far right).**
- **The Doczi method of Dinergic Wave Diagrams (See next page).**
- **Clear acrylic Phi grids with nested proportions. Not scalable.**
- **The Phi Matrix™ grid software is a wonderful way to quickly assess Phi harmonics with reasonable accuracy. One can choose between square Phi grids or concentric/ovoid Phi grids, all scalable.**



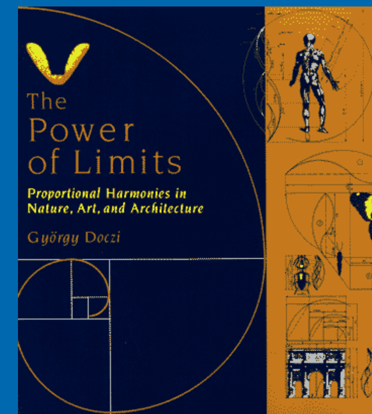
↑ A Phi gauge testing the "eye" on a peacock's tail.

↑ A steel Phi gauge. www.goldennumber.net



↑ Chalavoux volumetric circles www.chalagam.com

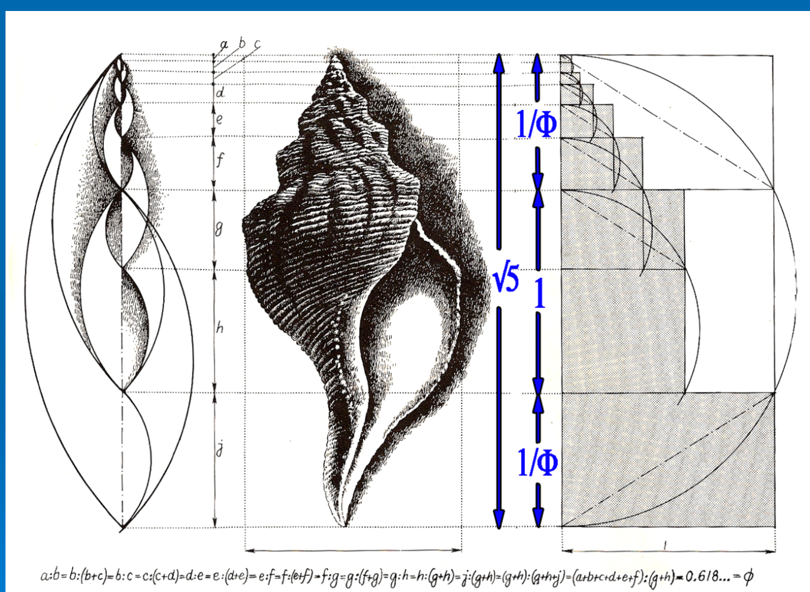
SG205B Interlude 1b. Harmonic Dinergy & Wave Diagrams



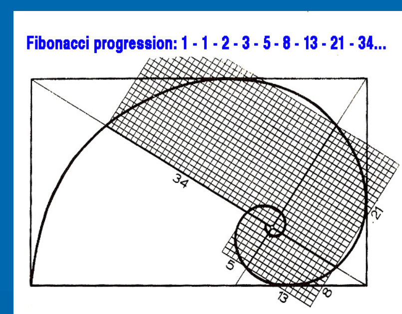
One of the most original and visually efficient methodologies developed for the study of harmonic patterns in nature is *Dinergic Analysis* or *Harmonic Wave Diagrams,* as created by György Doczi.

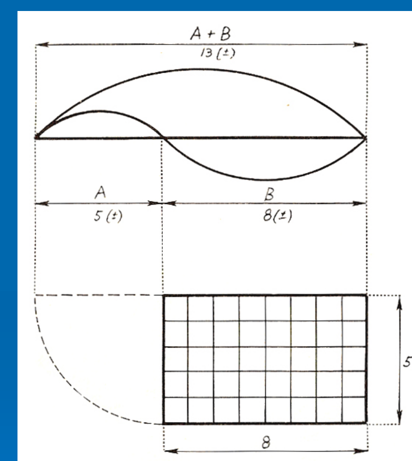
We have already encountered the remarkable work of Sacred Geometry architect György Doczi. In his now classic *Powers of Limits* (1981), Doczi documents and illustrates a general pattern-forming process: the union of complementary opposites, and, more specifically, the harmonic union of the Small and the Large within the Whole - as exemplified in the Golden Ratio.

Doczi coined the new word *"DINERGY"* to mean the generative/growth power of this pattern-forming process of union. Thus, Harmony is a *dinergic relationship* in which different elements complement each other by joining. Doczi is using the direct connection between musical harmony and sacred geometry to visualize what he calls the *harmonic wave diagrams* of forms & shapes in nature & culture. To understand his methodology, we give below two diagrams from *The Power of Limits*: the wave diagram of a shell and the classic Phi wave diagram.



🡅 The Harmonic Dinergy analysis for a whelk shell shows that all the neighboring whorls share the same Phi relationships.
Left: wave diagram which immediately "speaks" music to our intuition.
Right: construction of the golden sections speaking to the mind.





➔ Wave diagram showing the approximation of the Phi proportion from the Fibonacci numbers 5, 8 and 13. This is the archetypal pulse that seems to sustain all nature.

In his life-time devoted to study harmonic patterns in nature, Doczi found that the relationships between the elements of an organism *"reveal growth patterns that are harmonious and dinergic in the sense that all the minors and the majors unite with their neighbors in proportions limited to ratios of the same small whole numbers which create the root harmonies of music."* *(Powers of Limits. p.11)*

SG205B. Chapter 5. Geometries in Minerals

The mineral world is where we can find the clearest expression of geometric volumes. In nature, minerals, and specially crystals, come the closest to the mathematical forms of pure geometry: they produce, in ideal conditions, perfect structures reflecting the configuration of their constituent atoms.

We know that ratios of simple whole numbers govern the electron shells of atoms, the musical octave, and the growth of plants. They also govern the shapes of regular crystals. As we have seen, the most harmonious & efficient ratio is the scale-invariant Golden Ratio Phi, resulting from the Fibonacci sequence 3/5, 5/8… and exemplified in 2D by the pentagon/pentagram. In 3D, the Phi ratio is present in the 5 Platonic Volumes.

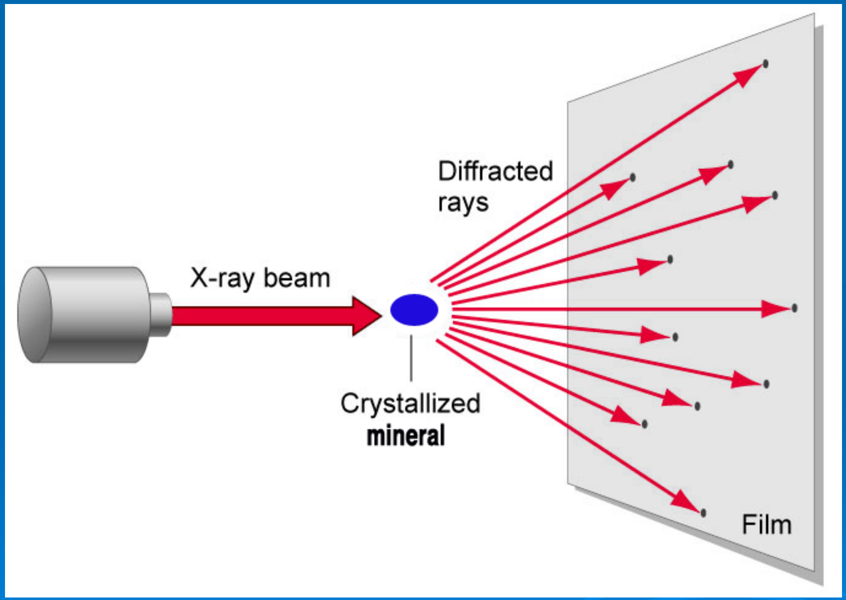
In this chapter, we first review examples of atomic configurations and elements of crystallography. We then travel through the most regular crystal system: the isometric/cubic crystal system which displays the best mineral examples of the 5 regular volumes in nature, the Platonic Solids. The story of Quasicrystals and their penta-symmetry will be broached again, as well as micro pictures of various minerals… and of snowflakes.

SG205B.5.1.1 Minerals - X-Ray Crystallography (1)

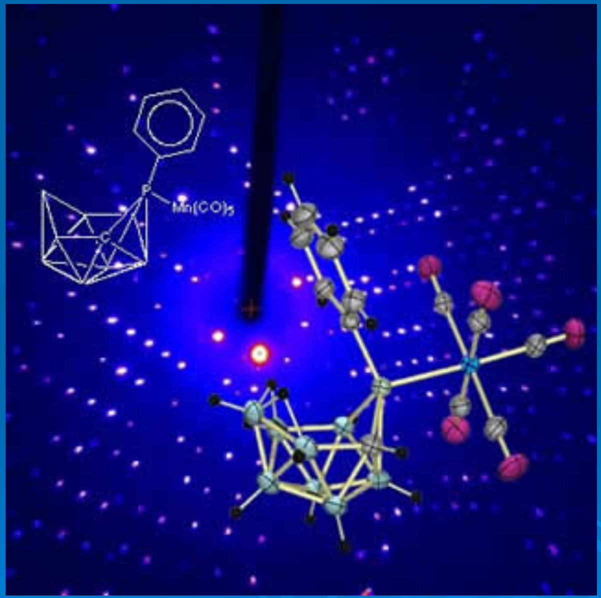
Mineralogy as a science began in the 1800's, after the development of the *petrographic microscope* (for studying rocks) and the *reflecting goniometer* (for accurately measuring angles between faces of a mineral). However the internal crystal structure of minerals could only be guessed from their external properties until William Roentgen's discovery of X-rays in 1895. This provided mineralogists with the tool they needed.

In 1912, Max von Laue sent x-rays through a crystal ball and onto an unexposed photographic plate. Upon developing the plate, Laue saw dark points arranged in perfect symmetry, thus proving that when X-rays are scattered by a crystal their behavior gives clues to the internal geometries and symmetric arrangement on the atomic scale. X-ray crystallography was born: a beam of X-rays strikes a crystal and diffracts into many specific directions. From the angles and intensities of these beams, a three-dimensional *density map of electrons* is produced. This electron density map, in turn, allows the determination of the mean positions of the atoms in the crystal, as well as information about their chemical bonds, their geometric symmetries and various other data.

Why are X-rays so useful to determine atomic structures? Because they have wavelengths similar to the size of atoms.



↑ The scattering of x-rays through a crystal or molecule gives an atomic diffraction pattern.
www.biochem.arizona.edu

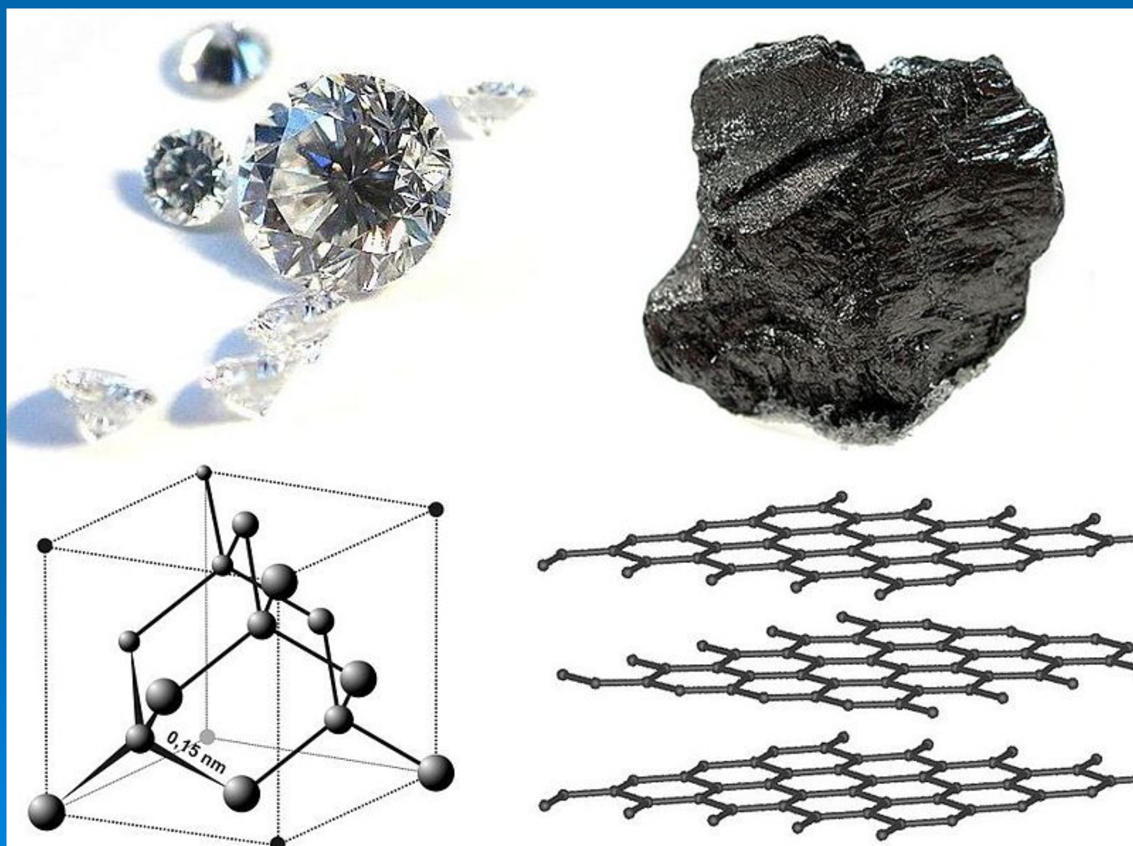


↑ From the diffraction pattern, a 3D density map gives the mean positions of the atoms.
www.macxray.chem.upenn.edu

SG205B.5.1.2 Minerals - X-Ray Crystallography (2)

The potential of X-ray crystallography for determining the atomic structure of minerals (and later organic molecules) was realized immediately. The earliest structures were simple inorganic crystals and minerals, but even these revealed fundamental laws of physics and chemistry. The first atomic-resolution structure to be "solved" (i.e. determined) in 1914 was that of *halite* or table salt. Then a systematic study of all the important mineral groups was launched and completed. Note: a similar technique was used to decode the double-helical spiral structure of DNA.

We show below a Wikipedia image of the comparative structure of diamond and graphite: the image shows the rough (or cut) mineral on top and the atomic structure below. In between, there is an x-ray diffraction pattern and density map (not shown).



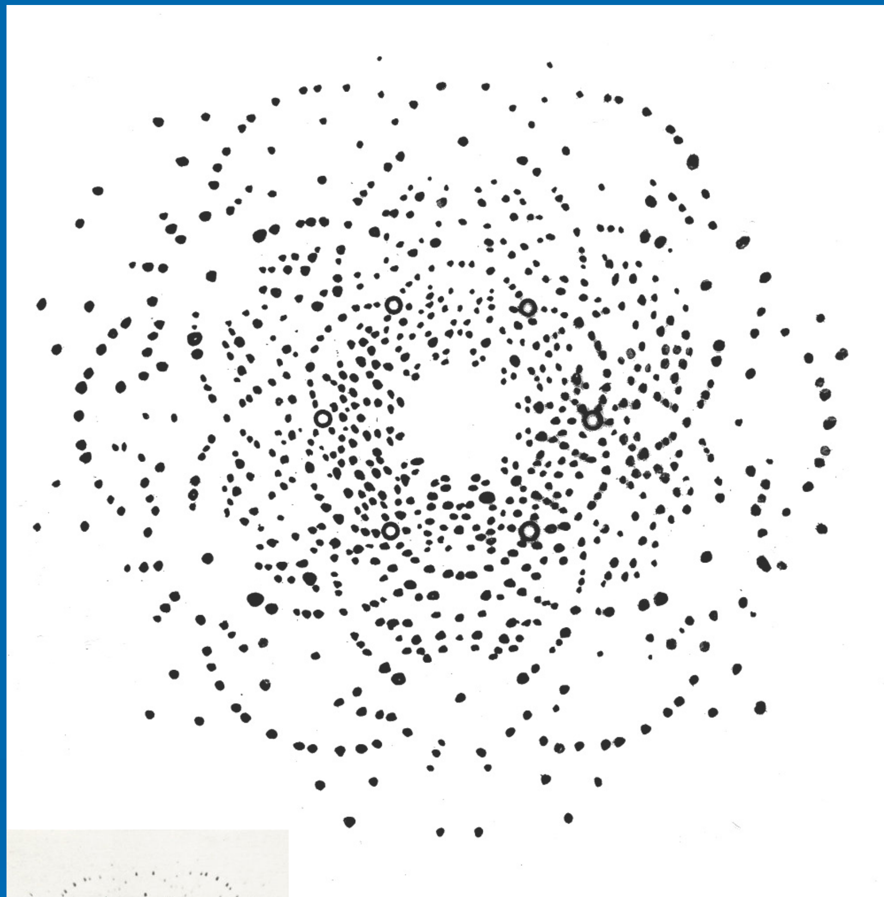
Although diamonds (top left) and graphite (top right) are identical in chemical composition, being both pure carbon, X-ray crystallography revealed that the arrangement of their atoms (bottom) accounts for their different properties.

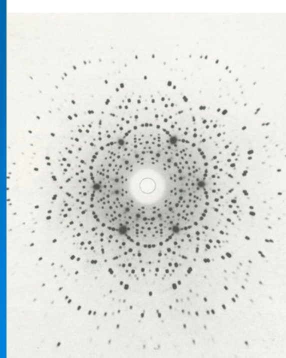
In diamond, the carbon atoms are arranged *tetrahedrally* and held together by single covalent bonds, making it strong in all directions. By contrast, graphite is composed of stacked sheets. Within the sheet, the bonding is covalent and has hexagonal symmetry, but there are no covalent bonds between the sheets, making graphite easy to cleave into flakes.

(Wikipedia)

SG205B.5.2.1 Atomic Symmetries (1)

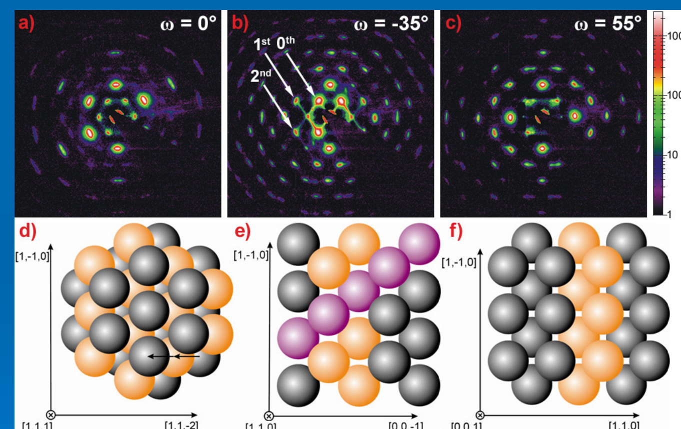
Matter is an exquisite choreography of harmonic waveforms





↑ Hand retraced X-ray diffraction pattern in beryl.

← The classical x-ray pattern of beryl.

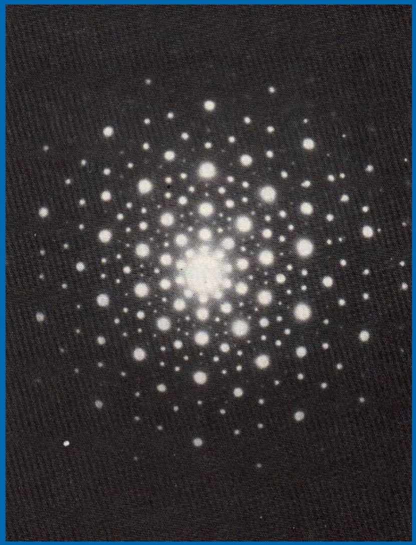


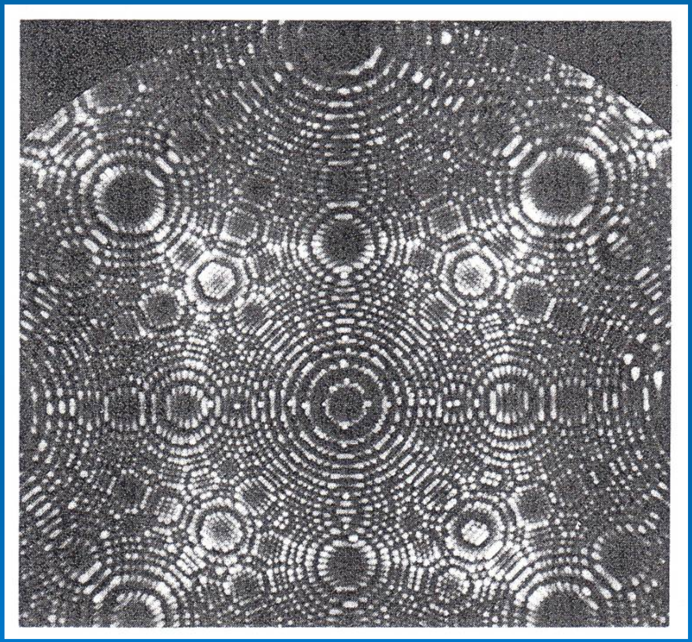
↑ Diffraction pattern images with their corresponding real space crystal orientations. www.esrf.eu

SG205B.5.2.2 Atomic Symmetries (2)

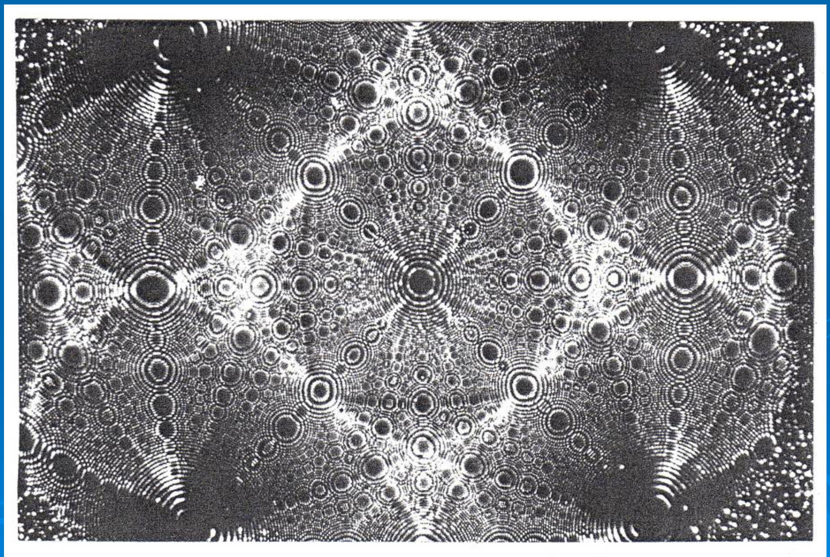
"What we perceive as various
qualities of matter
are actually differences in periodicity".
(Bertrand Russell)

Quasicrystal ➔
Diffraction pattern





🡑 Iridium crystal.
x 1,000,000 times.

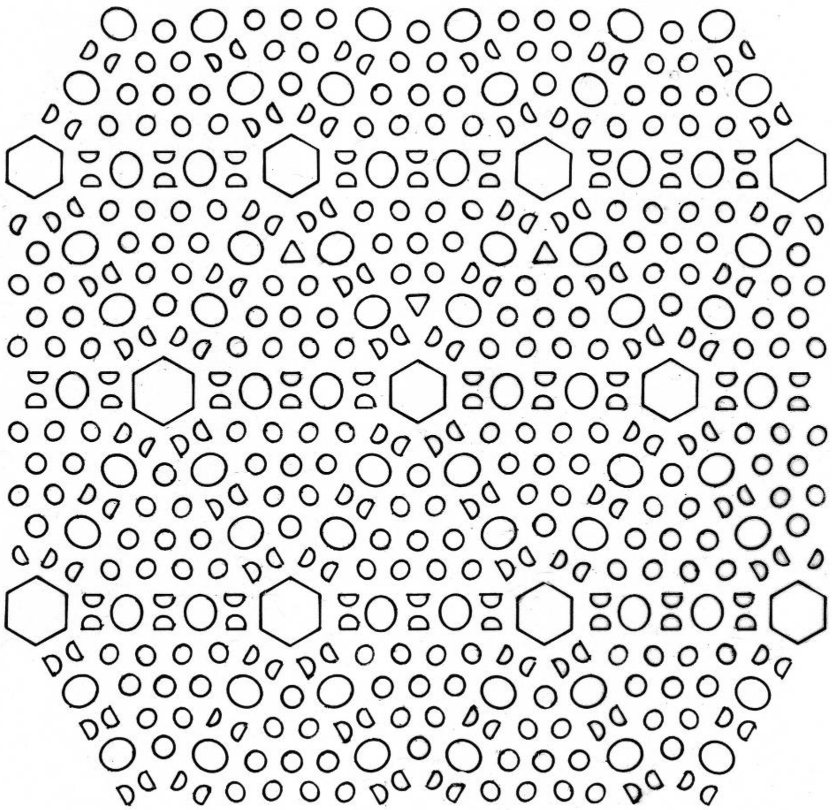


🡑 Platinum crystal. x 750,000 times.

SG205B.5.2.3 Atomic Symmetries (3)

Atomic Structure of Silicon Crystal

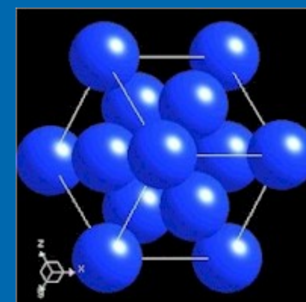
(x 25 million times)



Pattern redrawn from the high resolution scanning electron micrograph of the atomic structure of a pure silicon crystal. Magnified 25 million times.

(After Heaven and Earth. Phaidon. 2002)

Silicon is not found in its pure form in nature but in silicon-bearing mineral compounds which make up to 95% of the earth 's crust.

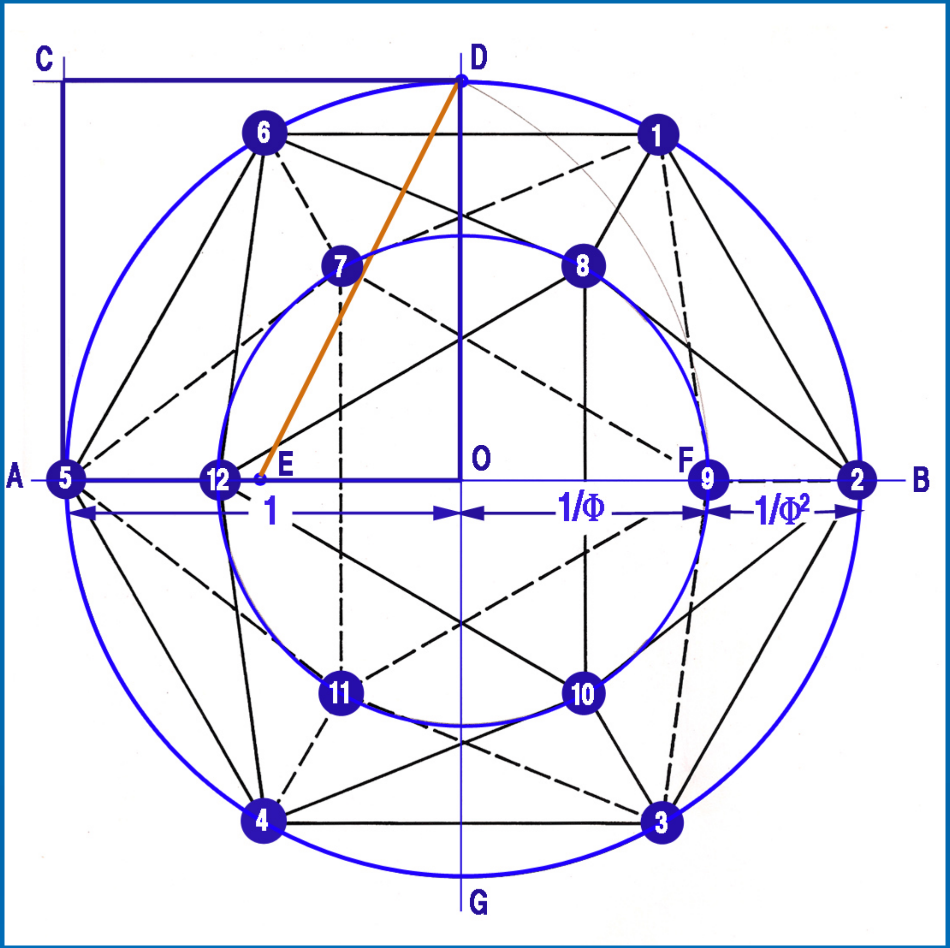


← **Silicon's atomic structure.** www.caribbean-icons.org

↑ **The metalloid *silicon*. (Wikipedia).**

← Pattern Recognition Practice:
There is one (intended) irregularity in this pattern.
Can you find the "artistic license" ?

SG205B.5.3.1 Platonic Harmonics - Reminder (1)



<u>Phi Construction of the Icosahedron</u>

Trace the large circle with radius AO = unit 1. Report the radius AO 6 times around the circumference in order to trace an hexagon (with vertices 1 - 6). Now trace the square AOCD on the baseline AB, with side = 1, then divide the side AO in two equal halves at point E. With a compass at center E and radius ED, trace the arc cutting AB in F. F is the Golden Cut such as AO = 1, OF = 1/Φ and FB = 1/Φ². Tracing a circle with center O and radius OF will give the 6 additional vertices (7 - 12) of the icosa. (Drawing after R. Lawlor. *Sacred Geometry*. 1982).

Crystals grow naturally in the shape of *polyhedra* - 3D shapes whose faces are polygons. Among polyhedra, the only ones that have regular (identical) faces are the 5 *Platonic Solids*. From the Platonic Solids, by the process of truncation (cutting off the corners), we have the semi-regular (2 or more different polygon as faces) *Archimedean Solids* [◆SG107].

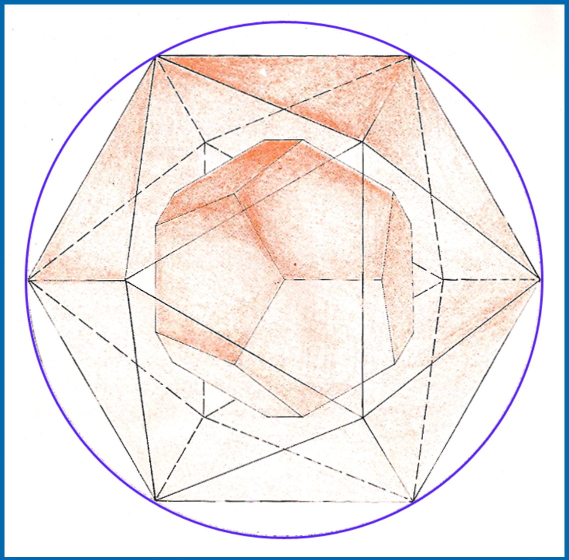
As the only 5 possible regular volumes inscribable in a sphere, the 5 Platonic Solids are the archetypal shapes taken by the Cubic/Isometric crystals (the most regular crystals closest to the sphere).

We are reviewing below the dynamics of nesting between the 5 Platonic Solids. All 5 Platonic can harmoniously fit into each other because the original "seed" is the golden proportion inherent in the ICOSAHEDRON. In the figure on the left, we have the following PHI ratios:

$$AO = 1$$
$$OF = 1/\Phi$$
$$FB = 1/\Phi^2$$

- **By connecting all the internal vertices of the ICOSAHEDRON, we get the DODECAHEDRON.**
- **By using 6 points of the dodeca and its center, we get the CUBE.**
- **By using the diagonals of the cube, we get the STAR-TETRAHEDRON (interlocking tetrahedron).**
- **The intersections of the star-tetra with the cube give us an inscribed OCTAHEDRON.**
- **Then inside the octahedron, there arises a SECOND ICOSAHEDRON, thus going through a complete cycle of archetypal forms, from "Phi seed" to "Phi Seed".**

SG205B.5.3.2 Platonic Harmonics - Reminder (2)

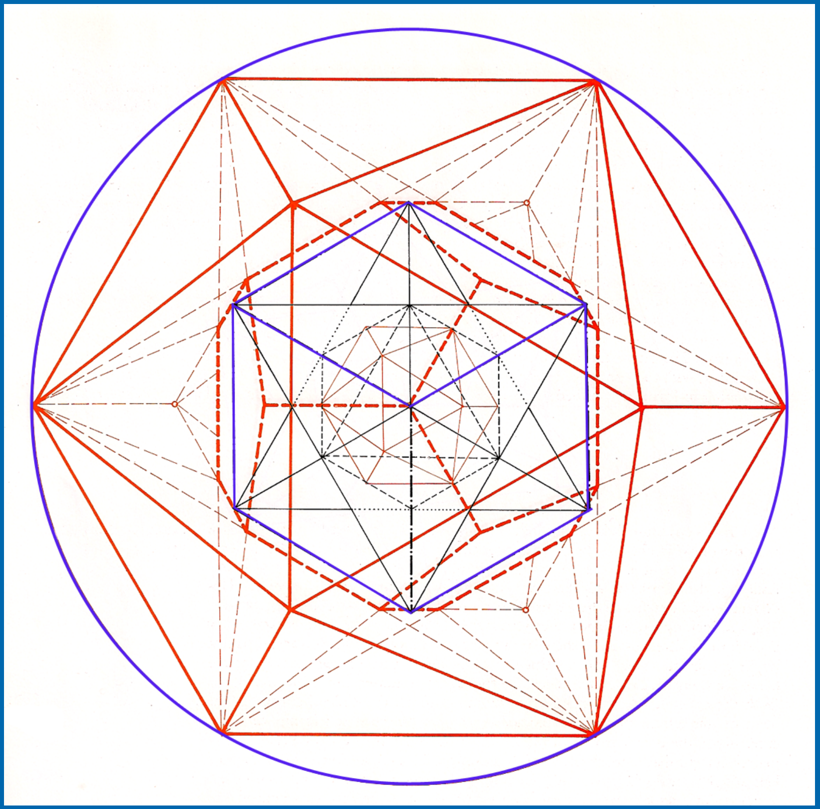


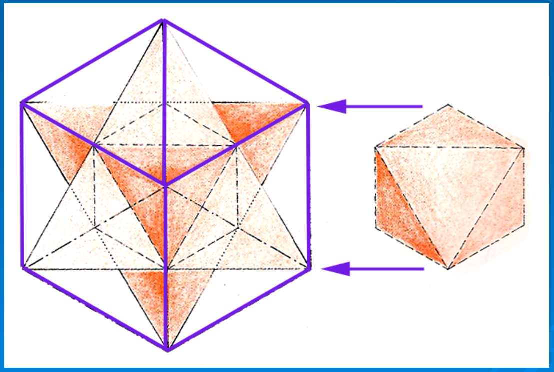
↑ The dodeca in the icosa.

Side lengths ➔:

Cube = 1
Outer Icosa = Φ
Dodeca = 1/Φ
Star-Tetra = √ 2
Octahedron = 1/√ 2
Inner Icosa = 1/Φ²

(Images from Robert Lawlor. *Sacred Geometry*. 1982)





↑ The octahedron & star-tetra in the cube.

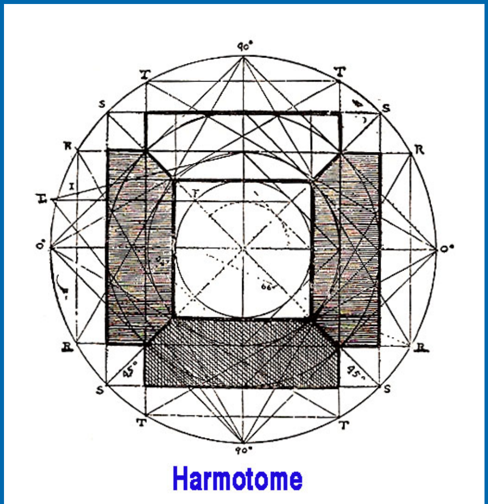
"The transcendent principles, the Icosahedron and the Dodecahedron, Purusha and Prakriti, the primal duality, each have Phi proportions. But when we arrive at the level of the natural world of oppositional dualities, yin and yang, and the cube of matter and its crystallization in the octahedron, it is the square root of 2 which is active.

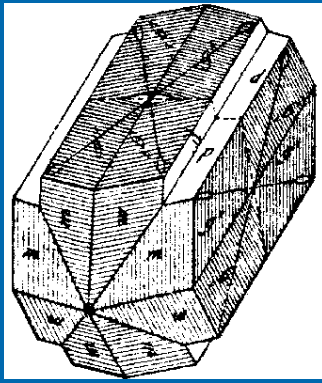
The square root of 2 is the way in which Phi acts on nature. And from the octahedron, the purified state of matter, its crystallization into the mineral gem, is reborn the icosahedron with its Phi dimension, 1/Φ²… an exact image (a fractal) of the initial, generating icosahedron."

(Robert Lawlor. *Sacred Geometry*. 1982. Parentheses by Aya)

SG205B.5.4.1 Traditional Mineral Diagrams (1)

The drawings (this & next page) are from Samuel Colman in his *Harmonic Proportion and Form*, published in 1912. We compare them with actual images and current crystallographic structure.

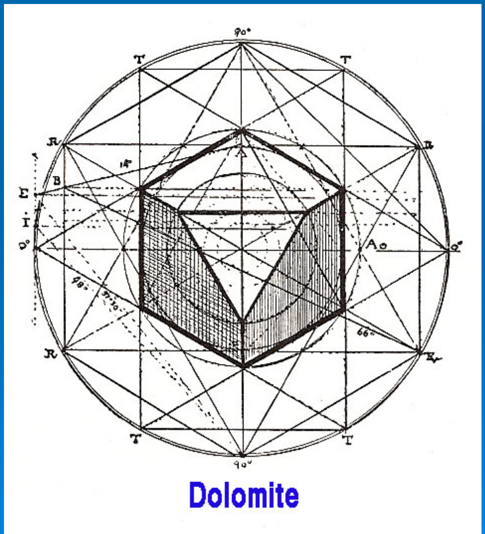




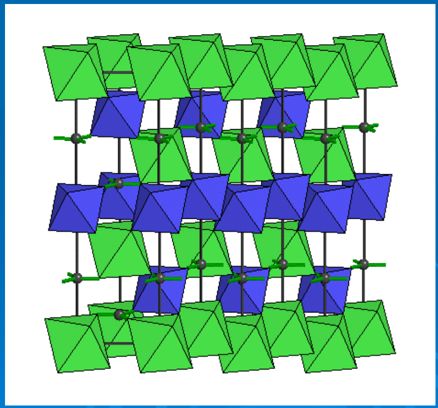
Harmotome ➔
(Germany)

//athena.unige.ch

🡐 *Harmotome*.
Crystal structure.

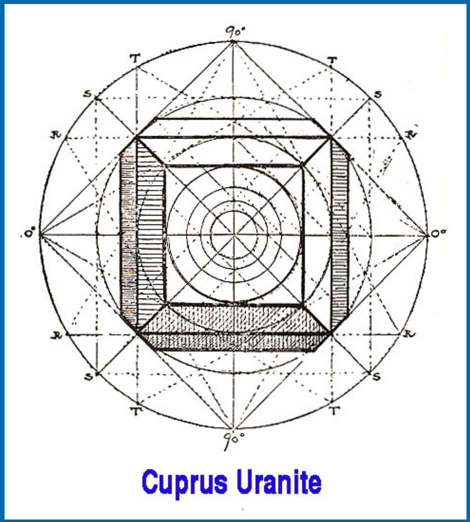


Dolomite //granitecrusher.net

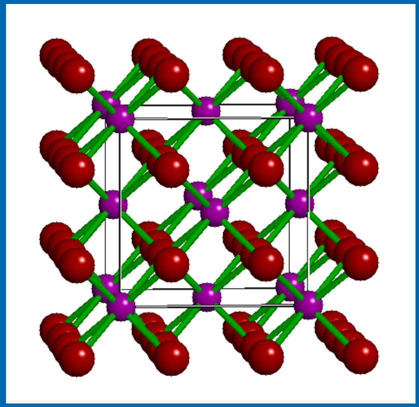


🡑 *Dolomite* crystal structure.
//ruby.colorado.edu

SG205B.5.4.2 Traditional Mineral Diagrams (2)

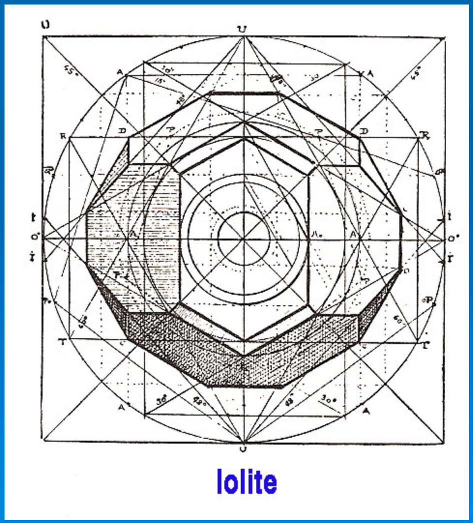


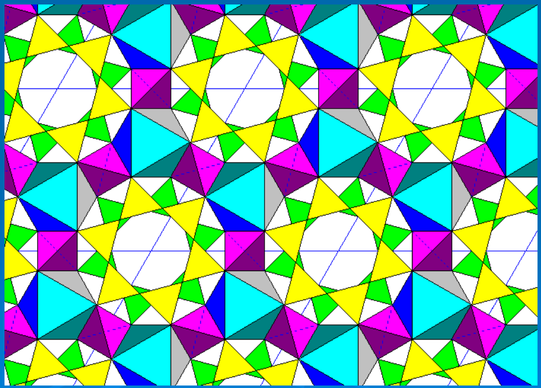
🡐 *Uraninite.*



🡑 ***Uraninite*** **atomic configuration.**
//ruby.colorado.edu

🡓 **Note:** ***"Iolite"*** **is the gemology name for** ***Cordierite.***





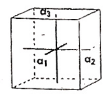
🡑 **The crystal structure of** ***Cordierite*** **is very similar to the structure of** ***Beryl.***
www.uwgb.edu

🡑 ***Cordierite*** **from Japan.**
www.kiseki-jp.com

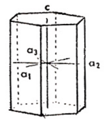
SG205B.5.5.1 Crystals - Classification

Crystals are usually grouped into seven morphological systems (6 groups if the rhombohedral system is included in the hexagonal). These 7 groups are defined by the length of 3 or 4 geometric axes and the angles between them.

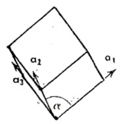
1. CUBIC -
3 mutually perpendicular axes of equal length. Drawn through the 3 pairs of faces or the 3 pairs of corners.



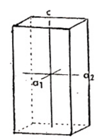
2. HEXAGONAL -
4 axes. 3 axes of equal length in a plane with angles of 120° between them. The 4th axis (any length) is perpendicular to the other 3.



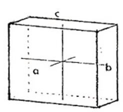
3. RHOMBOHEDRAL -
3 axes of equal length but with an angle other than 90° between them. (Sometimes included with the Hexagonal system).



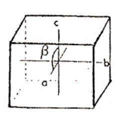
4. TETRAGONAL -
3 mutually perpendicular axes, 2 of which are of equal length. 4 faces rather than 6. Also di-tetragonal shapes.



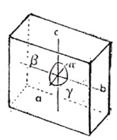
5. ORTHORHOMBIC -
3 mutually perpendicular axes of different lengths. Only 2-fold axes. No 3-fold, 4-fold or 6-fold symmetry.



6. MONOCLINIC -
3 axes of different length, 2 of which are perpendicular. The 3rd axis makes an angle with one of the other two axes. Looks like deformed orthorhombic crystals.



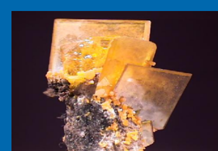
7. TRICLINIC -
3 axes of different lengths, none of which is perpendicular to the others. Low symmetry system restricted to 2 and 1 parallel planes.



Diamond

Quartz

Dolomite



Wulfenite

Aragonite

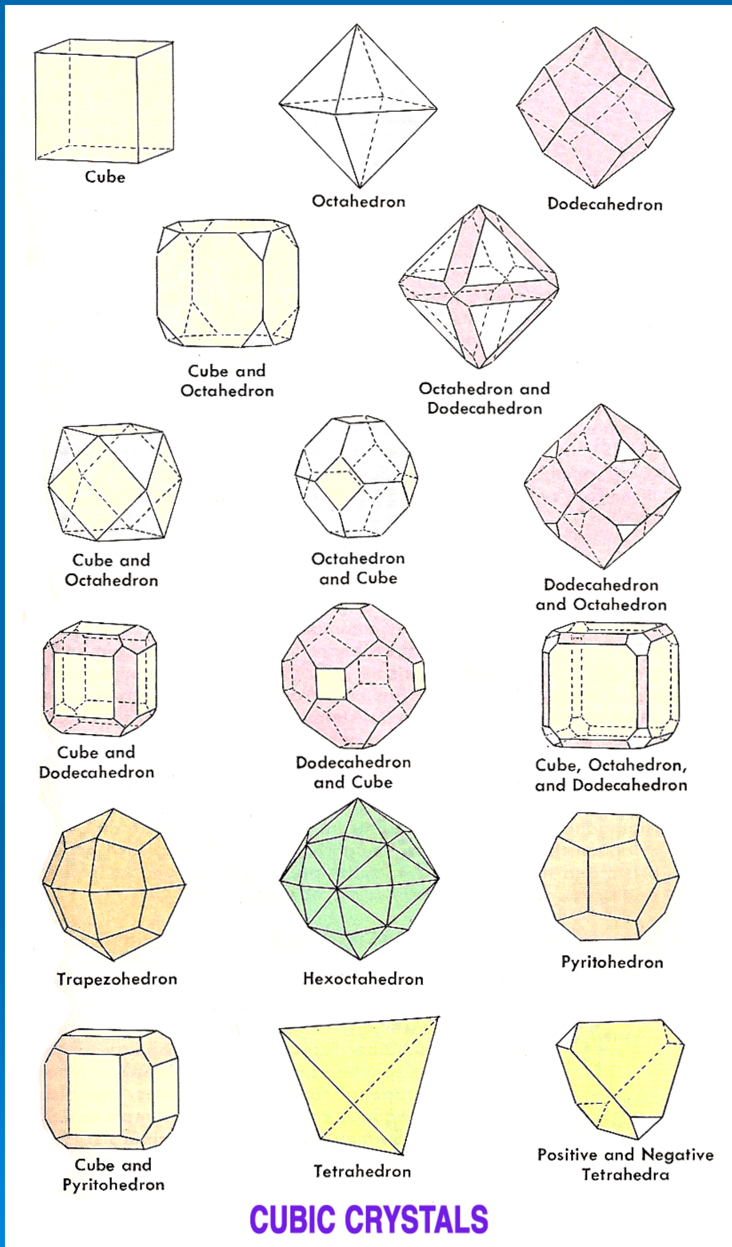
Muscovite

Copper Sulfate

Crystals build up and "grow" in a manner similar to the growth of organic living forms. The gnomonic pattern of crystallization consists of creating small fractal duplicates of the original "seed" form and then fitting them up together to form a larger whole (remember the definition of the Golden Ratio: the Small is to the Large like the Large is to the Whole). Perfect shapes are rare and the actual shapes are most of the time affected by the dynamics of adjacent structures & minerals in the process of growth.

Classical crystallography has recognized 7 classes of crystals, each different from the next by a structural change in the properties of their symmetry axes.
Of course, the discovery of *quasicrystals* (see *infra*) with their "forbidden" penta-symmetry has revolutionized crystallography. The Cubic/isometric system (see next page) is the system where Sacred Geometry shapes are the most visible.

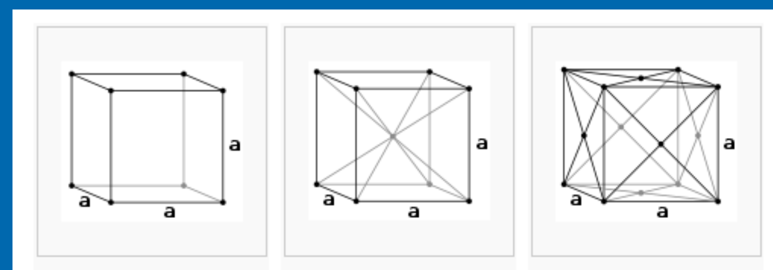
↑ Earrings based on the 7 crystal systems.
//ariathans.files.wordpress.com



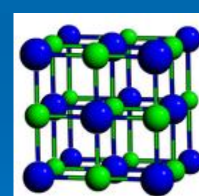
SG205B.5.5.2 Crystals - Isometric/Cubic Crystals

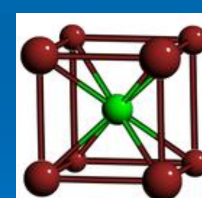
The *isometric* (or *cubic) system* is the most symmetrical system possible in 3D space. It is composed of three crystallographic axes of equal length and at right angles to each other. In simple words, the unit cell is in the form of a cube, one of the most common and simplest shapes found in crystals and minerals. Minerals that form in the isometric system include all Garnets, Diamond, Fluorite, Gold, Lapis Lazuli, Pyrite, Silver, Sodalite, Sphalerite, Spinel…

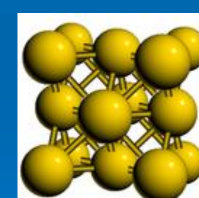
There are three main varieties of these cubic crystals: simple cubic (sc), body-centered cubic (bcc), and face-centered cubic (fcc).



↑↓ Simple Cubic (sc) | **↑↓ Body-centered cubic (bcc)** | **↑↓ Face-centered cubic (fcc)**





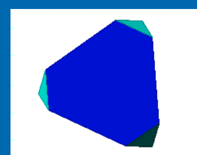


← "Cubic" crystals show many variations of the Platonic & Archimedean solids.

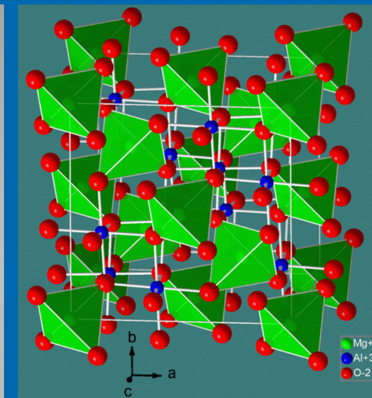
In the next few pages, we are going to visit with minerals most representative of the 5 Platonic Solids.

SG205B.5.6.1 Platonic Minerals - Tetrahedron

← ***Tenantite.***
Tsumeb, Namibia.
www.tsumeb fineminerals.com



↑ *Spinel*. Burma.
www.wellarrangedmolecules.com



↑ Tetrahedral crystal structure of *spinel*.

↑ *Sphalerite*

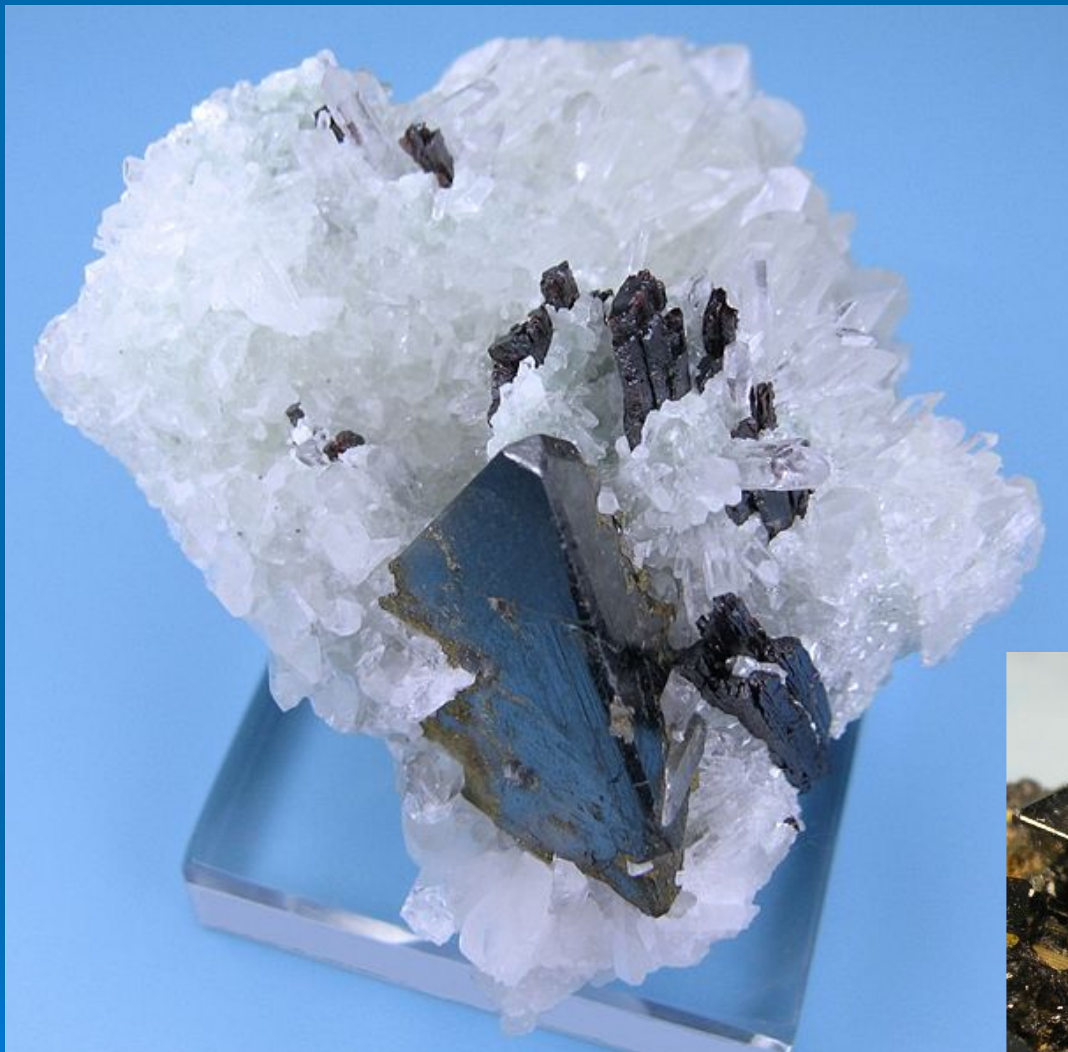
→ ***Chalcopyrite*.**
skywalker.
cochise.edu

SG205B.5.6.2 Platonic Minerals - Tetrahedrite

Tetrahedrite is a copper antimony sulfosalt mineral with formula: $(Cu,Fe)_{12}Sb_4S_{13}$.

Tetrahedrite gets its name from the distinctive tetrahedron shaped cubic crystals. The mineral usually occurs in massive form as a steel grey to black metallic mineral. It was first described in 1845 for occurrences in Germany.

(Wikipedia)



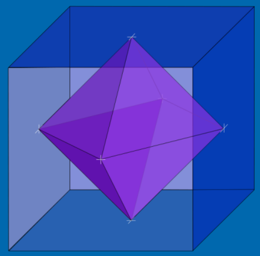
↑ *Tetrahedrite* crystal with dark *hübnerite* on a bed of colorless quartz.

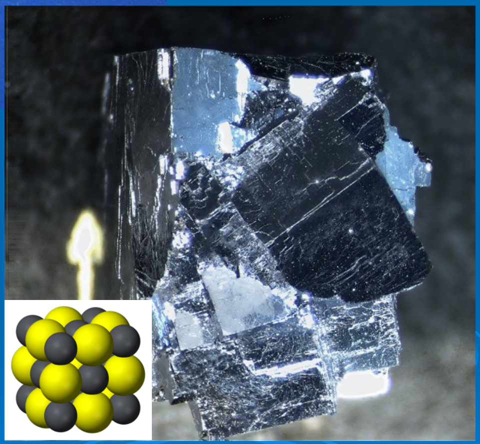
↑ *Tetrahedrite* crystals with *chalcopyrite* and *sphalerite* (Peru).

SG205B.5.7.1 Platonic Minerals / Cube (1)

↑ *Bixbyite* from Utah. Note: you can see here the beginning of "truncation" at the apices. irocks.com

↑ *Pyrite* (FeS2)





↑ *Galena* with unit cell. www.mineralatlas.com

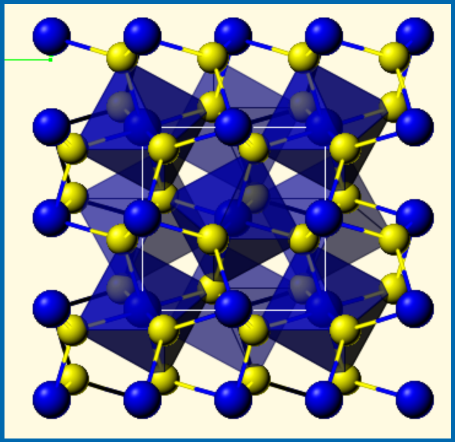
↑ *Halite* (common rock salt)

← Boleite. //webmineral.com

Pyrite (Greek *"pyrites lithos"* = stone which strikes fire), an allusion to the sparking produced when iron is struck by a lump of pyrite.

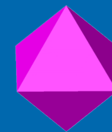
SG205B.5.7.2 Platonic Minerals / Cube (2) Pyrite

↑ *Pyrite*. Spain (Wikipedia).



← Animated applet of pyrite's crystal structure. //webmineral.com

→ *Pyrite*. www. crystalradio.net

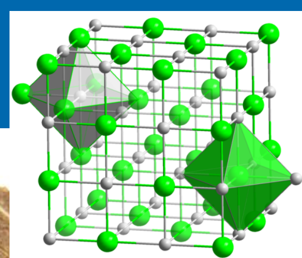


SG205B.5.8.1 Platonic Minerals / Octahedron (1)

Fluorite.

↑ *Cumengite.* www.irocks.com

← Rough diamond. www.irocks.com



↑ The *Halite (rock-salt)* crystal structure.

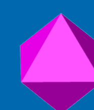
↑ *Dolomite-Halite*. Oklahoma.
This crystal illustrates the cubic growth lines of halite with a very unique pyramidal termination. (Wikipedia)

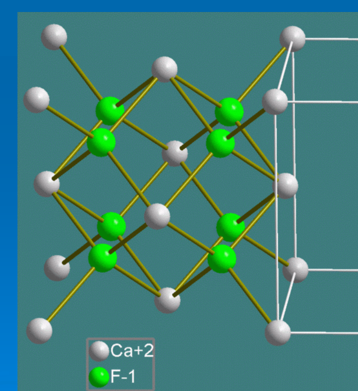
Zircon →
www.mtholyoke.edu

↑ *Cuprite.* //mineralzine.chez.com

SG205B.5.8.2 Platonic Minerals / Octa (2) Fluorite

Fluorite (calcium fluoride) is an isometric mineral with a cubic habit, though octahedral and more complex isometric forms are not uncommon. The word *fluorite* is derived from the Latin root *fluo*, meaning "to flow" because the mineral is used in iron smelting as a flux to decrease the viscosity (increase the fluidity) of slags at a given temperature. This increase in fluidity is the result of the ionic nature of the mineral.

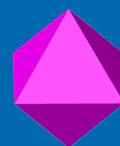




↑ The unit cell of fluorite crystal structure.

SG205B.5.8.3 Platonic Minerals / Octa (3) Alabandite

← www.irocks.com



www.irocks.com

Wikipedia/Alabandite

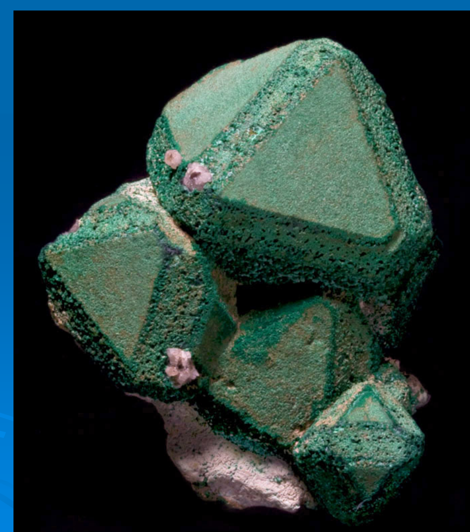
↑ www.mineralman.com

SG205B.5.8.4 Platonic Minerals / Octa (4) Cuprite

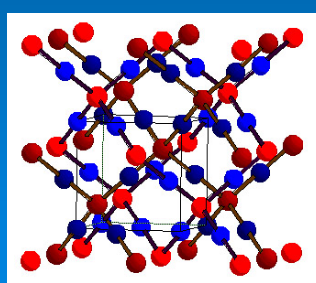
↑ *Cuprite*. Tsumeb, Namibia. (Wikipedia).

↑ *Cuprite*
www.amgueddfacymru.ac.uk

↑ *Cuprite.* Russia.
www.irocks.com



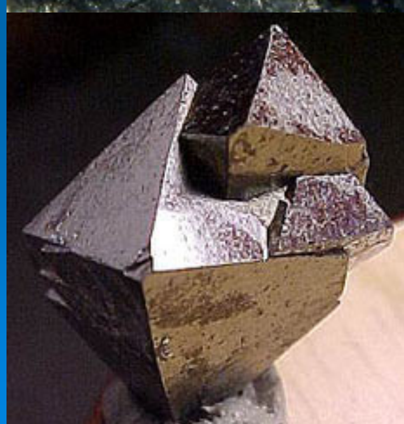
← *Cuprite* with coating of *Malachite.* Ongaja, Namibia.
www.mineralmasterpiece.com



← Crystal structure of *cuprite.*

SG205B.5.8.5 Platonic Minerals / Octa (5) Magnetite

Magnetite (FE_3O_4) is the most magnetic of all the naturally occurring minerals on Earth.
Naturally magnetized pieces of magnetite, called lodestone, will attract small pieces of iron.
This is how ancient people first noticed the property of magnetism.



↑ www.arrowwoodminerals.com

← www.thunderhealing.com

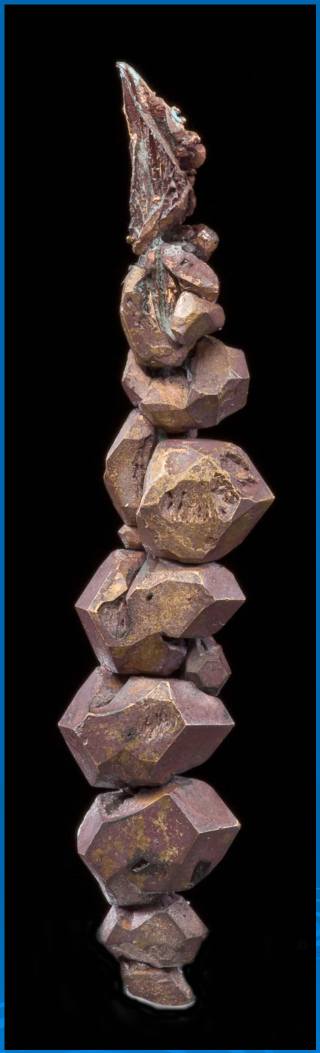
↑ www.guardian.co.uk

SG205B.5.9.1 Platonic Minerals / Icosa-Dodeca (1)

↑ *Garnet*. www.crystal-cure.com

↑ *Boracite*
www.minfind.com

↑ *Andradite*. Mali.
Wikipedia/Andradite



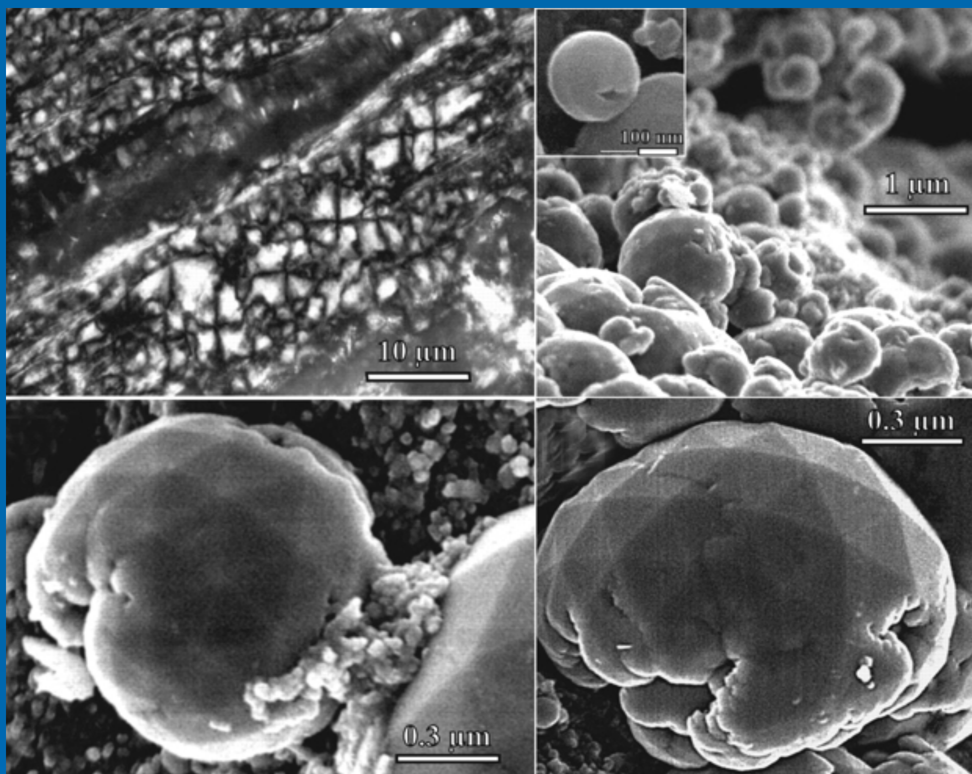
Copper. Karangady,
Kazakhstan.
www.irocks.com

↑ *Pyrope*. China.
www.irocks.com

↑ *Spessartite*.
www.minerals.net

↑ *Betafite*. Canada.
www.wheretobuyminerals.com

SG205B.5.9.2 Platonic Minerals / Icosa-Dodeca (2) Quasi-Icosa

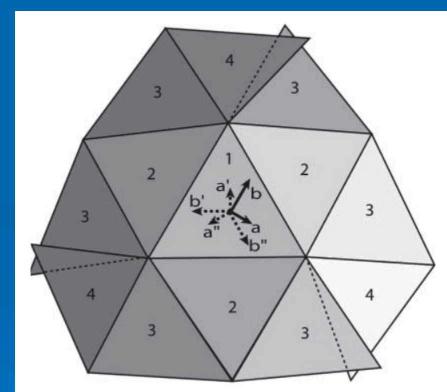


🡅 Spheroids of *Serpentine.* Note the tri-hexa faceted geometry.
//ammin.geoscienceworld.org

Alain Baronnet, Muriel Andreani et al.
Onion morphology and microstructure of polyhedral serpentine.
American Mineralogist, Volume 92, pages 687−690, 2007
//muriel.andreani.free.fr

The structure of Serpentine spheroids has been found to resemble geodesic domes made of about 160 to 180 triangular facets. These polyhedral "onions" correspond to a novel type of spherical nanostructure for layered materials.

However, while carbon-based & related synthetic nanostructures introduce pentagons within their hexagonal grid to ensure icosahedral sphericity (like geodesic domes), no 5-fold symmetry corners have been observed in serpentine. Serpentine spheroids could maintain a spherical morphology while ensuring lateral continuity of the layers by:
(1) introduction of small-angle tilt boundaries between the structures of adjacent facets.
(2) slight curvature of the facets and edges of sectors.
(3) a combination of mechanism 1 and 2.



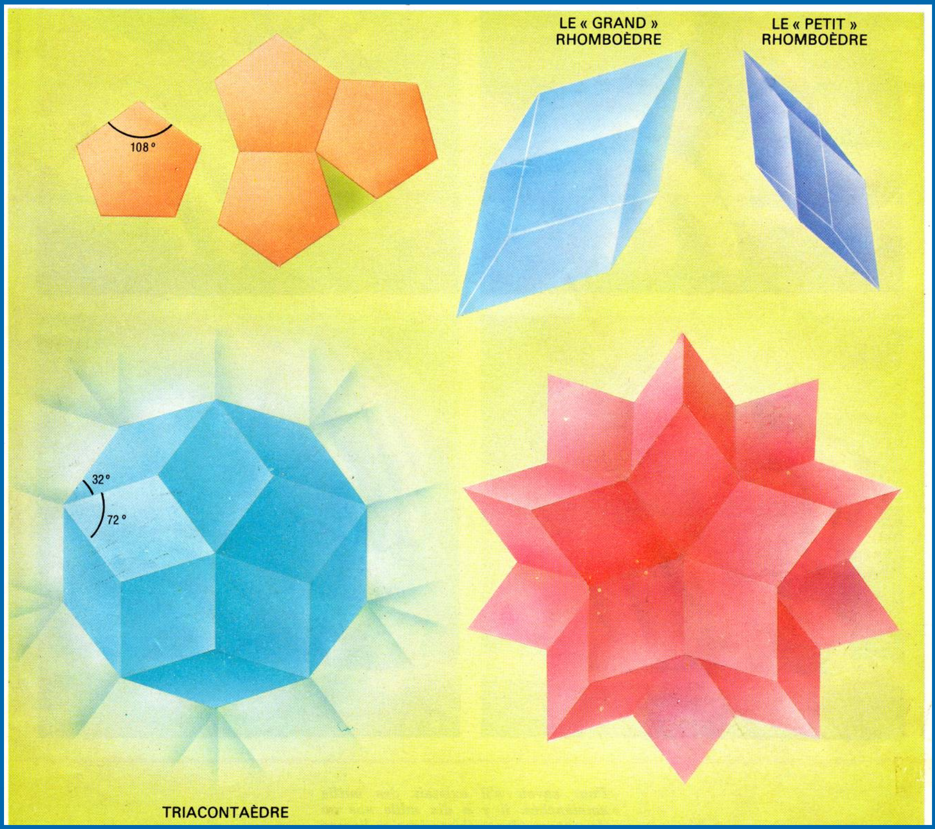
🡅 Schematic drawing of a few adjacent equilateral triangular sectors showing that the spherical assembly of equilateral triangles cannot be maintained without modification of angles or curvature of the faces and edges. In polyhedral serpentine, it is expected that defects at sector boundaries, and/or slight curvature of the layers allow the polyhedral morphology to be maintained.

SG205B.5.10.1 Quasicrystals (1)

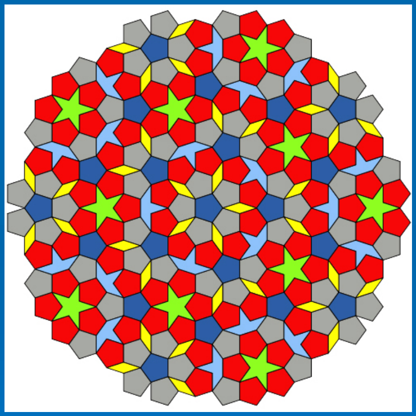
<u>1984: Discovery</u>
<u>of an “impossible” crystal:</u>

An aluminum manganese alloy (Al_6Mn) that is non-periodic and exhibits a 5-fold symmetry.

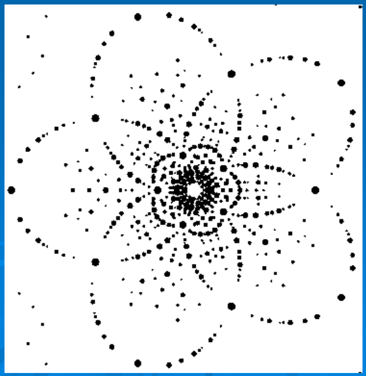
5-symmetry *quasicrystals* are based on the *Penta-Modules* [◆SG106] and golden rhombohedra. They share Phi properties with the *Penrose tiles* [◆SG106] and allow a once forbidden freedom: penta-symmetric architecture in 2D and 3D.



🡅 One (concave) 60-faced polyhedron is sandwiched between two (convex) triacontahedra.



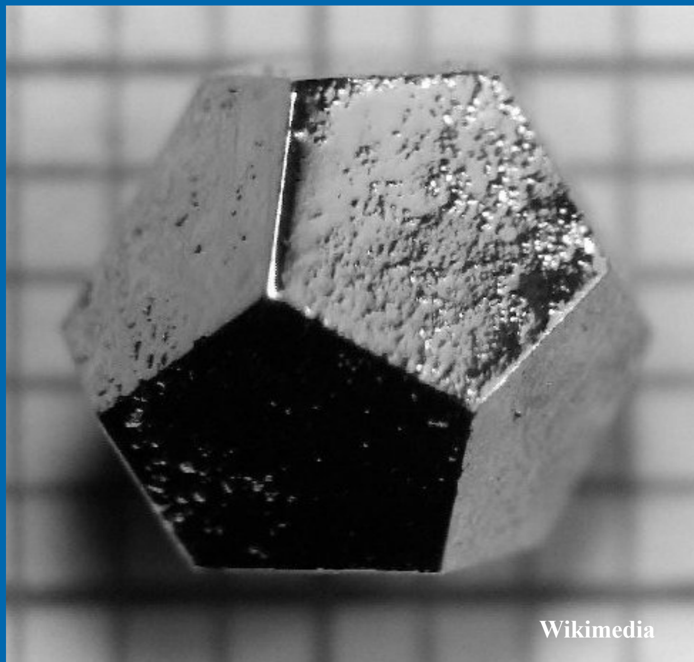
🡅 Penrose Tiling. Wikipedia.



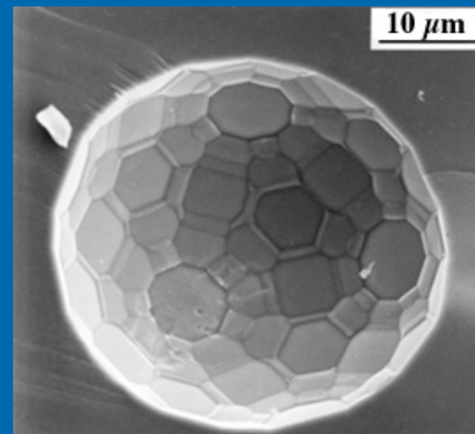
🡄 Diffraction pattern of an icosahedral quasicrystal.
<u>www.jcrystal.com</u>

More on Quasicrystals & Penrose Tiling [◆SG203-A]

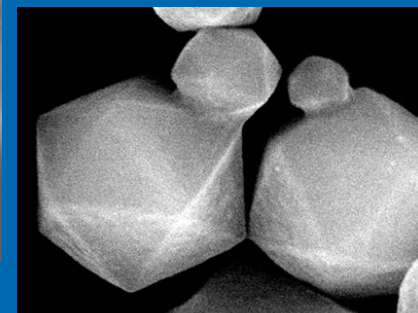
SG205B.5.10.2 Quasicrystals (2)



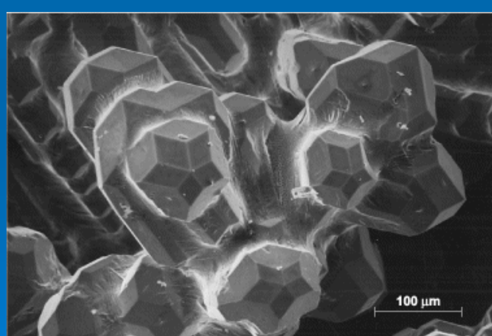
↑ Ho-Mg-Zn, a dodecahedral quasicrystal.



↑ "Best Picture" award at the 7th International Conference on Quasicrystals, Stuttgart, Germany. 1999. Dr. C. Beeli (Zurich, Switzerland). www.solid.phys.ethz.ch

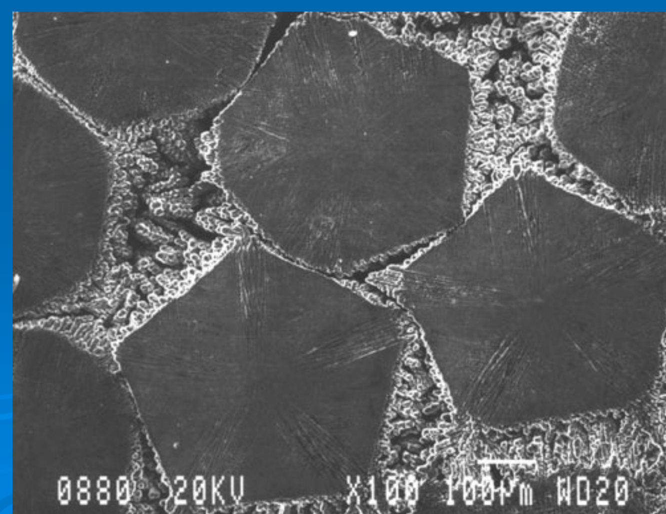


↑ Quasicrystal isosahedra. www.nature.com



↑ Quasicrystals of an alloy of aluminum, copper, and iron, displaying an external form consistent with their icosahedral symmetry.

//content.answcdn.com



← SEM Micrograph showing stable quasicrystals of $Al_{65}Cu_{20}Ru_{15}$. The large (up to 0.5 mm) quasicrystals show a very well formed five-fold symmetry.

C. Politis et al., Mod. Phys. Lett. B 3, 615 (1989).

www.lhtm.des.upatras.gr

SG205B.5.10.3 Quasicrystals (3) Natural QC

Up to recently quasicrystals (QC) have been synthesized in the laboratory under controlled conditions. This is no longer the case. In 2009, the first evidence of a naturally occurring QC was found in Russia as documented by Peter Lu et al. in Science (5 June 2009: Vol. 324 no. 5932).

The article describes an icosahedral quasicrystal that includes six distinct 5-fold symmetry axes. The mineral, an alloy of aluminum, copper, and iron, occurs as micrometer-sized grains associated with crystalline *khatyrkite* and *cupalite* in samples reported to have come from the Koryak Mountains in Russia.

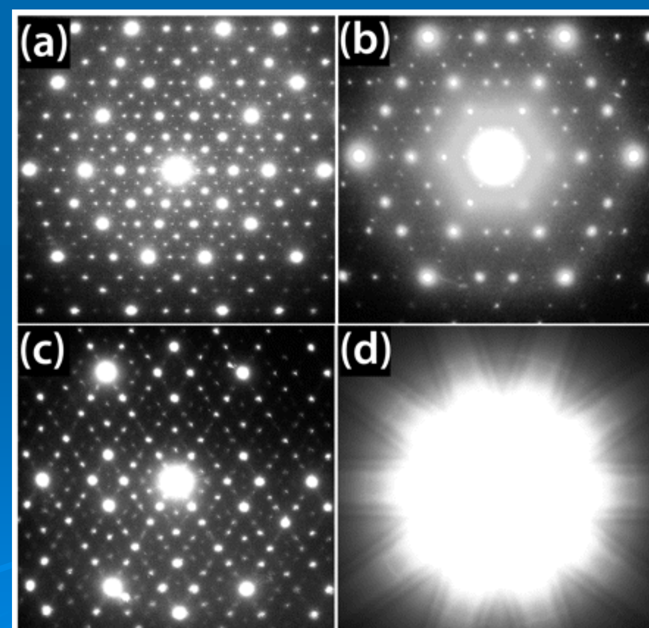
[More on QC: ◆203A.2]

↑↑ Russian QC with 5-fold micro-structure.
//peterlu.org

In 2011 (American Mineralogist. Vol. 96), Luca Bindi et al. describe the newly discovered *icosahedrite*. Icosahedrite, ideally Al63Cu24Fe13, is a new mineral from the Khatyrka River, southeastern Chukhotka, Russia.

The new mineral is named for the icosahedral symmetry of its internal atomic structure, as observed in its diffraction pattern. Both the new mineral and mineral name have been approved by the Commission on New Minerals, Nomenclature and Classification, IMA (2010-042).

The discovery of the *iscosahedrite* is the result of a decade-long systematic search for a natural QC. There are numerous motivations for mounting such a search. The discovery of natural QCs fundamentally alters the conventional classification of mineral forms.



← The 5-fold (a), 3-fold (b), and 2-fold (c) electron diffraction patterns for *icosahedrite.*

The patterns correspond perfectly, up to experimental resolution, with the 5-fold, 3-fold, and 2-fold patterns predicted for a face-centered icosahedral quasicrystal.

Panel (d) shows the convergent beam diffraction pattern obtained along the 5-fold axis, providing further physical evidence of the symmetry and high degree of translational order.

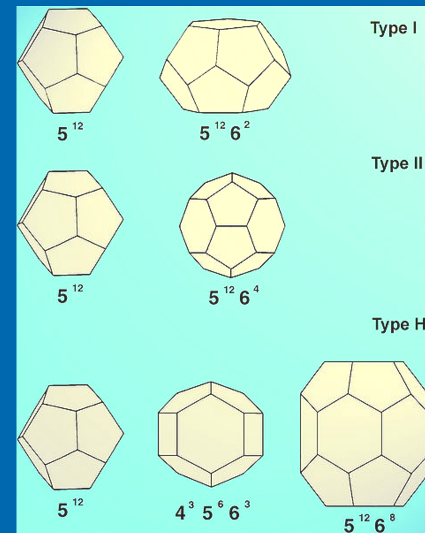
//ammin.geoscienceworld.org

SG205B.5.11.1 Clathrates in Minerals (1)

Clathrates are materials with cage-like framework structures ("host molecule") occupied by a guest species ("guest molecule"). First documented in 1810 and now found to occur naturally in large quantities, *clathrate hydrates* (or *gas clathrates*, *gas hydrates*, *clathrates*, *hydrates*, etc.) are crystalline water-based materials physically resembling ice, in which small gas molecules are trapped inside "cages" of hydrogen bonded water molecules. Hydrate clathrates come in 3 types of structures, all based on the dodecahedron.

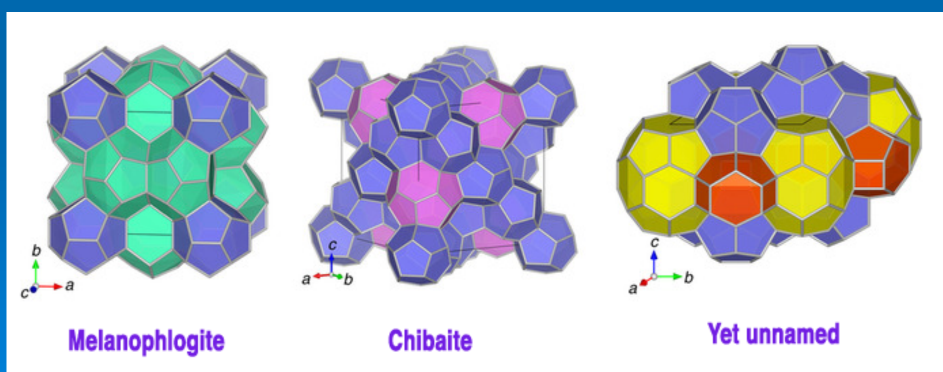
Now, crystalline mineral materials have been found to be *clathrates* as well: they are *isostructural* with the hydrate clathrates.

"Geological and mineralogical observations show that these silica clathrate minerals are traces of low-temperature hydrothermal systems at convergent plate margins, which are the sources of thermogenic natural gas hydrates. Given the widespread occurrence of submarine hydrocarbon seeps, silica clathrate minerals are likely to be found in a wide range of marine sediments." (Koichi Momma et al. *New Silica Clathrate Minerals*. *Nature Communications* 2, Article #196. Published 15 February 2011)



The 3 structures of hydrate clathrates. (Wikipedia > Hydrate clathrate)

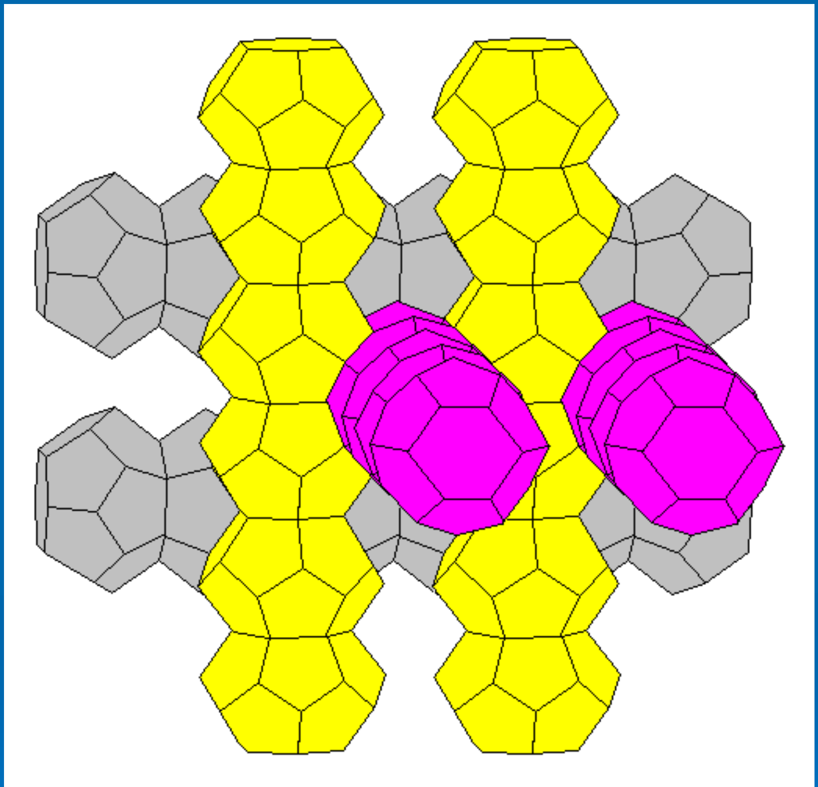
Melanophlogite ➔
www.weblio.jp



🡅 Newly discovered *clathrasils* (silica minerals). Koichi Momma and al. www.nature.com

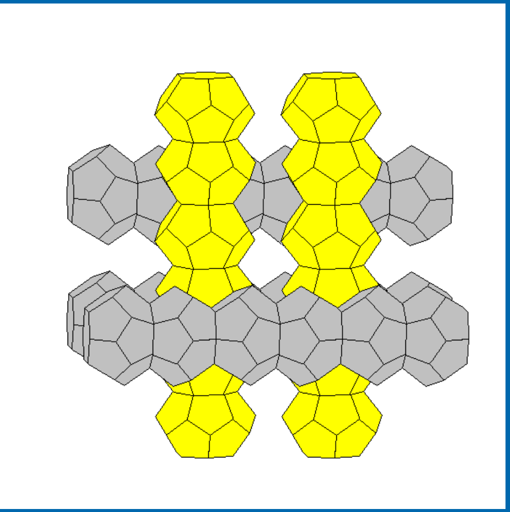
🡅 *Melanophlogite*.
www.iwatteru.blog47.fc2.com

SG205B.5.11.2 Clathrates (2) Models



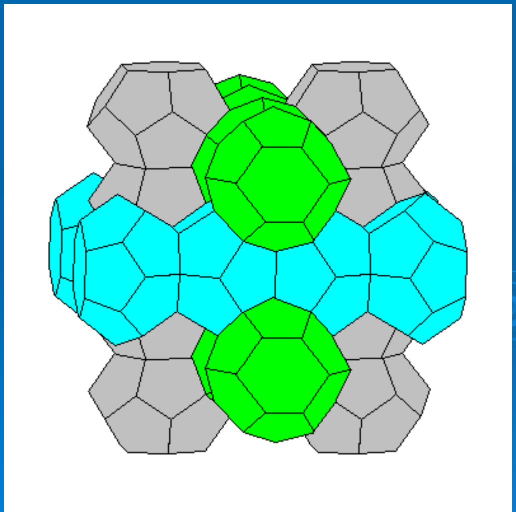
🡩 The 3rd set of columns perpendicular to the other 2 sets.

The interstices ➔ between the dodecahedra are occupied by cages with hexagonal ends and 12 pentagonal faces.
Some of the pentagonal faces are shared with dodecahedra, others with 14-faced cages.
Two sets of columns are shown.



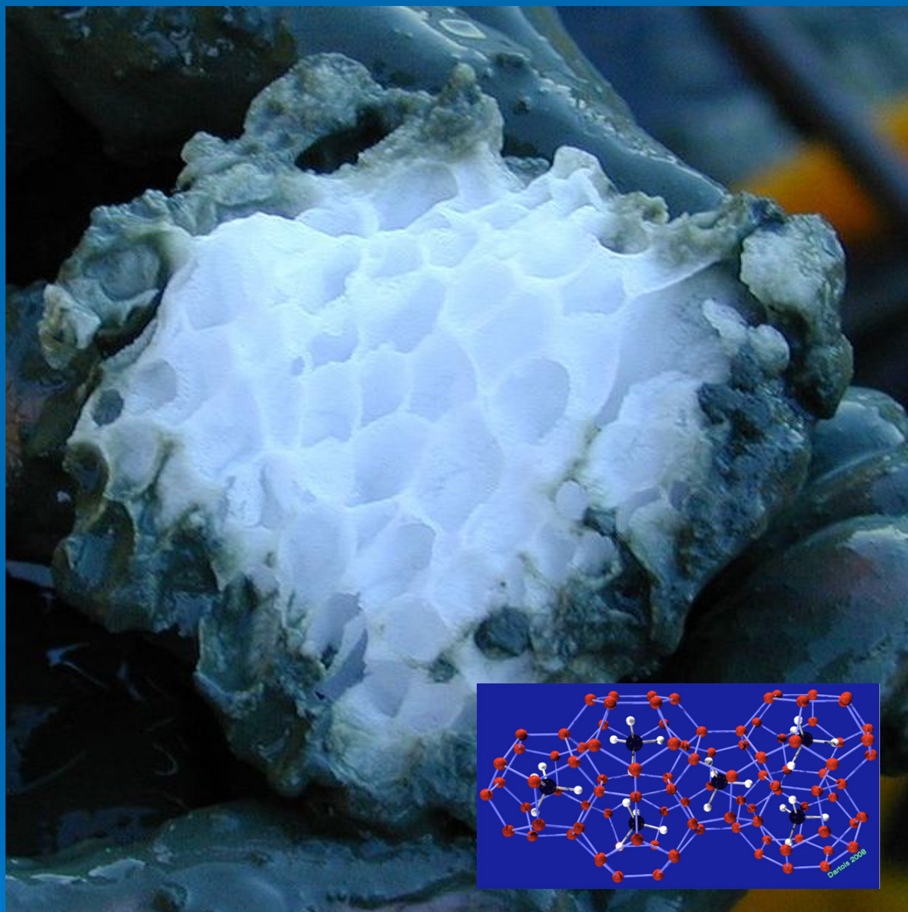
14-faced cages of a unit cell ➔

These fit between the dodecahedral cages.



Credit:
http://www.uwgb.edu/dutchs/Petrology/Clathrate-1.HTM

SG205B.5.11.3
Clathrates (3) Fire Ice



Structure of a gas (methane) clathrate block
embedded in the sediment of hydrate ridge, off Oregon, USA.
Image: Wikimedia Commons. Insert: www.gashydratedesalination.blogspot.com

Methane clathrate (also called *hydromethane*, methane ice, or "fire ice") is a solid clathrate compound (more specifically, a *clathrate hydrate*) in which a large amount of methane is trapped within a crystal structure of water, forming a solid similar to ice but melting at temperatures well above ice.

Originally thought to occur only in the outer regions of the Solar System where temperatures are low and water ice is common, significant deposits of methane clathrate have been found under sediments on the ocean floors of Earth.

The worldwide amounts of methane bound in gas hydrates is conservatively estimated to total twice the amount of carbon to be found in all known fossil fuels on Earth.

Methane clathrates are common constituents of the shallow marine geosphere, and they occur both in deep sedimentary structures, and as outcrops on the ocean floor. (Wikipedia).

🡐 "Fire Ice" (Wikipedia)

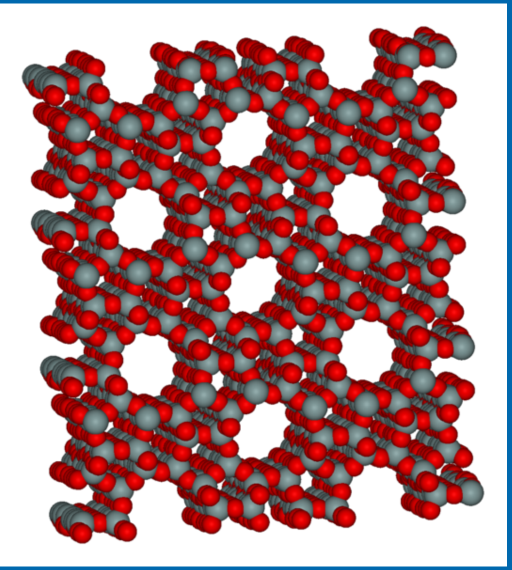
Clathrate methane ice burns releasing heat.

Inset: clathrate dodeca structure.

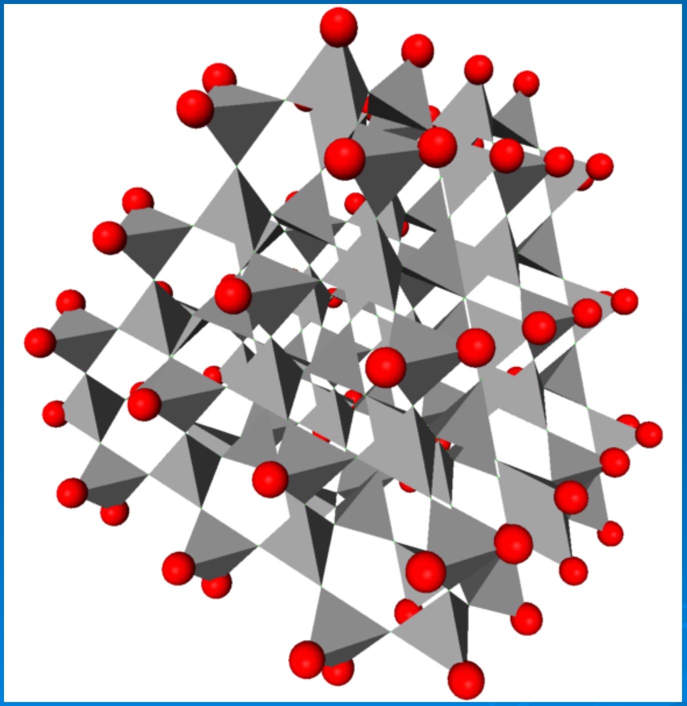
SG205B.5.12.1 Zeolite Frameworks (1)

Zeolites are microporous, aluminosilicate minerals. A large segment of the global economy is based on the use of crystalline zeolites in many different applications. The term *zeolite* was originally coined in 1756 by Swedish mineralogist Axel Fredrik Cronstedt, who observed that upon rapidly heating the material stilbite, it produced large amounts of steam from water that had been adsorbed by the material. Based on this, he called the material *zeolite*, (Greek *zeo* = to boil + *lithos* = stone).

In silicate grids, the basic building block is an SiO_4 unit, with the four oxygen atoms arranged around the central silicon atom in the shape of a regular tetrahedron. Zeolite silicate structures are composed of TETRAHEDRAL UNITS covalently joined by bridging O atoms to produce various types of framework. As of November 2010, 194 unique zeolite frameworks have been identified, and over 40 naturally occurring zeolite frameworks are known.



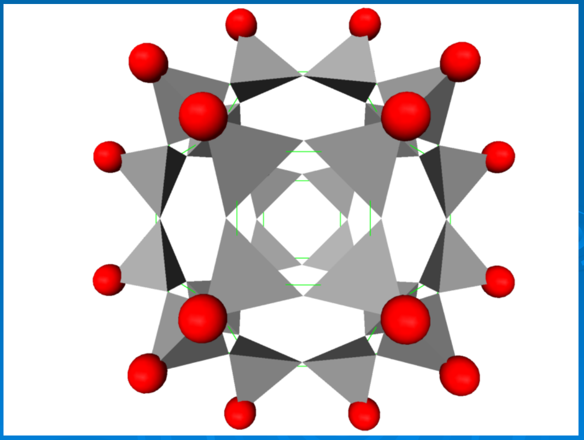
↑ Structure of *zeolite* ZSM-5.
Zeolites are also called "molecular sieves".



← Small part of a space-filling silica grid.

Each tetrahedron represents an SiO4 silica unit tetrahedron. Unit tetrahedra connect by sharing oxygen atoms at their vertices. The red spheres visualize unshared oxygen atoms.

Credit:
//idav.ucdavis.edu

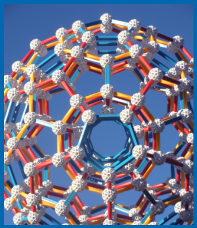


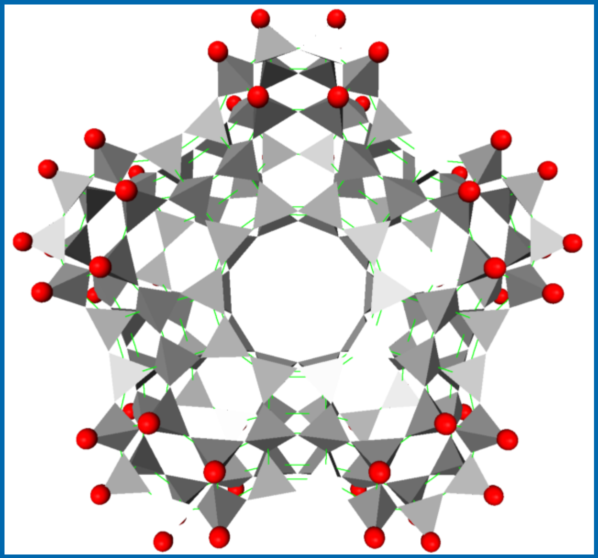
↑ A *zeolite beta-cage* consisting of 24 silica unit tetrahedra.

SG205B.5.12.2 Zeolite Frameworks (2) Nanotech

Remember the Hyper-Platonics (such as the Hyper-dimensional dodecahedron) and the Fullerenes (such as the "Buckyball")? [◆SG107]. Nanotech scientists are now busy bio-mimicking nature and exploring the possible "frameworks" resulting from various combinations of primordial platonic units.
Below are two zeolite architectures created at UC Davis, California.

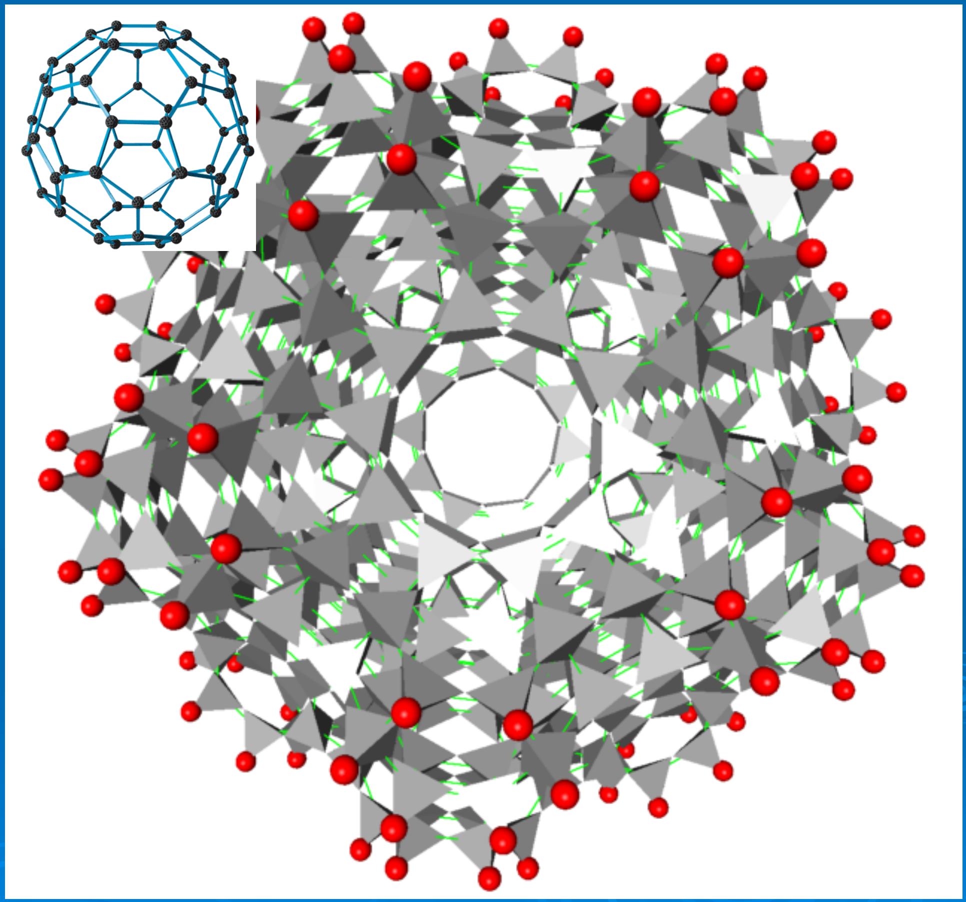
➔ C_{60} model ("Buckyball") in zometools.





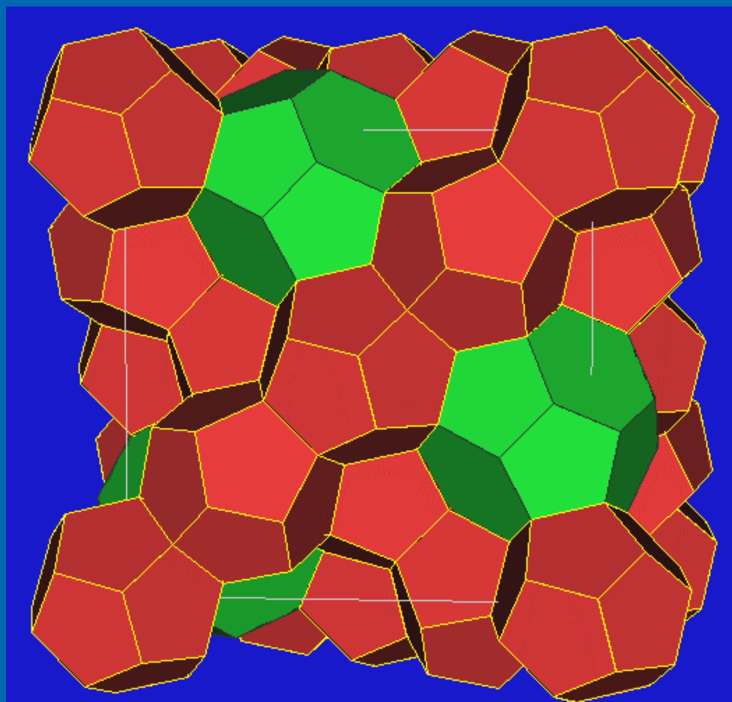
🡩 Five zeolite "beta-cages" connected to form a pentagon.

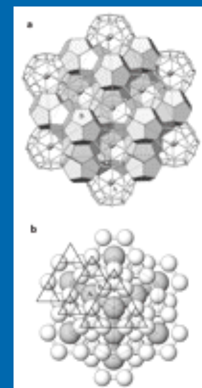
🡨 Stereoscopic display at the Nanotech Construction Lab. UC Davis.



🡩 20 zeolite beta-cages connected to form a dodecahedron. Each of the twelve pentagonal faces has the structure shown in the image above left.

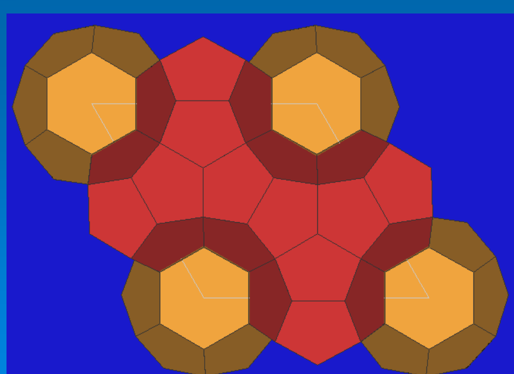
SG205B.5.12.3 Zeolite Frameworks (3) Dodecasils



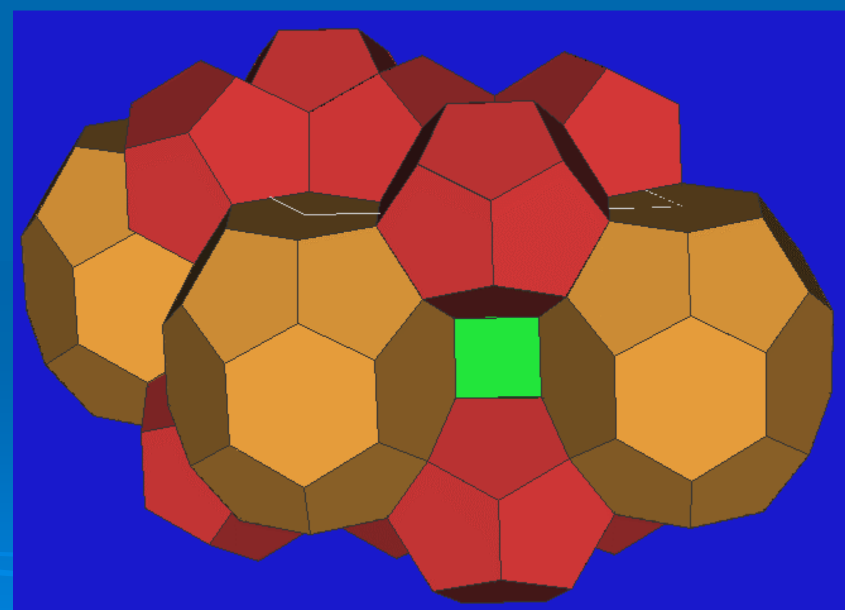


The dodecasils 1H and 3C are all zeolite *clathrasils* with isolated cavities.
They have pentagonal dodecahedral [5^{12}] cages, associated with other cavity types.

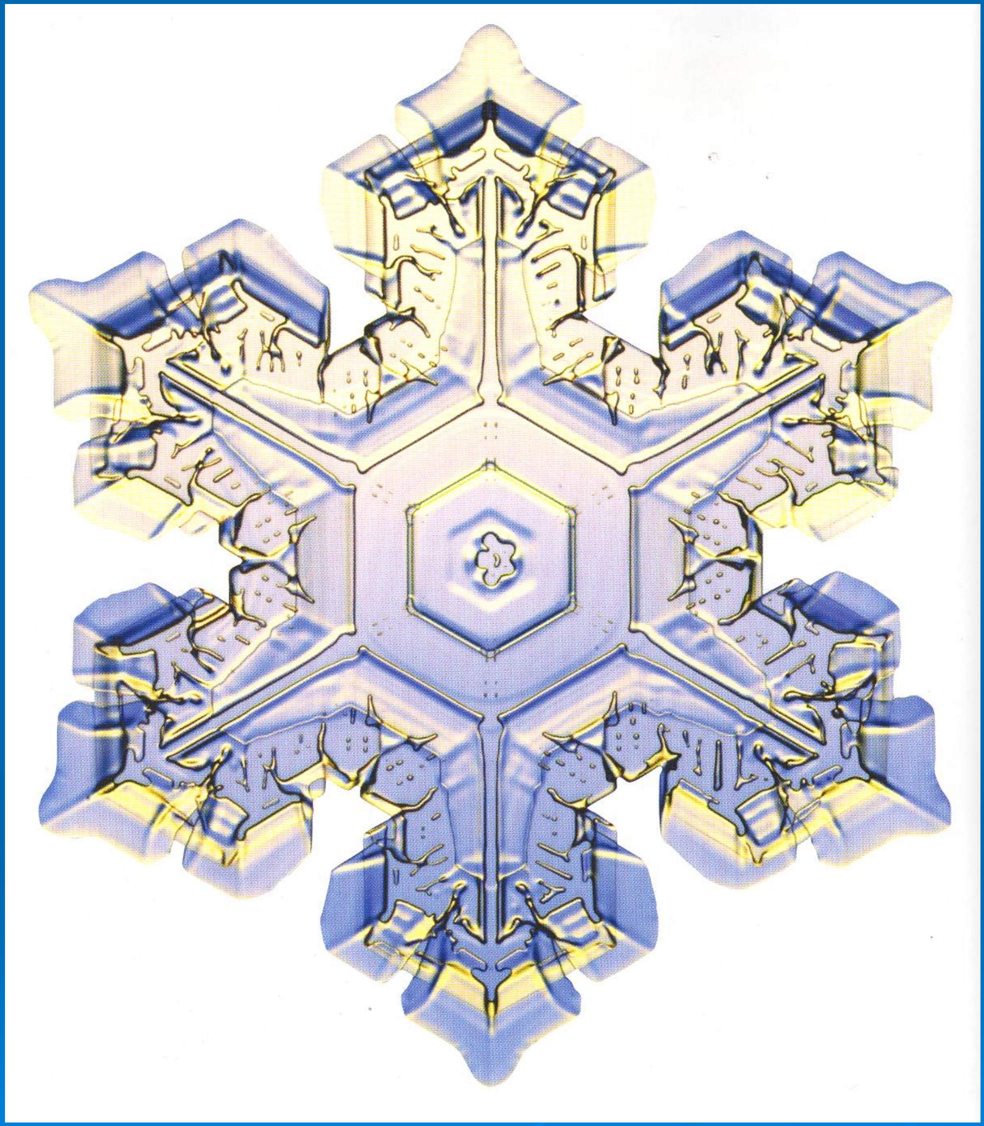
↑ Dodecasil 3C //ruby.chemie.uni-freiburg.de



↑ Dodecasil 1H →



SG205B.5.13.1 Snow Flakes (1) Beauty



🡅 Celestial crystal-flower of water from the sky.
(K. Libbrecht & P. Rasmussen. *The Snowflake*. 2003)

🡅 Terrestial crystal-flower of mineral from the earth.
("snowflake" *cerussite*).
www.irocks.com

"Beauty is its own excuse for Being".

(Ralph Waldo Emerson. *The Rhodora*. 1839)

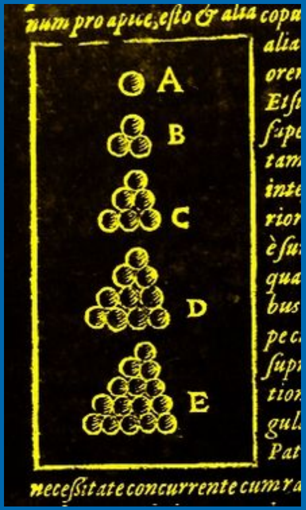
SG205B.5.13.2 Snow Flakes (2) Early Studies

Snow Crystals Studies - A Timeline

- 135 B.C. The first mention of the hexagonal form in relation to a snow crystal was made by Han Ying in *Hanshi waizhuan*. "Flowers of plants and trees are in general five-pointed. However, flowers of snow, which are called ying, are always six-pointed."
- 1611. In his essay "On the Six-cornered Snowflake", Johannes Kepler was looking for the geometric & harmonic "formative principle" of snowflakes. When snow began to fall while he was walking across the Charles Bridge in Prague late in 1610, he asked himself the following question: Why do snowflakes, when they first fall, and before they are entangled into larger clumps, always come down with six corners and with six radii tufted like feathers? To answer his question, Kepler investigated "close packing".
- 1637. French Philosopher & mathematician René Descartes gave a description of snowflakes crystals in his study *Les Météores*.
- 1665. English scientist Robert Hooke sketched snowflakes in his *Micrographia*.
- 1820. English explorer William Scoresby made sketches of snowflakes during his Arctic voyage (*An Account of the Arctic Regions*).
- 1864. In her book *Cloud Crystals,* Frances K. Chickering published cut paper outlines of snowflakes she observed.
- 1911. Samuel Colman gives 20 geometric diagrams of snowflakes in his *Nature's Harmonic Unity*.
- 1931. In 1885, Wilson Bentley, a farmer from Vermont, took his first successful snow crystal photo-micrograph with his own combined equipment of camera-microscope. He went on to document over 5,000 snowflakes images on old-style glass photographic plates. Bentley's life work was published in 1931 as *Snow Crystals*.
- 1954. Inspired by Bentley's photographs, Japanese physicist Ukichiro Nakaya (the first "snow scientist") started a systematic study and classification of snow crystals. He also was the first to grow snow crystals under controlled conditions.
- 1990's. Computer modeling and simulation of snowflakes in 2D and 3D are making headways.
- 2003. Physicist Kenneth Libbrecht and photographer Patricia Rasmussen shared in *The Snowflake* the extraordinary beauty & science of snow crystals.

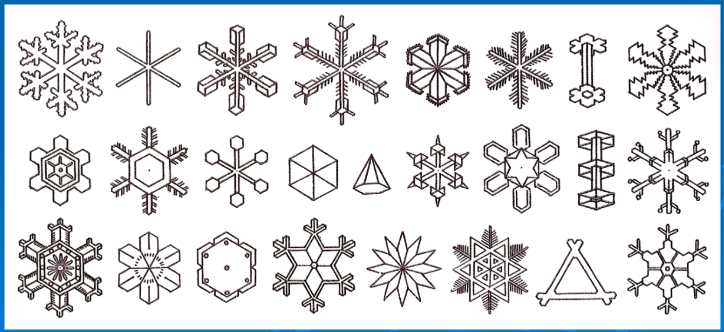
"A snowflake and a dewdrop
are the product of enthusiasm."

Henry Thoreau. Journal, Jan. 6, 1858.



↑ J. Kepler (1571-1630)

← Kepler's drawings to study hexagonal packing as the densest sphere packing ("Kepler's Conjecture").



↑ Sketches of snowflakes made by explorer W. Scoresby. *An Account of the Arctic Regions*. 1820.

SG205B.5.13.3 Snow Flakes (3) W. A. Bentley

Wilson Alwyn Bentley at work.

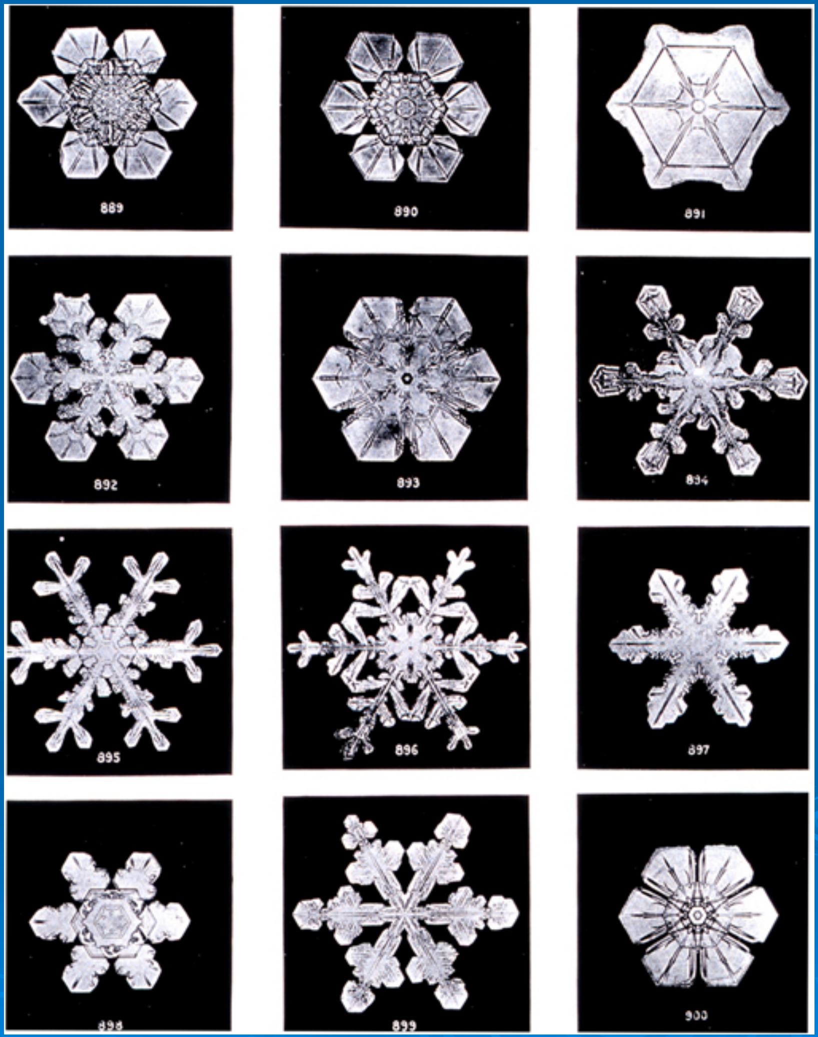
"Every snowflake has an infinite beauty which is enhanced by knowledge that the investigator will, in all probability, never find another exactly like it. Consequently, photographing these transient forms of Nature gives the worker something of the spirit of a discoverer."

(W. A. Bentley. *Photographing Snowflakes*. Popular Mechanics, Vol. 37. 1922.)

"A careful study of the (snowflake's) internal structure not only reveals new and far greater elegance of form that the simple outlines exhibit, but by means of these wonderfully delicate and exquisite figures much may be learned of the history of each crystal, and the changes through which it has passed in its journey through cloudland.

Was ever life history written in more dainty hieroglyphics!"

(W. A. Bentley. *A Study of Snow Crystals*. Appleton's Popular Scientific Monthly. May 1898.)



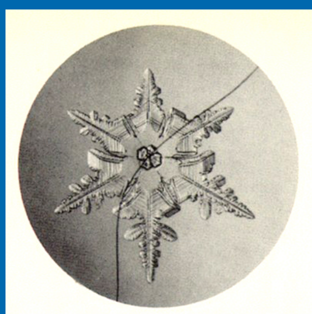
↑ Some of Bentley's snowflakes images.

SG205B.5.13.4 Snow Flakes (4) U. Nakaya

🡐 U. Nakaya

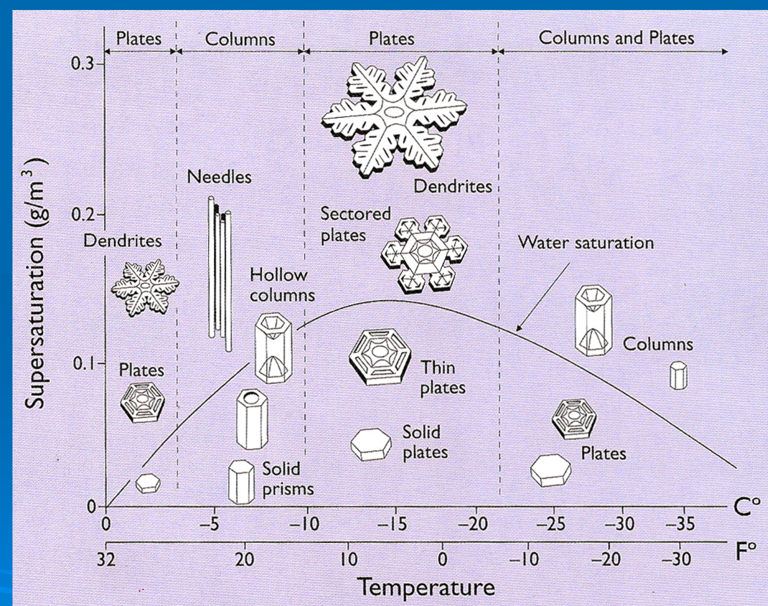
"Snow crystals may be called letters sent from heaven." (U. Nakaya)

Starting in 1933, Japanese physicist Ukichiro Nakaya observed natural snow and created 3,000 photographic plates of snow crystals. In the course of these observations, taking photographs of natural snow and sorting them by appearance according to weather conditions, Nakaya felt the need to make artificial snow from ice crystals grown in the laboratory.
Contrary to his initial expectations, creating snow crystals was not an easy task. Nakaya's Low Temperature Science Laboratory opened in 1935, and experiments continued with various materials for the ice nucleus. These experiments revealed that woolen string is better than cotton string; however, the snow crystals were still not forming as intended. One day Nakaya found a snow crystal on the tip of a hair of a rabbit-fur coat in the lab. This was the breakthrough that led to the production of the first artificial snow crystal.



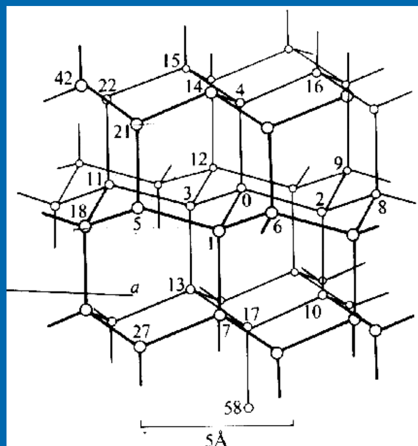
🡐 The first synthetic snow crystals were grown on a rabbit's hair.

🡐🡑 The Nakaya Museum of Ice & Snow. www.kagashi-ss.co.jp



🡑 Nakaya's diagram about snow crystal morphology.

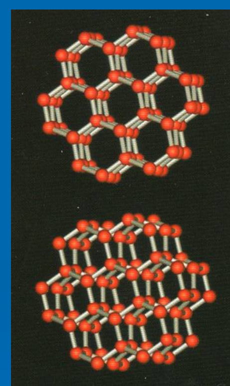
SG205B.5.14 Snow Crystals - Physics of Ice



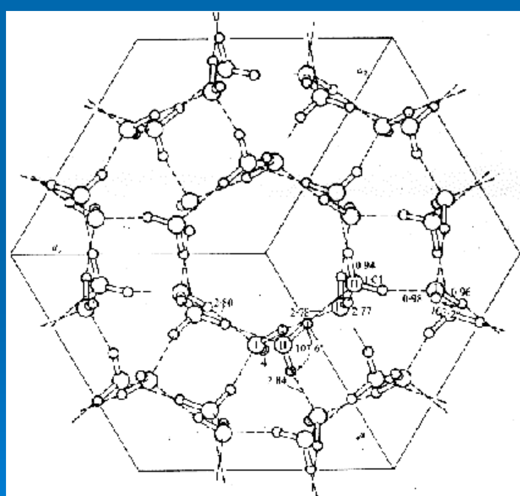
↑ Hexagonal crystal structure of Ice-I (regular ice). www.cs.cmu.edu

The ice we encounter in everyday life is known as ice-I in the science literature.

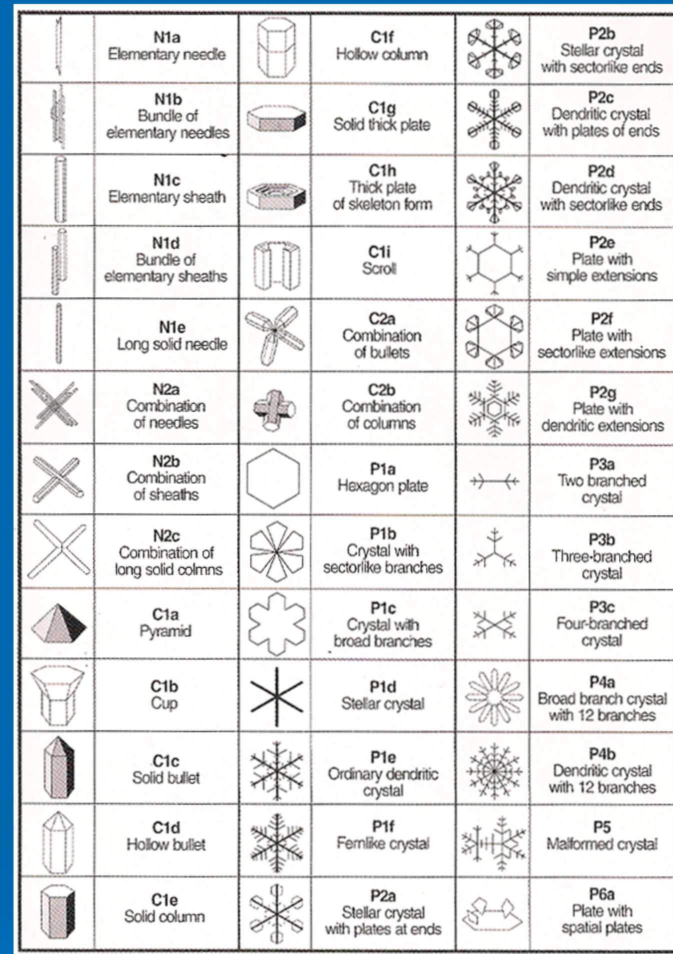
Additional phases (called ice II through ice IX) have been created under special laboratory conditions.



← The hexagonal lattice structure of ice scales up into the 6-fold symmetry of snow crystals.



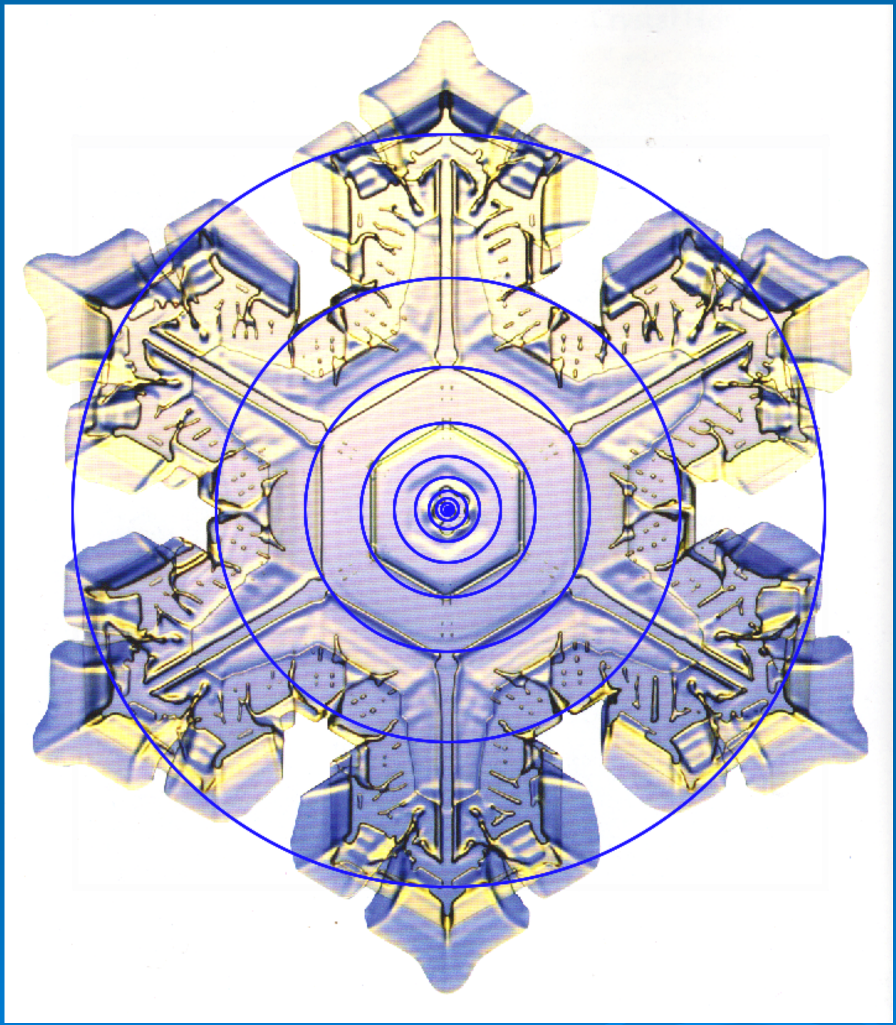
↑ Structure of Ice II, viewed along the hexagonal axis. Ice II exists only at pressures greater than 2000 atmospheres. www.cs.cmu.edu



↑ 39 of the 80 currently recognized types of snow crystals, as classified by Nakaya and subsequently extended by C. Magano and C. W. Lee.

Caltech physicist Kenneth Libbrecht states, in his beautifully illustrated *The Snowflake* (2003), that "even today we cannot fully explain why no two snowflakes are alike… The mystery remains unsolved". He adds:
"Just look at an elaborate snow star and it begs the questions: How do the six arms each develop the same ornate shape? How do the branches coordinate the intricacies of their growth?"

SG205B.5.15.1 Snow Flakes and Phi (1)



We show here (this and next two pages) some pictures of snowflakes overlaid with the PhiMatrix ™ concentric Phi circles or SG grids.

Here is an interesting research project based on a precise protocol of search over a large number of snowflake pictures: is there a "prevalent tendency" of Phi Ratio in the axial & circular growth segments of snowflakes? Do snowflakes (specially the star dendritic types) tend to exhibit a Phi phyllotaxis or Golden Branching in the growth proportion of their segments?

As natural fractal flowers, it would make sense that snowflakes, as an *average*, follow the Fibonacci-based proportional growth patterns (Phi expansion factor) we have been studying in so many other areas of nature: starting with 1/1, 1/2, 1/3 and going into 2/3, 3/5 which is the Phi ratio…

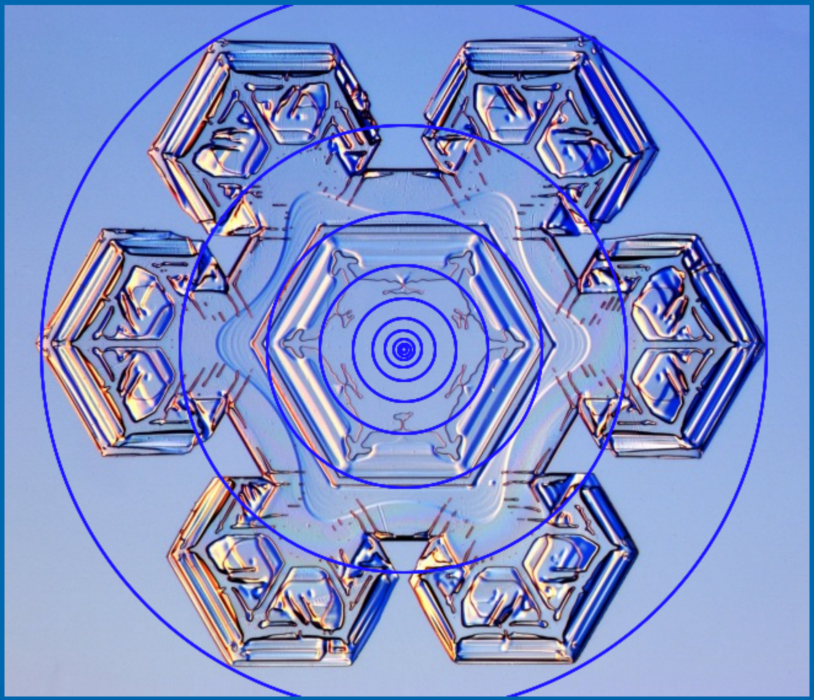
The old (and still severely reductionist) scientific paradigm of physicists & meteorologists claims that "water is water" and snowflakes are created by too many minutely changing weather conditions to have any kind of common harmonic coherence such as a Phi geometry dynamics. They ignore the larger context (Field) and its formative convergence to harmonic efficiency (Phi).

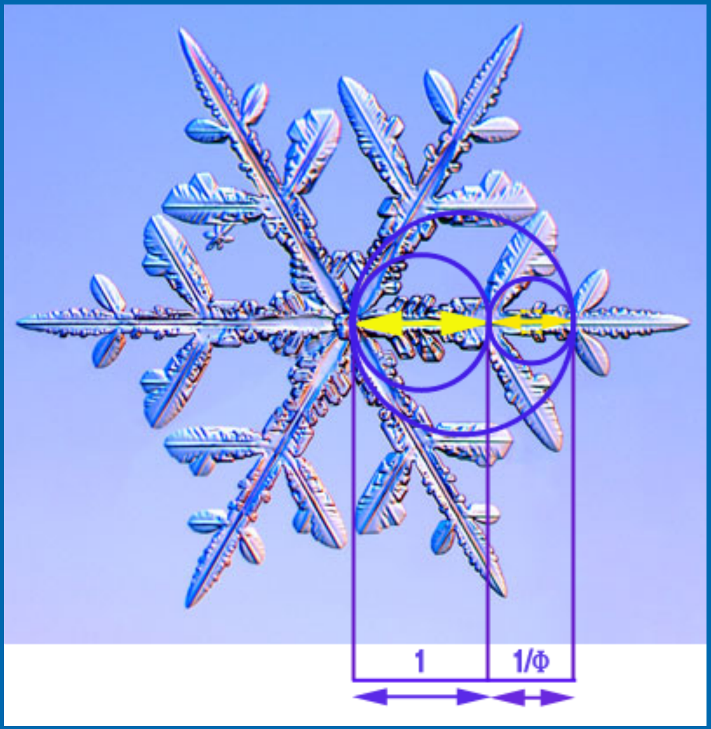
The emerging paradigm scientists are now aware of a cosmic field of oneness or quantum plenum pervading all scales of growth & evolution with a non-local, fractal, holographic-like interconnectedness or formative resonance. Expanding the still fragmented understanding of science, larger wholes are continuously discovered and bring us to unify previously separate parts into the picture of an overall orchestra of exquisitely precise harmony.

The wheel has turned: nature, life and consciousness, formerly understood as separate domains of evolution, are now discovered to be inter-linked (entangled) and ripe with creative, teleological meaning and to point to a supra-intelligent and highly coherent source of universal orchestration.
We call it the Golden Fractal Cosmos.

Sources of images: *The Snowflake* (K. Libbrecht).
www.snowflakes.com. Also Web images / snowflakes.

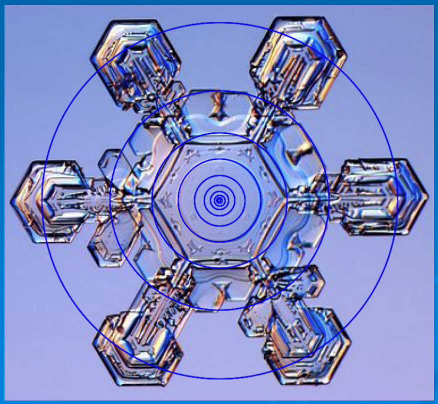
SG205B.5.15.2 Snow Flakes and Phi (2)



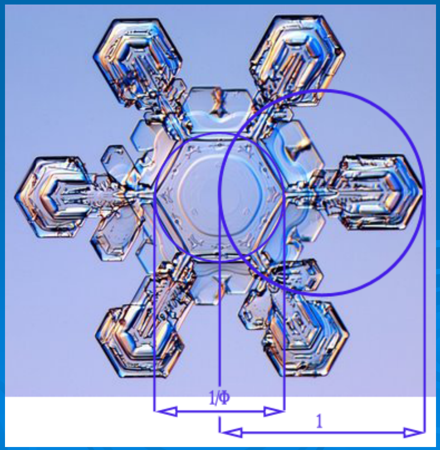


↑ Image:
//green-buzz.net

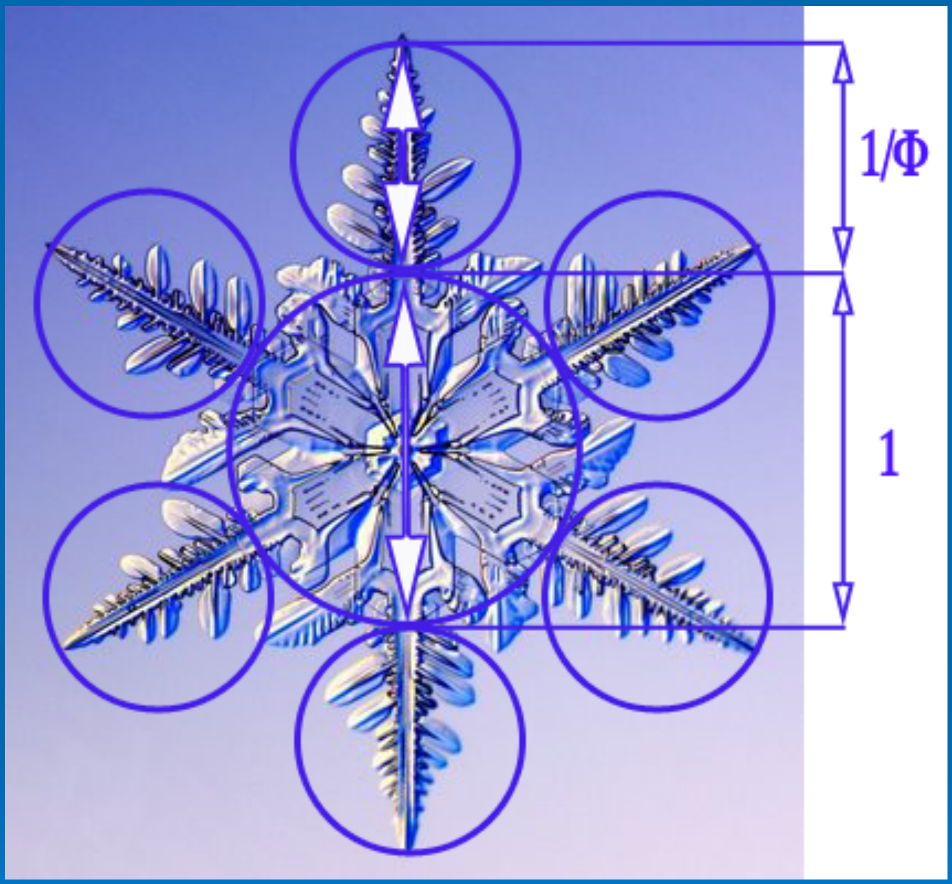
↑ Image:
www.its.
caltech.edu



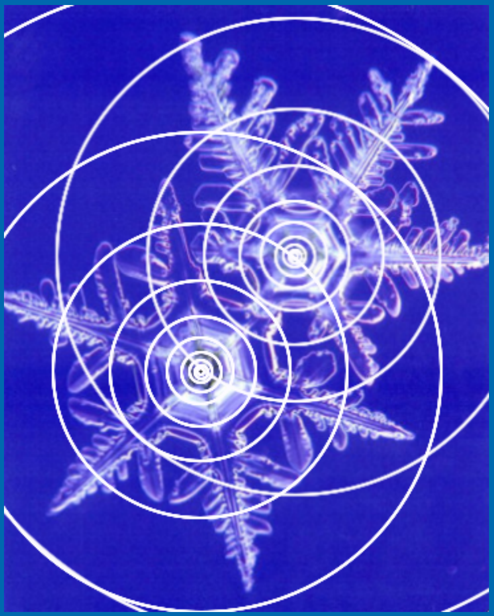
↔
Phi proportions
in this snowflake from:
www.zuzafun.com
(Original images
by K. Libbrecht)



SG205B.5.15.3 Snow Flakes and Phi (3)

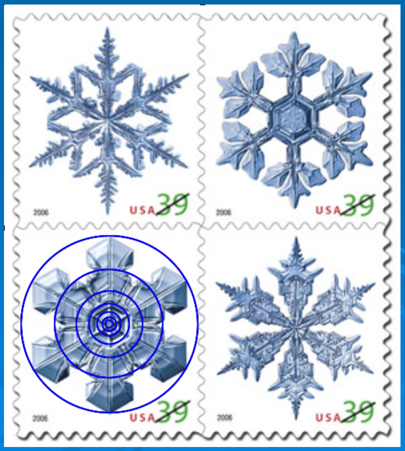


www.zuzafun.com
(Original images by K. Libbrecht)

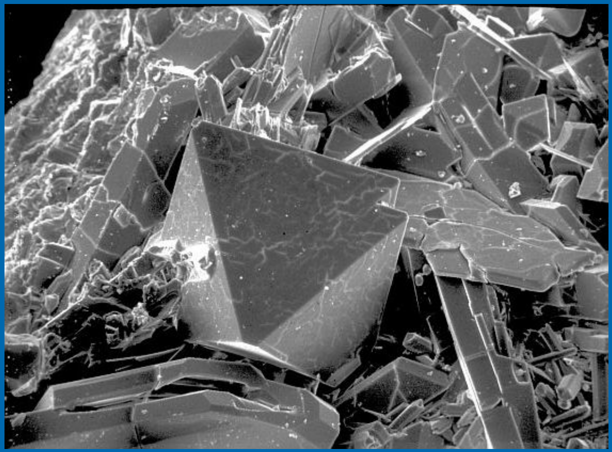


↑ Could twin snow crystals exhibit a Vesica geometry?
(Image: Yokuro Yoshida)

2006 USPS postage stamps →



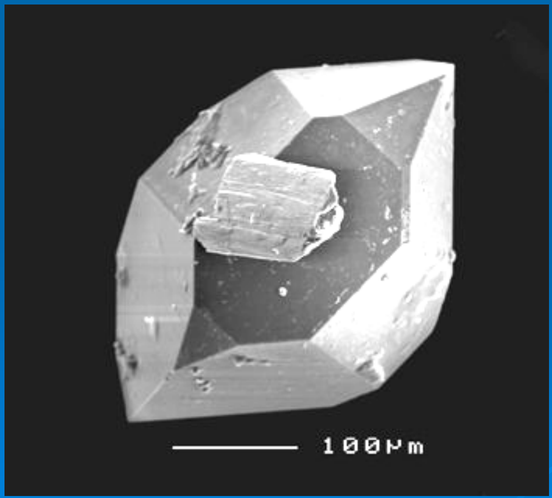
SG205B.5.16 Micro Geometries in Minerals & Crystals (1)



↑ Octahedral *cristobalite* crystal. Germany.
SEM x 125. //minerals.caltech.edu

[SEM = scanning
electron microscope.
The scale is
in *micrometres*.
1 *micrometre* or *micron*
= one-millionth of a metre
or *meter*.)

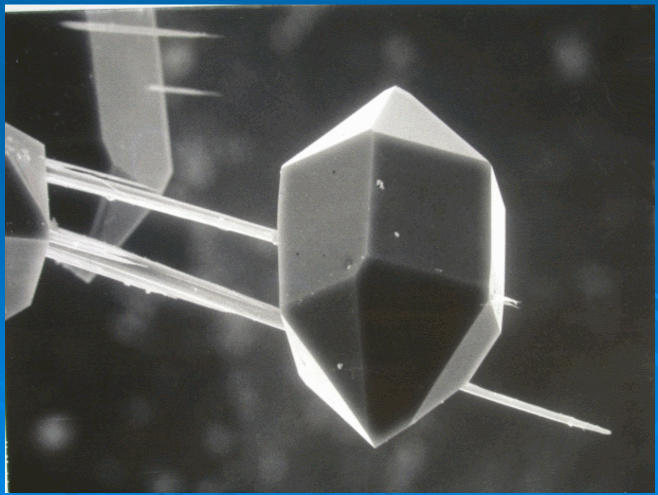
The mineral *cacoxenite* →
Micro photo
with transmitted light.
By H. Cocera La Parra.
Spain.
(Olympus Selection 2010).



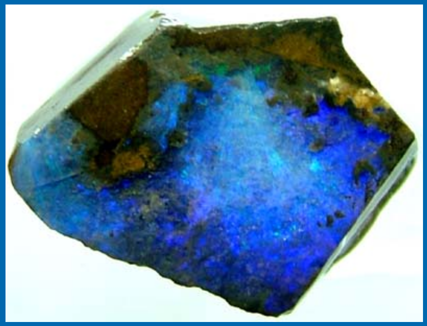
SEM of a *realgar* crystal. www.museumwales.ac.uk

Double-terminated →
quartz crystal
impaled on *goethite*.
Mexico. SEM.

//minerals.caltech.edu

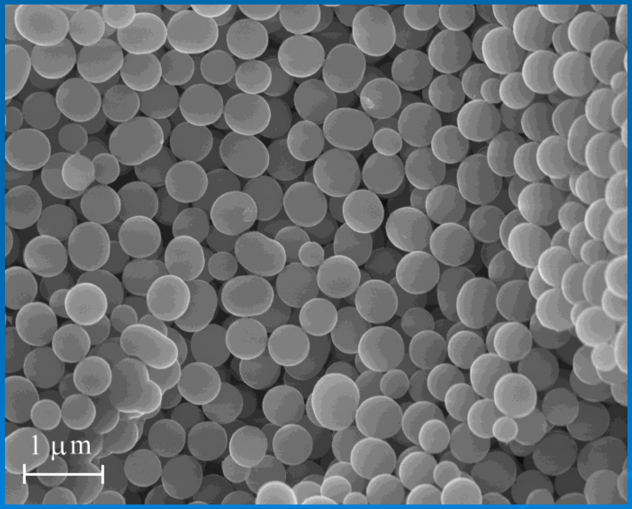


SG205B.5.16 Micro Geometries in Minerals & Crystals (2)

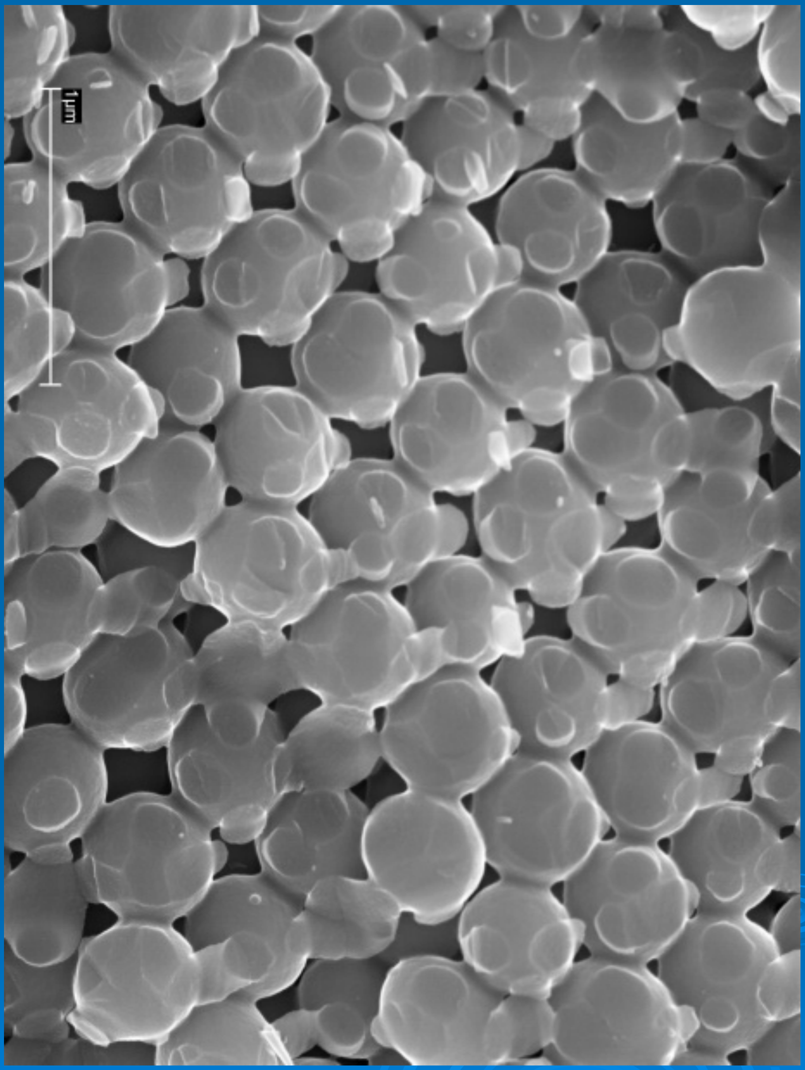


↑ An opal. Naked eye view.
www.rough-opal.com

Zooming
in
on an
opal gem.



↑ SEM image of near-gem quality *opal*.
//minerals.caltech.edu



↑ SEM image of gem-quality *fire opal*. x 100,000.
Note the higher geometric perfection,
compared to the near-quality specimen (left).
//minerals.caltech.edu

SG205B.5.17 Co-Evolution of Minerals

Who are the animals, the minerals and the plants in relationship to each other? Have they "evolved" as independently as we are told in school? Is the geosphere separate from the biosphere?

New findings show that minerals have co-evolved with life. This is called *biologically mediated mineralogy* or *bio-mineralization* and has been an active area of research since the seminal paper by Robert Hazen, Dominic Papineau et al. in American Mineralogist (November 2008).

R. Hazen , D. Papineau and 6 colleagues of the Carnegie Institution's Geophysical Laboratory, reviewed the physical, chemical, and biological processes that gradually transformed about a dozen different primordial minerals in ancient interstellar dust grains to the thousands of mineral species on present-day Earth.

They found that what ultimately had the biggest impact on mineral evolution was the origin of life, about 4 billion years ago. *"Of the approximately 4,300 known mineral species on Earth, perhaps two thirds of them are biologically mediated,"* says Hazen. *"This is principally a consequence of our oxygen-rich atmosphere, which is a product of photosynthesis by microscopic algae."* Many important minerals are oxidized weathering products, including ores of iron, copper, and many other metals.

Microorganisms and plants also accelerated the production of diverse clay minerals. In the oceans, the evolution of organisms with shells and mineralized skeletons generated thick layered deposits of minerals such as calcite, which would be rare on a lifeless planet.

"For at least 2.5 billion years, and possibly since the emergence of life, Earth's mineralogy has evolved in parallel with biology,"* says Hazen. *"One implication of this finding is that remote observations of the mineralogy of other moons and planets may provide crucial evidence for biological influences beyond Earth."

Stanford University geologist Gary Ernst called the study *"breathtaking,"* saying *"the unique perspective presented in this paper may revolutionize the way Earth scientists regard minerals."*

The Wikipedia article on bio-mineralization states: *"Bio-mineralization is the process by which living organisms produce minerals, often to harden or stiffen existing tissues. Such tissues are called mineralized tissues. It is an extremely widespread phenomenon; all six taxonomic kingdoms contain members that are able to form minerals, and over 60 different minerals have been identified in organisms. Examples include silicates in algae and diatoms, carbonates in invertebrates, and calcium phosphates and carbonates in vertebrates. These minerals often form structural features such as sea shells and the bone in mammals and birds. Organisms have been producing mineralized skeletons for the past 550 million years."*

The evolution of organisms with mineralized skeletons, such as this fossil trilobite, had a huge impact on the types of rocks and minerals formed at the Earth surface. Credit: *Robert Hazen.*
www.astronomy.com

↑ The iridescent nacre inside a Nautilus shell.

Nacre, a major component of mollusk shells, is 95% made of the mineral aragonite (CaCo3). The other 5% are organic biopolymers.

SG205B Interlude 2a. Our Animal Friends

(Unknown web image)

Our co-dwellers, neighbors and allies upon the Earth Garden.

"Whatever happens to the beasts also happens to man…
This we know. All things are connected like the blood which unites one family.
Whatever befalls the Earth befalls the sons of the Earth. Man did not weave the web of life, he is merely a strand in it.
Whatever he does to the web, he does to himself." **(Chief Seattle).**

SG205B Interlude 2b. The Enchanted Web of Life

↑ An ancient rendition of a "Council of Animals".

Could it be that "Every animal knows more than you do" as states the Native American proverb? Many traditions and fairy tales tell about times of harmonic and peaceful communication between animal species. Ancient sages & saints of all traditions (see ◆SG102 for reports of Pythagoras taming wild animals), shared with animals the language of spirit harmony and were literally "sharing hearts" with them.

The reoccurring theme of the "Council of Animals" may be a hint as to updating and empowering a real "Council of Nations" dedicated to global happiness. The "Enchanted Forest" theme of fairy tales is actually describing the interconnectedness of the Web of Life.

Animals hold many sacred keys of harmony, including peaceful communion with mankind and between mankind and nature.

← Adam & Eve.

Diana Bryer.

(www.fantasyartdesign.com)

SG205B Interlude 2c. Animalia - Classification

The animal kingdom is vast and its current classification a bit abstruse at first.

To put things in perspective, the lineage of *Homo sapiens* is as follows: our subkingdom is *Bilateria* (two sided body structure) while our superphylum is *Deuterostomia* (with two openings). As *Deuterostomia*, we belong to the phylum *Chordata* and the subphylum *Vertebrata (*animals with a backbone). The *Vertebrata* (or Vertebrates) comprise about 60,000 species including fish, amphibians, reptiles, birds and mammals. The last family is ours: the mammals (about 6,000 species). *Homo sapiens* is one species among the mammals. Even on this single Gaia planet, Life is vast and beautiful.

Bilateria
↓
Deuterostomia
↓
Chordata
↓
Vertebrata
↓
Mammals
↓
Humans

v · d · e **Extant phyla of kingdom Animalia by subkingdom** [hide]

Parazoa	**Porifera** (Calcarea, Demospongiae, Hexactinellida) · Placozoa (*Trichoplax*)						
Mesozoa	Orthonectida · Rhombozoa						
Eumetazoa	Radiata	Ctenophora · **Cnidaria** (Anthozoa, Hydrozoa, Scyphozoa, Cubozoa, Staurozoa, Myxozoa)					
	Bilateria	Protostomia	Ecdysozoa	Cycloneuralia	Scalidophora	Kinorhyncha · Loricifera · Priapulida	
					Nematoida	**Nematoda** · Nematomorpha	
				Panarthropoda	Onychophora · Tardigrada · **Arthropoda**		
			Lophotrochozoa	Spiralia	Platyzoa	**Platyhelminthes** · Gastrotricha	
						Gnathifera	Rotifera · Acanthocephala · Gnathostomulida · Micrognathozoa · Cycliophora
					Trochozoa	Sipuncula · Nemertea · **Mollusca** · **Annelida**	
				Lophophorata	Phoronida · Brachiopoda · **Bryozoa**(?) · Entoprocta(?)		
		Deuterostomia	Ambulacraria	Hemichordata · **Echinodermata** · Xenoturbellida			
			Chordata (Craniata (Vertebrata, Myxini), Cephalochordata, Tunicata)				
	Basal/disputed	Acoelomorpha (Acoela, Nemertodermatida) · Chaetognatha					

↑ Divisions & subdivisions of the Kingdom *Animalia*. Wikipedia.

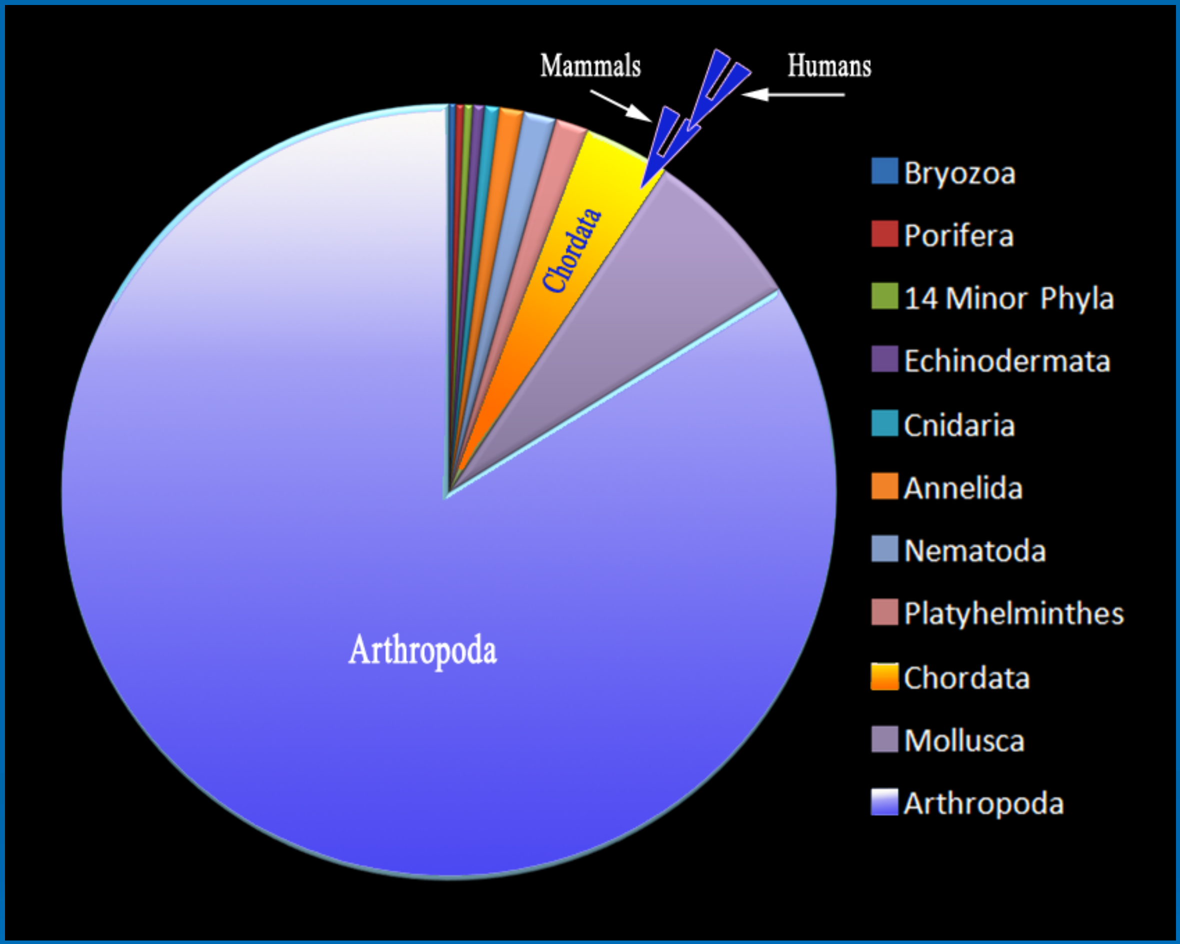
↑ "Gaia" (Unknown web image).

<u>About "Contemplative Biology"</u>

In her book *Hidden Beauty* (2002), photographer & scientist France Bourély pursues the path of "contemplative biology":

"Contemplative biology is both an art of discovery and a science of astonishment… I stand up against those researchers who manipulate (and classify) life without taking the time to CONTEMPLATE it…
Through gazing, my skill as a researcher softened, my observation became gentler, more respectful, and gradually, a quiet intimacy was established between my 'models' and me"

SG205B Interlude 2d. Animalia - Relative Importance



↑ Pie chart of the *Animalia* Kingdom by relative importance of the phyla.
(after chart in Wikipedia).

↑ Orangutan.
(Cover of Smithsonian.
December 2010.)

Humans are a small part of the *Mammals*,
in turn a small part of the *Chordata*,
in turn a small part of the whole sphere of animal life.

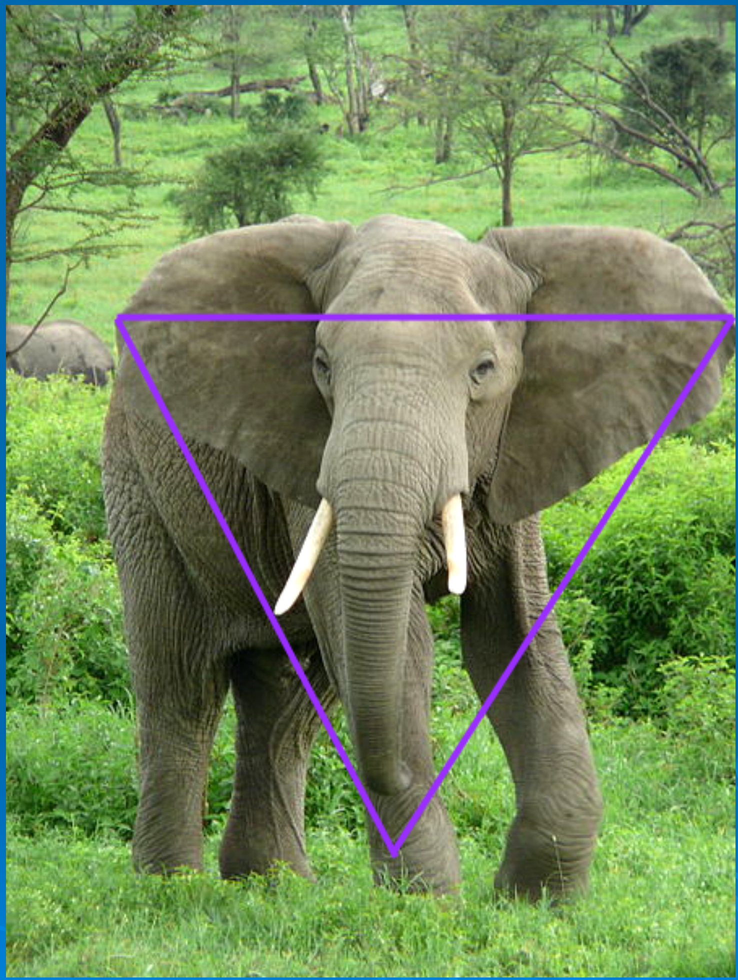
The *arthropoda* are by far the largest animal phylum: they including insects, spiders, crabs, and their kin.

The next chapters will be like a promenade through the animal kingdom, which we will approach not so much as a zoo with enclosed animals (to be watched by "free" visitors) but rather as the realm of animal friends whom a Pythagoras or a St Francis of Assisi were familiar with and talking to, in the common & primordial language of harmonic love.
We want to befriend the animals as brothers & sisters in the Web of Life, as we all exist in the same inter-connected ocean of cosmic harmony.

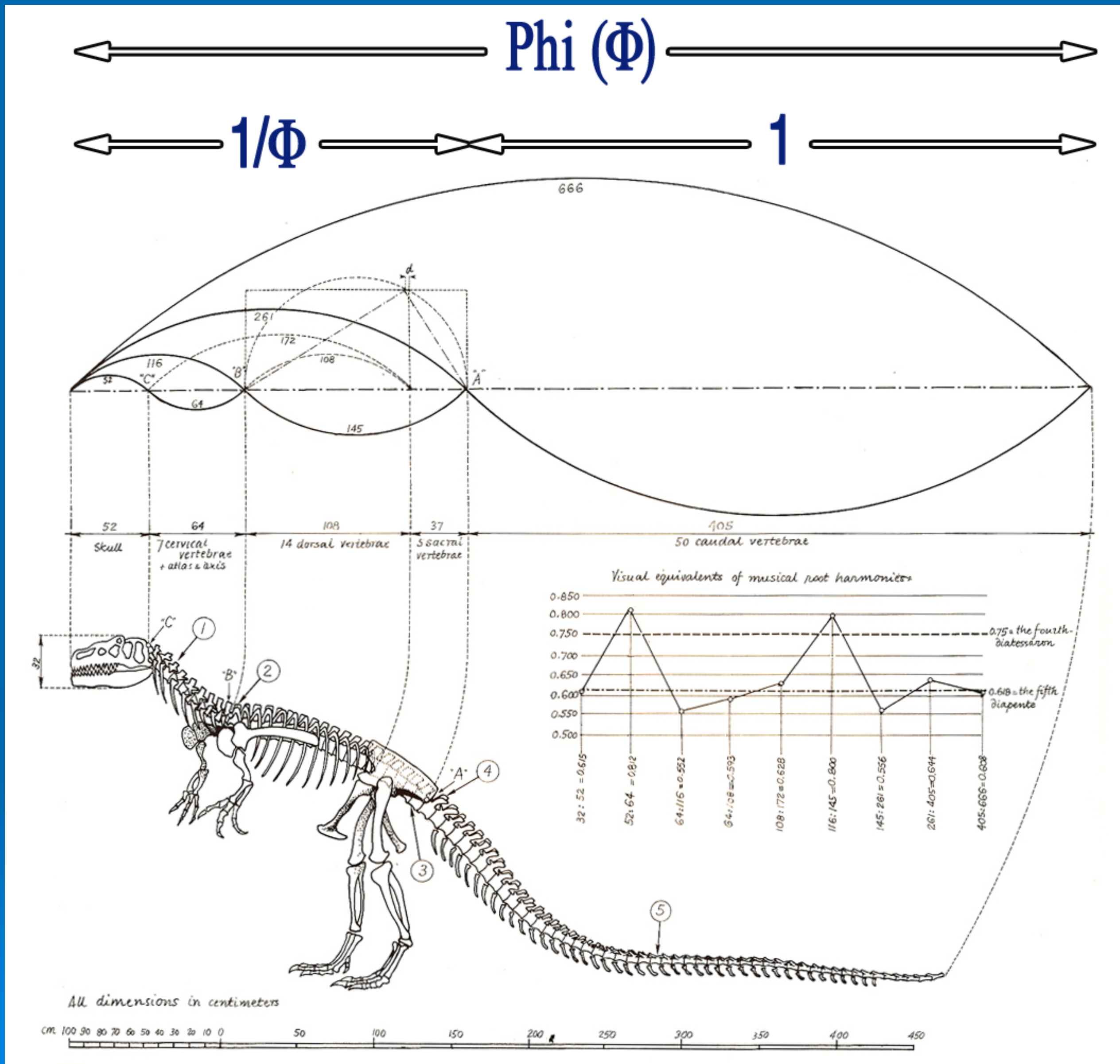
Our goal is to study the presence of harmonic geometries & structures in the animal kingdom.
The field is enormous and in its infancy. All we can really do here is present pioneer steps for future studies that will require much further research re: the harmonic & Golden fractal resonance in animal body shapes and patterns of action & motion.
Data need to be accumulated on large numbers of individual measurements in order to draw out conclusions about *average patterns*. Just like measurements for human bodies, the Phi ratio measurements in animal bodies will oscillate above & below the ideal proportion, but the group *average* will point to the underlying harmonic pattern. So, at times, we will simply *suggest* possible Phi or Phi-based (fractal multiples or submultiples of Phi) relationships.

Technical note: Exact measurements on photographs taken from various angles do not offer reliable accuracy.
Skeletons offer more precision, as a couple of studies by G. Doczi show.

SG205B. Chapter 6. Geometries in Land Animals



(Wikipedia)



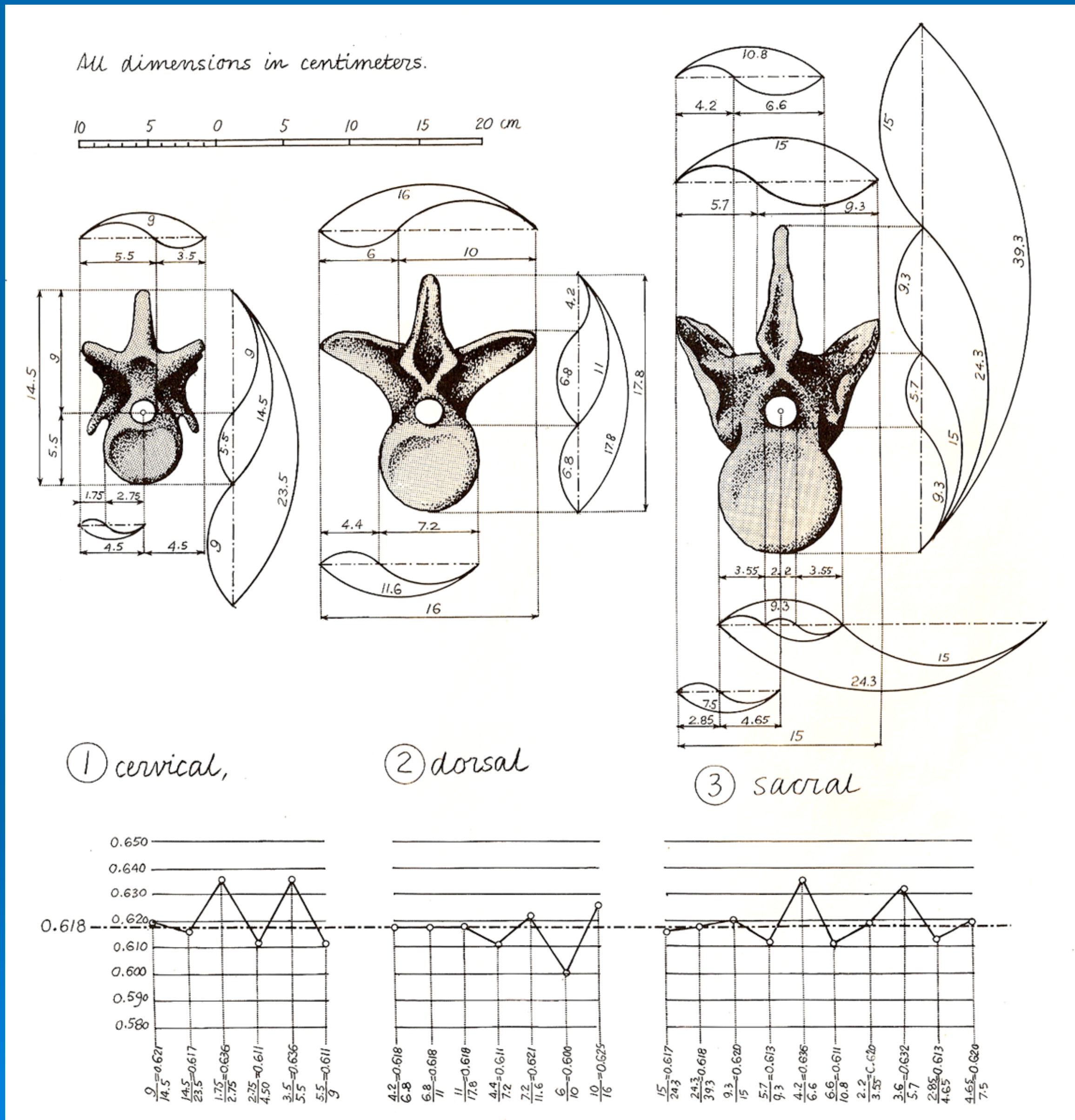
SG205B.6.1.1 The Allosaurus (1) Body

G. Doczi, in his *Powers of Limits*, presents an exhaustive study of his measurements of the skeleton of an Allosaurus.

This giant reptile lived about 140 million years ago. The skeleton was unearthed in Utah and reassembled at the University of Washington, Seattle.

In his wave diagram renderings of the Allosaurus, G. Doczi finds the musical root-harmonies of the fifth (diapente) and the fourth (diatessaron).

"These relationships fluctuate around the 0.75 ratio of the Pythagorean Triangle, and the golden section's 0.618 ratio… The length of sacrum and trunk are in reciprocal golden relationship…" (Doczi)



SG205B.6.1.2 The Allosaurus (2) Vertebra

"Every single vertebra shares the same proportional relationship that unite the whole body, and every one does it in a different way, appropriate to its station within the whole body and to its specific function…

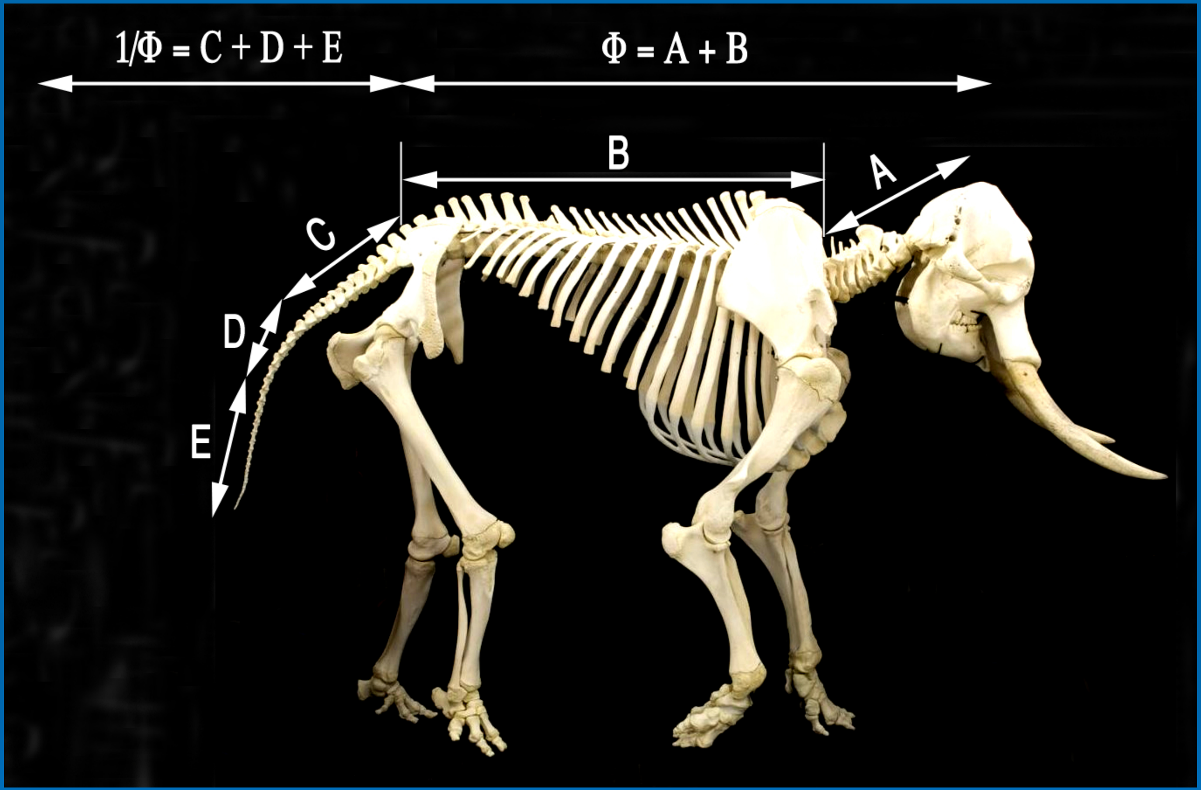
The wave diagrams reveal that the rhythmic unity of these delicately sculptured shapes is based on a sharing of golden relations between many diverse neighboring parts. For instance the round hole of the nerve channel is always very near the golden section point of the total height…" (Doczi)

G. Doczi gives us here a great example of the Harmonic Approach we have already encountered: the details of the relationship between parts and larger wholes may not be mathematically exact and yet the averages and the overall tabulations are clearly pointing to Golden Harmonics. The body manifestations of life seem to be sustained by a framework or field of formative, fractal Golden Relations.

SG205B.6.2 The Elephant

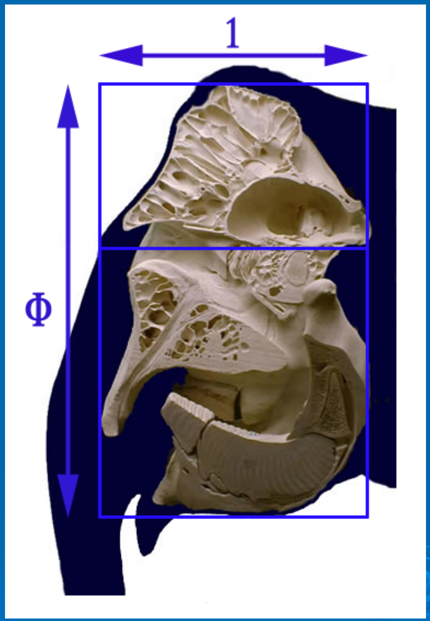
Elephants are a symbol of wisdom in Asian cultures and are famed for their memory and intelligence, where their intelligence level is thought to be equal to that of dolphins and primates.

(Wikipedia)



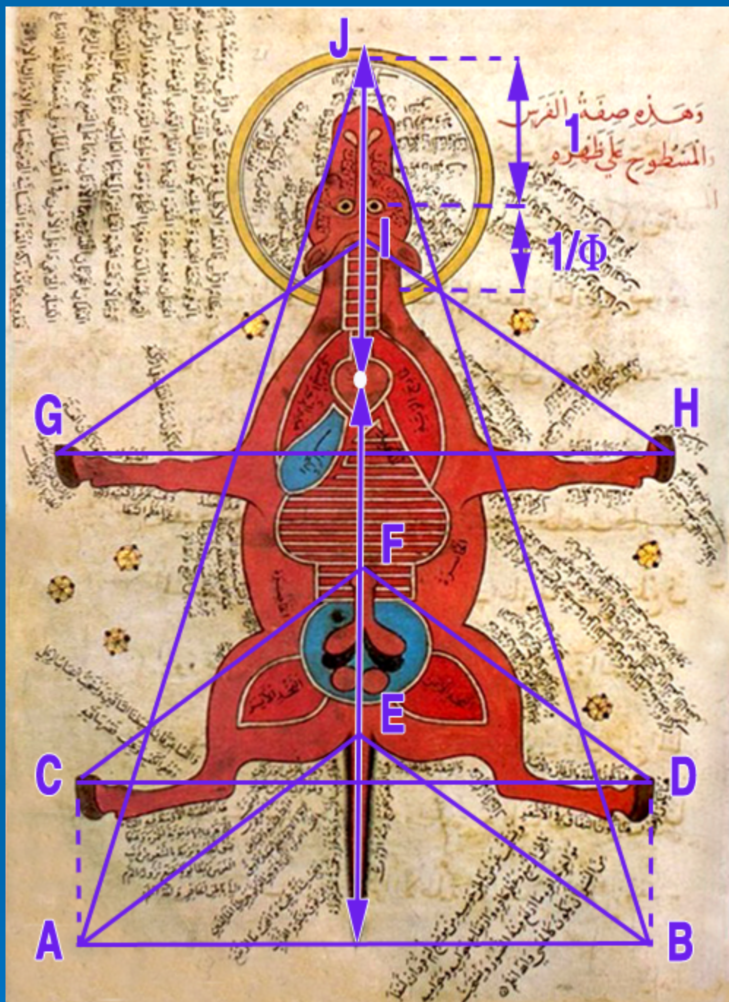
↑ A rough measurement on an elephant skeleton suggests that the length of the spinal column all the way to the top of the head might be in golden proportion to the length of the tail.
A more systematic study is obviously needed.

(Image: Wikipedia Commons)



↑ This image of an elephant's skull fits a Golden Rectangle.

(Image: www.upali.ch)

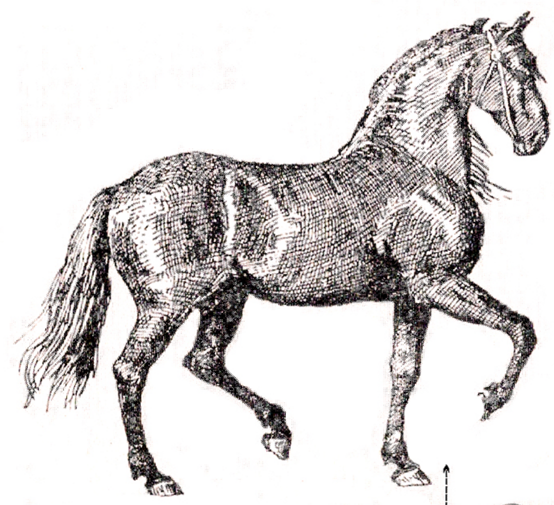


↑ Anatomy of a horse. Arabic manuscript. 15th century.
http://moncabinetdecuriosites.tumblr.com
This medieval drawing shows an intuitive sense of Phi proportions:
• ABE, CDF and GHJ are Golden Gnomons • ABJ is a Golden Triangle
• The eyes mark the Golden Cut in the inner circle of the head
• The Heart is the Golden Cut of the entire length

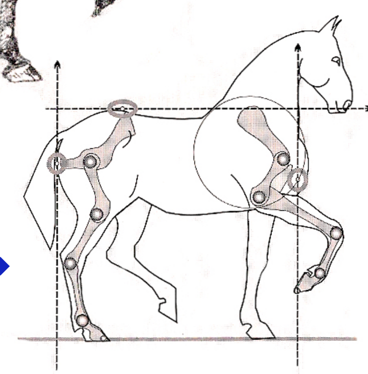
SG205B.6.3.1 The Horse (1)

In his wonderful booklet *"Nombre d'Or"* (2001), engineer & sacred geometer Robert Chalavoux researched the proportions of the horse. The question is: could there be a Phi-based common denominator between the main types of horses, given the fact that breeding has specialized horses for different tasks?

Taking averages between various types of horses, Chalavoux established an average profile. The precise points of articulation were measured from anatomy plates. Next page shows the conclusions.



↑ Drawing of a Napolitan horse by A. Millot. 1896.

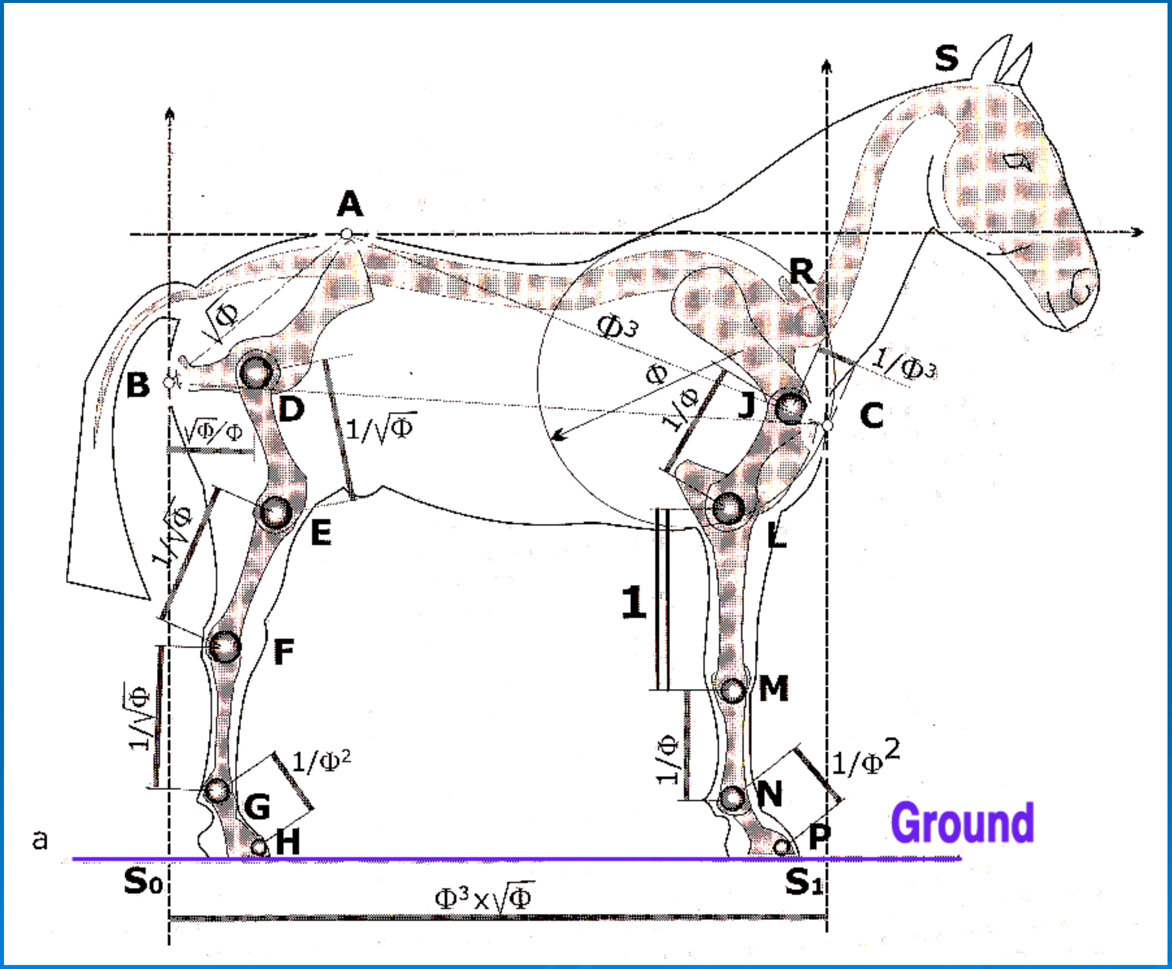


Average horse model → by Robert Chalavoux.

(Credit: R. Chalavoux. *Nombre d'Or*. www.chalagam.com)

SG205B.6.3.2 The Horse (2)

Below is the archetype horse model presented by R. Chalavoux, along with his commentaries.
(Credit: R. Chalavoux. *Nombre d'Or*. www.chalagam.com)



"A, B and C are the fixed points: A and B are connected with the pelvis;
C is connected with the sternum."

"The radius ML is taken as unity.

All the other lengths are defined by direct proportion with the Golden Number PHI (Φ) and its root (√ Φ).

The length of the front legs are defined by PHI (Φ) and the length of the back legs by √ Φ.

The whole system of harmonics is linked by:

AB = √ Φ,
AC = Φ^3
and S0-S1 = Φ^3 x √ Φ."

"It is this harmony of the 'part' to the 'whole' that creates our admiration for this wonderful companion of humans."

SG205B.6.4 The Lion

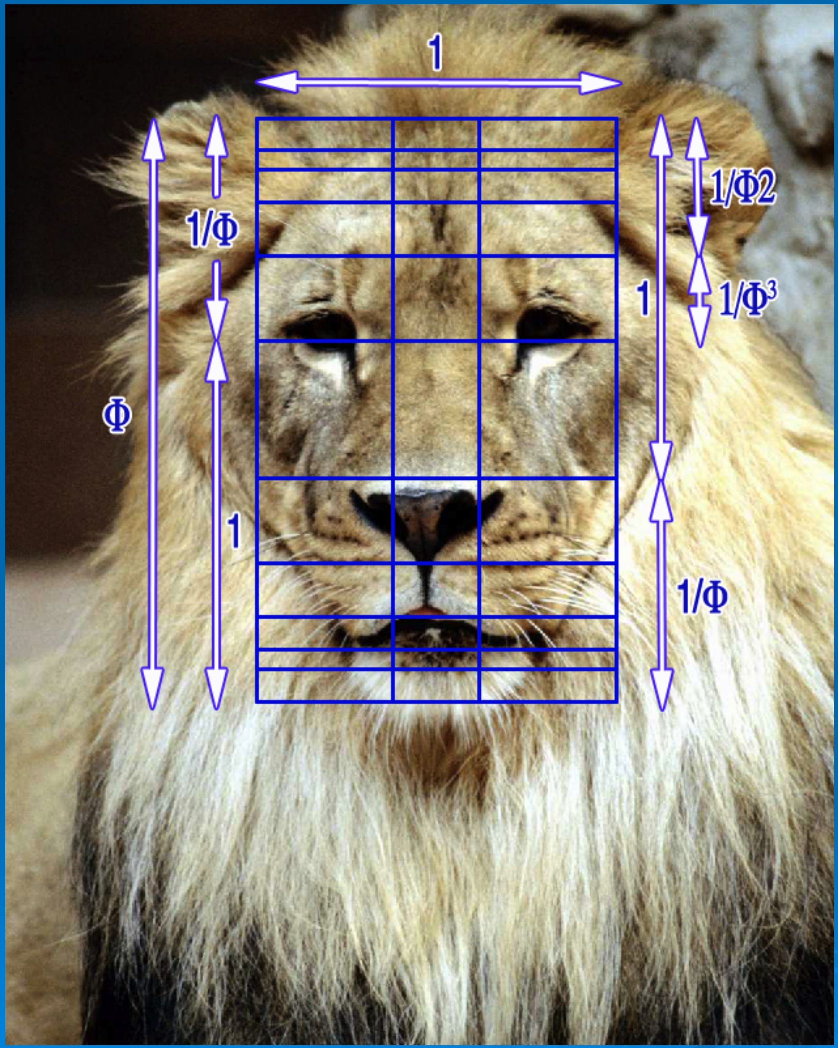
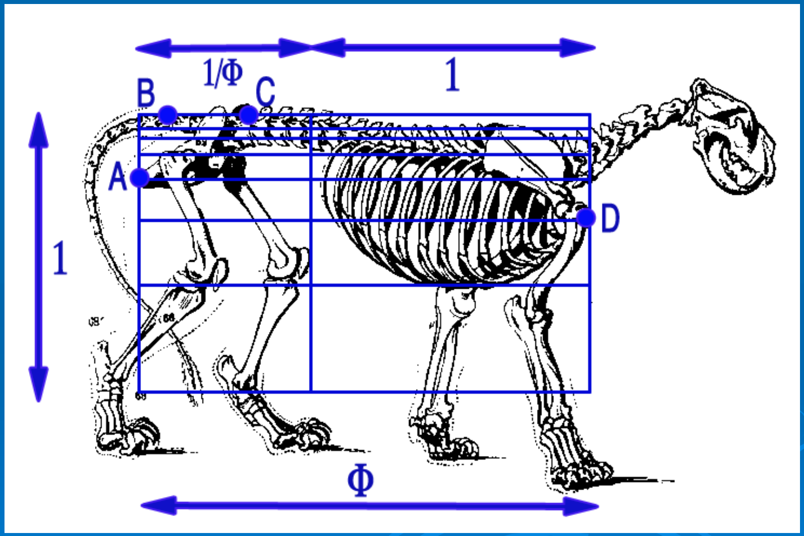


Image credit

Approaching the Phi lion…

(These measurements are suggestions for more comprehensive studies.)

White lion. Image credit

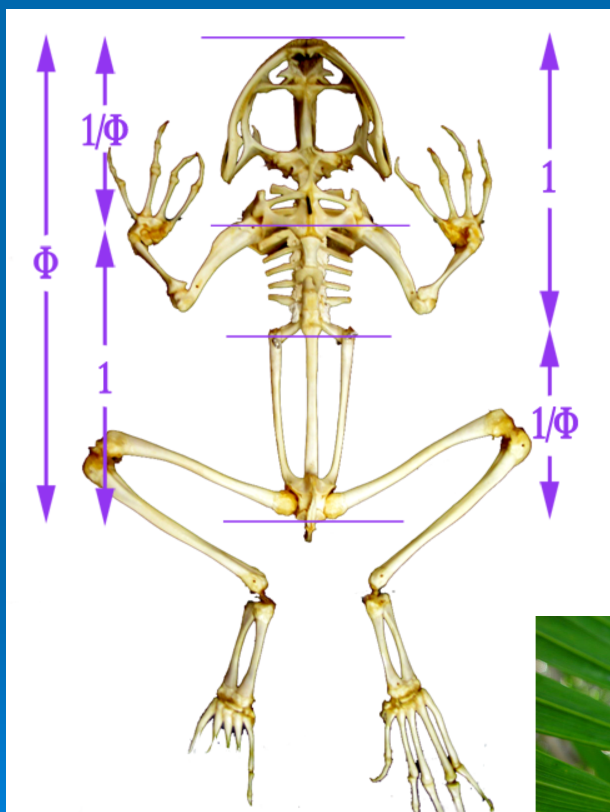


↑ Taking the 4 reference points (A,B,C,D), we applied a Golden rectangle PhiMatrix™ grid
Image credit

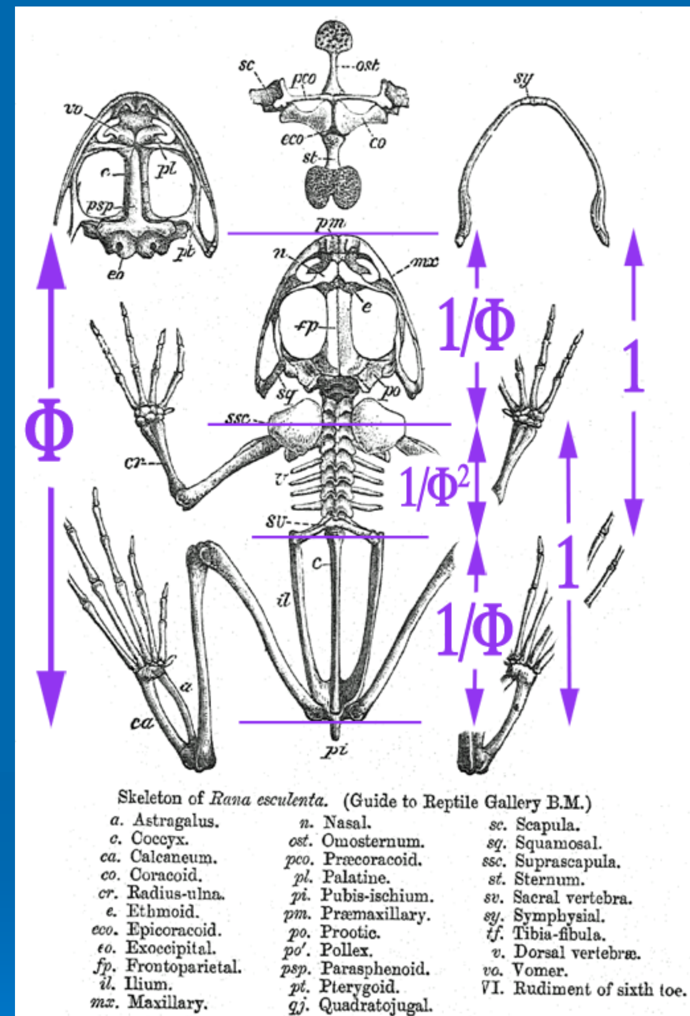
SG205B.6.5 The Frog

The benign and friendly frog (the familiar name "*rana*" is a genus of frogs) croaking or "ribbitting" away are prominent features in fairy tales, folklore and traditional cultures around the world. 5,250 species of frogs have been described.

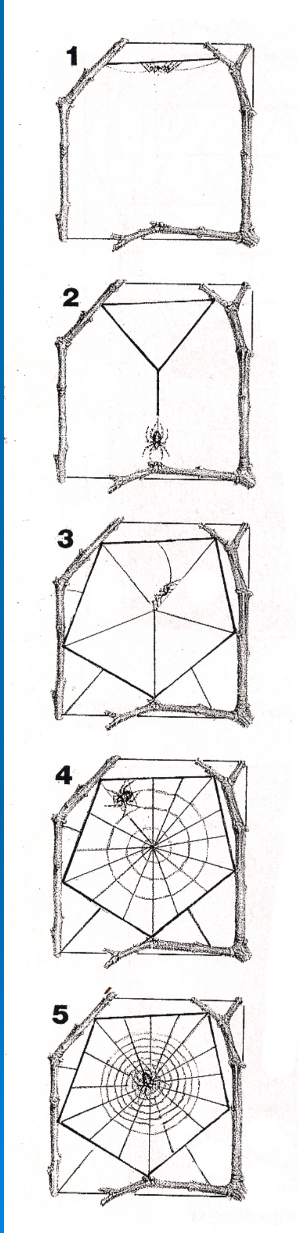
A systematic study of frog proportions is certainly needed. In these two examples of frog skeletons, we are pointing to a basic symmetrical Phi ratio in the upper body.



↑ Ventral View of frog skeleton with PHI symmetries. Image: [quepid.org]



Dorsal view of frog skeleton with Phi proportions added. (Image: Wikipedia > Frog)



SG205B.6.6.1 The Spider's Web (1)

The story of Arachne

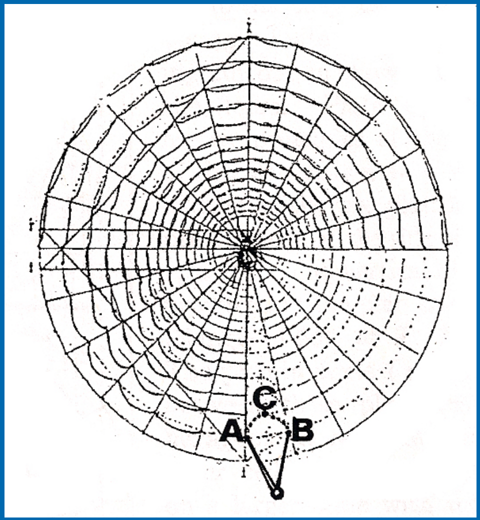
In Greek mythology, as told by Ovid in his *Metamorphoses*, Arachne, a Lydian maiden, was a master weaver and had challenged the goddess Pallas Athena herself to a contest.
Athena appeared under the guise of an old woman who advised her to be less presomptuous. Arachne rejected the warning and Athena, revealing herself, launched the contest. Arachne created a perfect work depicting the scandalous acts of the gods & goddesses. Upon seeing it, Athena was so angry that she destroyed Arachne's work. From despair, Arachne hung herself. To further revenge, Athena changed Arachne into a spider… *and this is why spiders are so good at weaving webs…*

🡐 Building a spider's web in 5 steps

Step 1: the spider excretes a silk thread to make the top horizontal "master beam".
Step 2: the first thread is doubled. At midpoint, the spider lets herself fall along a third vertical thread until it meets a base anchor point.
Step 3: the spider stretches the threads in the shape of "Y" whose intersection point will be the hub of the web. The rest of the frame is built (note the pentagonal geometry here) and then the radial spokesd of the web.
Step 4: a large *dry* spiral is now built, working from the center to the periphery.
Step 5: upon this canvas, the spider deposits the *sticky* spiral (to catch prey) unto the successive radii, working inwards from the periphery and eating up the dry spiral. The center of the dry spiral is kept as the "hunting platform".

Note 1: the spider always keeps one of her front legs on one of the spokes to feel a potential vibration that will betrays the presence of prey.

Note 2: when the male spider approaches for courting the female spider, he vibrates her web according to a special rhythm to signal her that a potential partner has arrived.



🡑 The spider's leg as natural compass.

"Spiders Appear to be specially endowed with a sense of proportion and with mathematical instincts so strongly developed that they employ their legs as measuring rods by means of which they obtain an exact ratio, using them as compasses to strike correct arcs.

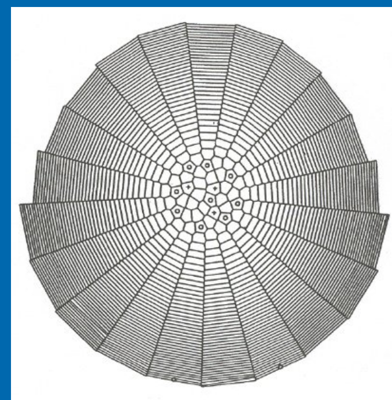
At each step, the leg is passed from A to B, placing at the point C the position of the next series of lines… The silk is now fastened in A, and this process is repeated until the web is complete, the length of the leg producing that regularity of form which renders the proportional spaces."

(Samuel Colman. *Nature's Harmonic Unity*. 1911)

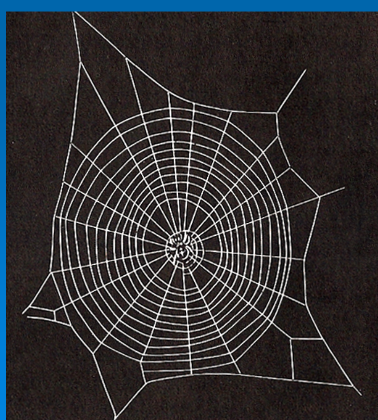
SG205B.6.6.2 The Spider's Web (2)

Spider webs have existed for at least 140 million years. They have evolved several types of web geometries: spiral orb and wheel-shaped webs (the usual "spider's web"); tangle webs; funnel webs; tubular webs, which run up the bases of trees or along the ground; sheet webs; dome or tent webs.

The web of the common garden's spider (*Arachnea diadematus*)
www.legardemysteries.com



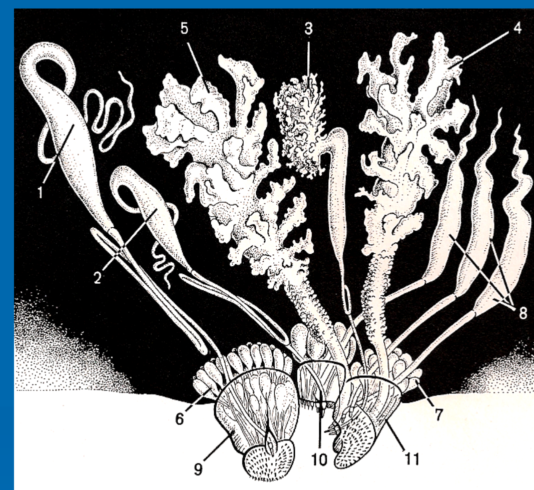
↑ Computer web with rational divergence angle.
Jay Kappraff www.mi.sanu.ac.rs



← The sticky trap spiral lies between the lookout and the frame. (Credit)

Silk-making engineering

The spider's web is made of pure silk produced by 6 pairs of glands capable of producing a variety of silken treads from which the spider can choose depending on the task to accomplish. (Diagram: K. von Frisch)



↑ Right side set of spinning glands:

1 & 2. Bottle glands - dry thread used to move around the web.
3. Thread gland - sticky thread.
4 & 5. Glue glands - coating to the sticky thread.
6. Gland 6 - adhesive for fastening the dry thread to a surface.
7. Gland 7 - a multitude of fine threads used to wrap up the prey.
8. Gland 8 - material for the egg cocoon.
9, 10 & 11 are the spinnerets.

SG205B Interlude 3a Animal Yoga Poses (1)

←↑ The "One Leg Stand" (Tree pose) or *Vrksasana*

We can't resist showing "animal yoga postures".

Every animal has a sacred gift for humans to learn, expressed in a specific pose, stand or posture.

Yoga asanas & moving art meditations such a Tai Chi all originated with keen observations of animal postures.

↑↓ Lemurs love to sit in an easy posture (*sukhasana*) or even a semi-lotus position (*ardha padmasana)*.

↑ "Downward Facing Dog" or *Adho* (downward) *Mukha* (face) *Svanasana* (svana = dog)

Both above images at www.arkive.org

SG205B Interlude 3b
Animal Yoga Poses (2)

The Cobra position
or ***Bhujangasana***

←
Lemur inversion on a branch "yoga swing".

<u>The following Yoga positions are named after an animal posture:</u>

• Dog (Downward Facing) - Adho Mukha Svanasana
• Cow - Bidalasana
• Cat - Marjaryasana
• Locust - Salabhasana
• Turtle - Kurmasana
• Pigeon - Rajakapotasana
• Camel - Ustrasana
• Fish - Matsyasana
• Cobra - Bhujangasana
Crocodile - Makarasana
• Rabbit - Sasangasana
• Eagle - Garudasana
• Lion - Simhasana

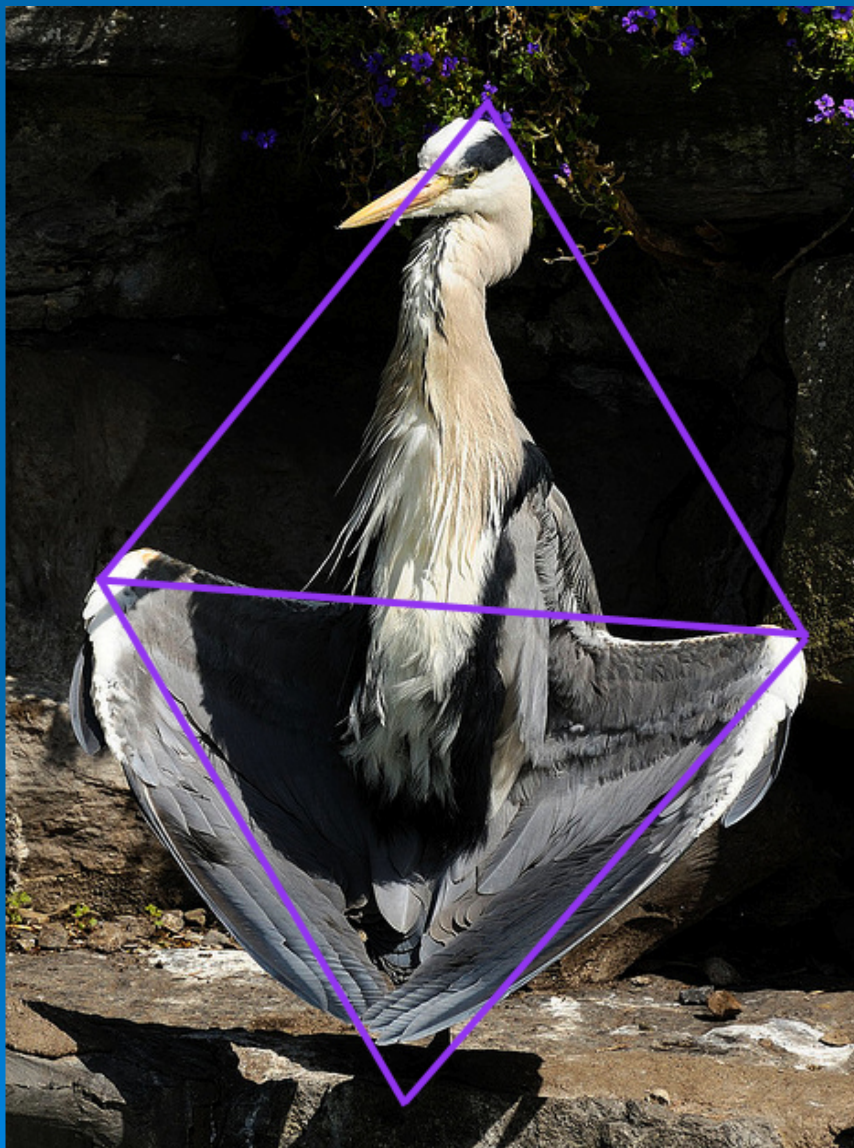
SG205B Interlude 3c. The Dragonfly's Handstand

The "obelisk posture" is a handstand-like position that some dragonflies and damselflies assume to prevent overheating on sunny days. The abdomen is raised until its tip points at the sun, minimizing the surface area exposed to solar radiation. When the sun is close to directly overhead, the vertical alignment of the insect's body suggests an obelisk. This is called postural thermo-regulation.

Dragonflies also use postural thermoregulation to increase body temperature. Keeping the flight muscles in the thorax warm is especially important, since otherwise the insect cannot fly. Dragonflies may position their wings to reflect sun onto themselves, or, if they are perched on a warm surface, to form a "greenhouse" over the thorax. When the sun is low in the sky, they may raise or lower their abdomens so that their bodies are perpendicular to the sun's rays, maximizing the surface area that receives direct sun; although this can resemble the obelisk posture, the purpose is opposite.

➔ Halloween Pennant (*Celithemis eponina*) in the obelisk position. (Wikipedia)

🡐 When the sun is low but the air is still hot, dragonflies may adopt a modified obelisk position with the abdomen only partially raised.



SG205B Chapter 7. Harmonies in Flying Animals

They have wings and roam the sky, some around the garden and some around the earth. They flap and glide or just hover… All birds evoke a sense of wonder by their unique ability to fly.

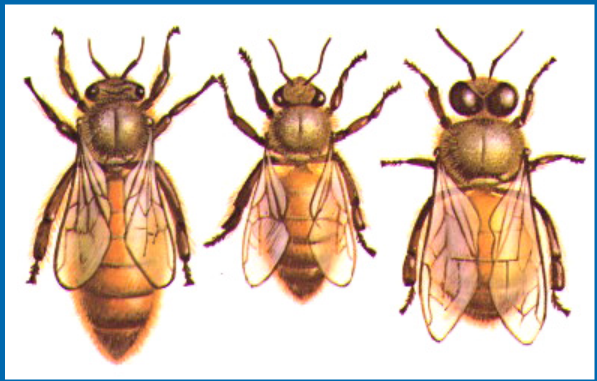
Birds have an ancient mythology & mysticism: they initiate into the teachings of the air element. In American Indian "Bird Medicine" teachings, air opens the realms beyond physical space/time and brings about the experience of levity and transcendence.

Air is the element separating earth and heaven, the bridge between earthly life and celestial life. Birds show us how to move with grace & ease between these two poles of our existence.

The choreography & geometric dances of the Winged Ones are a wonderful invitation to practice Sacred Geometry Yoga & Dance. Birds remind us that we can rise above any situation and view it from a "bird's perspective".

🡐 Master Heron in Embracing Posture www.globalanimal.com

SG205B.7.1.1 Bees (1) Phi Proportions

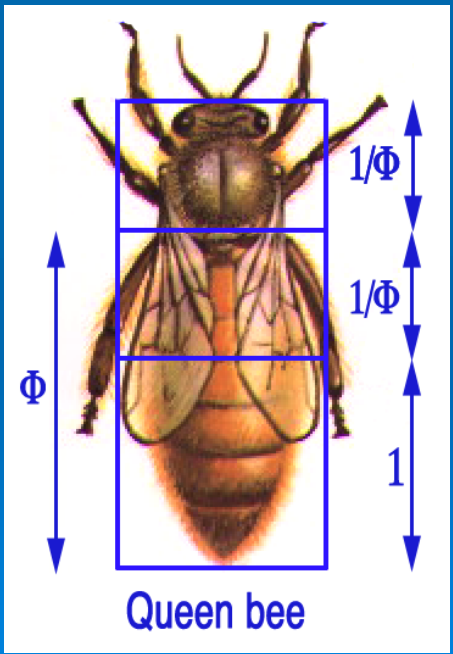


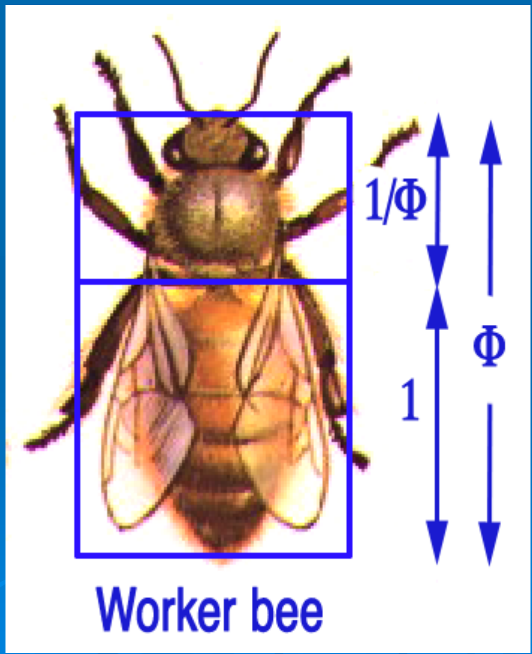
↑ The 3 types of bees: Queen, Worker and Drone.
Credit: //belfrybees.com

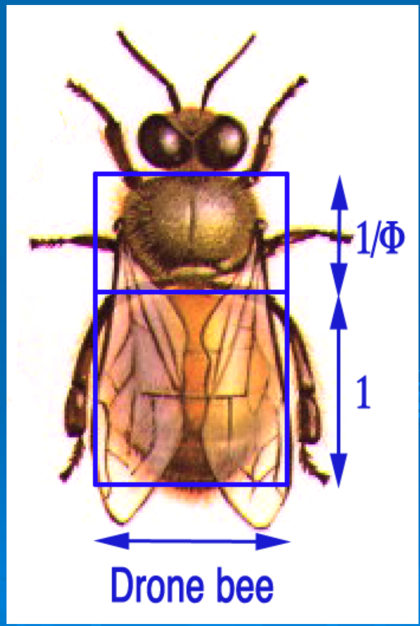
↑ Worker bee. Credit

Almost all of the world's food supply depends greatly on crop pollination by our friends the honey bees.

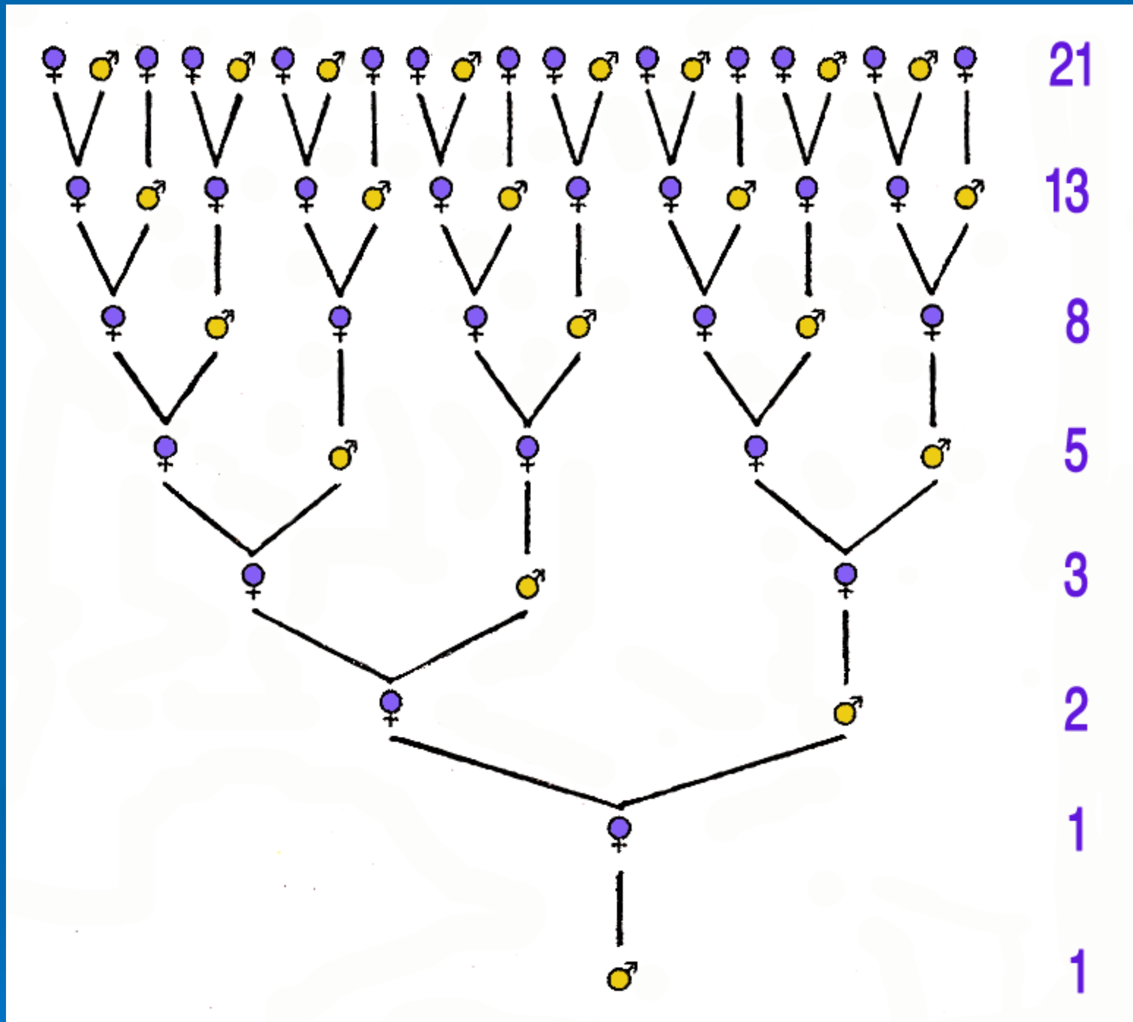
Bees have different bodies depending on their function:
- The *Queen bee* with a slender body shape.
- *Worker bees* are female bees that lacks the full reproductive capacity of the colony's queen bee. They perform most functions of the hive.
- *Drone bees* are the male bees. They develop from eggs that have not fertilized. Drone bees have a shorter and stouter body.







SG205B.7.1.2 Bees (2) Drone Fibo Genealogy



The family tree of a drone bee.
Note that each line of Fibonacci numbers
is made out of the two lower Fibonacci numbers:
Example: top line of total = 21 of which 8 males and 13 females.

The genealogical tree of the drone bee is a classic example of the Fibonacci series applied by nature.

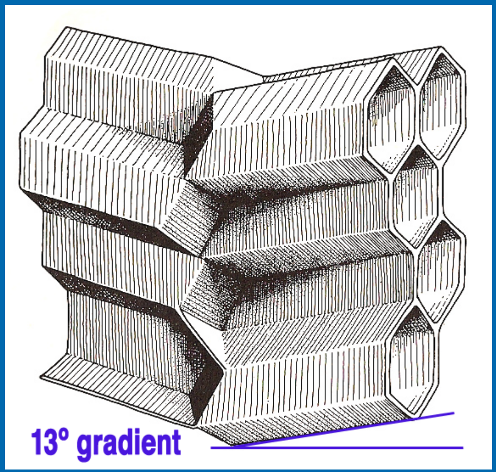
The Queen's eggs are fertilized by drones and develop into females (queens or workers). So, female bees have two parents: a mother and a father. On the other hand, a male bee (*"drone"*) comes from the un-fertilized egg of worker bees.
So a drone has no "father" and only a "mother".

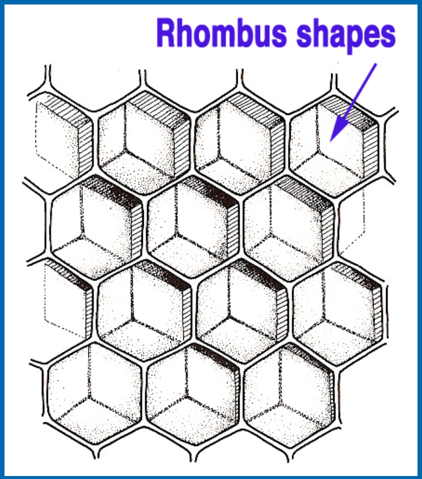
The family tree of a drone will then exhibit: 1 parent in the first line (its mother), 2 grandparents (its mother's parents) in the second line, 3 great-grandparents (2 parents of its grandmother + 1 of its grandfather) in the third line, 5 great-great-grandparents etc…

**You see the number pattern:
The Fibonacci series!**

SG205B.7.1.3 Bees (3) as Architects (1)

We take for granted the shapes of the honeycombs made by the "busy" bees but, when looking into the details of how they are constructed, the engineering feats of the bees are amazing.





• When bees start building, they attach themselves to each other in chains. Soon they form themselves into a dense ball, the building cluster within which they maintain a temperature of 35º C (95º F): this is the temperature needed for the secretion of the wax. The wax appears as flakes between the ventral scales and is passed forward the front legs and mandibles for the bee to knead and mix it thoroughly with a secretion of her salivary gland. This treatment gives the wax the necessary homogeneous consistency and plasticity to be best molded.

• Bees usually begin at 2 or 3 different places at once. The individual sections grow rapidly, both laterally and vertically, so that a continuous building front is soon reached. The joints are so perfect that no traces of the separate beginnings remain visible (see image next page).

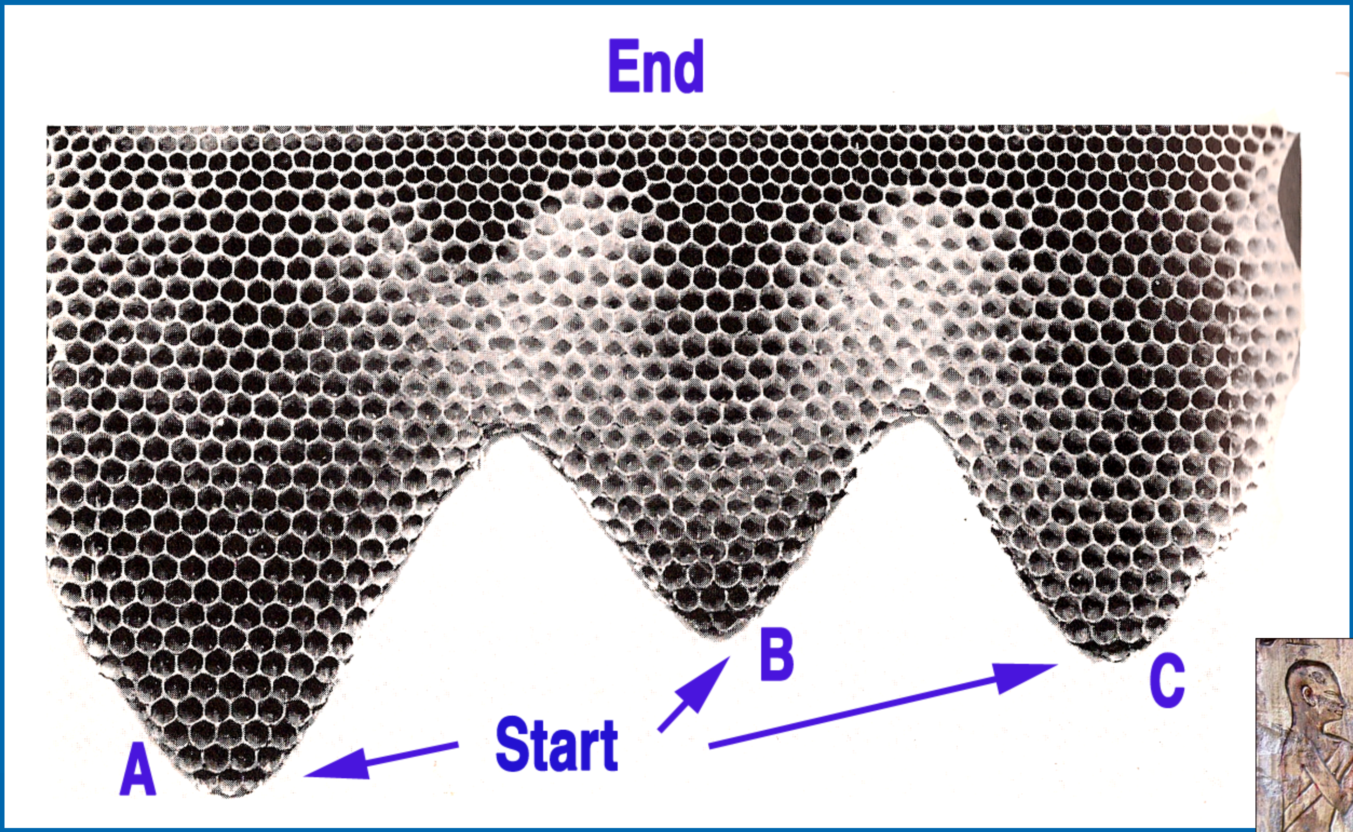
• What is even more remarkable is that many bees are employed in the building of each individual cell and that they often relieve each other at intervals no more than half a minute or so. Karl von Frisch comments: *"Apparently, each bee immediately comprehends what stage the construction has reached at the place where she starts to work, and she picks up the jog accordingly".*

• The distance between the cell walls is 5.2 mm in a worker cell, and 6.2 mm in a drone cell.

• The thickness of the cell walls is 0.073 mm, with a tolerance of no more than 0.002 mm (millimeter).

🡅 A "futuristic" Hive City built by bees underneath a couch in a courtyard. Canoga Park, CA. www.dwell.com Note the sophisticated engineering.

SG205B.7. 1.4 Bees (4) as Architects (2)



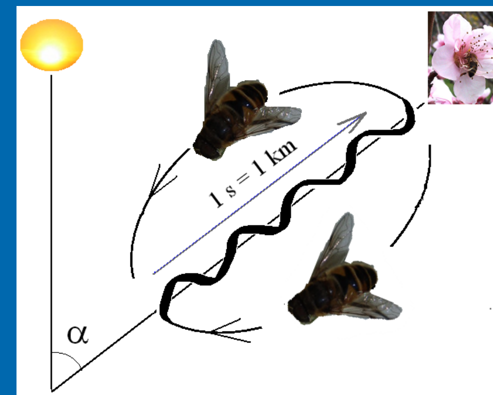
A honey comb in the process of construction.
(This is a picture showing the amazing "non-local" coherence / coordination of bee engineering.)

Three clusters of bees start the comb in 3 different places (marked A, B, and C). When the originally separate tapering sections of the comb in construction meet each other at the top, note the perfect fit of the comb's hexagonal cells where two sections join together. How is that precision possible?
Note: the parts that are light in tone are made of new wax. Darker parts indicate reused wax.

(Image from: *Animal Architecture.* Karl von Frisch. 1974.)

SG205B.7.1.4 Bees (5) as Dancers

The *Waggle Dance* is the figure-eight dance of the honey bee (*apis mellifera*). It was first described by Austrian biologist Karl von Frisch in 1956 (and earned him the 1973 Nobel Prize in Medicine). This has been confirmed by complex recent experiments.
By pairing the direction of the sun with the flow of gravity and relying on their internal clock, bee foragers can share precise information about the direction and distance to patches of flowers yielding nectar and pollen, to water sources, or to new housing locations.

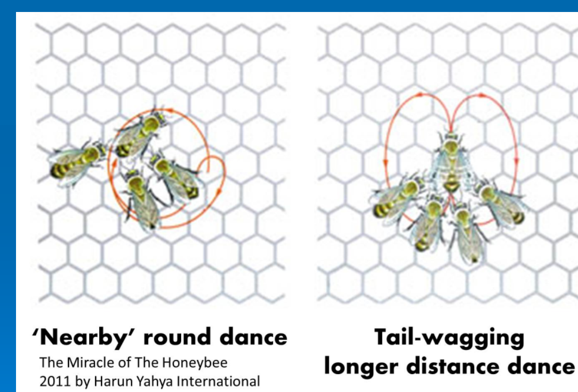


The direction the bee moves in relation to the hive indicates direction: if it moves vertically upwards the direction to the source is directly towards the Sun. Angles to the right or left correspond to similar angles from the vertical.
The duration of the waggle part of the dance signifies the distance. (Wikipedia).

A waggle dance consists of one to 100 or more circuits, each of which consists of two phases: the *waggle run* and the *return run*. A worker bee's dance involves running through a small figure-eight pattern: a waggle run followed by a turn to the right to circle back to the starting point (aka return run), another waggle run, followed by a turn and circle to the left, and so on in a regular alternation between right and left turns after waggle runs.

The orientation and duration of waggle runs are closely correlated with the direction and distance of the food source. Flowers located directly in line with the sun are represented by waggle runs in an upward direction on the vertical combs, and any angle to the right or left of the sun is coded by a corresponding angle to the right or left of the upward direction. The farther the target, the longer the waggle phase, with a rate of increase of about 75 milliseconds per 100 meters.

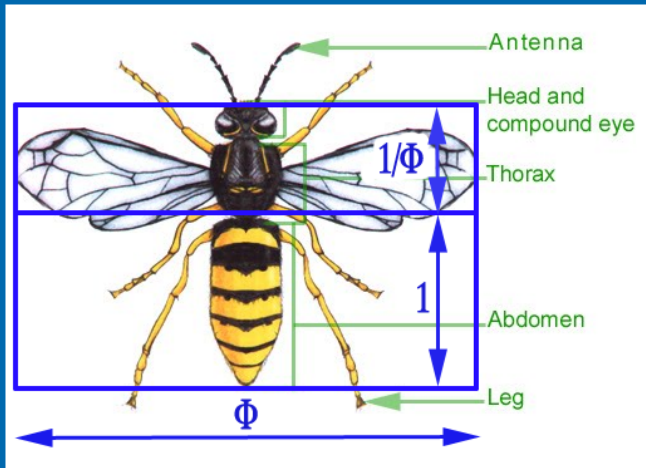
Bees have two built-in tools:
• Their ability to see ultra-violet and polarized light allows them to determine the position of the sun at all times. This functions as a sun-compass for navigation because the sun moves during the day from east to west. Bees, whose bodies are slightly longer than one centimeter, precisely navigate to flowers situated as far as 10 km from their beehive. Waggle dancing bees that have been in the hive for an extended time adjust the angles of their dances to accommodate the changing direction of the sun.
• Their internal clock allows them to time their visits to flowers when nectar and pollen flow is at its highest. They can learn to reach flowers at nine different points of time during the day within an accuracy of about 20 minutes.



↑ The "round dance" is a simplified "waggle dance" used to point to *nearby* food sources. (//blogs.nature.com)

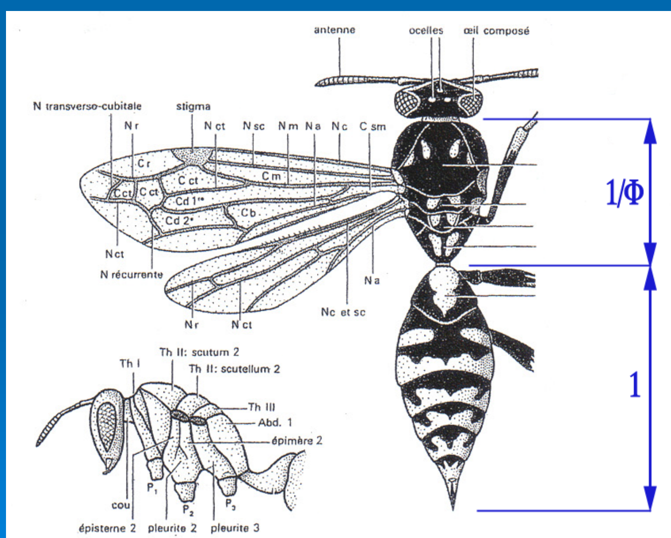
Watch this great video by Georgia Tech's College of Computing:
http://upload.wikimedia.org/wikipedia/commons/b/bf/The_Waggle_Dance_of_the_Honeybee.ogv

SG205B.7.2
The Wasp



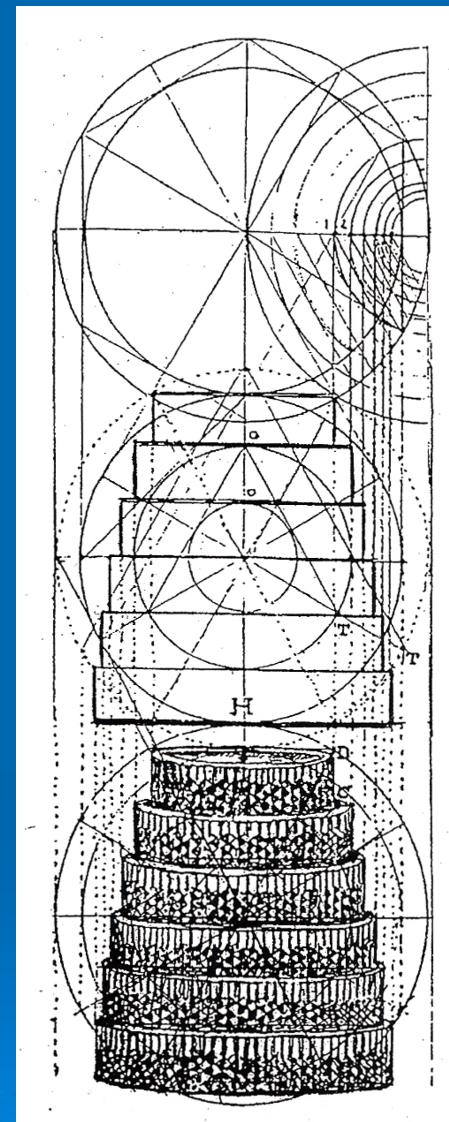
🡅 Golden rectangle and Phi proportion in the Tarantula Hawk wasp. //zoologybe.blogspot.com

//magickcanoe.com



🡅 Phi ratio in the body measurements of a wasp (*Pollistes gallicus*). Encyclopedia Universalis. 1968.

➔ Wasp nest. Vertical plan. S. Colman.



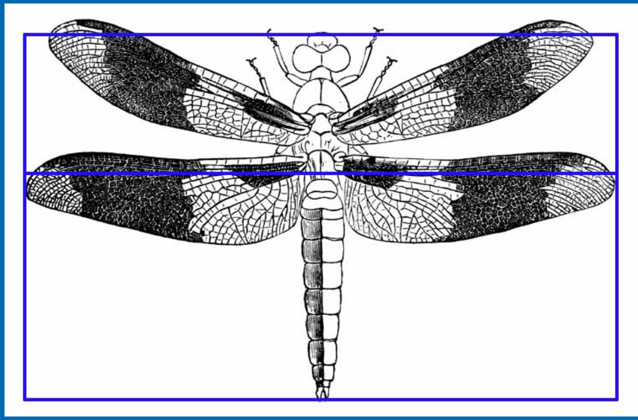
"The pasteboard making wasp builds its nest on the general principle of six stout circular platforms. These are fixed to the walls of the nest at equal distances; they are smooth & concave above and have convex and hexagonal walls beneath."

S. Colman. *Nature's Harmonic Unity*.

SG205B.7.3.1 The Dragonfly (1)

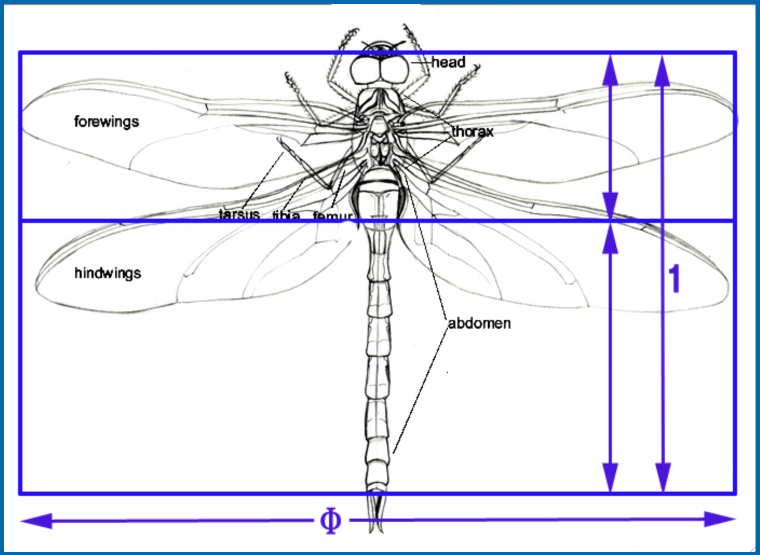
From checking a few dragonfly's images with the PhiMatrix™ Golden rectangle grid, it seems that dragonflies fit quite nicely into a simple Golden rectangle, the height of the body being unit 1 and the span of the wings being Phi or 1.618.

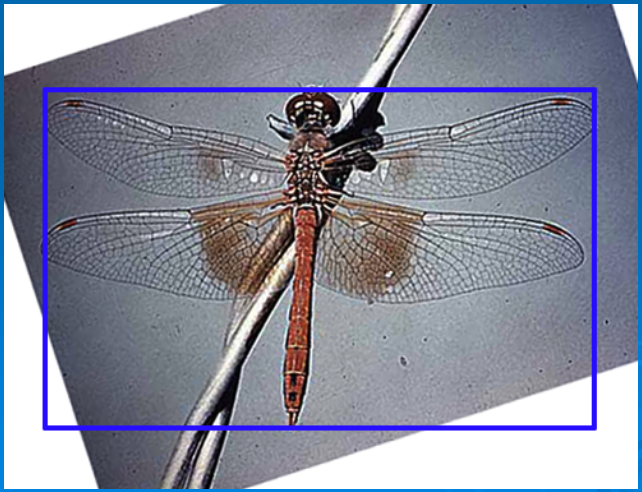
The estimated number of dragonflies species being about 6,000, there is a large research project right here.



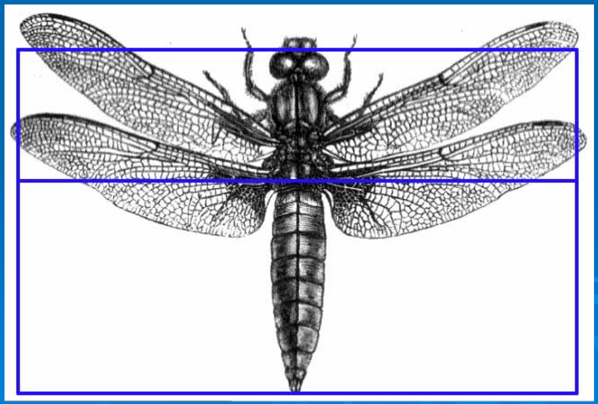
↑ //etc.usf.edu

➔ Credit



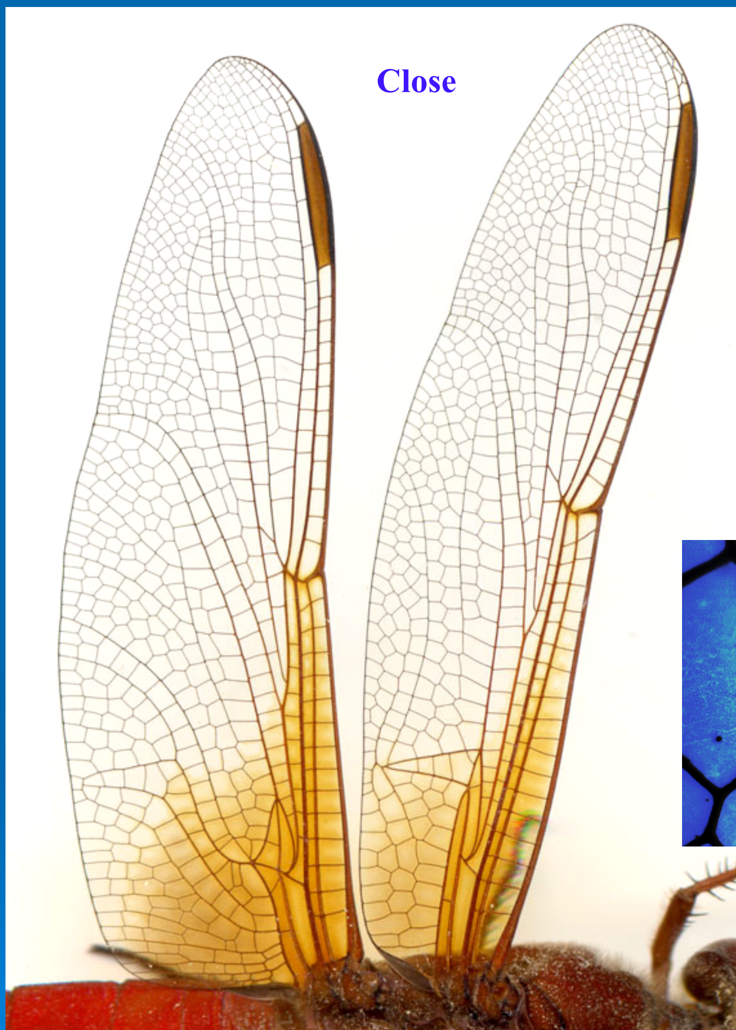


← ucmp.berkeley.ed



↑ www.bumblebee.org

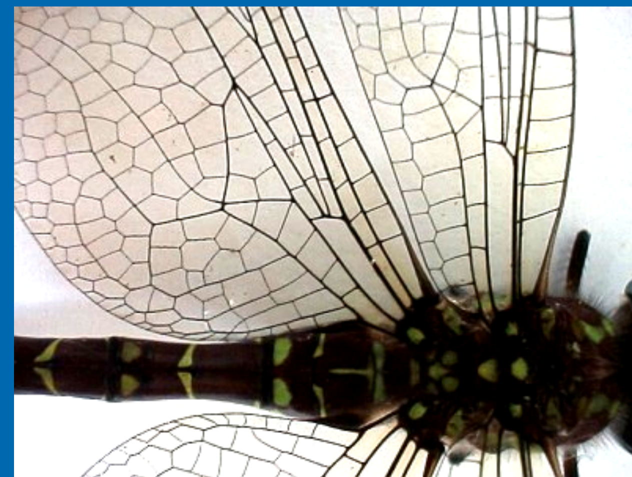
SG205B.7.3.2 The Dragonfly (2) Wings



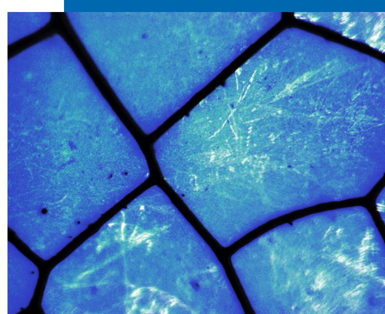
Credit

➔ A little closer

Credit



🡻 Really close



🡹 Through a light microscope at 500 x. Credit

🡹 SEM of dragonfly wing by Gregory Paulsen. //scienceblogs.com

SG205B.7.4.1 Hummingbirds (1) - Lore

Credit: www.worldofhummingbirds.com

Hummingbird Lore

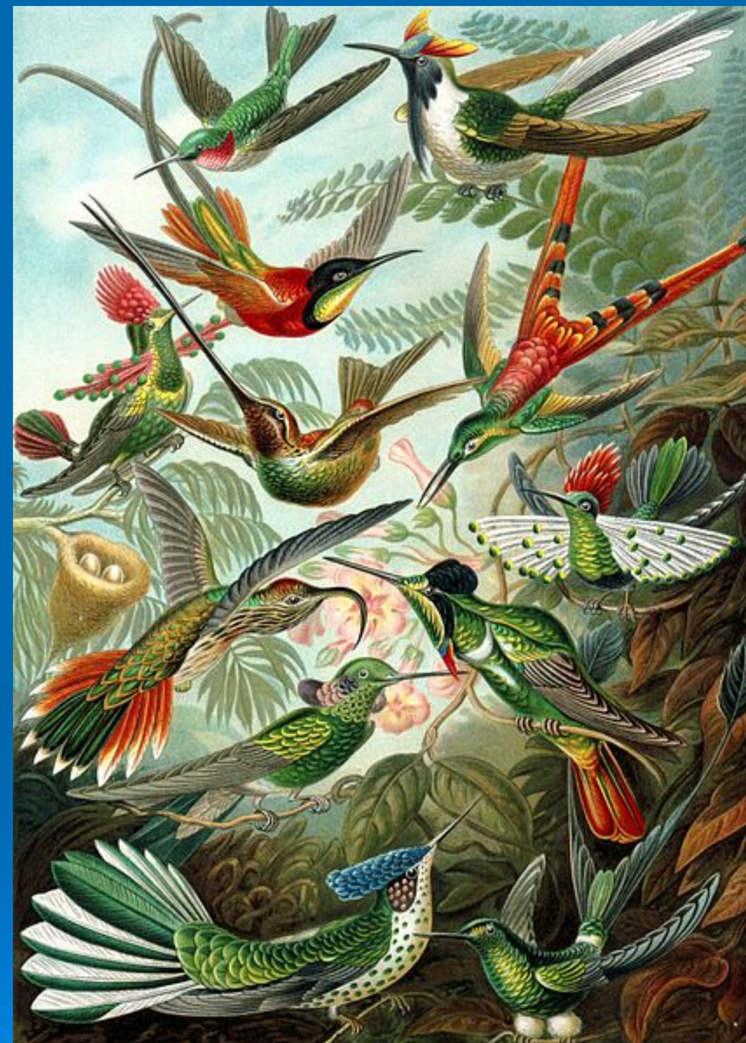
Hummingbirds hold a respected position in many cultural belief system and mythologies. Here is the Taino Hummingbird story.

In the Taino tradition, the hummingbird is the symbol of the spreader of life on earth. They believe that hummingbirds where once flies that the Sun Father (named Agueybaba) transformed into little birds. The hummingbird was seen as being very peaceful, but able to protect the homeland with the heart of an eagle. To the Taino, the hummingbird was a symbol of rebirth. Because of this the Taino Nation calls their warriors the Colibri Warriors or Hummingbird Warriors.

When the Spanish arrived in the New World, they called hummingbird *Joyas Voladores* or *Flying Jewels*. The French called them *Oiseau Mouche*, *Flower Bird* or *Colibri*. When Columbus landed in the New World, he called hummingbirds Flying Marvels.

The travelers to the new world had a hard time describing the hummingbirds to friends and family in Europe who have never seen or heard of a hummingbird. They could not understand how there could be so much life in a little ball of feathers or how such colors could glisten only in the sunlight. They thought that hummingbirds where magical. Pilgrims arriving in the New World imagined hummingbirds hummed as they went about their chores.

(From www.worldofhummingbirds.com)



↑ Color plate from Ernst Haeckel (*Artforms in Nature* - 1899) showing a variety of hummingbirds.

Hummingbird anatomy is different than any other bird in the world and the details are fascinating.
Below are quotes from www.worldofhumminbirds.com

Bones: In order to be as lightweight as possible, most of the hummingbird's bones are extremely porous. Some hummingbird bones, like those in the wings and legs, are hollow to save even more weight.

Brain: A hummingbird's brain is approximately 4.2% of its body weight, the largest proportion in the bird kingdom. Hummingbirds are very smart and they can remember every flower they have been to, and how long it will take a flower to refill.

Ears: A hummingbird has two ears located on each side of the hummingbird's head. A hummingbird can hear better and easily decipher small fluctuations of tones better than most humans.

Erythrocytes: Erythrocytes are the red blood cells in a hummingbird's blood. Hummingbirds have a greatest concentration of erythrocytes than any other animal in the animal kingdom.

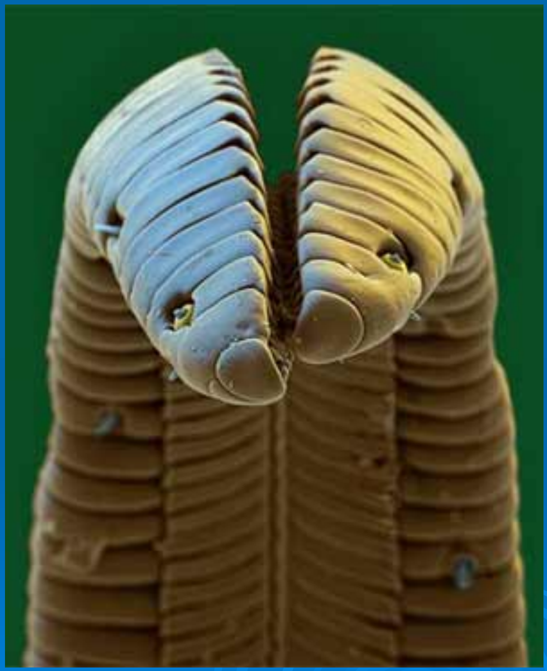
Eyes: Hummingbirds have very large eyes in proportion to their body weight. The eyes are set on the side of the head allowing the hummingbird to see both ahead (binocular vision) and on the side peripherally (monocular vision). Hummingbirds have many more rods and cones than humans in their eyes to help them see well.

Heart: A hummingbird's heart is a relatively large organ in comparison to a hummingbird's body weight. It makes up 1.75% to 2.5% (depending on the type or species of hummingbird) of the hummingbird's total weight. This makes the hummingbird's heart relativity the largest heart in the animal kingdom. A hummingbird's heart beats about 250 beats per minute at rest and about 1,260 beats per minutes while flying.

Neck Vertebrae: These are the bones that hold a hummingbird's head. Many types or species of hummingbirds have fourteen (14) or fifteen (15) neck vertebrae. Most mammals have only seven (7) neck vertebrae.

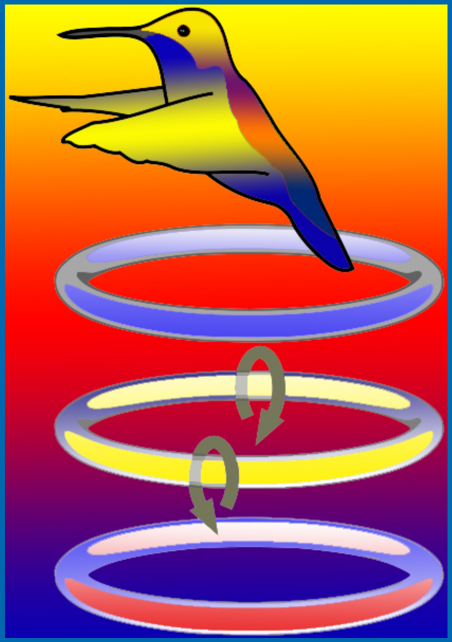
SG205B.7.4.2 Hummingbirds (2) - Anatomy

From looking at the catalog of hummingbirds offered by the www.worldofhummingbirds.com website (356 species on record), the variations are such that it seems impossible to rapidly establish some standard of body proportions. However a dedicated researcher could look for system proportions in specific species.



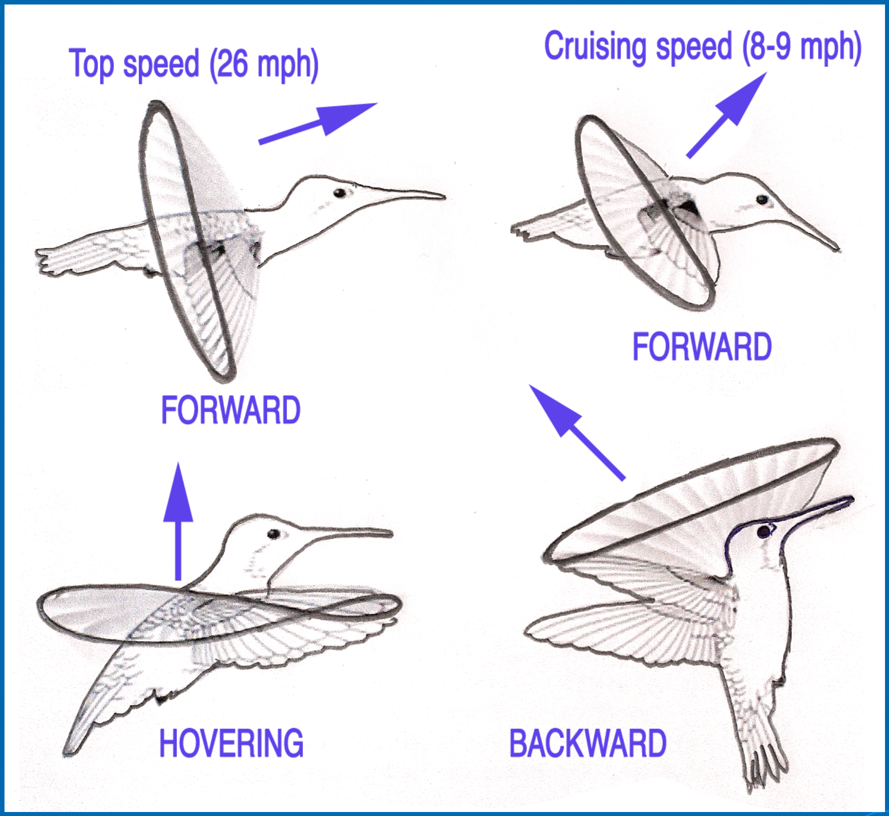
The end of the tongue (proboscis) of a hummingbird hawkmoth.
SEM image. iclickfun.com

SG205B.7.4.3 Hummingbirds (3) - Flight



↑ Vortex making.
A trail of wake vortices generated by a hummingbird's flight.
Discovered by recording airflows in the wake with stereo photography.
(Wikipedia)

The flight patterns → allowed by the rotating wing joints.

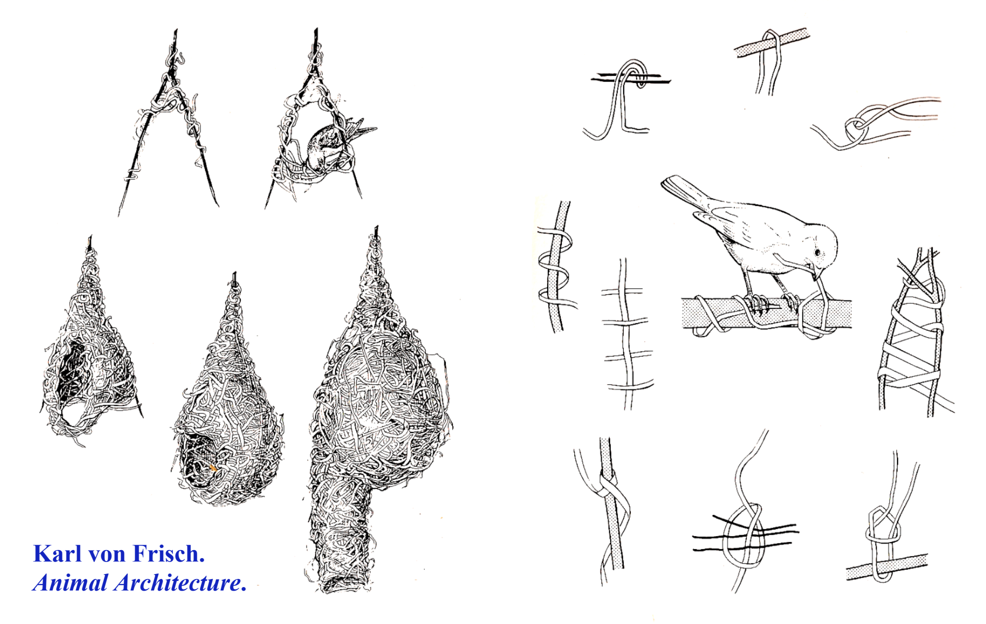


Hummingbirds have more feathers per square inch than any other bird. Their wings are also unique: unlike most birds that flap their wings up and down, hummingbirds rotate their wings, thus forming different wing patterns and allowing them to perform feats of acrobatics such as fly forward, backward, hover, and even fly upside-down for a short period of time.

• The shoulder joint is a ball and socket joint allowing hummingbirds to rotate their wings one hundred eighty (180) degrees in all directions.
• Hummingbird wings beat about seventy (70) times per second while in regular flight and up to 200 times per second when diving.
• A hummingbird can fly at an average speed of twenty-five (25) to thirty (30) miles per hour, and dive at a speed of up to sixty (60) miles per hour. • Hummingbirds don't flap their wings, they rotate them.
• Oval patterns allow the hummingbird to fly in a particular direction.
• The figure-eight pattern allows the hummingbird to hover.
• When hummingbirds fly, they fly upright, facing the world, not flat like most birds.

SG205B.7.5 The Nest of the Weaver Bird

The weaverbird is a master knot-maker and a nest architect with a flair for beautiful egg-shape proportions. Below, some of the engineering aspects.



Karl von Frisch.
Animal Architecture.

(Wikipedia)

(kumarakomvillage.com)

↑➔ Weaverbirds build beautiful nests that seem to have harmonious (golden?) proportions.

Weaverbird housekeeping

"Though he male weaverbird is anxious to make the fabric strong, he avoids pulling his knots too tight for a very good reason.
As soon as the nest has taken shape, the weaverbird tries to find a mate. The females see the nest and understand the meaning of the male's fluttering display around the nest entrance, but they are very fastidious and make considerable demands on the quality of the home that is offered them.
If the male has not been able to find a female that will accept his nest within a week or so, he himself demolishes the fabric that has taken such pains to make. In that case. It is an obvious advantage if the knots are not tied too firmly. He then tries to produce a better nest in the same spot.
If this approved of by a female, she takes over decorating its interior with grass and other soft materials."

(K. von Frisch. *Animal Architecture*. 1974.)

SG205B.7.6 Fireflies - Sync in Light Patterns

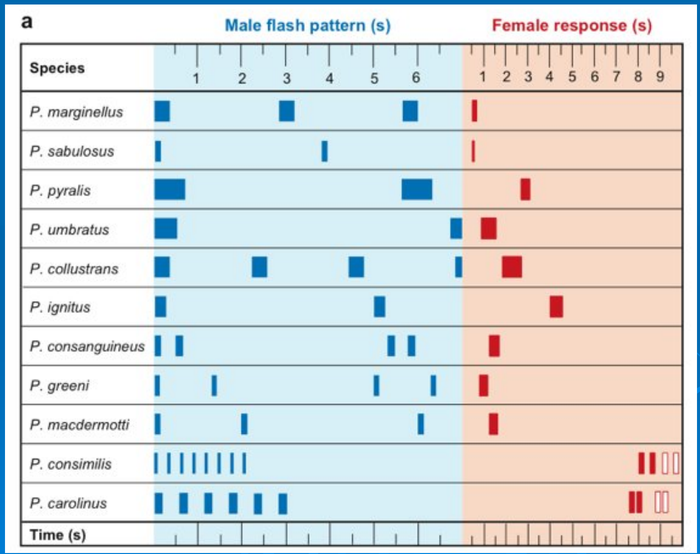
"Fireflies are winged beetles (commonly called "lightning bugs") famous for their conspicuous crepuscular use of *bioluminescence* to attract mates or prey. Fireflies produce a "cold light", with no infrared or ultraviolet frequencies. This chemically produced light from the lower abdomen may be yellow, green, or pale-red, with wavelengths from 510 to 670 nanometers. There are 2,000 species of firefly found in temperate and tropical environments. Tropical fireflies, in particular, in Southeast Asia, routinely synchronize their flashes among large groups. This phenomenon is explained as phase synchronization and spontaneous order". (Wikipedia). Fireflies are examples of natural harmony.

In his book *"Sync, The Emerging Science of Spontaneous Order"* (2003), Steven Strogatz takes up the study of *synchrony* or tendency, in enormous systems, to synchronize themselves. The mass synchrony of fireflies, for long believed to be a fleeting coincidence, is now firmly established in science because *"it represents one of the few tractable instances of a complex, self-organizing system, where millions of interactions occur simultaneously - when everyone changes the state of everyone else."* (Inter-connectedness and entanglement). Strogatz comments that the study of fireflies has an even broader significance for science as a whole: *"The tendency to synchronize is one of the most pervasive drives in the universe, extending from atoms to animals, from people to planets… Virtually all the major unsolved problems in science today have this intricate character".*

The humble fireflies are revolutionizing human science: *"Scientists have long been baffled by the existence of spontaneous order in the universe. The laws of thermodynamics seem to dictate the opposite, that nature should inexorably degenerate toward a state of greater disorder, greater entropy. Yet all around us we see magnificent structures - galaxies, cells, ecosystems, human beings - that have somehow managed to assemble themselves."* (Strogatz).

Fireflies not only flash in unison but they also flash in rhythm, with constant patterns. Through experiments, it was found that *"the flash rhythm was regulated by an internal, resettable oscillator… The fireflies organize themselves… No maestro is required… Sync occurs through mutual cuing."* (Strogatz).

LATEST. A new study shows that when male fireflies synchronize their flashes, it helps their female counterparts to find males of her own species among the other species of fireflies flitting about on warm summer evenings. When she sees males flashing together in the right pattern, she can then answer with her "come hither" counter flash. "What the females are doing is looking for the number and tempo of flashes," said firefly researcher Andrew Moiseff of the University of Connecticut. (//news.discovery.com)



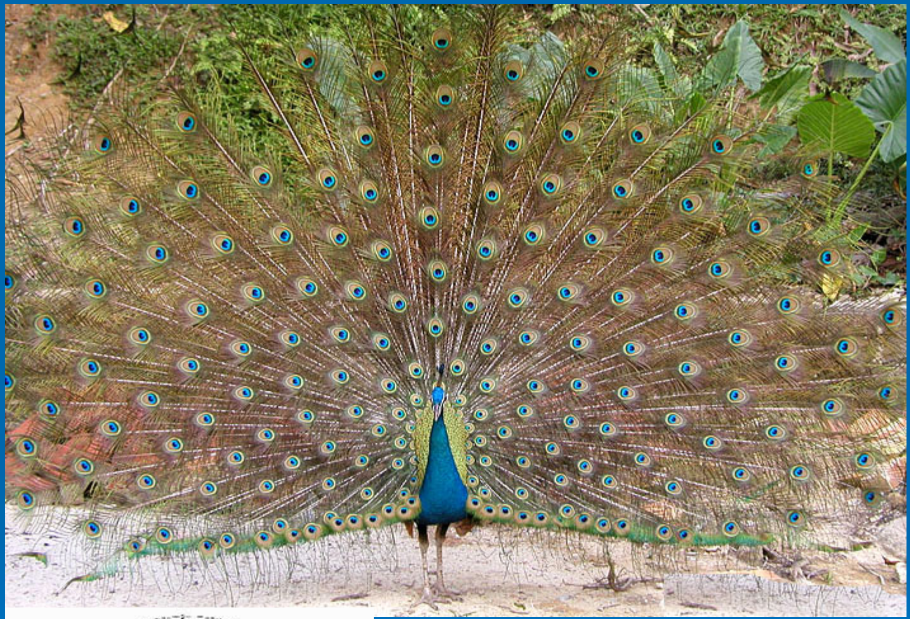
↑ This chart shows how different species of fireflies have evolved different flash signals. (Sara M.Lewis. Quoted in //blogs.discovermagazine.com)

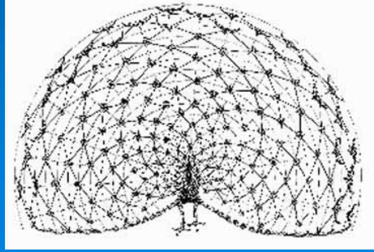
SG205B.7.7.1 The Peacock (1) Tail Spiral Wheel (1)

"How did the peacock get his tail?" This question has challenged biologists ever since Darwin, who noted in his Journal: *"The sight of a feather in a peacock's tail, whenever I gaze at it, makes me feel sick!"* (letter to Asa Gray, April 30 1860). We are here briefly showing aspects of the complex precision and stunning harmonic beauty of a peacock's tail.

When a peacock (or male peafowl - the female is the "peahen") displays his tail feathers during courtship, a magnificent fan formation ("train") of feathers forms a beautiful *mandala* backdrop to his body.

🡑 Peacock displaying its tail. In this half-way position, the tail resembles a dish antenna.





🡐 Drawing of peacock's tail by Ernest Thompson Seton (1860-1946), naturalist and artist who left a legacy of about 4,000 pieces of artwork depicting wildlife and nature. Seton was also one of the founders of the Boy Scouts.

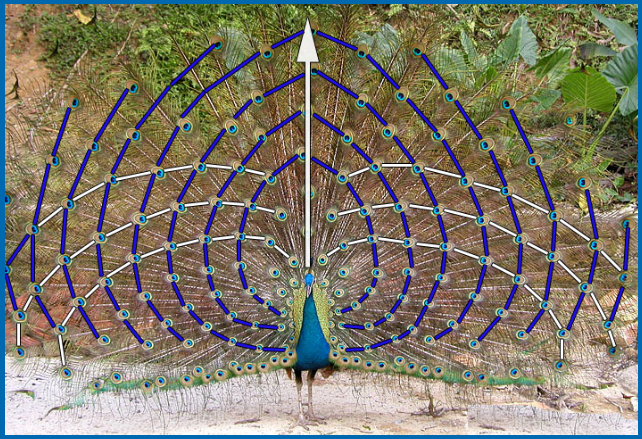
The physiology of displaying the peacock's tail is quite remarkable. We quote the following technical details from a web article by Stuart Burgess.

- *"The fan formation is very even because the axis of every feather can be projected back to an approximately common geometric center.*
- *The radial projection of the feathers requires the root of each feather to be pointed with a great degree of accuracy.*
- *The displayed feathers are deployed into position by muscles in the peacock's tail.*
- *Not only can the peacock deploy the feathers, but he can also make them vibrate and produce a characteristic hum".*

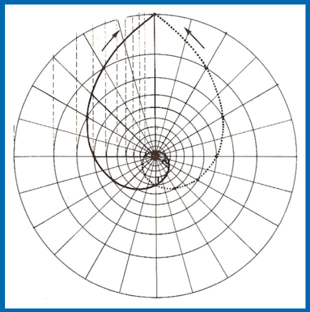
But the most remarkable feature of the peacock's fan-wheel is the spiral pattern in the spacing of the eyes. The question arises: what kind of spiral phyllotaxis is it? Precise measurements need to be taken over a large sample of peacocks but, at first glance, it looks like a daisy flower type of phyllotaxis: two set of spirals that are logarithmic and equiangular - see the overlays next page.

(Credit for tech quotes: www.answersingenesis.org)

SG205B.7.7.2 The Peacock (2) Tail Spiral Wheel (2)

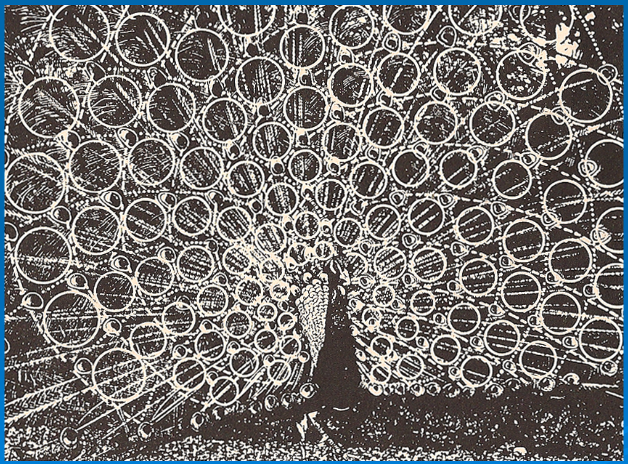


↑ Overlay #1 showing the mirror symmetry
around a central axis.

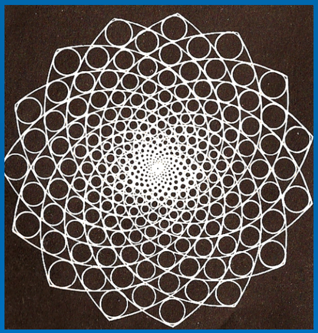


↑ Logarithmic spirals
of a daisy flower.

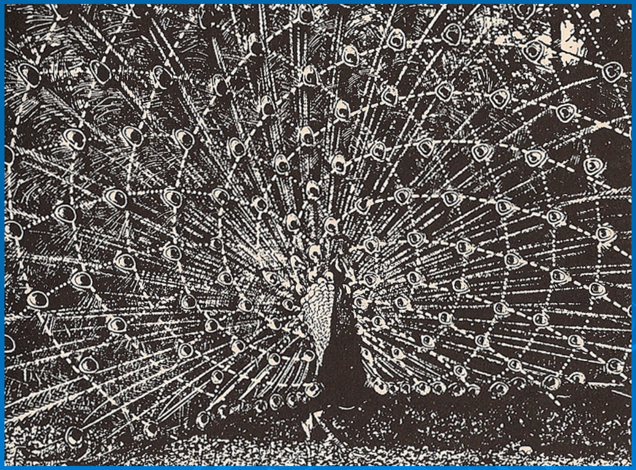
↑ Overlay #2 showing (in white)
some of the full clockwise spirals.



↑ The white circles show the same patterns
shared by the peacock and the daisy.
(G. Doczi. *The Power of Limits*.)



↑← Daisy pattern
overlaid on peacock's
pattern



↑ The eyes of the peacock's pattern are
at the intersecting points of logarithmic spirals.
(G. Doczi. *The Power of Limits*.)

SG205B.7.7.3 The Peacock (3) Tail Feathers

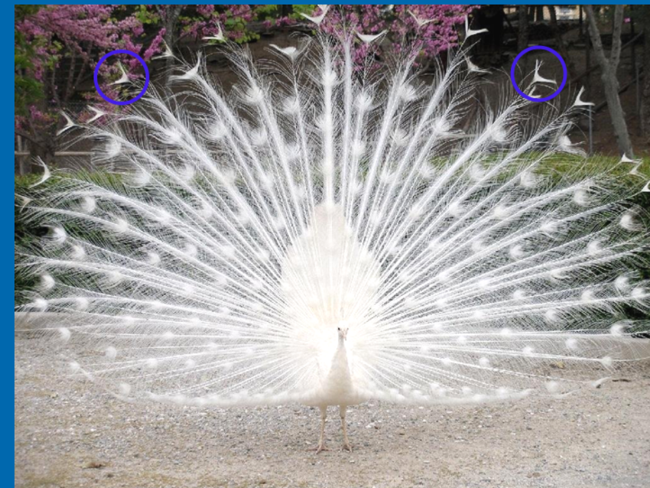
The "tail" of a peacock is actually made of very elongated uppertail *covert feathers.* Generally, birds have two types of feather: flight feathers and covert feathers. The flight feathers obviously provide flight maneuvering, while the covert feathers protect the flight feathers, in this case the tail feathers.

In the vast majority of birds, the tails covert feathers are small. However, some birds like the peacock have very large tail-coverts doubling up as ornamental elements.

"An adult peacock has an average of 200 tail feathers and these are shed and re-grown annually. Of these 200 feathers, about 170 are "Eye" feathers and 30 are "T" feathers.

Even though the display contains around 170 eye feathers, they are all visible and all spaced apart with a remarkable degree of uniformity. All the eyes are visible because the feathers are layered with the short feathers at the front and the longer feathers at the back."

(Credit for tech quotes: www.answersingenesis.org)



↑ The "T" feathers (some in blue cricles) are very visible on the white peacock (not an albino, just a color mutation). fanpop.com

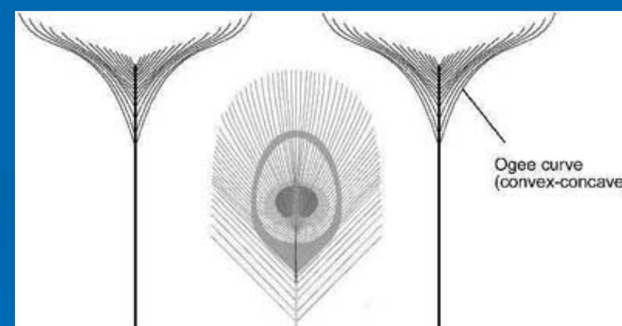
↑ A rear view of an Indian Peacock's true tail and elongated uppertail covert feathers. (Wikipedia)

The "T" Feathers

The long "T" border feathers provide a perfectly finishing touch to the tail display: they follow and outline the curves of the peacock's "Eye" feathers.

Mathematically, the "T" feathers form a shape called an *ogee curve,* consisting of a concave arc flowing into a convex arc. The left side of a "T" feather and the right side of another form an open arch contouring the "Eye" feather and the "eye" design itself - exactly like in an architectural arch. The ogee shape is characteristic of the late Gothic style of architecture. Ogee windows and arches were introduced to Europe from Islamic architectural design.

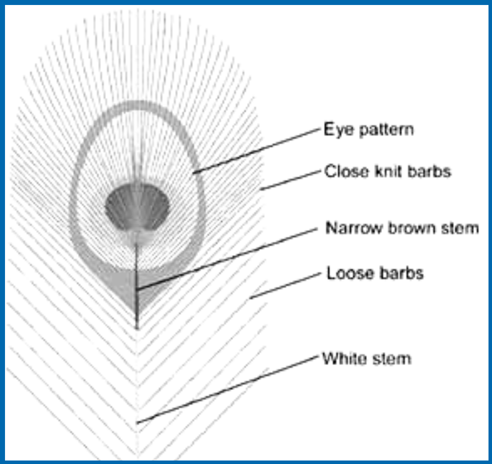
In order to form an ogee curve, each *barbule* at the end of the "T" feather has a unique length and curvature index harmoniously coordinated with all the others.



↑ The "T" feathers form an ogee arch over the "Eye" feathers. www.answersingenesis.org

← An *ogee* curve.

SG205B.7.7.4 The Peacock (4) Tail "Eyes"



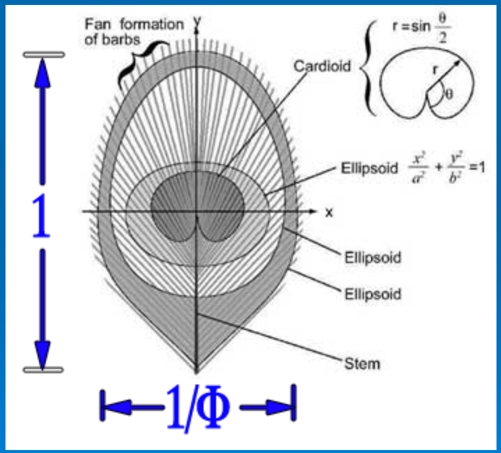
↑ The ocellus pattern

The eye-like designs (called "ocellus" - from Latin *oculus* = little eye) at the end of each "Eye" feather have been traditionally assigned all sorts of stories and functions, from the "hundred eyes of Argus" to the "all-seeing eye". The display of these eye-like patterns is also an image of the stars, the universe, the sun, the moon, and the vault of heaven.

To biologists, the trivial function is to frighten away potential predators by appearing to be a larger animal. Some species of potential predators have a different type of vision which focuses more on the shiny areas of another animal. The "eye" indeed has the unique optical property of reflecting light by "thin-film interference" (see next page).

The geometry of the peacock's ocellus is what interests us here.

↑ Elegance in the design: the stem is absent from the top half of the eye design thus bringing a unifying smoothness.



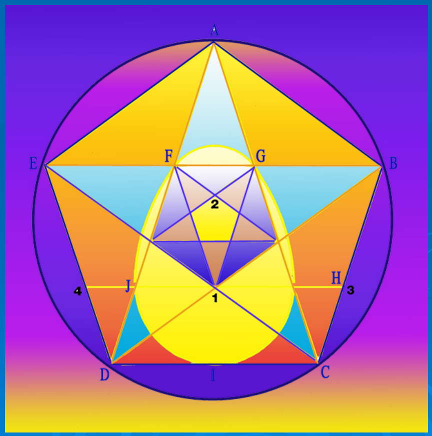
Original diagram & above:
www.answersingenesis.org

Geometry of the Peacock's *ocellus*

Here is another research project: collecting measurements on a large number of "eyes" and determine a statistical average proportion.

Looking at individual examples, it seems that the overall geometry is close to the "egg-shape" forms we have encountered in studying Schauberger's vortex technology. [See ◆S203B - Egg-Shape Power]

Could it even be a Golden Ovoid? Further research will tell. The diagram on the left does measure to Phi.



↑ The Golden Ovoid in the pentagram.

SG205B.7.7.5 The Peacock (5) Geometry of Barbules

The shiny, and somewhat iridescent, colors in the peacock's "eyes" are not produced by pigments but by optical effects called *thin-film interference* (secondary light reflection) and *Fabry-Perot interference* (a cascade of multiple offset beams interfering with each other). The result is that visible colors are different at different angles of view: they shimmer.

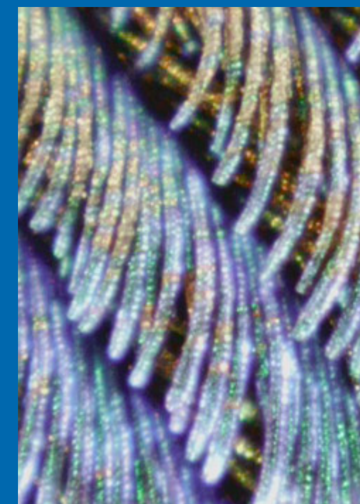
In the case of the peacock, thin film and Fabry-Perot interferences are made possible by the structural geometries of the *barbules*, sort of "twigs" coming out of the "branches" of a feather (we are looking here again at a fractal geometry).

**<u>Data:</u> the total number of barbules in a feather is nearly 1 million.
Each barbule is about 60 µ (1 micrometer = 1 millionth of a meter) wide and 5 µ thick and has a foam core 2 µ thick covered with three layers of very thin keratin (about 0.4-0.5 µ thick). This matches them with the wavelengths of visible light (between 0.4 and 0.8 µ).**

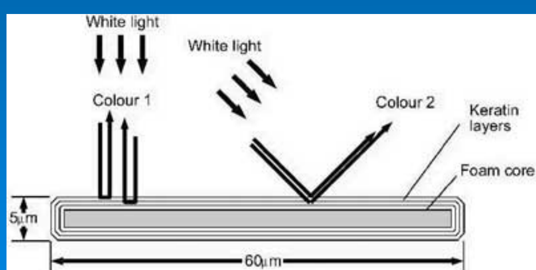
According to recent research in China & Japan, the barbules contain "nanoscale photonic lattices". (//hyperphysics.phy-astr.gsu.edu)

"The only pigment in the peacock tail are arrays of melanin cylinders, which gives the barbs a uniform brown color. This provides a dark background color for the optical interference. The shimmering interference effect is due minute differences in the thickness of the keratin layers. In order to produce a specific color, the keratin thickness must be exact to within 0.05 µ (one twenty thousandth of one millimeter!). The barbules are also slightly curved in the longitudinal direction. This curvature causes a mingling of slightly different colors, which produces a softening of the colors seen in the keratin layers." (www.answersingenesis.org)

**↑ A 50x zoom on the barbules shows the rows of color elements.
(Above & right image: //hyperphysics.phy-astr.gsu.edu)**

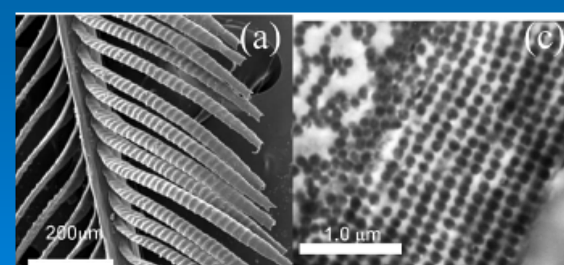


↑ A 200x zoom on the barbules shows subtle variations in color as well as areas which seem to "fire" with more reflected intensity than neighboring regions.



www.answersingenesis.org

**← Thin-film interference in a single layer of keratin covering a barbule.
White light is reflected off the front and back surfaces of the thin film (color #1). Some light also passes through the keratin and because it is retarded it emerges from the keratin to give off a modified color (color #2).**

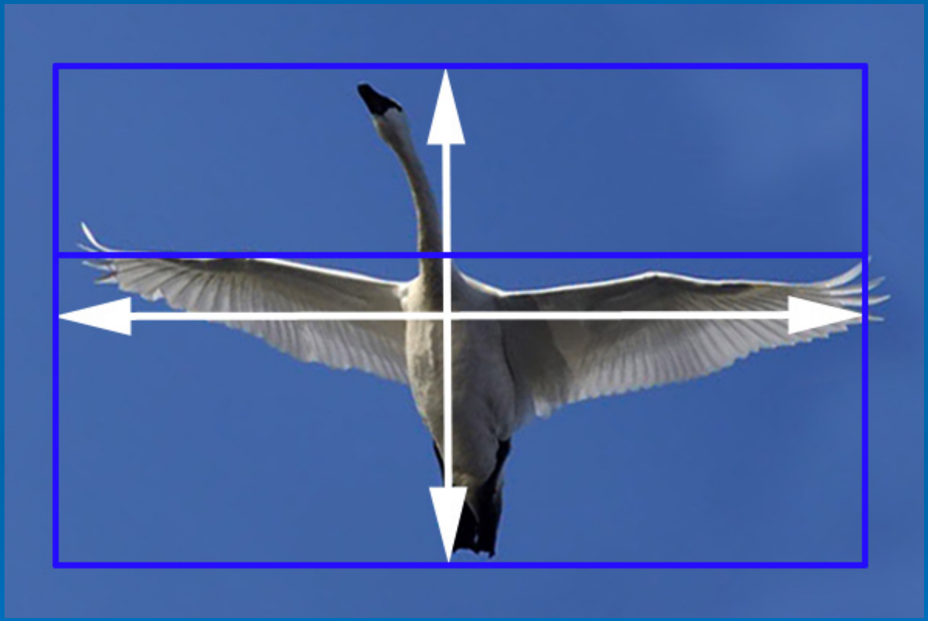


**↑ Barbules.
Left: A series of barbules off a feather's branch.
Right: zoom on a cross-section of one barbule.
(Yoshioka & Kinoshita)**

SG205B.7.8 The Swan

When in full flight, what is the proportion of the swan's body length to the span of its wings?
Would the wing span / body length average to Phi?

↑ A picture of pure harmony…
(www.animalsgallery.com)



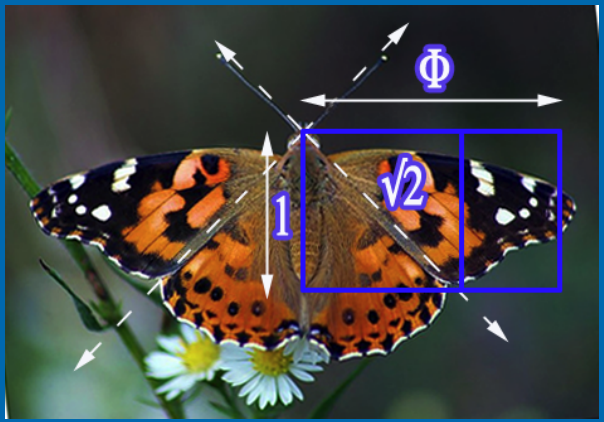
↑ (Image credit)

(Image credit) →

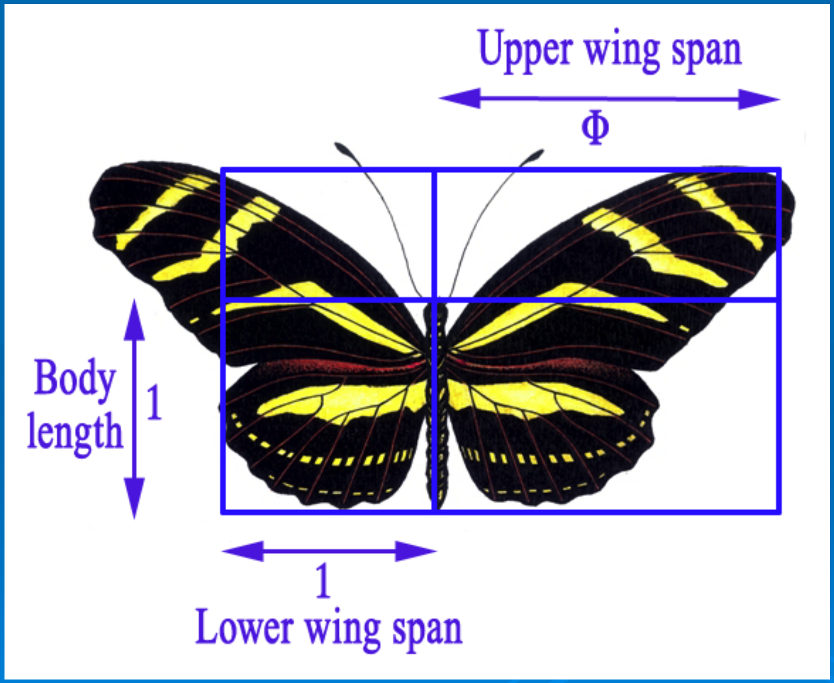
SG205B.7.9.1 Butterflies (1) Phi Harmonics

There are an estimated 17,500 species of butterflies in the world. Much research is to be done in terms of the proportions of their body shapes. But butterflies provide simple elements to measure: body length, span of lower wing, span of upper wing, ratio of overall height and width, and proportions thereof. Based on a few case studies with the PhiMatrix™, we made the following observations (limited to the few examples we looked at):

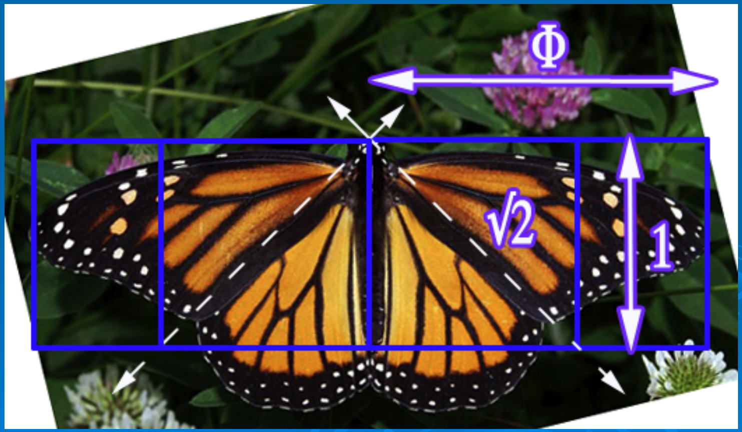
1. In some species, the body length is close to the span of the shorter (lower) wing.
2. In some species, the body length is close to be in Golden ratio to the span of the longer (upper) wing .
3. When 1 applies, it follows that the lower wing span is close to be in Golden ratio to the upper wing span.



↑ "Painted lady" butterfly.
Body length ~ span lower wing.
Body length / span upper wing ~ Phi
Lower wing / upper wing ~ Phi.
Note the √ 2 lines of the wings junction and the antennas.



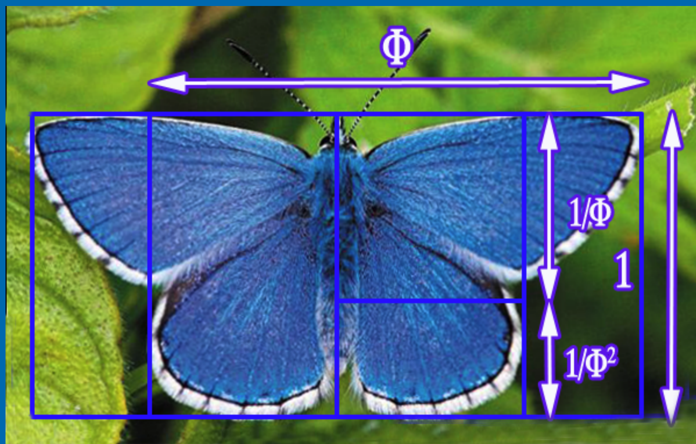
↑ *Heliconius charitonius* butterly.
Body length = lower wing span - Body length / span upper wing ~ Phi.
Lower wing / upper wing ~ Phi.



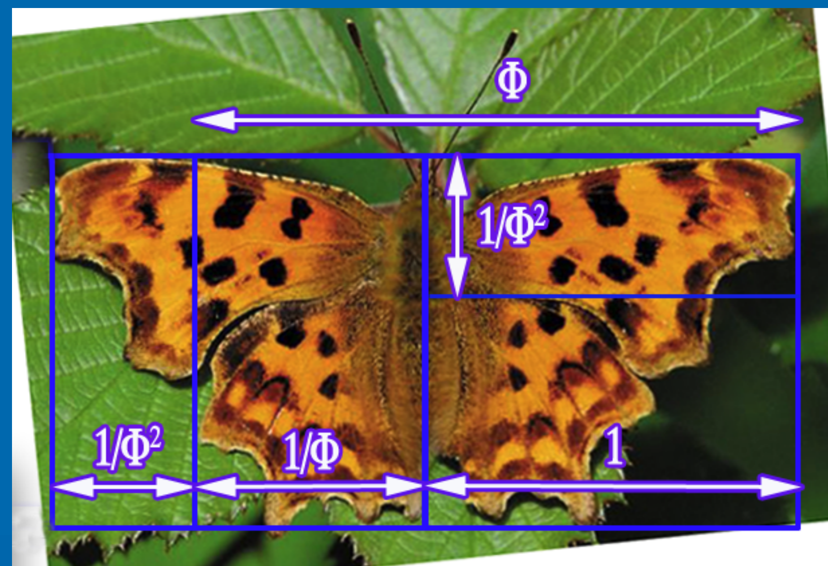
↑ Monarch butterfly.
Body length ~ span lower wing.
Body length / span upper wing = Phi
Lower wing / upper wing ~ Phi.

SG205B.7.9.2 Butterflies (2)
Golden Rectangles

The Golden rectangle by itself (and its sub-multiples) provide a good matching pattern for the overall height / length measurements of butterflies.



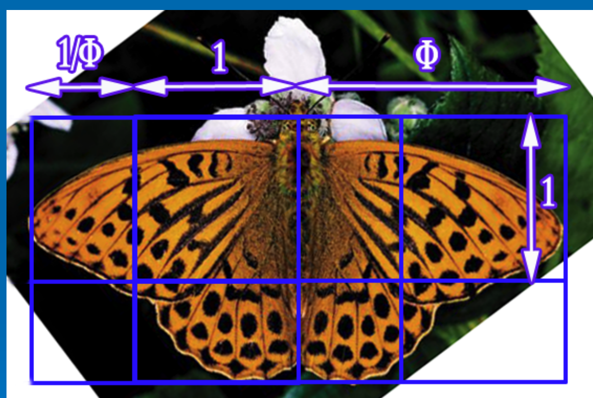
🡐 Adonis Butterfly
(*Lysendra bellargus*)



🡑 Comma Butterfly
(*Polygonia c-album*)

Silver Washed Fritillary 🡒 (*Argynnis paphia*).

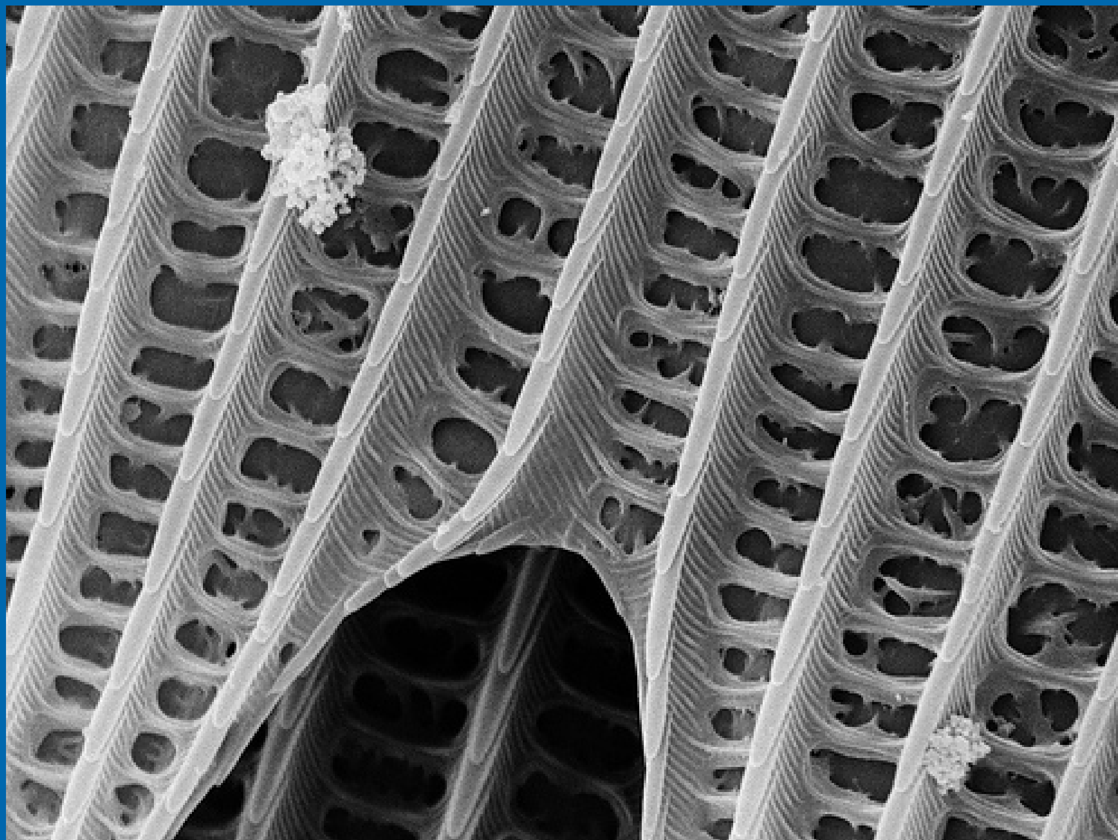
(With protruding head included).

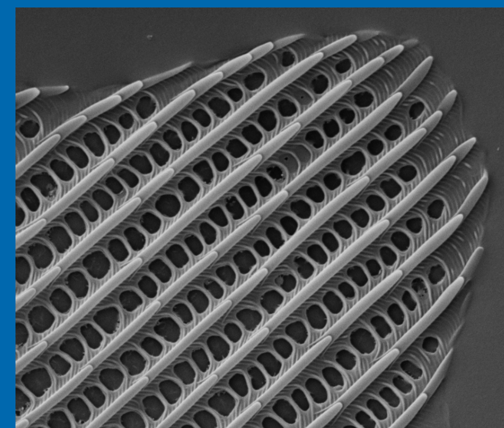


Butterflies, like all of nature, offer endless variations on the principle we have already encountered: fractal coherence, oftentimes Phi-based. Every living being, such as our friendly butterflies, is a *harmonic system* in fractal resonance with larger & smaller harmonic systems. Every living being is an integral part of the interconnected web of life, itself an overall template of harmonic balance.

The question is no longer: is there (Phi-based) fractal harmony? We find it everywhere, obvious or hidden. The question now is: what is the exact, unique, music-like harmonic system that each living being in nature has achieved in order to partake of the universal orchestra? And, how can we become fluent in this vibratory, common language in order to celebrate, with all plants & animals, the Beauty of Life as Unity in Diversity? Sacred Geometry is an invitation to merrily enter the Dance of universal Harmony, rather than deny it or attempt to control it.

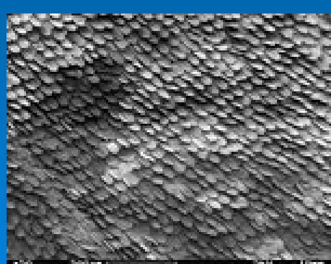
SG205B.7.9.3 Butterflies (3) Wing Architectures





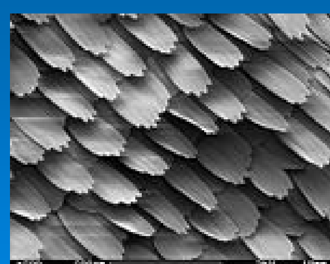
↑ SEM of isolated scale x 18,010. Hummingbird Hawk-moth (*Macroglossum stellatarum*), Lepidoptera. www.flickr.com (Seelensack photostream)

← Same. Magnification x 19,580.



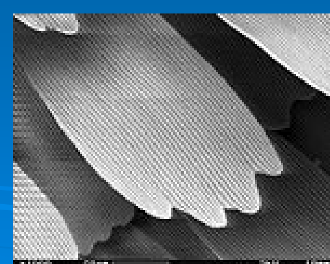
A patch of wing

→



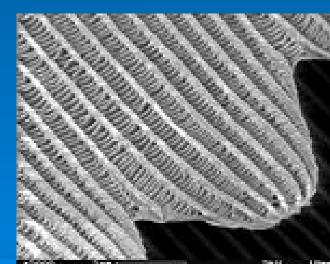
Zoom on scales

→



A single scale

→

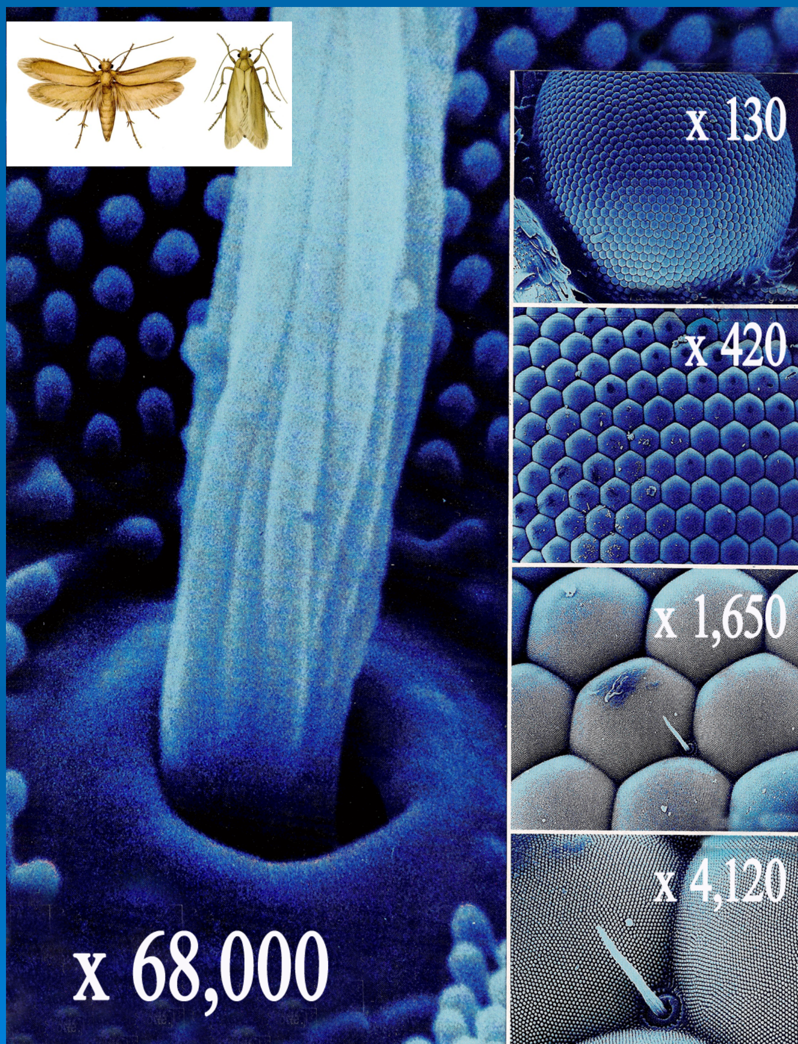


Micro structure of scale

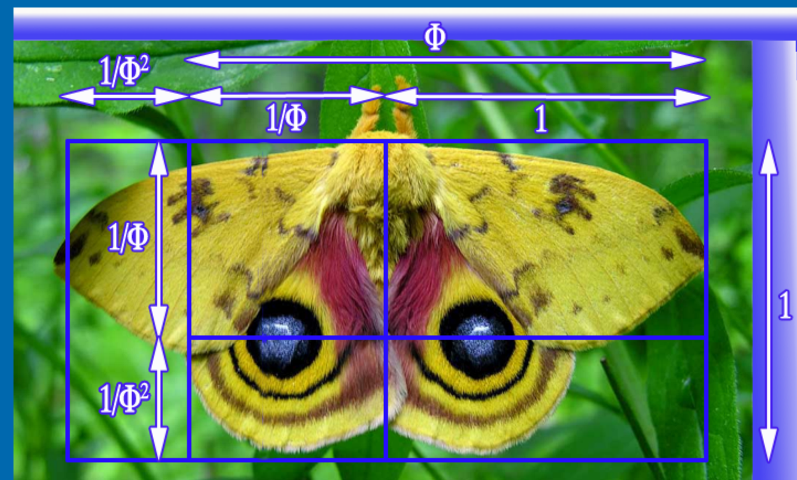
(Wikipedia)

SG205B.7.10 Moths

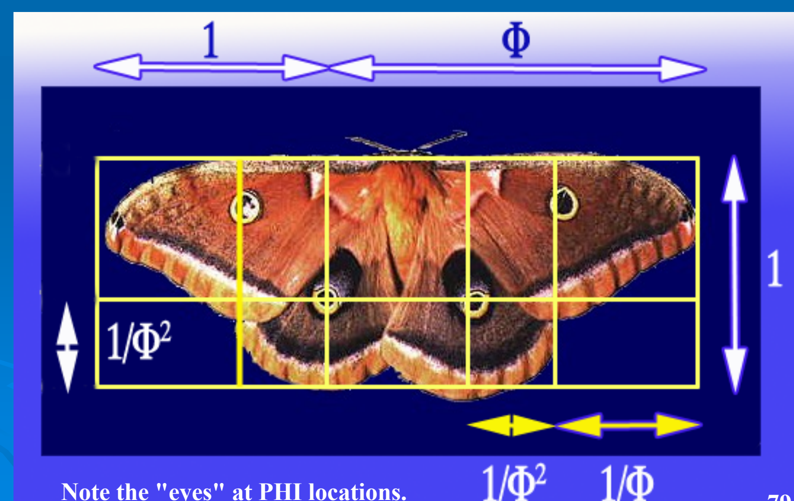
Moths are insects closely related to the butterflies, both being of the order Lepidoptera. Moths form the majority of this order. Biologists estimate that there are 150,000 to 250,000 different species of moth (about ten times the number of species of butterfly), with thousands of species yet to be described.



↑ A sensory antenna (at 68,000 magnification) in the eye of a common moth (*Tineola bissiliella*)



↑ Phi cascades in the Flared eye moth. Image: //students.cis.uab.edu



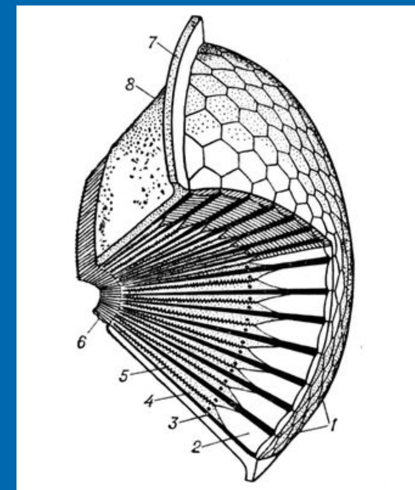
Note the "eyes" at PHI locations.

SG205B.7.11 Insect Compound Eyes

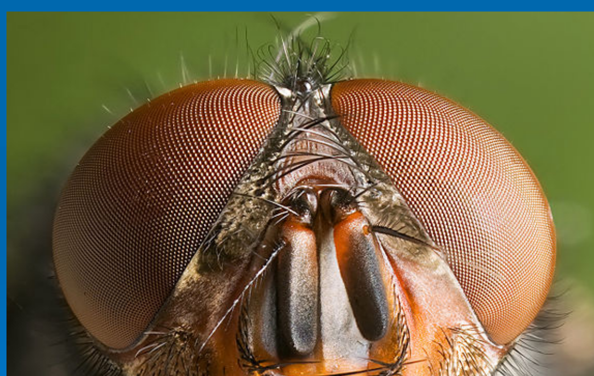
Compared to the eye of the vertebrates (a lens-bearing eye), the eye of the *arthropods* (insects, crustaceans…) is built quite differently: it is a *compound eye*. The moth's eye (in the preceding page) is a compound eye. Compound eyes are composed of many simple facets which, depending on the details of anatomy, may give either a single pixelated image or multiple images, per eye. Each sensor has its own lens and photosensitive cell(s). Some eyes have up to 28,000 such sensors and can give a full 360º field of vision. [*For comparison, the main dish of the world's largest radio telescope, in Arecibo, is composed of 38,778 individual panels.*]

A compound eye may consist of thousands of individual photoreceptor "eye units" or *ommatidia* (plural of *ommatidium*). The image perceived is a combination of inputs from the numerous ommatidia, which are located on a convex surface, thus pointing in slightly different directions. Compared with simple eyes, compound eyes possess a very large view angle, and can detect fast movement and, in some cases, the polarization of light. There is a mathematically precise spherical geometry to the array of ommatidia. This geometry can be defined as *geodesic* (the shortest path between two points in a curved space) and also optimally space-filling. Basically it is an hexagonal matrix quite similar to the structural arrangement of the geodesic domes.

Nanotechnology researchers are now developing "fly eye nanostructures" using a low-temperature atomic layer deposition technique. [◆SG208. "Bio-Mimicry Technology"]

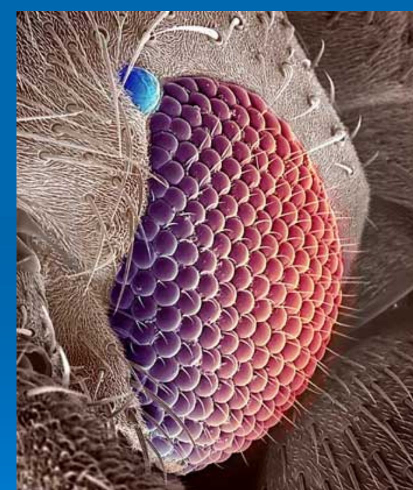


↑ Anatomy of a compound eye. Wikipedia.



↑ Eye of a house fly. Wikipedia.

↑ Buckminster Fuller with his "Fly Eye" dome.



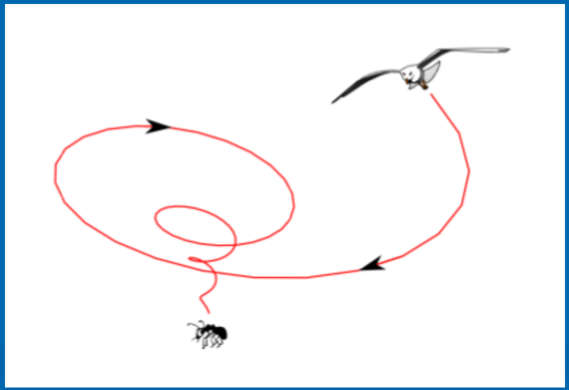
↑ Mosquito's eye. (www.nanowerk.com)

ECO-HARMONY:
When we realize the complex elegance of a house fly's eye, it becomes hard to just swat it: each and every creature in nature is absolutely unique and deserves to be perceived and treated with an attitude of harmonic balance.

SG205B.7.12.1 Spirals Flight Paths
(1) Falcon

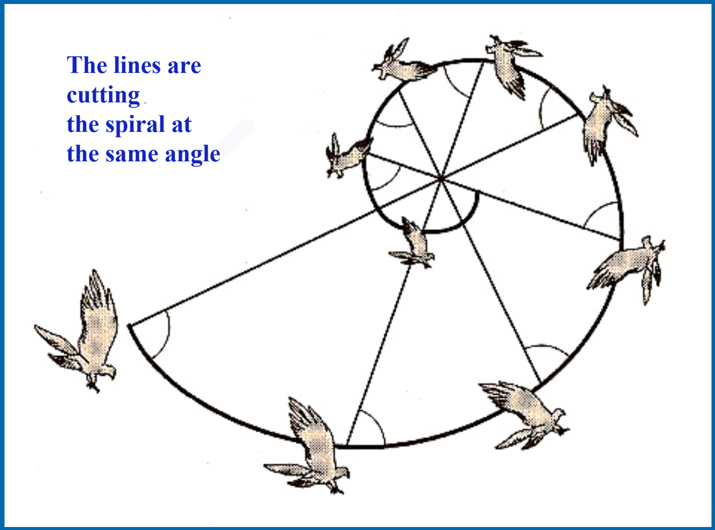
The logarithmic spiral is also called "equiangular" because if this property: if one draws a straight line from the center of the spiral to any point on the curve, it will cut the curve at exactly the same angle. Peregrine falcons take advantage of this property when descending on their prey.

In the November 2000 issue of the Journal of Experimental Biology, Vance A. Tucker shows that falcons (who have eyes on either side of their head) use a log spiral flight in order to keep their head straight (thus avoiding to cock it - which would slow them down) while maximizing their speed.



🡅 Spiral trajectory of a falcon flying down on a prey.
www.duke.edu

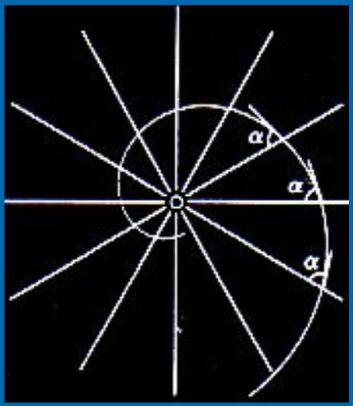
Peregrine falcon ➔
www.stoneflync.com



🡅 The spiral flight of falcons.
(Image. Mario Livio. *The Golden Ratio*. 2002)
Adult falcons have thin tapered wings, which enable them to fly at high speed and to change direction rapidly.

🡅 Peregrine Falcons have been recorded diving at speeds of 200 miles per hour (320 km/h), making them the fastest-moving creatures on Earth.

SG205B.7.12.2 Spiral Flight Paths (2) Insects



↑ Spiral flight path of an insect as it draws towards a radial light source.

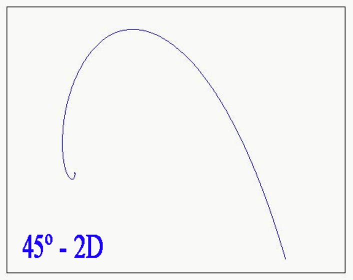
(//online.redwoods.cc.ca.us)

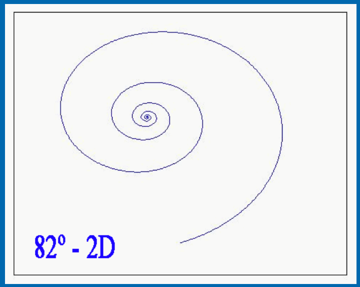
"A singular instance of the logarithmic spiral is given by the route which certain insects follow towards a candle. Owing to the structure of their compound eyes, these insects do not look straight ahead but make for a light which they see abeam, at a certain angle. As they continually adjust their path to this constant angle, a spiral pathway brings them to their destination at last".

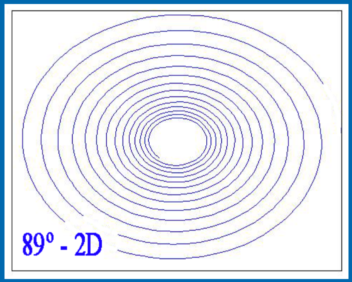
(D'Arcy W. Thompson. *On Growth and Form*. 1917).

An insect's compound eyes give it an ideal photographic positioning mechanism. A compound eye is formed of many *ommatidia*, which are single detectors of light. Light beams from a single source stimulate a small group of ommatidia determining the insect's angular position towards a radial source of light, while keeping a constant angle a with the radial light beam and the tangent vector formed at each position on the trajectory.

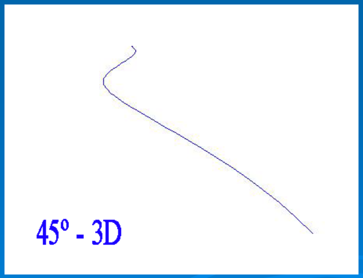
Insects use this positioning to adjust their path during flight. A radial light source at close distance causes the flight of the insect to spiral towards the light source, while keeping a constant angle a with the radial light beam and the tangent vector. The research questions here are: what is the angle that creates a golden spiral flight path? Would that correlate with observational data?

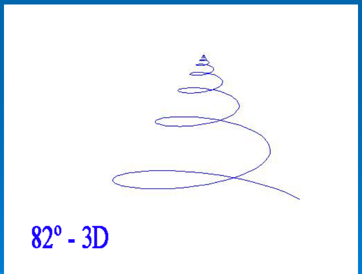


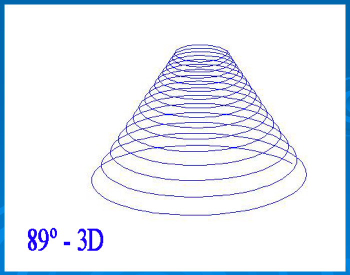




↑ The 3 above diagrams show the flight path in 2D, with various angles.







↑ Flight paths in 3D with the same angles.
(Diagrams above: //online.redwoods.cc.ca.us)

SG205B Interlude 4a. Insect Eggs (1)

Insect eggs are about the size of a grain of raw sugar. The eggs in these images range in diameter from 0.7 to 2 millimeters. The micro-photographs were made with a scanning electron microscope, which uses beams of electrons to trace the surfaces of objects. The resulting black-and-white images were then colored to reflect the eggs' natural appearance by Martin Oeggerli.

"Insects evolved hardened eggs and with them a special appendage, an ovipositor, which some use to sink their eggs into the tissue of Earth. Lift a stone and you will find them. Split a piece of wood, and they are there, but not only there. Birds struggle to find good places to nest, yet insects evolved the ability to make anything (wood, leaves, dirt, water), even bodies (especially bodies) a nursery. If there is a single feature that has ensured insects' diversity and success, it is the fact that they can abandon their young nearly everywhere and yet have them survive because of those eggs. They began simply, smooth and round, but over 300 million years, insect eggs have become as varied as the places where insects reign. Some eggs resemble dirt; others resemble plants. When you find them, you might not know what you are seeing at first. The forms are unusual and embellished with ornaments and apparatuses. Some eggs breathe through long tubes that they extend up through water. Others dangle from silky stalks. Still others drift in the wind or ride on the backs of flies. They are as colorful as stones, shaded in turquoises, slates, and ambers. Spines are common, as are spots, helices, and stripes. More than biology, their designs suggest the work of an artist left to obsess among tiny forms. They are natural selection's trillion masterpieces; inside each is an animal waiting for some cue to break free." **(Martin Oeggerli)**

See Martin Oeggerli's interview video on the National Geographic website

"From childhood on, I was very curious about everything. I grew up close to a forest… I like to be astonished by new things."

Julia heliconian **butterfly egg (Dryas iulia)**

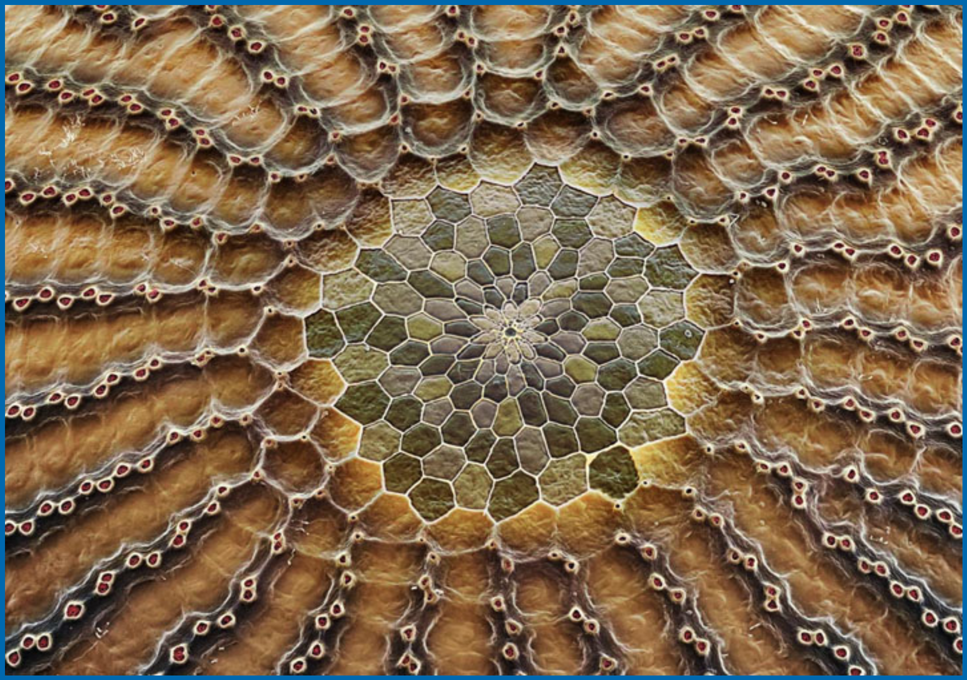
Perched on the tendril of a Passiflora plant, the egg of the Julia heliconian butterfly may be safe from hungry ants. This species lays its eggs almost exclusively on this plant's twisted vines. (M. Oeggerli).

← A "village" of butterfly eggs on a raspberry plant.

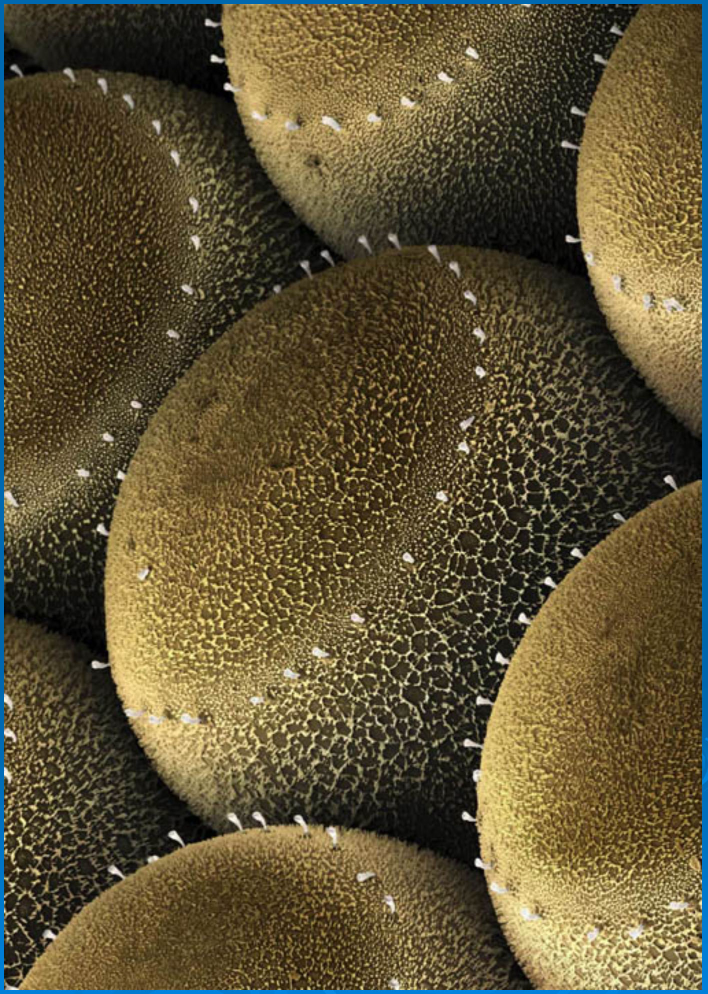
These eggs have already hatched.

www.telegraph.co.uk

SG205B Interlude 4b. Insect Eggs (2)



🡅 Owl butterfly egg (*Caligo memnon*)
The mosaic pattern on an owl butterfly egg looks like a landing pad.
At the center is a minute opening, called a *micropyle*,
through which the sperm enters the egg.



Stinkbug eggs (Pentatomidae) ➔
Stinkbugs often lay their eggs in clumps.
Individual eggs are glued not only to each other
but also to the leaf on which they are left.
The delicate projections may aid, like snorkels, in respiration.

Images: Martin Oeggerli. National Geographic

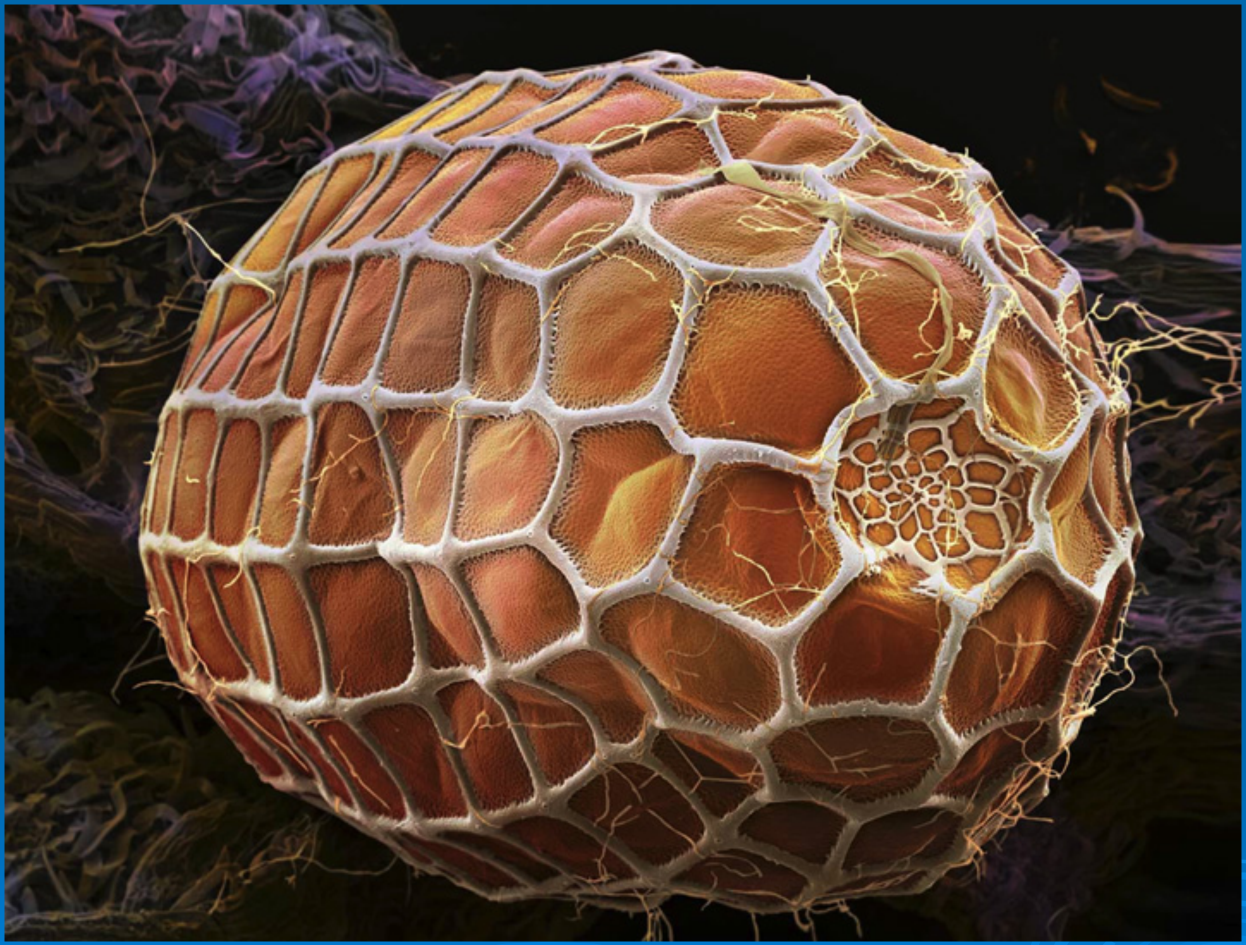
SG205B Interlude 4c. Insect Eggs (3)

🡅 **Adonis blue butterfly egg (*Lysandra bellargus*)**
The Adonis blue butterfly is rare because iti s choosy. It lays its eggs (like the one above) only on horseshoe vetch, a European perennial. What's more, it looks for patches cropped by rabbits that allow easy landing.

Martin Oeggerli. National Geographic

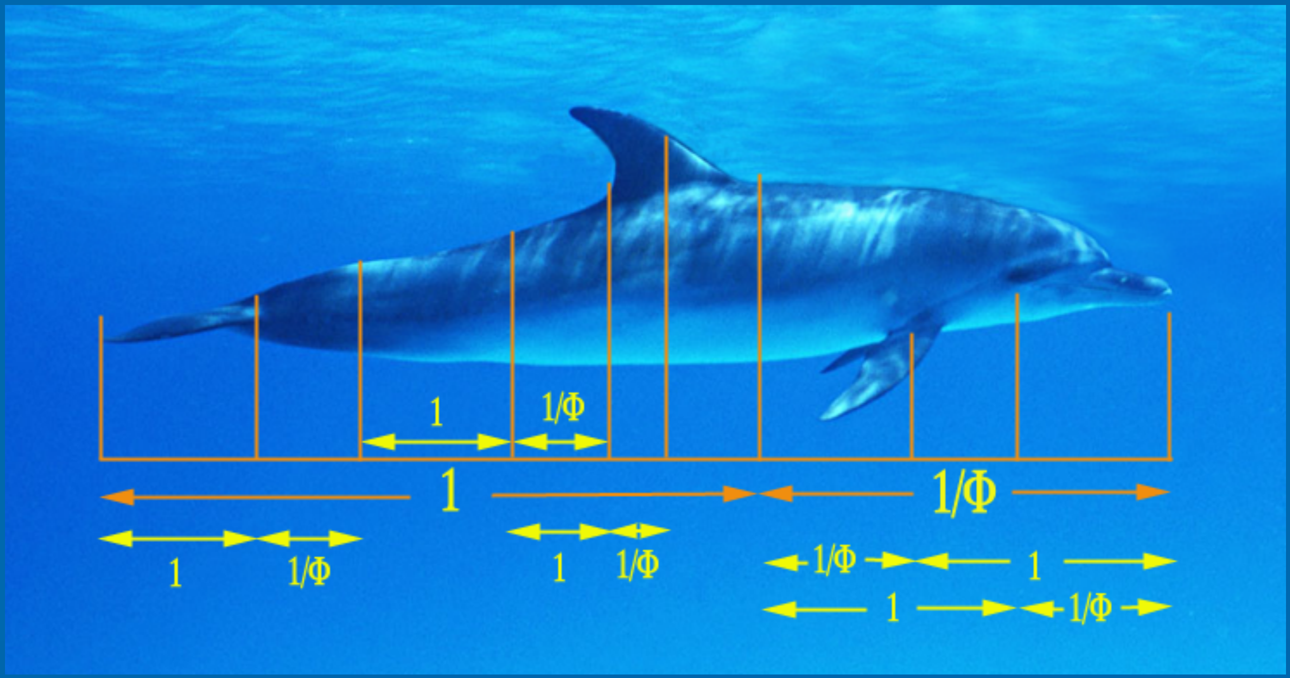
🡅 **Adonis blue butterfly egg (*Lysandra bellargus*)**
Zooming on the egg's strutures.

SG205B Interlude 4d. Insect Eggs (4)



Zebra longwing butterfly egg (*Heliconius charithonia*)
The orange hue of this zebra longwing butterfly egg may warn predators: "Eat me if you dare." The threat would not be idle. The egg contains cyanide and other toxins ingested by adults from the plants they eat.
Martin Oeggerli. National Geographic

SG205B Chapter 8. Geometries in Water Animals



Beings of the water element have shapes & bodies adapted to an optimum motion in a fluid medium with more resistance than the air. They swim (the equivalent of flying and walking) through the waters by their own fin motion and also by dancing with the direction, temperature & pressure of the water currents. They know how to minimize individual effort by taking advantage of the sustaining power of their medium.

The "aerodynamics" of fish forms is a fine-tuned result of harmonic immersion and reciprocal offering: the fish gives to the ocean just like the ocean gives to the fish. All balance requires a union of (musical) harmonies.

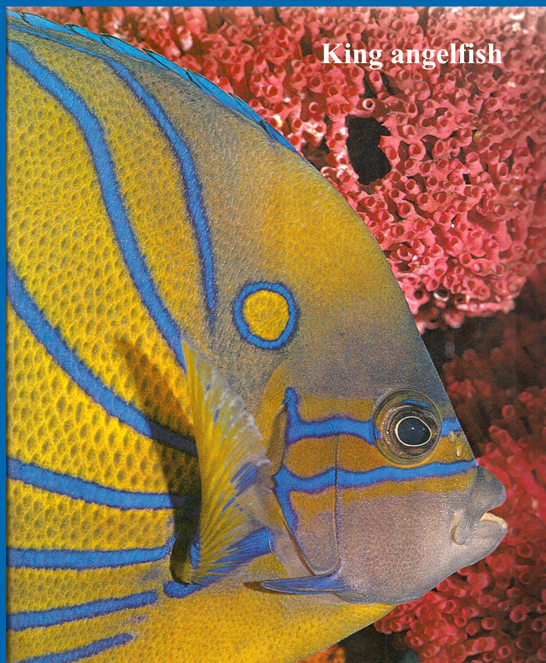
Like other aspects of nature, water animals display Phi-based proportions, with all the intricate sub-harmonics of the powers & reciprocals of Phi.

SG205B.8.1 The Swimming Ones

"The fish and the ocean" are an age-old metaphor to signify the relationship between individual and universal consciousness. "The fish does not fight the ocean: it just swims in it".

Just like the fish is sustained by the watery ocean, human beings are immersed in the larger, energy ocean of the web of life, and the even larger ocean of consciousness and universal harmony.

The swimming ones teach us how to embrace & trust the ocean of life. Swim in Beauty!



King angelfish

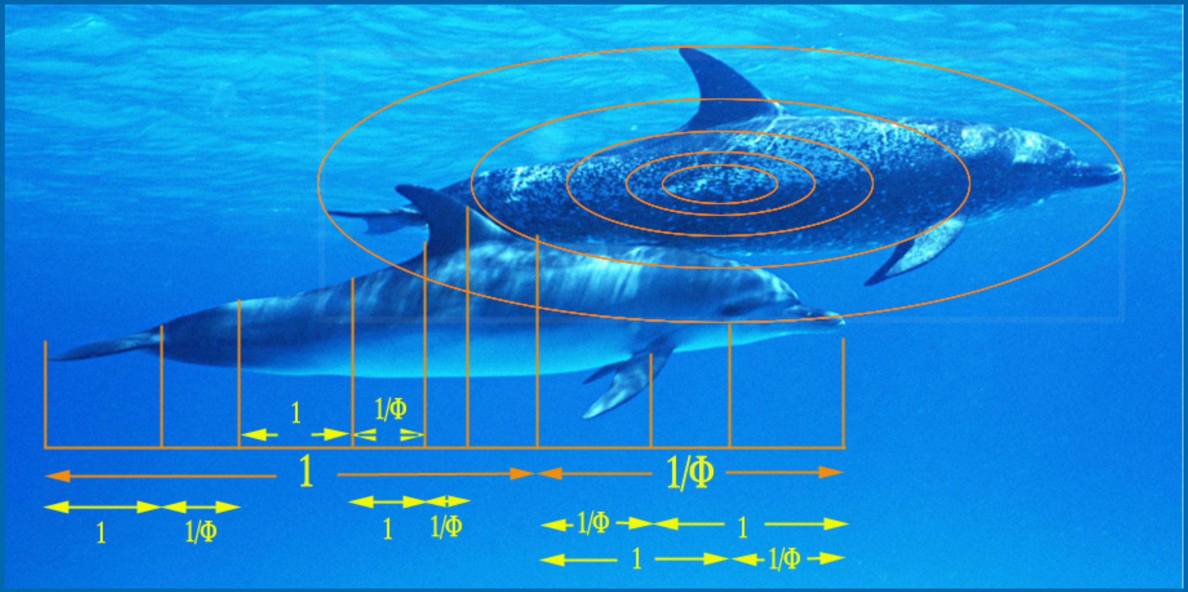
🡐 King blue-faced angelfish

(Image credit)

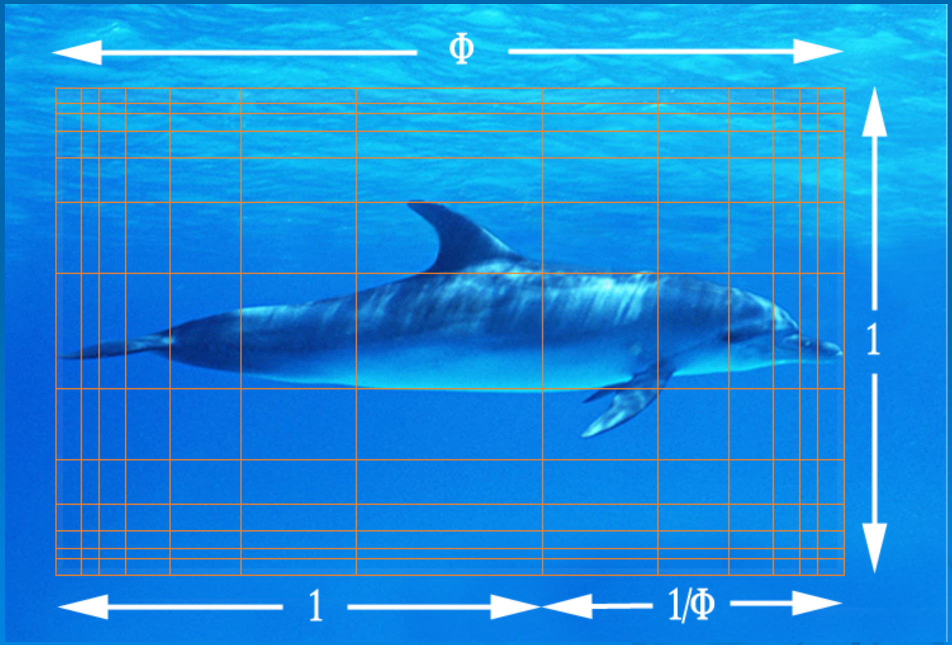
🡑 Queen angelfish

🡑 Various friendly faces

SG205B.8.2.1 Dolphins (1) Phi Rectangle Grid



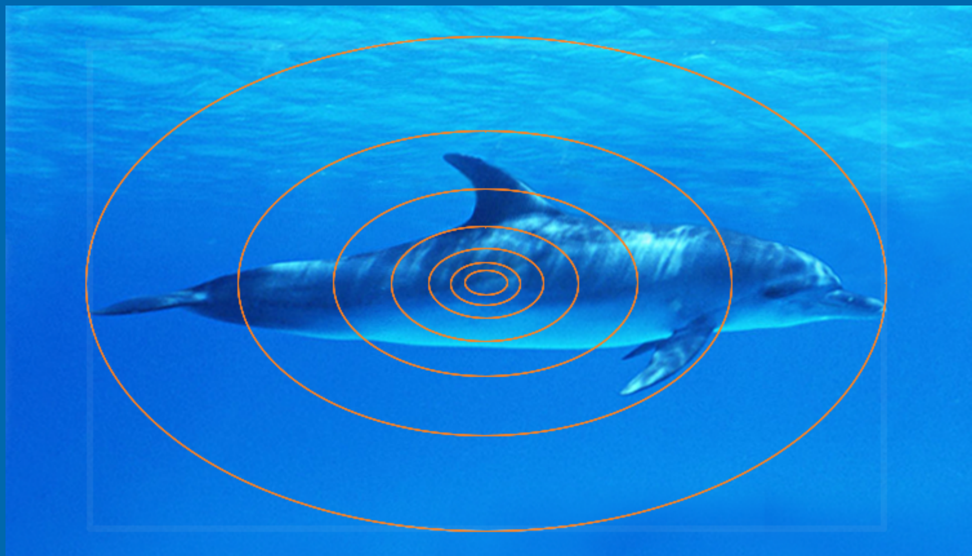
↑ StarWheel #109. Detail.
"Li-La-Nai"

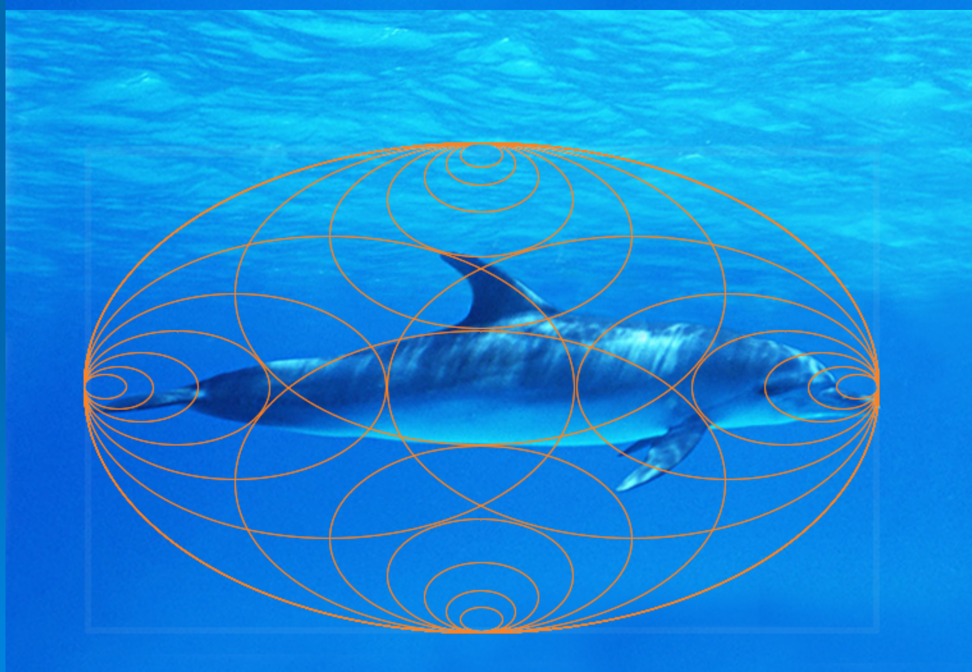


Phi grid images

Top:
The light skin dolphin was measured (on the enlarged image) for the two Phi proportions Unit 1 and 1/Φ = .618).
The spotted dolphin was assessed with PhiMatrix™, using a flattened Phi circle.

Left:
The light skin dolphin was isolated and straightened to a horizontal line.
PhiMatrix™ was used in a Phi ratio rectangle mode with horizontal axis set on Top & Bottom, and vertical axis set on Left & Right.





SG205B.8.2.2 Dolphins (2) Phi Ellipse Grid

A Golden Ellipse is precisely inscribed within a Golden Rectangle of long side = Phi and short side = unit 1 [◆SG105.6].

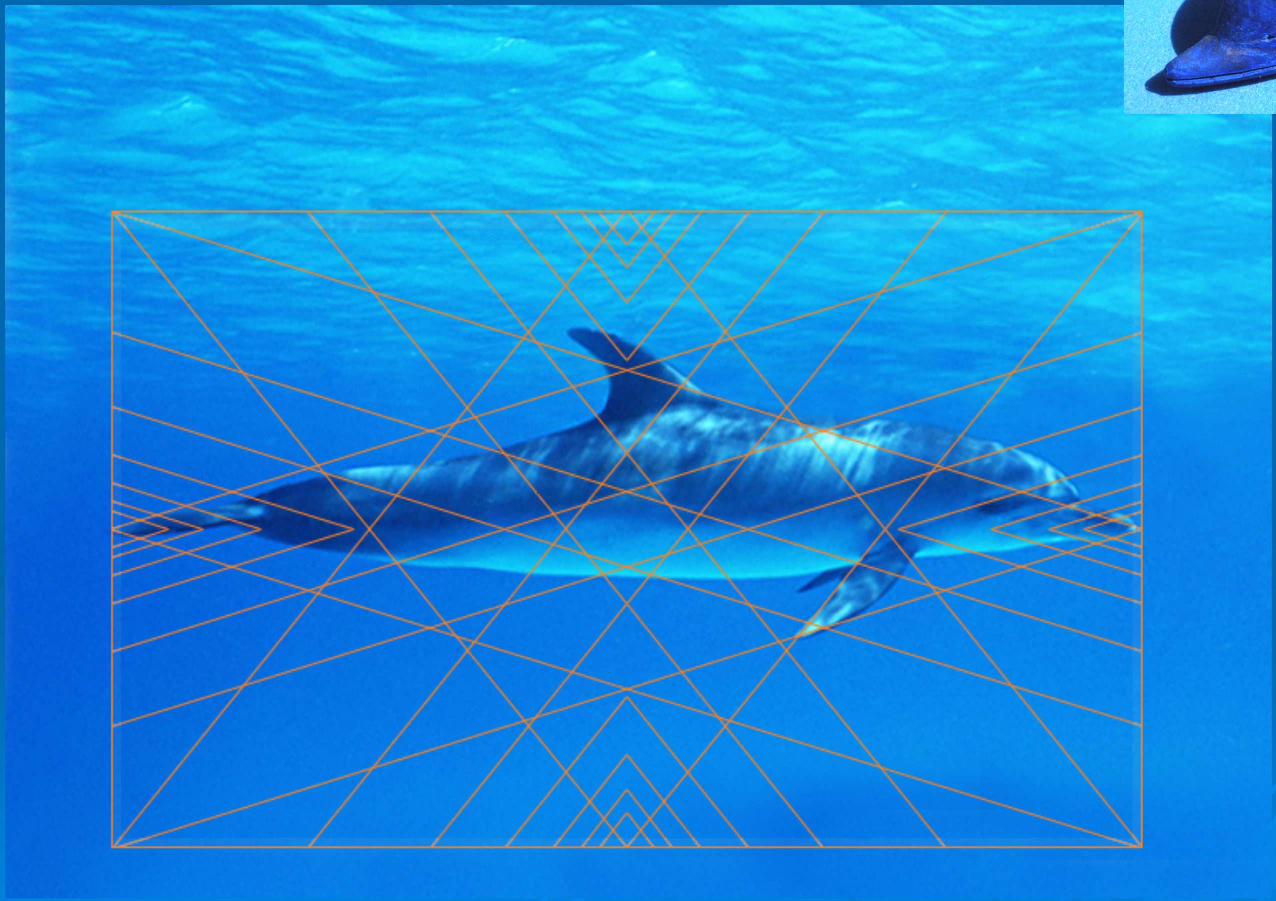
An ellipse (or oval) is an organic shape defining the energy field around a living being. Nested Phi ellipses point to centers of gravity or balance and harmonic structural layers.

Nested mirrored Phi ellipses give a sense of animation to the dynamics of harmonic structures in the physical body or energy field.

Top Left
PhiMatrix™ grid in oval mode.
Aspect = 1 : Phi
Line ratio = Phi.
Horizontal axis: center
Vertical axis: center

Bottom Left
PhiMatrix™ grid in oval mode.
Aspect = 1 : Phi
Line ratio = Phi.
Horizontal axis: top & bottom
Vertical axis: left & right.

SG205B.8.2.3 Dolphins (3) Phi Triangle Grid



🡡 Dolphin carved
in Bali.
Colored by Aya.

🡠 Using PhiMatrix™ in the Triangle mode offers another view of the Phi harmonics inherent in and around the dolphin shape.

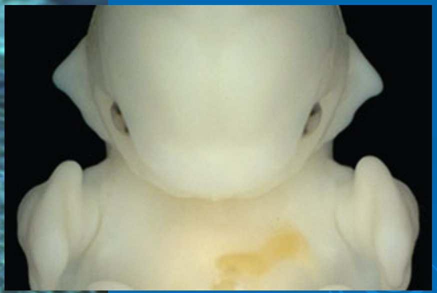
Shape = (inside) triangle.
Aspect = 1 : Phi.
Line ratio = Phi.
Horizontal axis = top & bottom
Vertical axis = left & right.

www.snazaroo.com

SG205B.8.2.4 Dolphins (4) Face

Suggestion: the dolphin's head would make an interesting research study in terms of geometric/harmonic proportions.

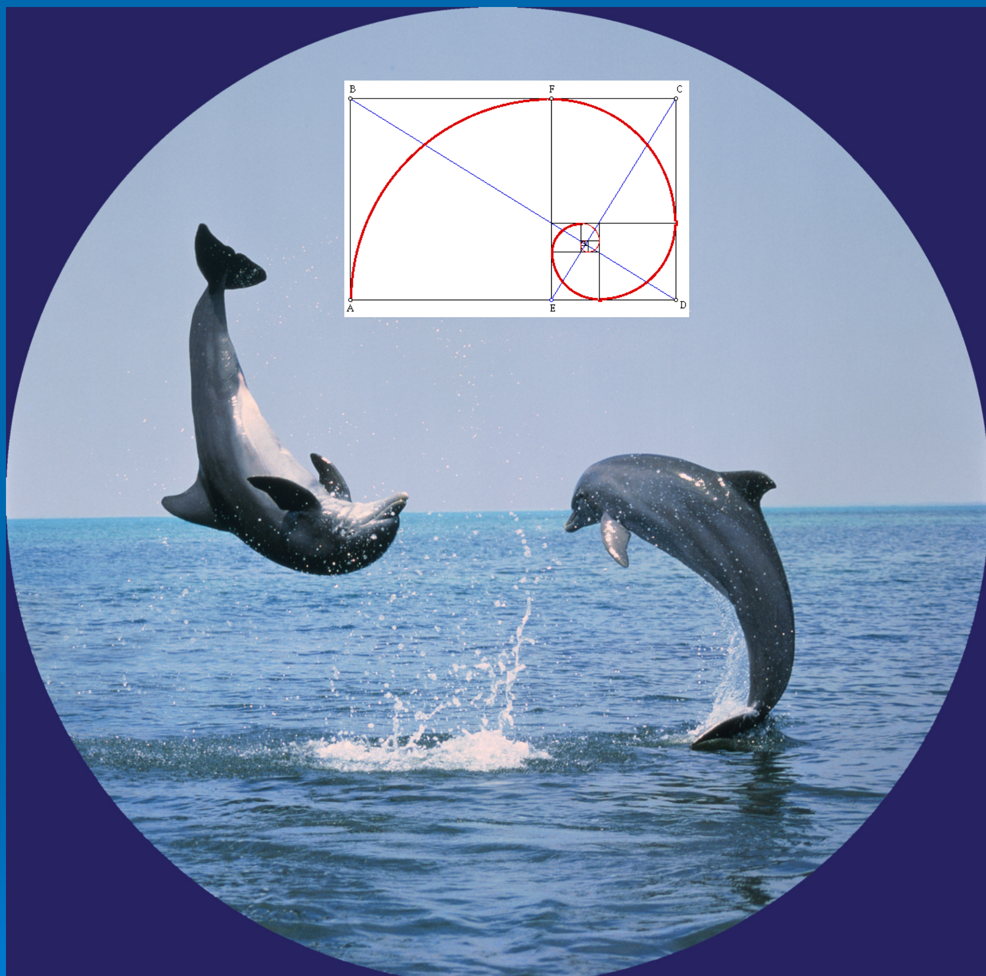
The whole head of a dolphin is a sound chamber. The shape + location of the *melon* and the *echolocation* apparatus should make harmonic sense, in terms of the geometry of frequency resonance.



Face of human embryo. Note how the eyes are spaced far apart. www.pbs.org

Even though this image is not full front, one can sense some remarkable spherical harmonics present in the smiling face of the dolphin, just by applying a PhiMatrix™ Phi circle grid. www.fleckensteins.com

SG205B.8.2.5 Dolphins (5) Dances



↑ Facebook image
Painting by Bruce Harman
www.harmanvisions.com

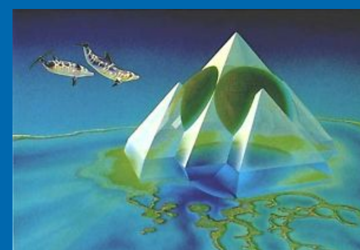
↑ 5-6 weeks embryos.
Left: dolphin. Wikipedia.
Right: human.
The tail folds in a spiral shape.

SG205B.8.2.6 Dolphins (6)
Jean-Luc Bozzoli

www.//jeanlucbozzoli.com

↑ "Starseed Child"

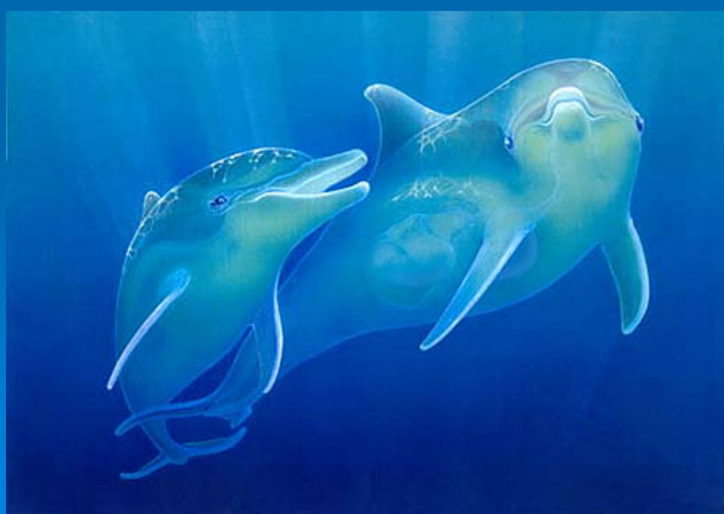
↑ J. L. Bozzoli



A French artist living in the Pacific Islands for the past 40 years, Jean-Luc Bozzoli has spent thousands of hours immersed in the holographic undersea world of wild dolphins and whales, sharing the visions, wisdom teachings and harmonic geometries awakened within him through his art.

His latest dvd *"Transmuteo"* is an immersion movie in the 3D animated universe of his starry & oceanic visions through multi-dimensional organic geometries.

"The wisdom of geometry within us (bones, tissues and atomic structure) is a stunning design. Its purpose is like a golden thread that weaves one reality to another, one world to another and one dimension to the next. We exist by our divine nature in more than one reality, we are multi-dimensional."
(J. L. Bozzoli)



← "Second Coming"

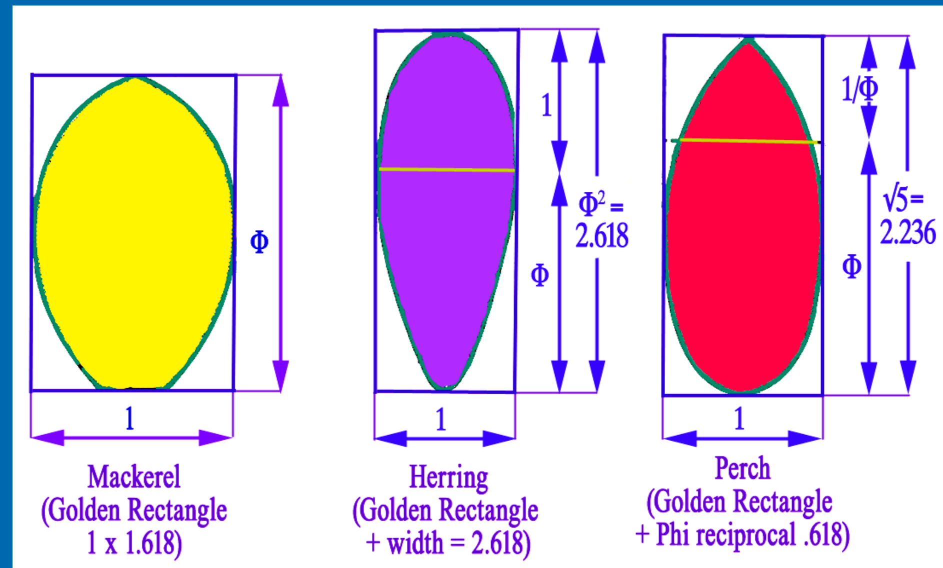
↑ "Galaxy Play"

SG205B.8.3.1 Swimming Phi (1)

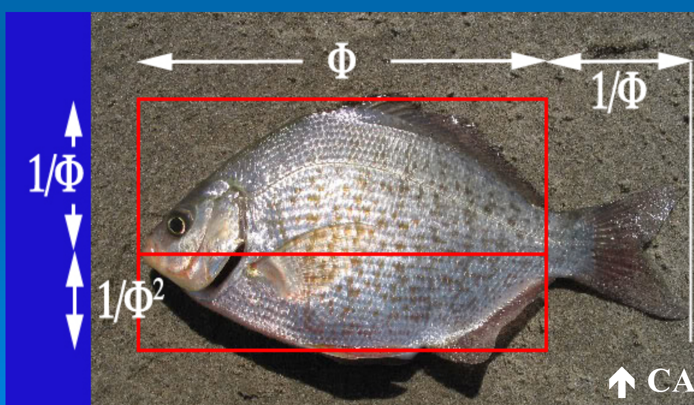
Based on his drawings & studies of a variety of fish, G. Doczi showed that they share both the proportions of the golden section and of the 3-4-5 triangle. (*The Power of Limits*. 1981)

Doczi observed that oftentimes the PHI proportions are a combination of multiples & reciprocals. In addition, *"in many instances, the mouth is at the golden section point of the body's height."*

We applied the PhiMatrix™ golden rectangle grid to several images of the same variety of fish (such as the Calico below), and found that the proportions are not necessarily exact but FLUCTUATE around the ideal Phi ratio - just like in a group of people, individual measurements of ratios will vary above & below Phi, but the AVERAGE in a sufficiently large group comes to Phi. (Remember how the Fibonacci series fluctuates above & below Phi in the ratio of small numbers and then settles closer to Phi in the ratios of larger numbers. ◆SG104)
It is the same in all of nature: some individuals carry the exact archetype of harmony and others approach it from above or below.

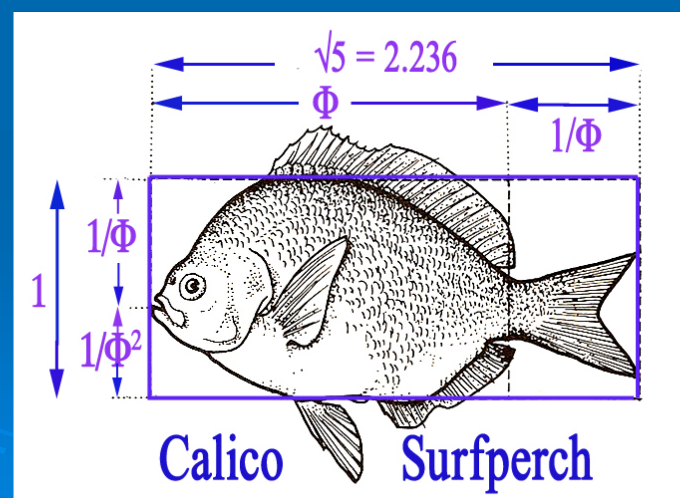


↑ Examples of ideal/archetypal PHI proportions in fish. (After Doczi).



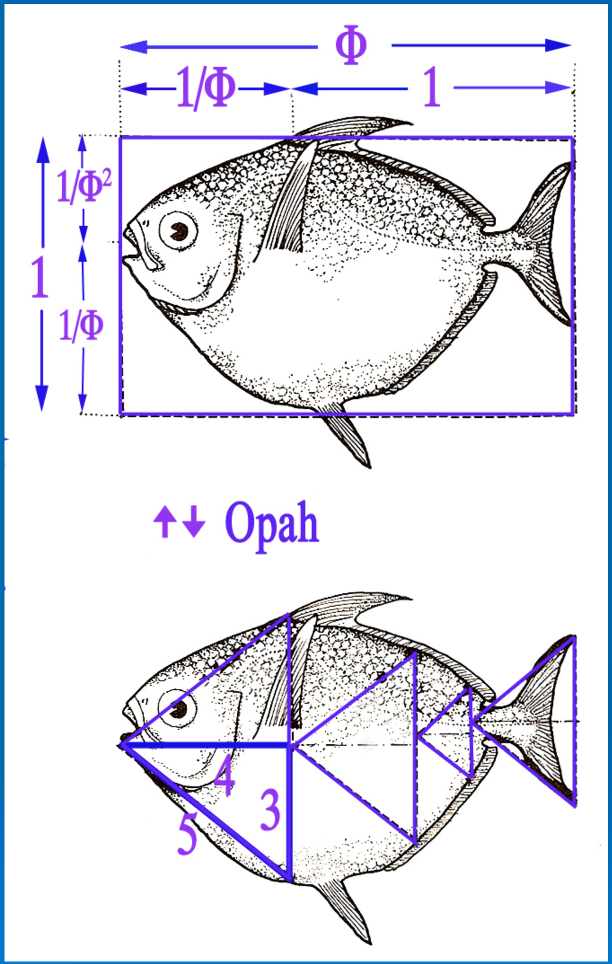
↑ CALICO →

↑ Image credit



↑ Original diagram by Doczi

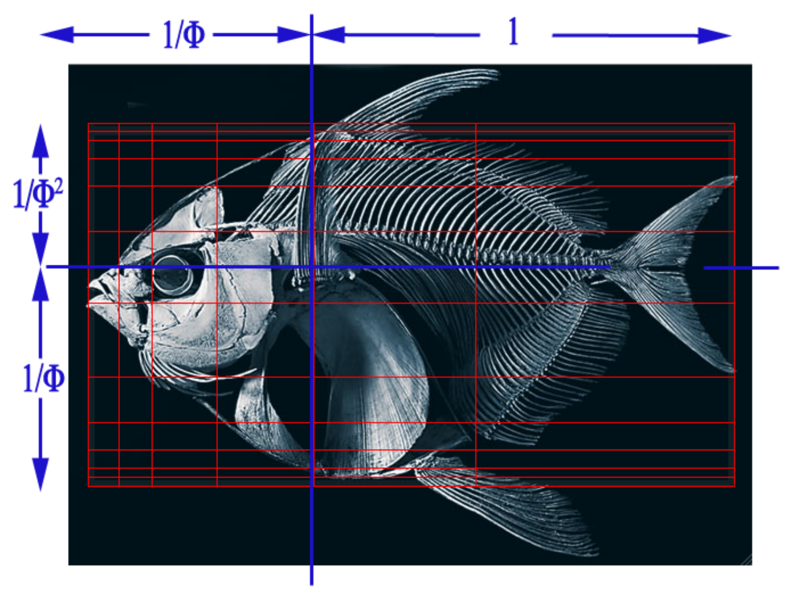
SG205B.8.3.2 Swimming Phi (2)

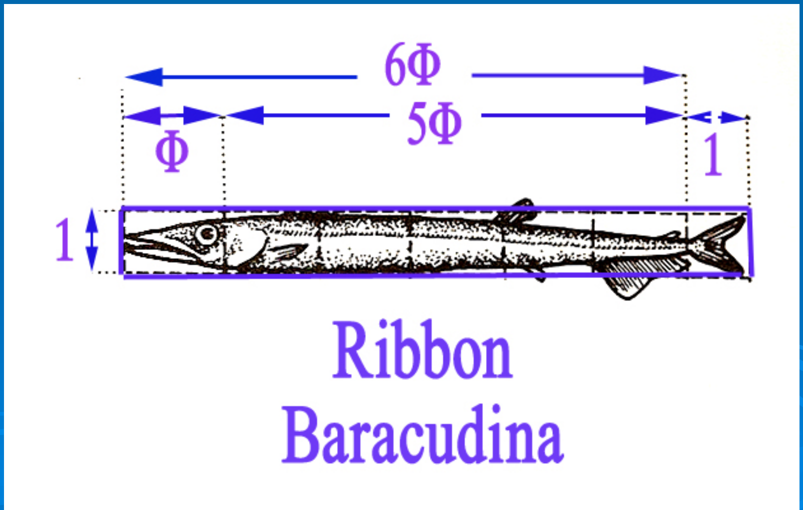


Study by Doczi.

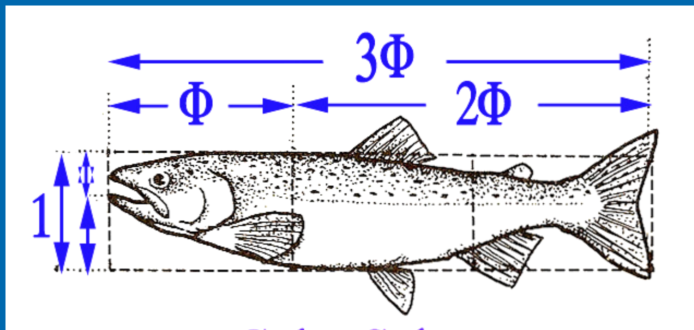
OPAH

Opah skeleton
dailymail.co.uk





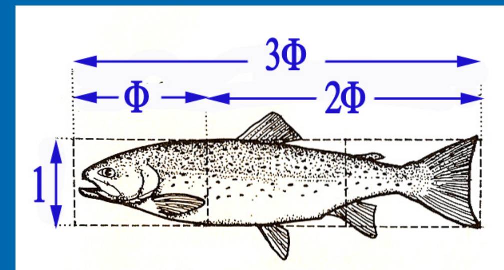
Study by Doczi



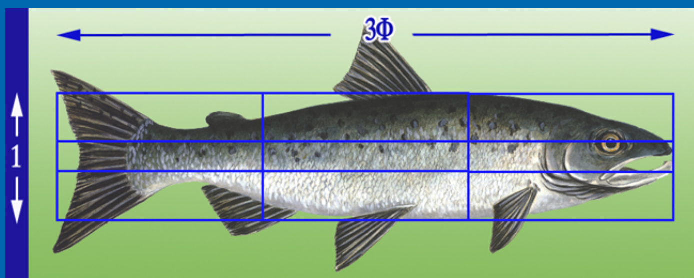
Silver Salmon ↑ ↓ (After Doczi)

SG205B.8.3.3 Swimming Phi (3)

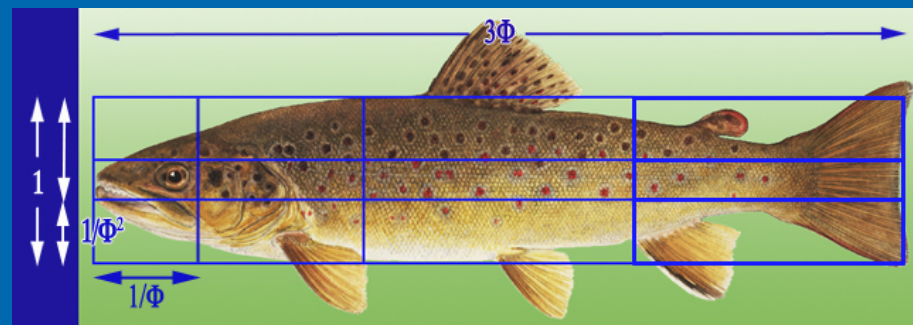
A common proportion in fish (large & small) is a length of 3 Golden rectangles.

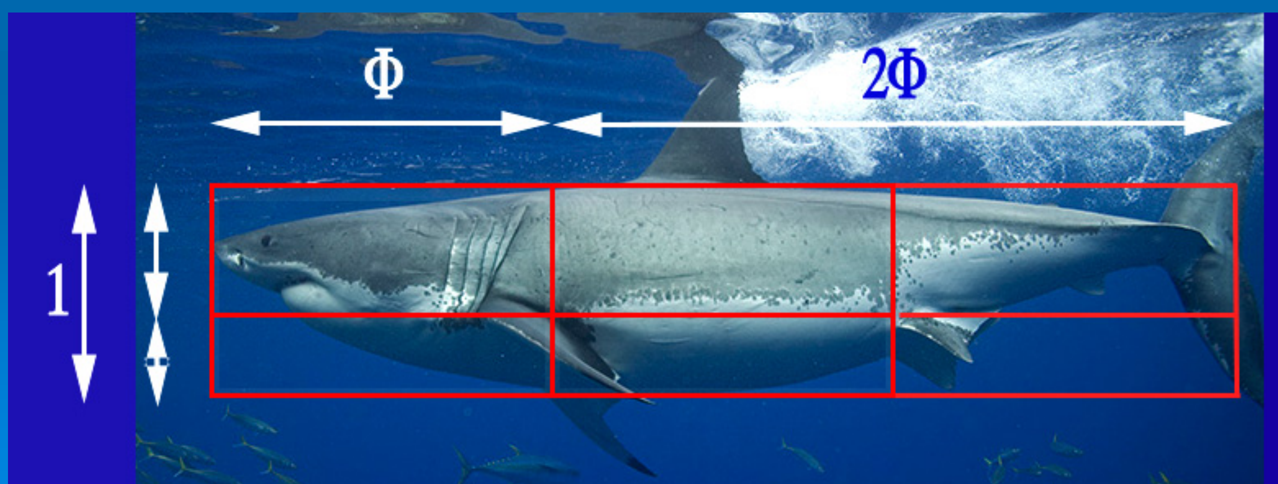


Brown Trout ↑ ↓ (After Doczi)



↑ Image credit



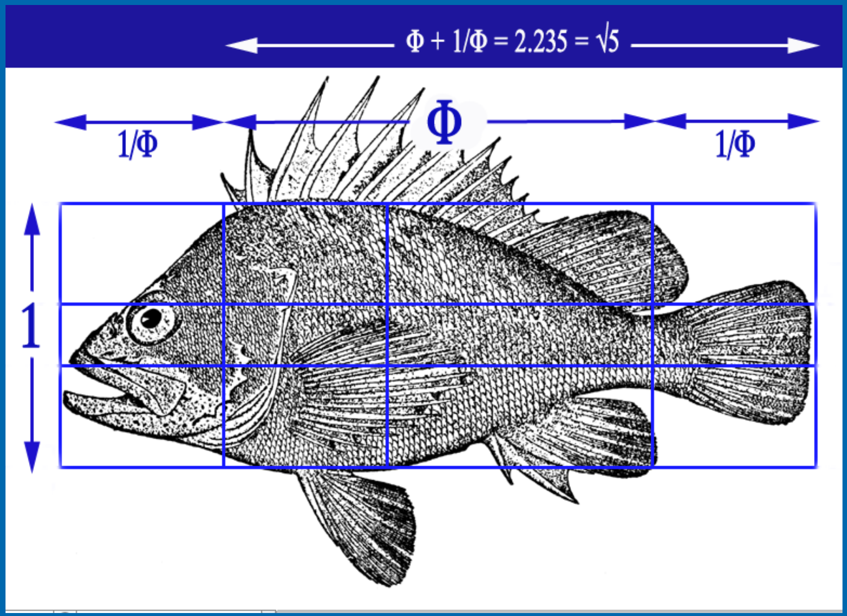


← White shark.

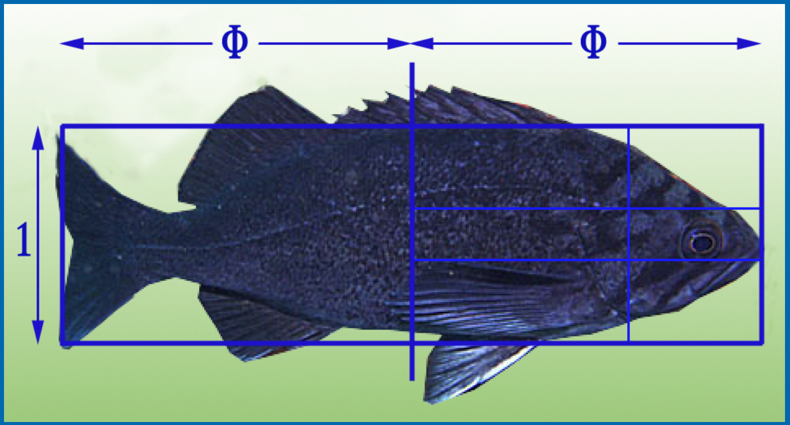
Image credit.

SG205B.8.3.4 Swimming PHI (4)

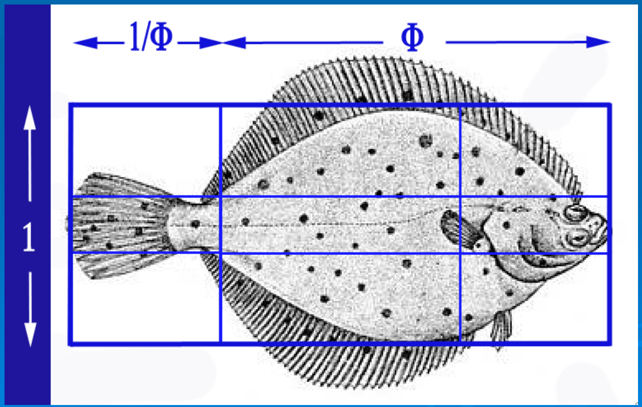
Other common Golden proportions in fish include:
2 x Φ (Blue & Black rockfish),
Φ + 1/Φ (Curlfin sole),
and Φ + 2 (1/Φ) (Quillback rockfish).



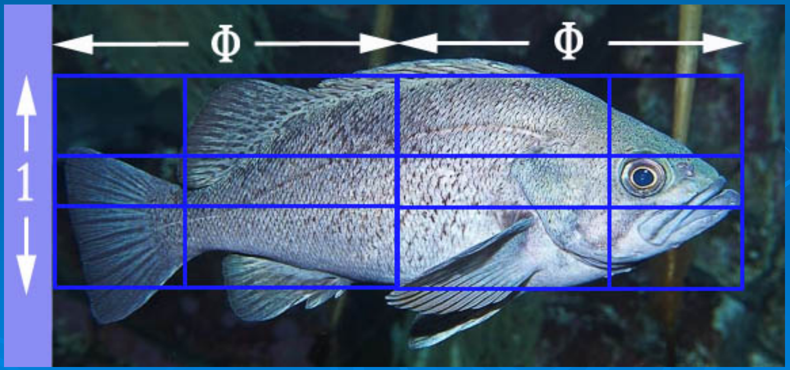
↑ The Quillback rockfish fits (with a little discrepancy for the tail in this sample) the proportion: Φ + 2 (1/Φ). [//etc.usf.edu/clipart]



↑ The Blue Rockfish shows a proportion of 2Φ. [Image credit].



↑ The Curlfin sole fits a Φ + 1/Φ template. [Image credit]



↑ The Black rockfish also has a 2Φ proportion.
Image credit

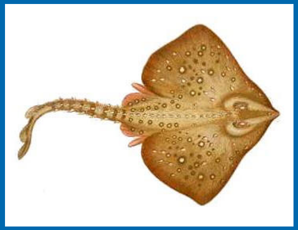
SG205B.8.4.1 Skates (1)

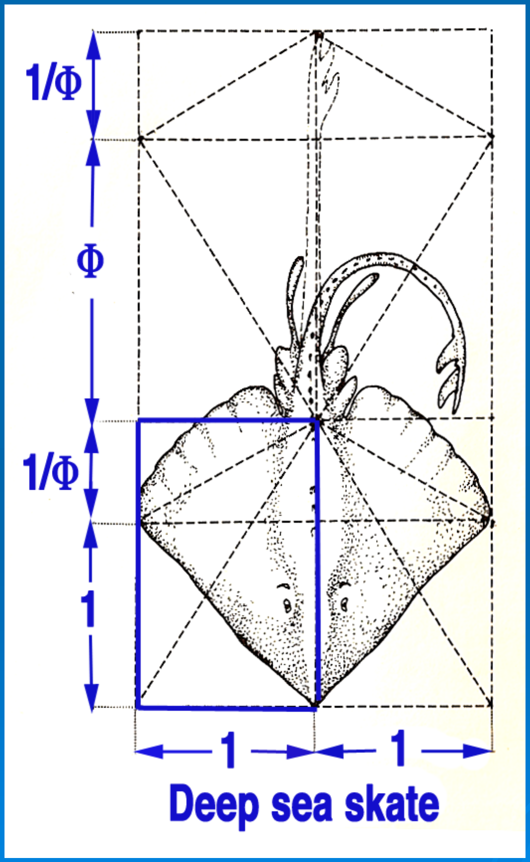
Skates are easy to study, from a geometric point of view: their shapes are simple and almost two-dimensional. They have a quiet majesty.

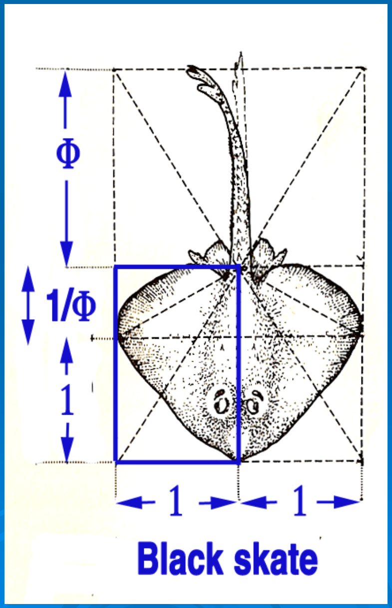
G. Doczy found two re-occurring features:

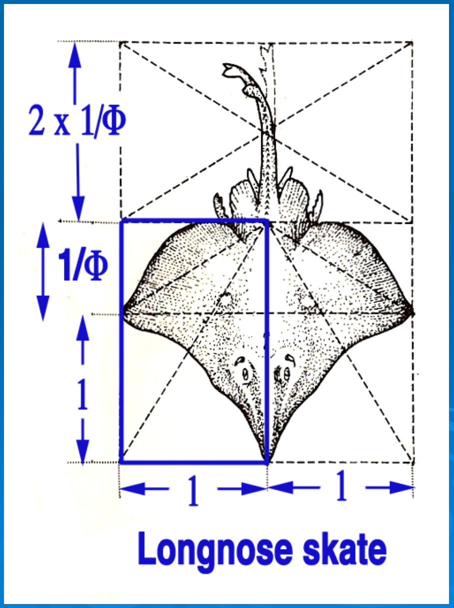
• In many skates, the main body is encompassed by two golden rectangles.
• The greatest width of the body oftentimes tallies with the golden section point of the height.

planetanimalzone.blogspot.com

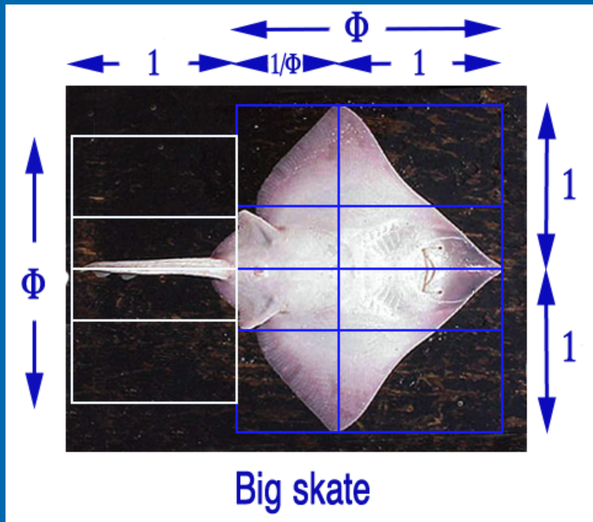








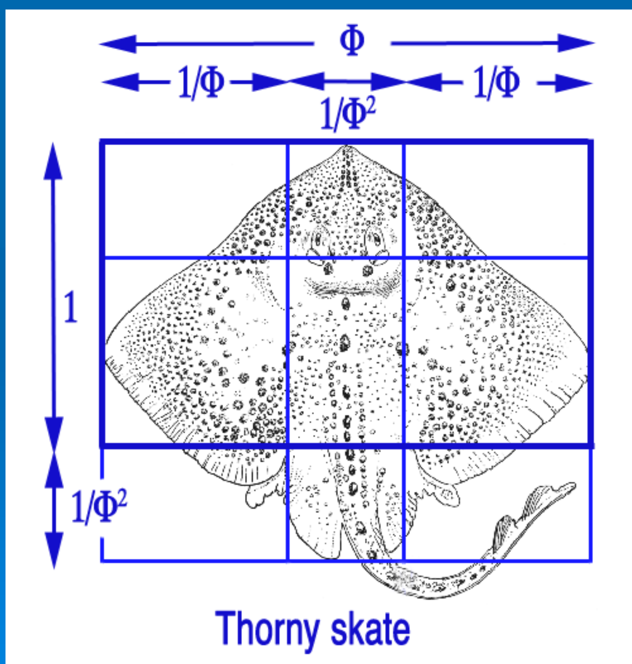
SG205B.8.4.2 Skates (2)



↑ Big skate. Dorsal view.

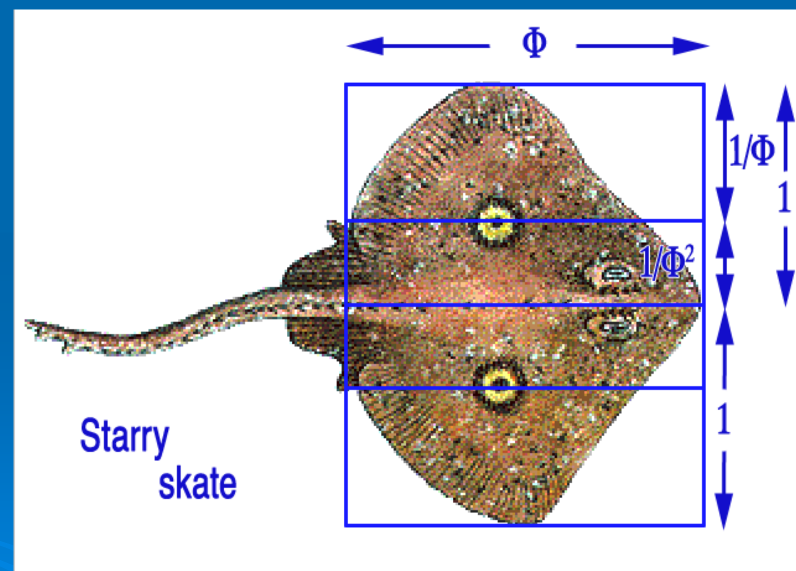
← Ventral view of Big skate (*Rajida binoculata*). www.flmnh.ufl.edu

↑ The Big skate dentition has a distinct phyllotactic pattern, similar to sunflower seedheads. www.flmnh.ufl.edu



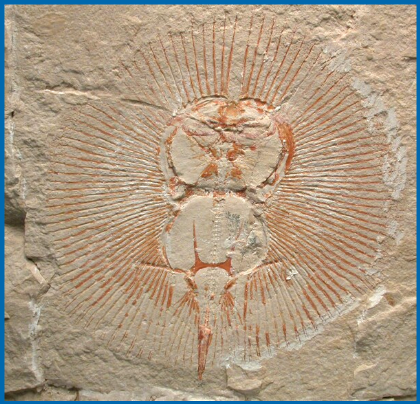
← *Raja radiata* skate.

Image: //www.gma.org (Drawing by Garman. 1913)



↑ *Raja stellulata*. Image: oregonlive.com

SG205B.8.4.3 Skates (3)



← This *Cyclobatis* skate fish fossil
was found in Lebanon.

The picture appears slightly skewed and less than accurate for height measurements.
But the radial symmetry is quite remarkable.

The *Cyclobatis* skate fossils go back to the middle cretaceous age (95 million years). The *Cyclobatidae* became extinct during the Cretaceous, but are thought to be distant relatives of modern-day skates (family *Rajidae*).

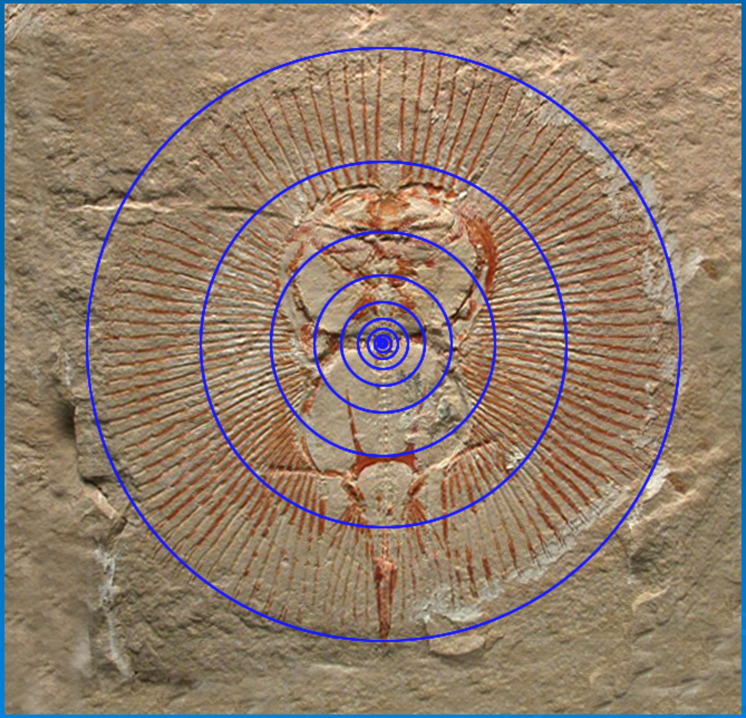
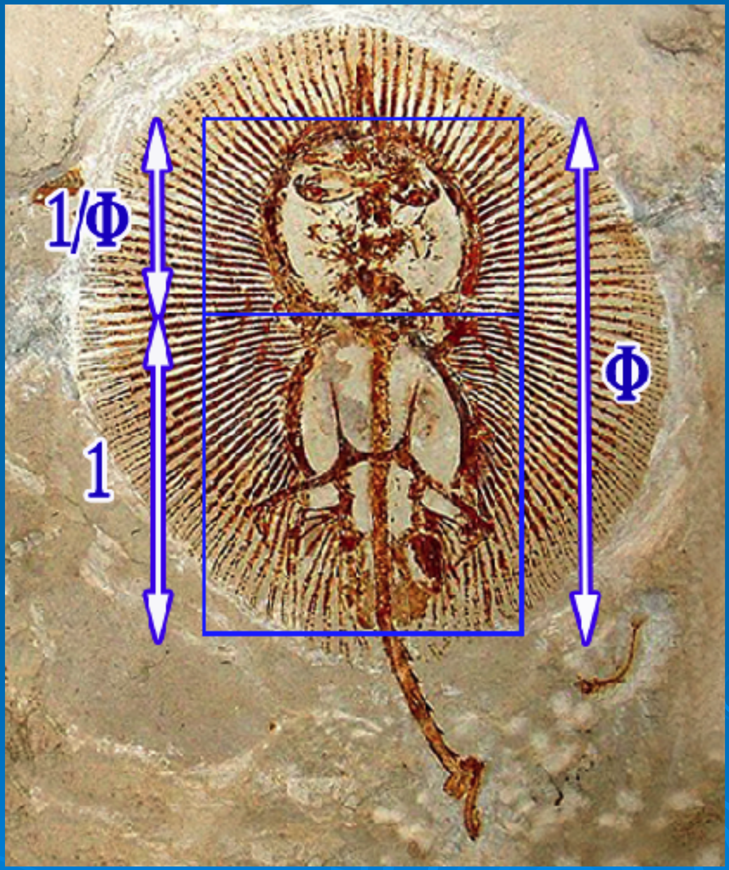


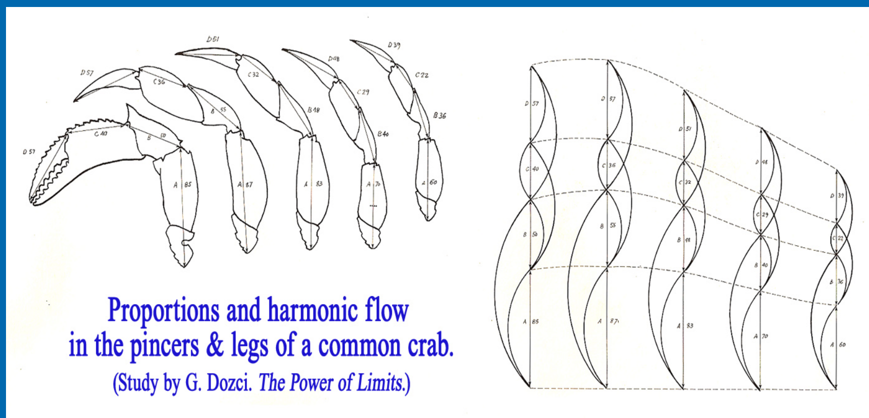
Image: www.fossilmall.com



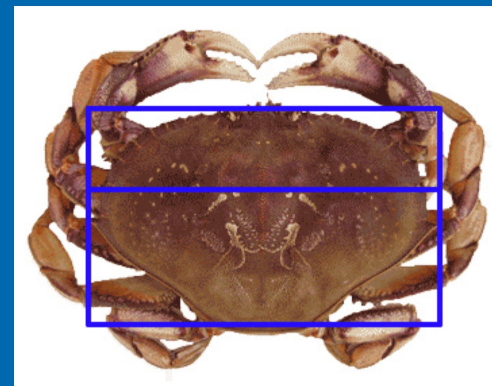
↑ *Cyclobatis* skate fossil. (Wikipedia file)
Museum of Natural History. Milano, Italy.
Isn't this *Cyclobatis* looking like a radiant meditating Buddha?

SG205B.8.5 Lobsters & Crabs

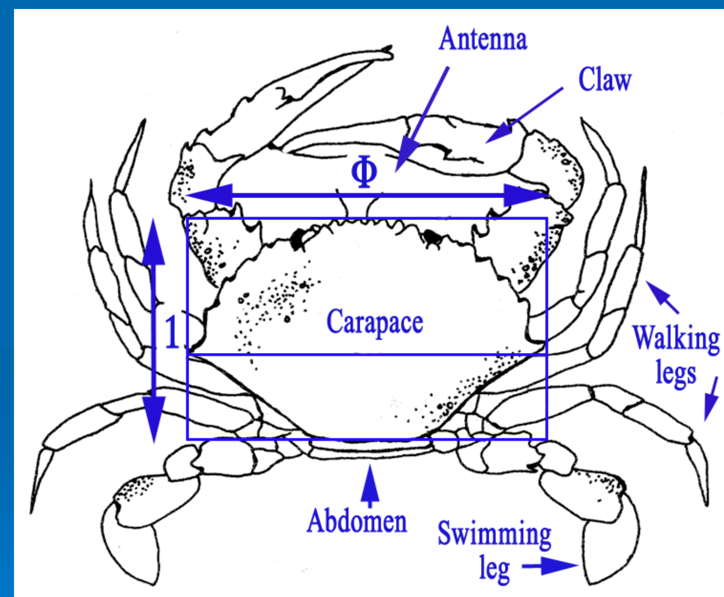
Does someone wants to do a comprehensive study of harmonic relationships shared by all neighboring parts of the anatomy, among the 50,000 described species of crustaceans? Below is a study by G.Doczi on the crab's legs.



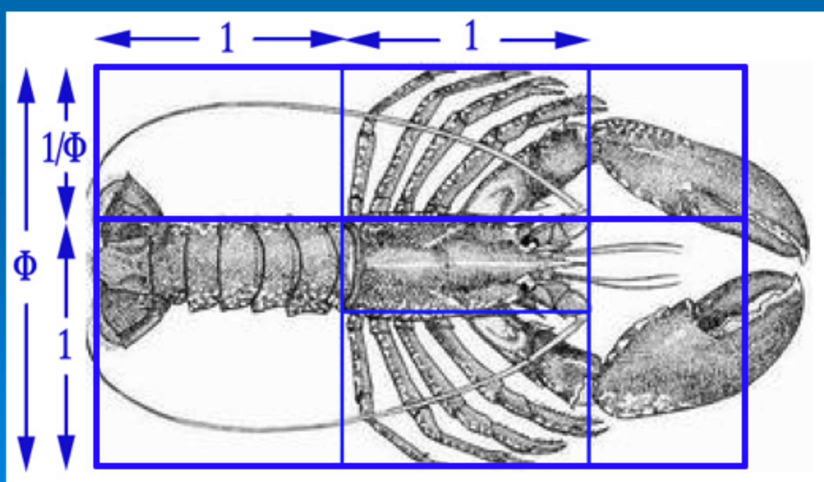
Proportions and harmonic flow
in the pincers & legs of a common crab.
(Study by G. Dozci. *The Power of Limits.*)



🡐 Image credit



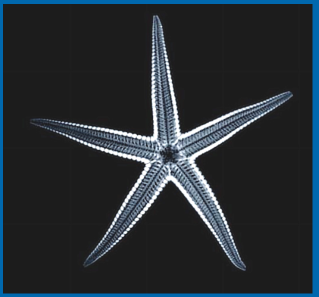
🡑 A Golden rectangle frames the carapace of a common crab. Dungeness crab (*Metacarcinus magister*). //library.enaca.org



🡐 Possible harmonic proportions in a lobster.

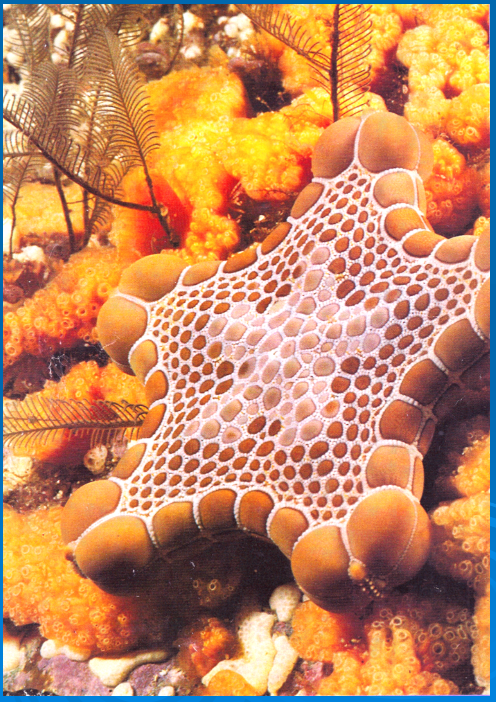
SG205B.8.6 Sea Stars

↑ A dancing sea-star



← Starfish five-fold endo-skeleton.

(Wikipedia).



← Sea-star. Unknown magazine picture.

↑ Red-knobbed starfish (*Protoreaster linckii*). Habitat: Indian Ocean. (Wikipedia).

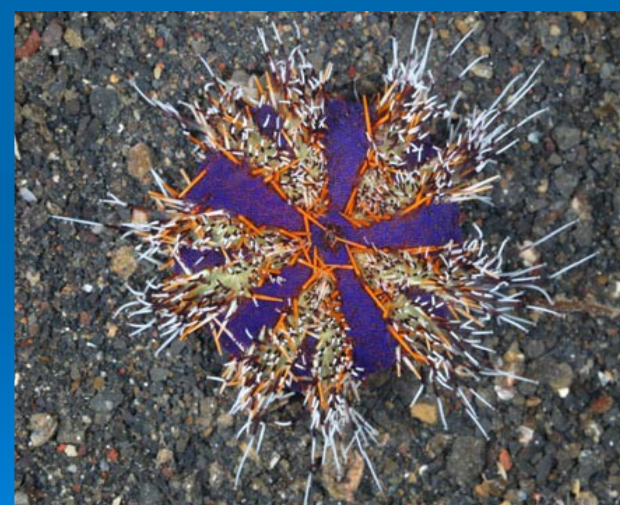
SG205B.8.7 Sea Urchins

← A "fractal" sea urchin, with baby on top. (Wikipedia).

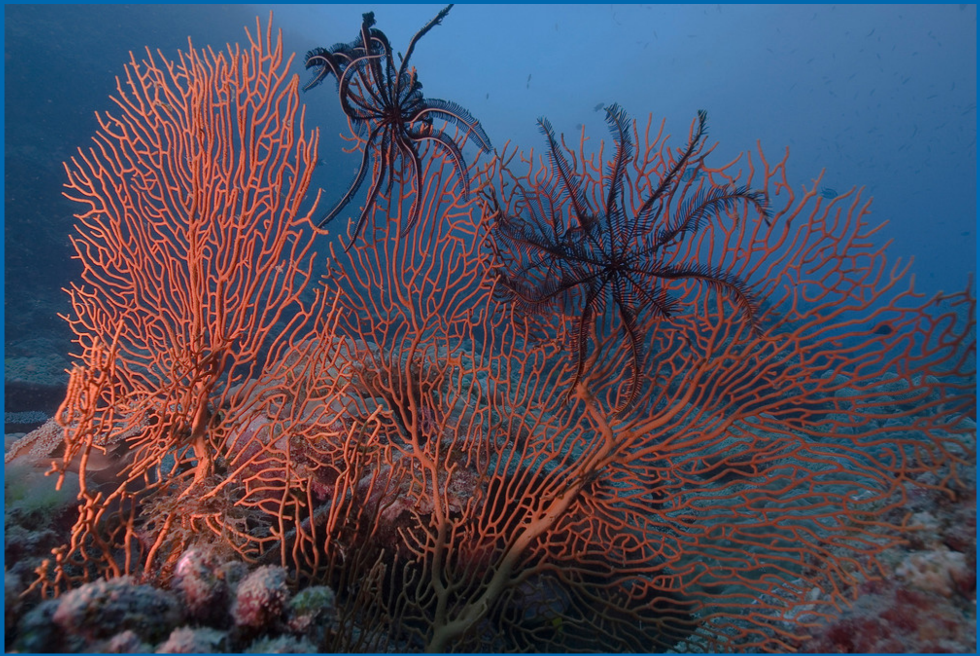
Note: early larvae have bilateral symmetry, but they develop 5-fold symmetry as they mature.

Echinothrix → *calamaris*. Malaysia. (Credit)

↑ *Mespilia globulus.* Philippines. (Credit).

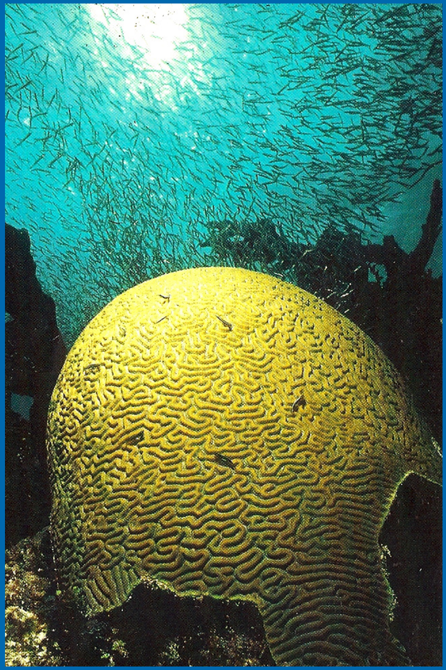


↑ *Tripneustes gratilla.* Indonesia. (Credit)



← Fractal sea fans (octocorals) & feather stars.

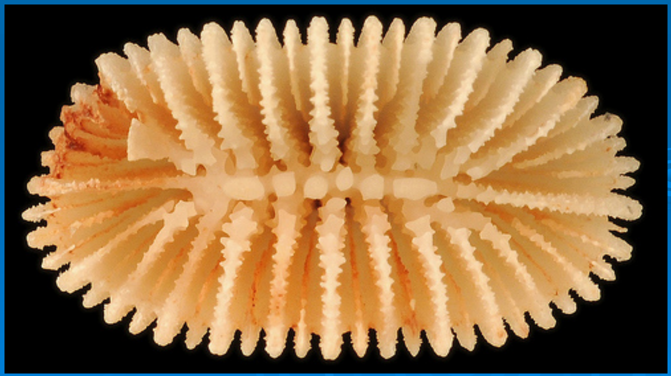
→ "Brain coral" (*Diploria labyrinthiformis*).



SG205B.8.8
Corals

Corals divide into two subclasses, depending on the number of tentacles or lines of symmetry:

- Hexacorals
- Octocorals



←"Mushroom coral" (*Fungia*)

↑ *Sphenotrochus gardineri*, an hexacoral *(coral with 6-fold symmetry).*

Interlude 5a. Spirals in Animals - Horns

↑ Gemsbuck (*Oryx gazella*)

In the great majority of horns there is a continuous logarithmic spiral.

We show here images of increasing spiral angle, from almost straight (Gembuck top left) to the amazing Albanian sheep (top middle).

↑ Albanian sheep (T. A. Cook)

↑↓ Markhor (*Capra falconeri*) with 2 and 3 spiral turns.

↑ Greater Kudu (*Tragelaphus strepsiceros)*

↑ Marco Polo sheep (*Ovis poli*)

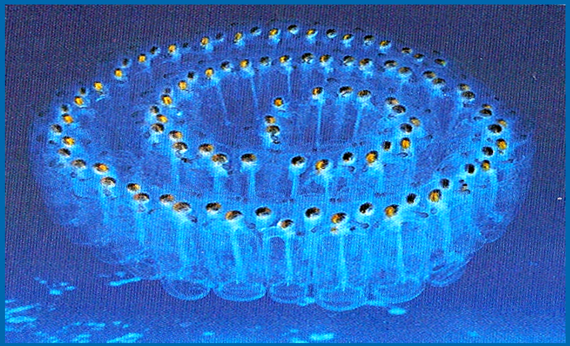
↑ Blackbuck (*Antelope cervicapra)*

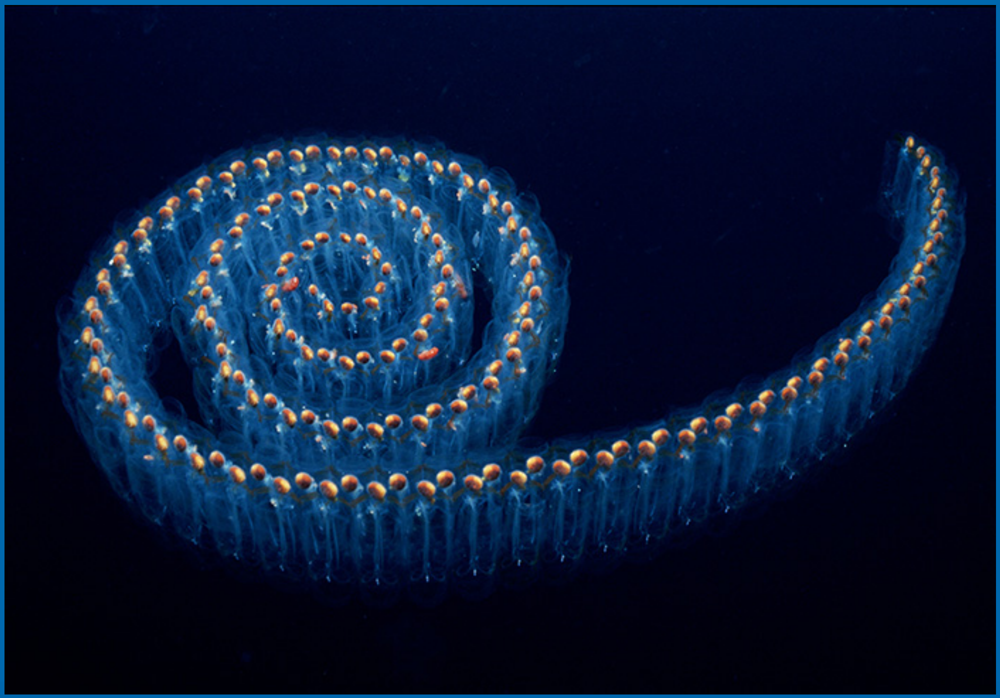
↑ Spanish Ibex (*Capra pyrenaica*)

↑ Wild goat (*Capra aegagrus*)

↑ Male sheep or Ram.

Interlude 5b. Spirals in Animals - Salps





↑→ Salp colonies

(Image by R. Herrmann). Unknown source.

A salp (plural salps) is a barrel-shaped, free-floating tunicate (or "filter-feeder"). It moves by contracting, thus pumping water through its gelatinous body. Salps have two openings in their body cavity: an in-current and an ex-current siphon. The water is pumped through internal feeding filters to retain the nurturing phytoplankton.

Salps swim and eat in rhythmic pulses, oftentimes forming spiral nets acting like vacuum-cleaners.

A National Science Foundation study states: "Their amazing performance relies on a feat of bioengineering - the production of a nanometer-scale mucus net -the biomechanics of which remain a mystery."

www.whoi.edu

Salp and carbon clean-up.
Scientists believe salps could have an important role to play by providing a potent, but natural, alternative to carbon capture and sequestration (CCS). The vast numbers of salp colonies now appearing off Australia could be part of nature's mechanism for combating carbon build-up.
As reported by the Woods Hole Oceanographic Institution, "one swarm covered 38,600 square miles (100,000 square kilometers) of the sea surface, containing perhaps trillions of thumb-sized salps… The swarm consumed up to 74 percent of microscopic carbon-containing plants from the surface water per day, and their sinking fecal pellets transported up to 4,000 tons of carbon a day to deep water."

SG205B. Chapter 9. Geometries in Shells

The shapes of shells (nearly all mollusks) have been the subject of many geometric studies showing that their harmonic proportions follow logarithmic, equiangular spirals and oftentimes golden (logarithmic) spirals. A particular property of the equiangular spiral is that is preserves its shape and form as it grows (gnomonic, fractal growth).

The usual question that comes up when looking at various shells is: they all seem visually somewhat different from the theoretical / archetypal golden spiral, so how can they be following the golden proportion? The answer is that the differences are in time, i.e. the rate of unfolding between radial and rotational growth varies from very tight to very open. Examples:

• In the Atlantic sundial (an almost circular shape), the spiral moves slowly: it goes through 20 radii between consecutive circles = a proportion of 20:1 between radial and rotational growth.

• In the Abalone (a very elongated shape), the spiral moves through 3.5 radii before the next circle = a proportion of 3.5:1.

• The Nautilus is somewhat in between and visually approximates the Golden spiral. But whereas the Fibonacci spiral increases in size by a factor of Phi in a quarter turn, the nautilus spiral takes a whole turn before it moves a factor of 1.618 from the center. See the proportional study by Rachel Fletcher.

In this chapter, we will show different studies done by researchers (classic and contemporary), revisit the Nautilus and also share some beautiful images of shells just for the sake of their pure beauty and their fractal inner architecture (when cut crosswise or lengthwise). The following Interlude touches upon the recent research on computer modeling of shells.

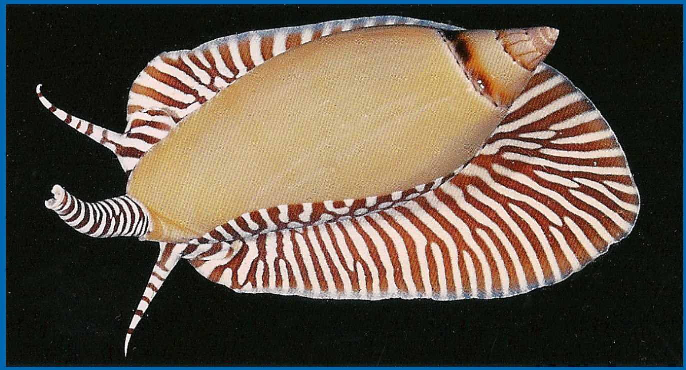
↑ *Mitra mitra* cut to show inner spiral architecture. (H & M Stix. *The Shell.* 1972).

SG205B.9.1. Shells and Living beings

When looking at shells, we easily forget that they are the empty houses left behind by once living residents. Let us not forget the beings who move around in these beautifully designed houses displaying the spiraling geometries of fractal growth.

Looking at shells is looking at the *exoskeletons* of invertebrate (without a backbone) animals. Most shells that are found in or near oceans are the shells of marine mollusks. Obviously, the shells are empty because the animal has died.

When the word "seashells" is used to refer only to the shells of marine mollusks then studying seashells is part of *conchology*. When studying the whole molluskan animal is included as well as studying the shell, then the study is known as *malacology*.



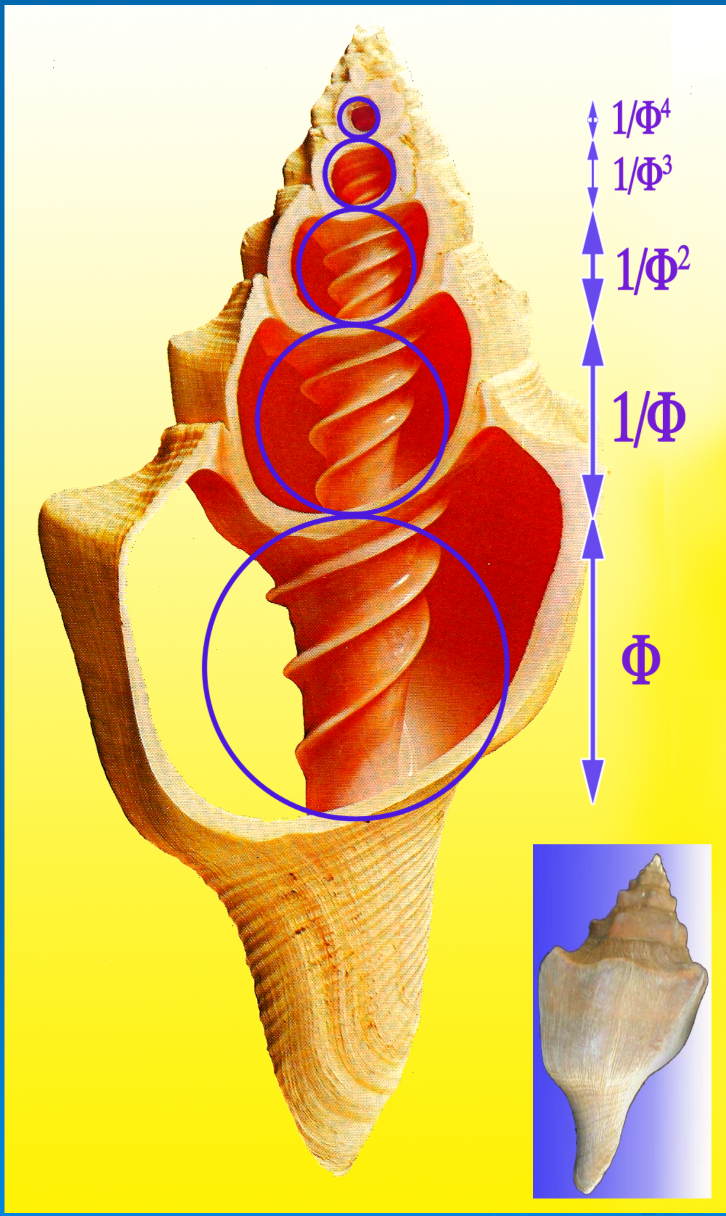
🡅 *Amoria grayi*. This is what a living mollusk looks like. When we look at a shell, let us always honor & remember the original inhabitant who created this unique living architecture from inside out and left us the "book" of its life in the form of a shell. Note the zebra-like patterns.

🡅 A live *Nautilus pompilius*.
In terms of the Web of life, the shell, the resident mollusk, the ocean, the earth and the cosmos are interconnected as one field of harmonic resonance.

Note on oceanic ecology & ethics

Shells have become a large business catering to museums and scientific institutions, private collectors and the tourist trade. While some shells are extremely abundant, others are quite rare and catch hefty prices on the international market. So, when buying shells, be aware of the environmental impact and the overall harmonic balance of the earth macro-system.

In the late 1970s, it was discovered that *tangle nets* were an efficient way to catch rare shells. One-inch-mesh monofilament nets are left on the sea bottom overnight to ensnare shells. They are operated by local fishermen who can overwork shell locations due to greed.
Dredging is a crude & invasive method: it employs a heavy blade to cut through the ocean floor and drag it along. This is "monitored" but should be totally prohibited as it severely destroys eco-systems.
Trawling is dragging the seabed with heavy net-like gear. This also is a destructive method as it involves coral shattering, damage to habitats and removal of seaweed.



SG205B.9.2 Shell Cross-Sections

Shells are beautiful in their external shapes and profiles but they are even more exquisite in their inner architecture & geometric proportions. Slicing shells (length-wise and cross-wise) is an efficient method to reveal their inner beauty. X-rays have also revealed the precise interiors of shells (see infra the Triton and the Whelk).

← *Cypraea mappa* or "Map cowrie". Sliced crosswise with mirror image to show the inner spiral.

Many shells live in spiral houses!

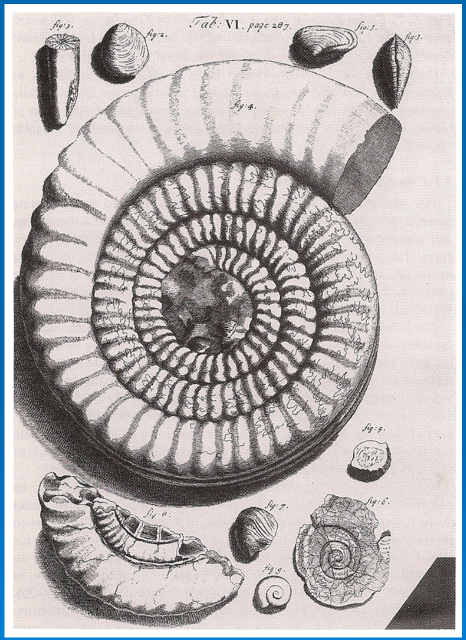
(Original images: H. & M. Stix. *The Shell*.)

← *Xancus angulatus*. Length-wise section. 8-10". Caribbean.
The shell *Xancus angulatus* ("Lamp chank") belongs to the family of the Xancidae.
A cascade of Phi circles seems to fit neatly.

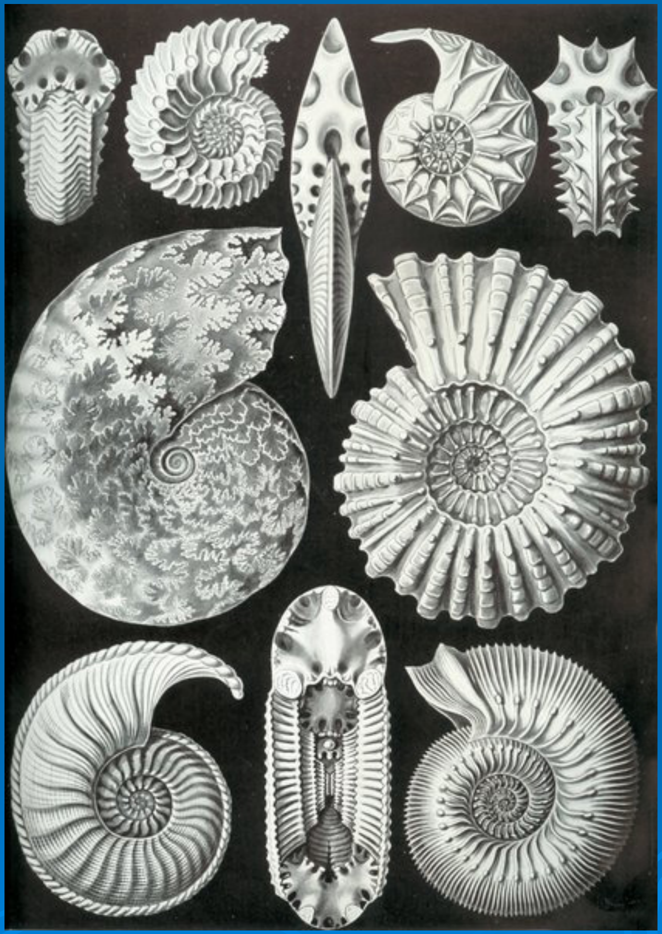
SG205B.9.3.1 Fossil Symmetries (1): Spiral Shells

The name *ammonite*, from which the scientific term is derived, was inspired by the spiral shape of their fossilized shells, which somewhat resemble tightly coiled rams' horns. Pliny the Elder (d. 79 AD. near Pompeii) called fossils of these animals *ammonis cornua* ("horns of Ammon") because the Egyptian god Ammon (Amun) was typically depicted wearing ram's horns.

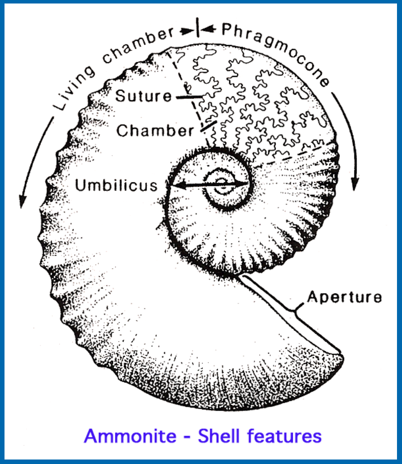
Some Ammonites are a direct function of Phi (see next page), some are a function of a multiple of Phi, and some are function of other constants.

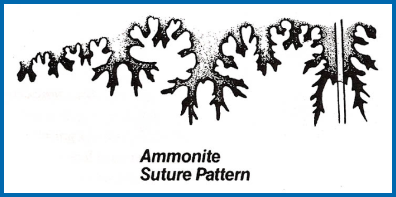


↑ Spiral shells. By Robert Hooke. *A discourse of Earthquakes*. 1705.



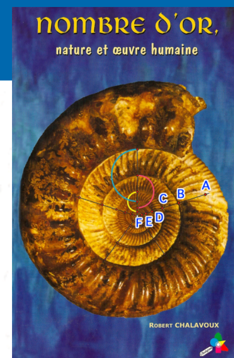
↑ Ammonites. Ernst Haeckel. *Art Forms in Nature*. 1904.

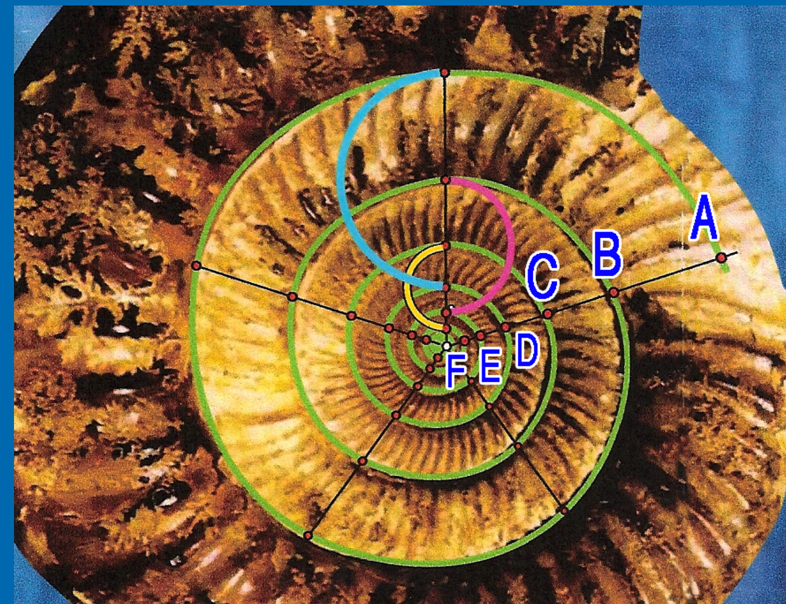


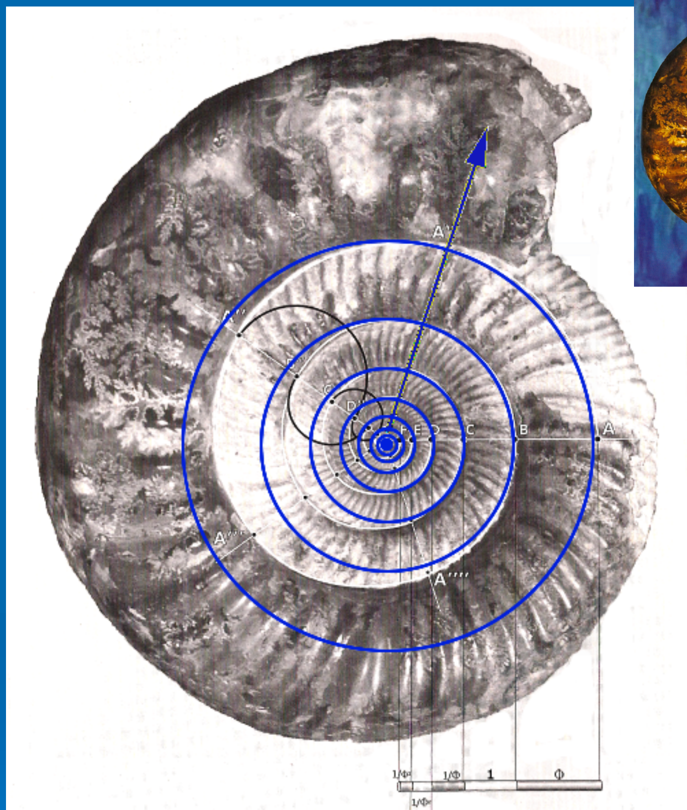


↑ *Asteroceras*, a Jurassic Ammonite. Wikipedia.

SG205B.9.3.2 Fossil Symmetries (2): Ammonite & Phi



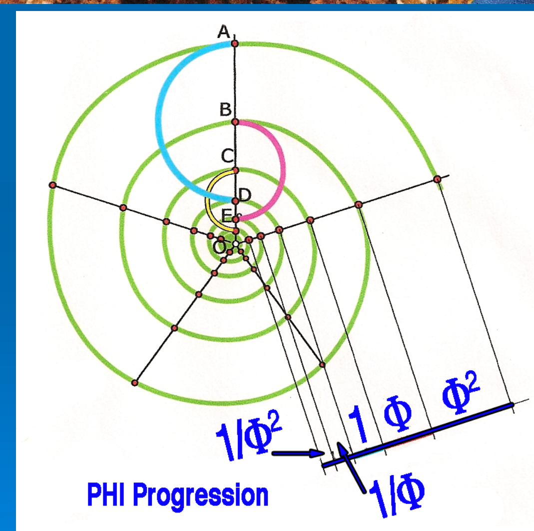




↑← Ammonite
Mesozoic ~ 100 million years.

The distances between the successive spires follow the Phi progression:

AB = Φ, BC = 1, CD = 1/Φ, DE = 1/Φ² etc… AB : BC = BC : CD = CD : ED etc… = Φ = Phi



(Measurements by Robert Chalavoux. *Nombre d'Or, Nature & Oeuvre Humaine.* 2001. www.chalagam.com

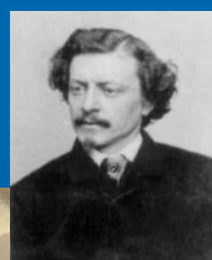
SG205B.9.4.1 Samuel Colman (1)

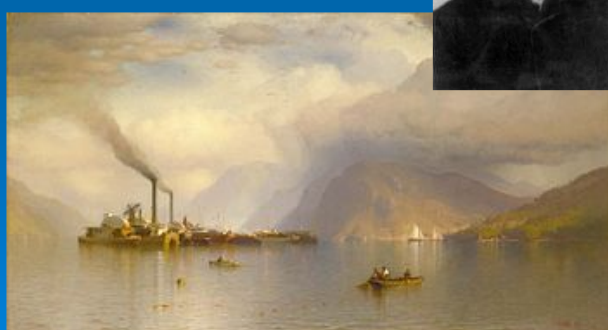
Samuel Colman (1832 - 1920) was an American painter, best remembered for his paintings of the Hudson River.

But he also wrote two influential treatises on Harmony and the laws governing proportional form, both in nature and in the arts/sciences: "Harmonic Proportion and Form" (1911) and "Proportional Form: Further Studies in the Science of Beauty" (1920).

Colman explains: ***"The further these investigations were pursued, the firmer became the conviction that the laws of proportion, as exemplified in Nature, were startlingly uniform, whatever might be the complexity of the application… These principles are the fundamental elements by which Nature creates Harmony, correlating the parts of her form-compositions into a perfect whole…"*** **(Preface to Harmonic Proportion and Form).**

Samuel Colman ➔





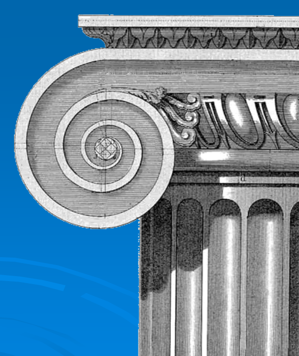
"Storm King on the Hudson". Samuel Colman. 1866.

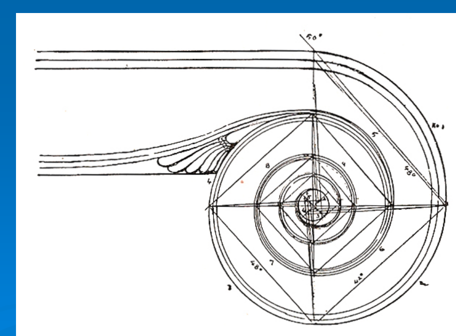
A centennial view

In his landmark treatise *Nature's Harmonic Unity* (1911), Samuel Colman writes about *conchology* (the study of shells):

"Among all the enchanting things in the realm of beauty, the shell is one of the most perfect as a representative form of the spiral construction and the one where the spiral is most obvious to the casual eye, at once announcing itself a geometric product.

We know that the Greek artists created from lines of the shell most beautiful things, many of which can never be improved upon for they were constructed under the influence of fundamental laws of nature. Of these the Ionic volute is perhaps the most perfect example. That this was designed under the influence of geometric principles is shown by the compass marks still in evidence on marble fragments of the period, and also by the fact that its spiral is logarithmic. That the shell is the source of the Ionic volute is emphasized by the fact that in this volute the equiangular spiral ceases at the last turn where the curve passes into the horizontal lines of the capital.

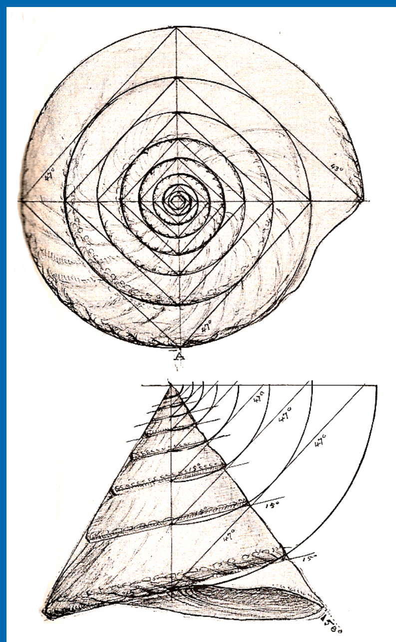




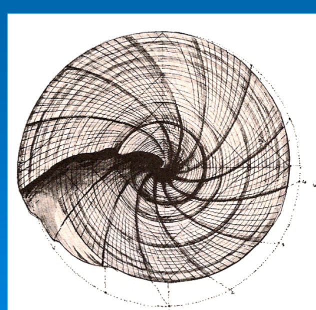
🡅🡄 Ionic volutes.

SG205B.9.4.2 Samuel Colman (2)

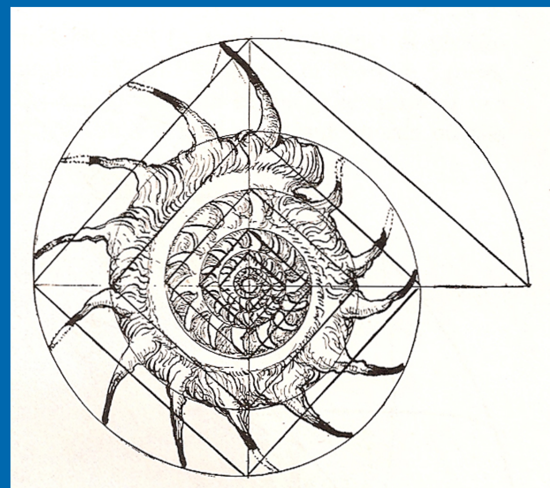
Below are some of the geometric renditions of shells that can be found in Colman's *Harmonic Proportion and Form*.



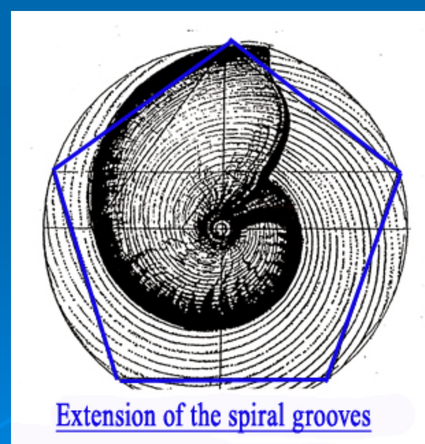
↑ *Trochus maximus*



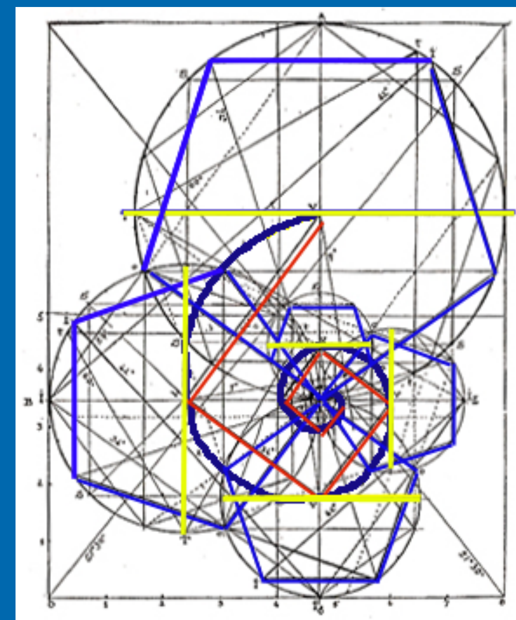
↑ *Trochus* (underside).



↑ *Xenophora solaris*



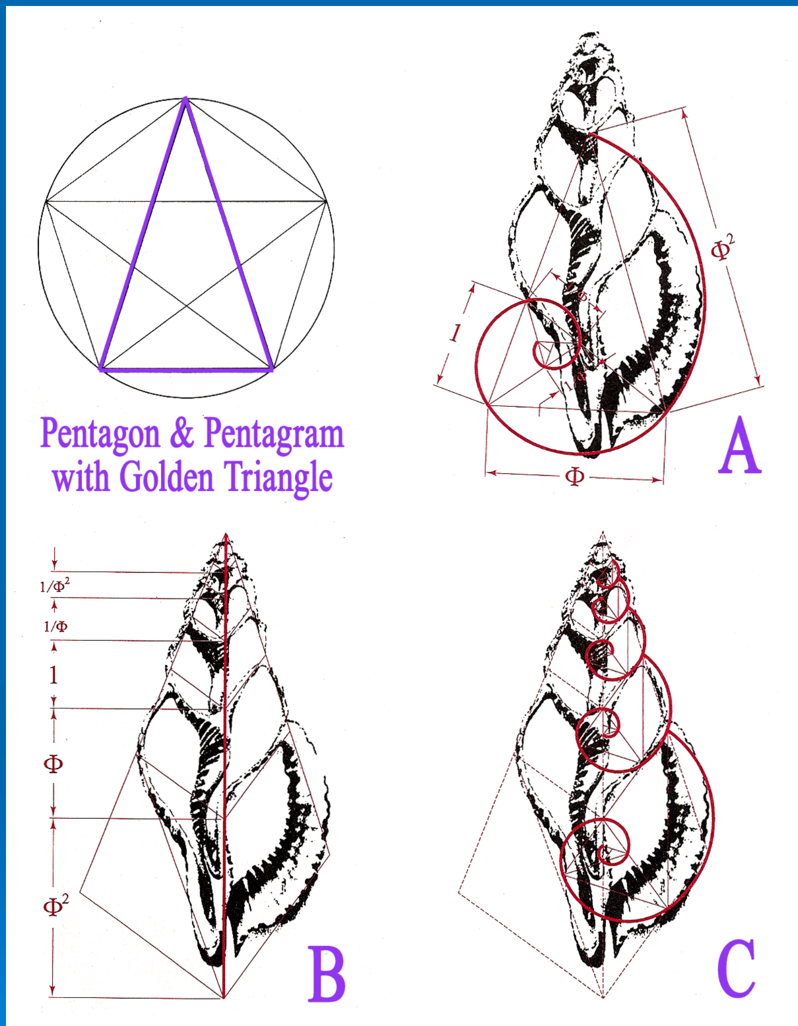
↑ Study of the Nautilus.



↑ Colman was most taken by the *Nautilus pompilius* and its "*wonderful harmony*". Colman's precise plans of symmetry, based on the quadrant vectors & chords, show the Nautilus pentagonal & hexagonal symmetries and its tangency to the diameters of harmonic circles.

"All the lines intersect the others at harmonic points, and this it would not do unless they were in unity".

SG205B.9.5 The Triton Shell



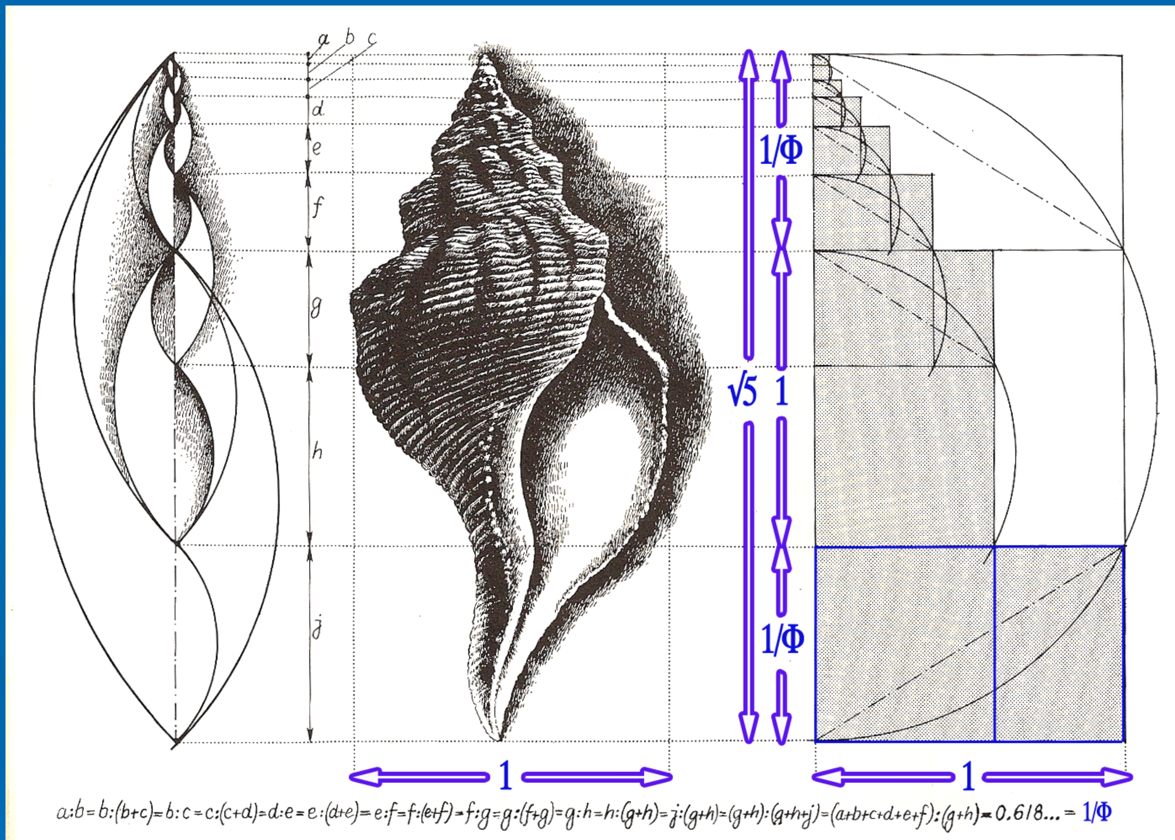
🡑 Phi study of the Triton shell by Rachel Fletcher.
(*Design Spirit.* Winter 1991.)

🡐 Triton shell
(*Charonia variegata*).
Wikipedia.

Tritons are named after the Greek god Triton, who was the son of Poseidon, god of the sea.

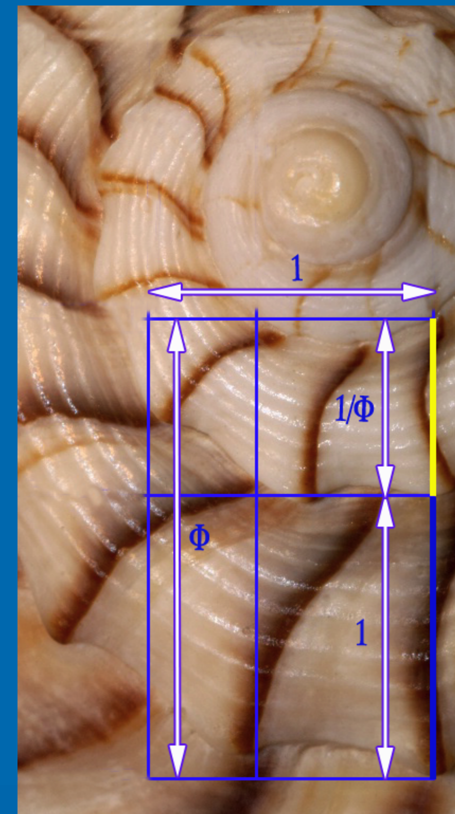
🡒 X-ray image of
the Triton shell.
(Wikipedia).

SG205B.9.6.1 The Whelk Shell (1)

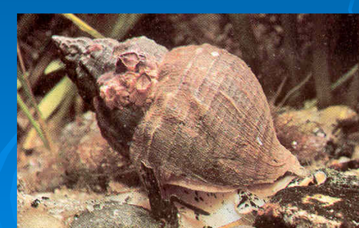


↑ Study by Dozci of the dilated Whelk (*Penion dilatus*).
Left: wave diagram showing how all whorls share the same golden relationships.
Right: diagrams of the golden sections.
Bottom: golden ratio relationships between parts, larger parts and whole.

(*The Power of Limits*. 1981.)

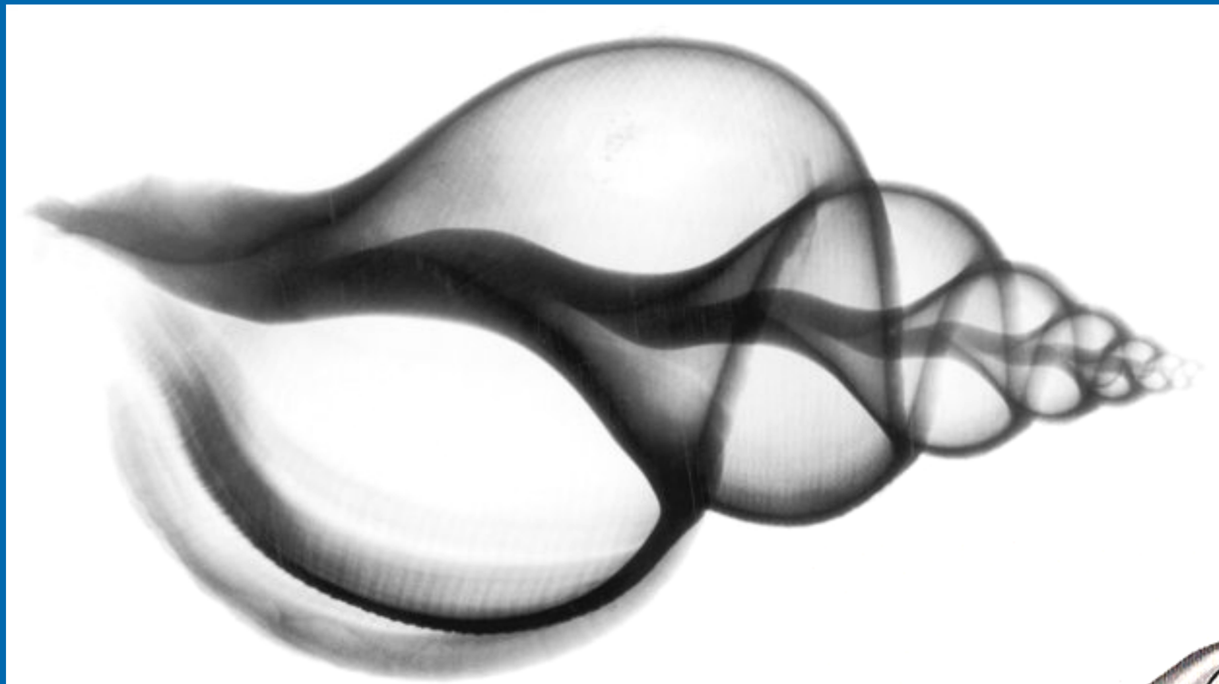


↑ Phi ratio from top view of Whelk shell. Image: H. Pickard. Credit.

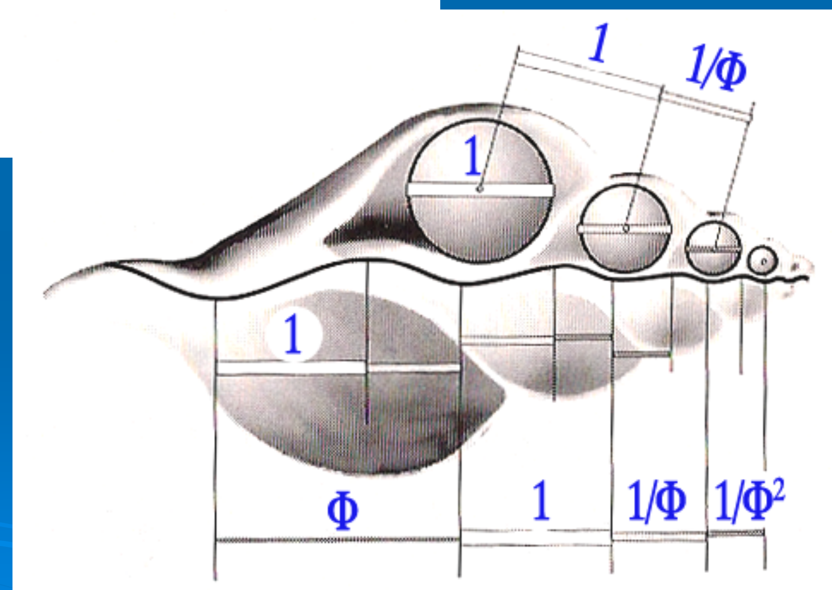


↑ Whelk. www.iisgcp.org

SG205B.9.6.2 The Whelk Shell (2) Inner Harmony



🡐 Famous 1910 x-ray image of a whelk shell taken by the inventor of the x-ray.
//goddesschess.blogspot.com



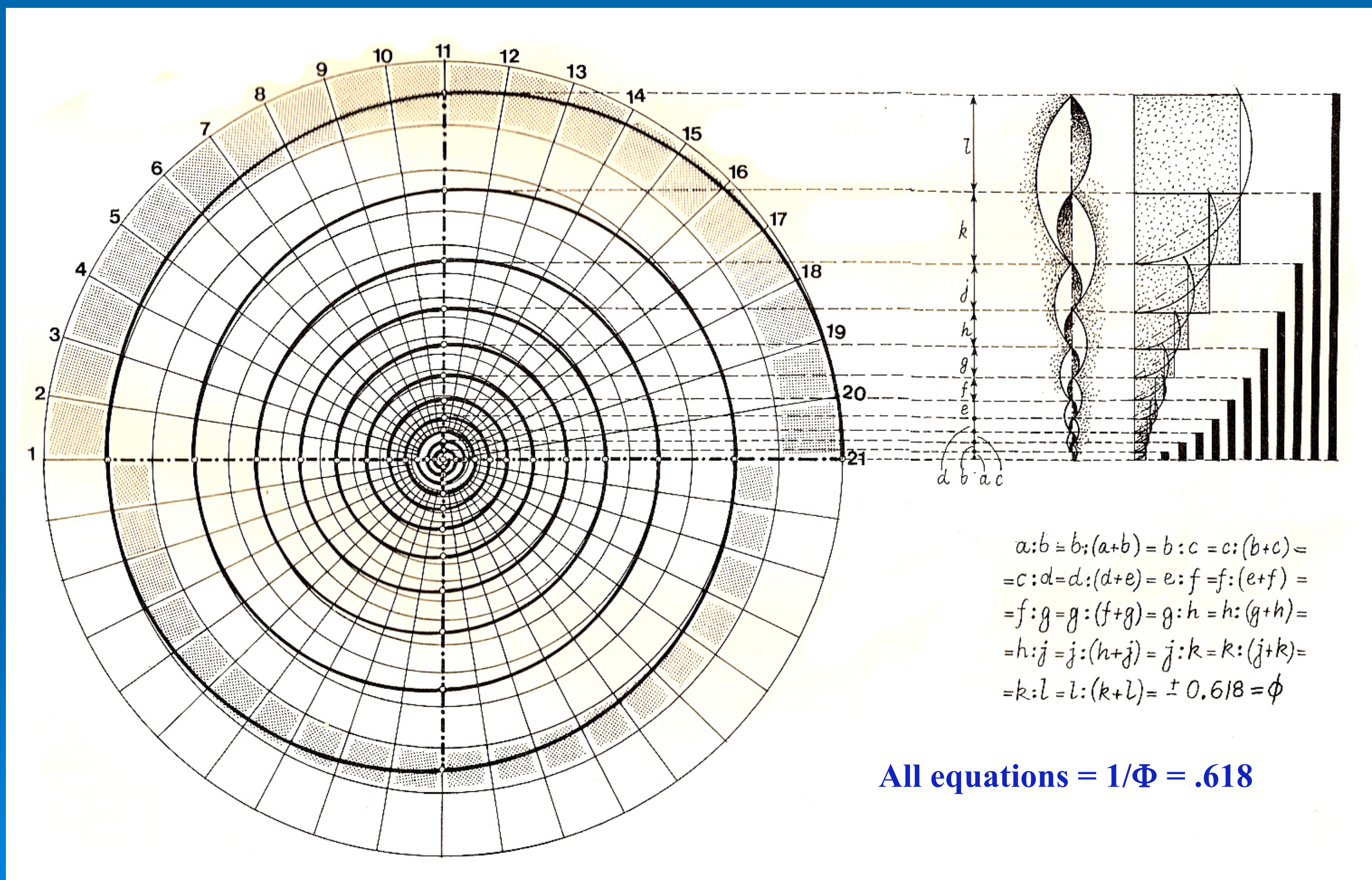
➔ Whelk shell.
Study by R. Chalavoux using his technique of volumetric circles.
The diagram shows the golden proportion of the inner chambers.
(*Nombre d'Or*. Chalagam. 2001)

SG205B.9.7 The Sundial Shell

• *"The Atlantic sundial's spiral moves slowly between consecutive circles. It crawls through no less than 20 radii, or squares, before reaching from one circle to the next: a proportion of 20 : 1.*

• *Construction of the golden section wave diagrams show that the proportions of the neighboring whorl-width follow PHI: qll the shaded rectangles are golden rectangles.*

• *The harmony created by this relationship is illustrated also by the organ-pipe-like bars, indicating the cumulative length of successively widening whorls."* (Quotes by G. Doczi).



← Proportional study of the Atlantic Sundial shell (*Architectonica nobilis*) by G. Doczi.

Doczi is using here his dinergic method of combined radial and rotational growth reconstruction.

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

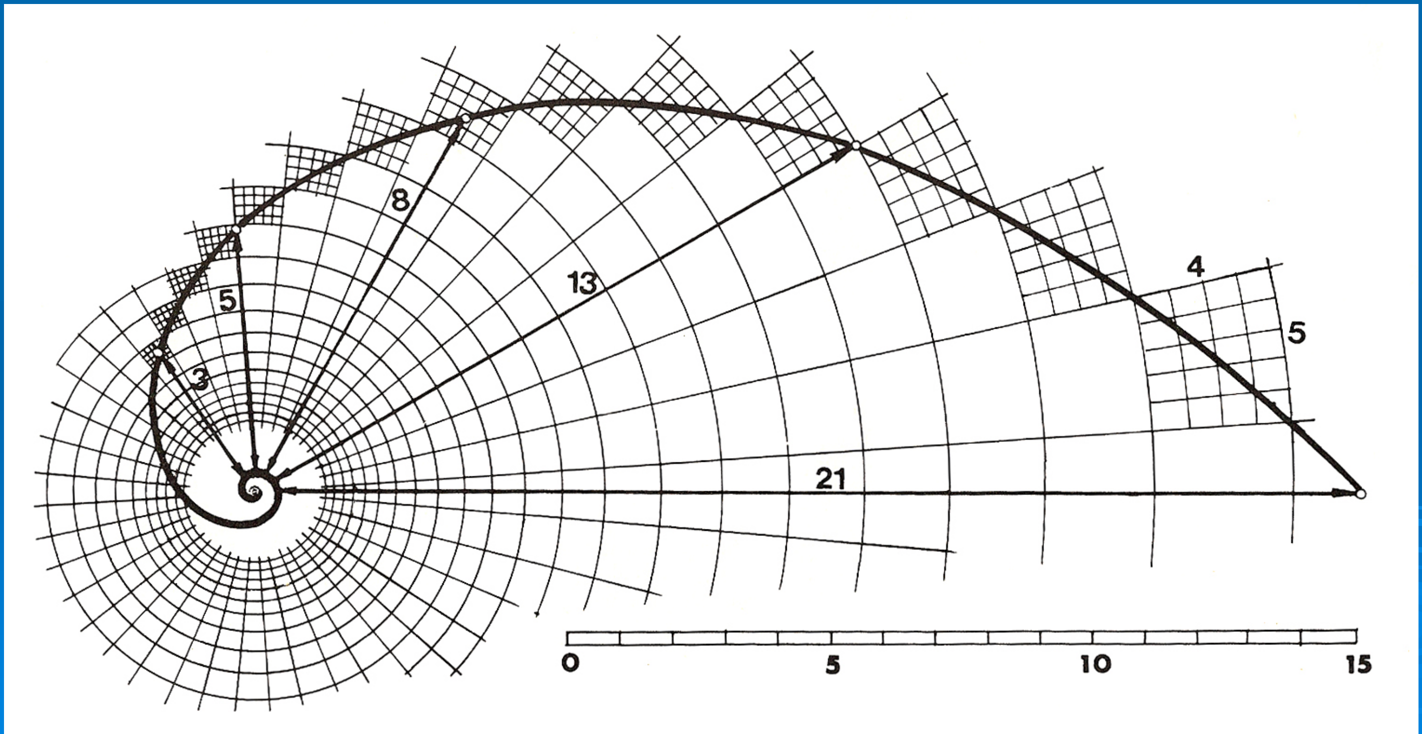
SG205B.9.8 The Abalone Shell

The donkey's-ear abalone (*Haliotis asinina*) is a fairly large species of sea snail, a tropical gastropod mollusk. Both the common name and the scientific name are based on the shape of the shell, which is long, narrow and curved, resembling the shape of a donkey's ear.

• The abalone's spiral moves much quicker than the sundial's spiral. The abalone's spiral takes only 3.5 radii, or squares, to move from one circle to the next: a proportion of 3.5 : 1.

• Successive stages of growth, measured along neighboring, equidistant radii, are Fibonacci numbers: 3 - 5 - 8 - 13 - 21

🡡 *Haliotis asinina* (Latin *asinus* = ass, donkey).
www.linnean-online.org



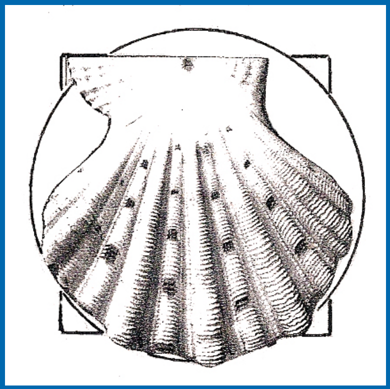
🡠 Dinergic reconstruction of abalone's shell by G. Doczi.

Stages of growth are Fibonacci numbers.

The power of Limits. (1981).

SG205B.9.9 The Scallop Shell

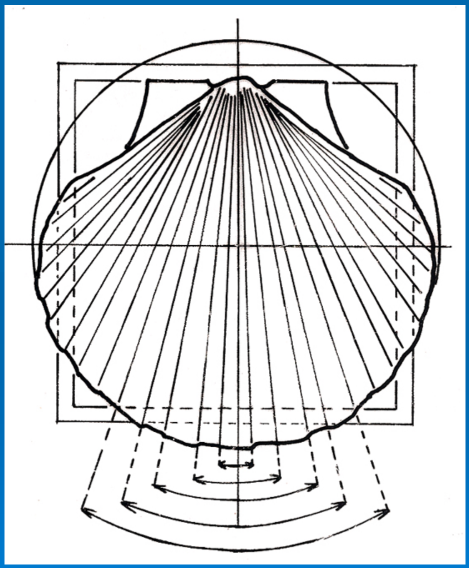
The Scallop Shell (*"Coquille Saint-Jacques"*), in addition to its history & symbolism, also has interesting geometries.



↑ The hinge delimits a square with *same perimeter* as the circle.

Geometry

• The lower half is a rough half circle, thus allowing for tracing an approximate circle.
• The flat hinge (where the two halves of the shell attach) delimits a square that has *the same perimeter* as the circle.
• The ridges of the scallop can bear numbers and number ratios. They can be used as the markings of a protractor for geometric layouts "on the field".
• The width of the main ridge gives the approximate location of a square with *the same area* as the circle.
[For explanations & constructions about "Squaring the Circle", see ◆SG302]



↑ Traditionally, the width of the 1st ridge delimits a square with the *same area* as the circle.

History

In the medieval times, (11th - 13th centuries), the Scallop shell was the recognition sign of the pilgrims who had completed their pilgrimage to the holy shrine of *St. James of Compostela*, in Northern Spain. Compostela was the final destination of all the pilgrimage routes throughout Europe and, as such, the "Way of St. James" attracted millions every year.

Legend holds that St. James's remains were carried by boat from Jerusalem to northern Spain where he was buried on the site of what is now the city of *Santiago de Compostela*. St. James is represented with a staff bearing the scallop shell, emblem of the pilgrim. The rays of the scallop identified it with St. James as the "ever effulgent Sun light".

More prosaically, the scallop shell was the pilgrim's daily utensil, being used as a scoop for water and as a plate for food, thus reminding the pilgrim of his vows of poverty and renunciation of worldly possessions. In recent years, the pilgrimage has regained popularity: the number of estimated pilgrims for 2010 was 270,000 (Wikipedia > Way of St. James).

↑ St. James with scallop shells.
www.sacredsites.com

Symbolism

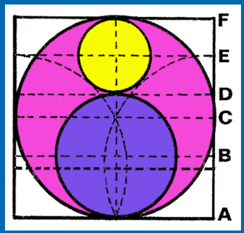
Shells, traditionally, represent the water element principle, the Feminine and the Moon. ("*Concha*", in Latin, means both "shell" and "vulva"). Shells are a universal symbol for the Gate of Life, the female matrix/yoni/vulva. And, by analogy, they symbolize Birth, Love & Fecundity.

Greek statues represent Aphrodite as emerging from twin scallop shells. Later, in Florence, Botticelli and other Renaissance artists used the same symbolism in their "Venus" paintings.

SG205B.9.10.1 The Snail Shell (1)

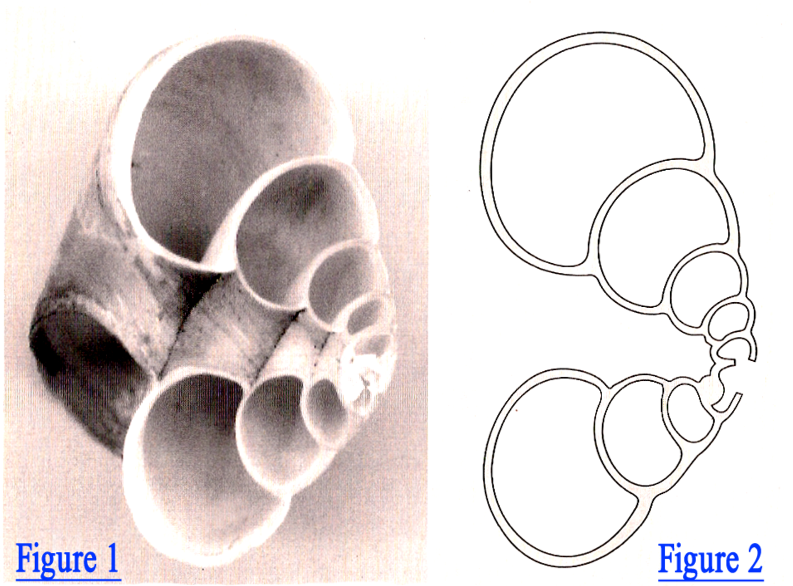
The tracings below are from the wonderful booklet by Robert Chalavoux *"Nombre d'or - Nature et Oeuvre Humaine"* (Chalagam. France, 2001)
www.chalagam.com

These diagrams illustrate Chalavoux's method of "volumetric circles".
Note: embedded PHI ratio circles form the "Arbelos" figure [◆SG302]

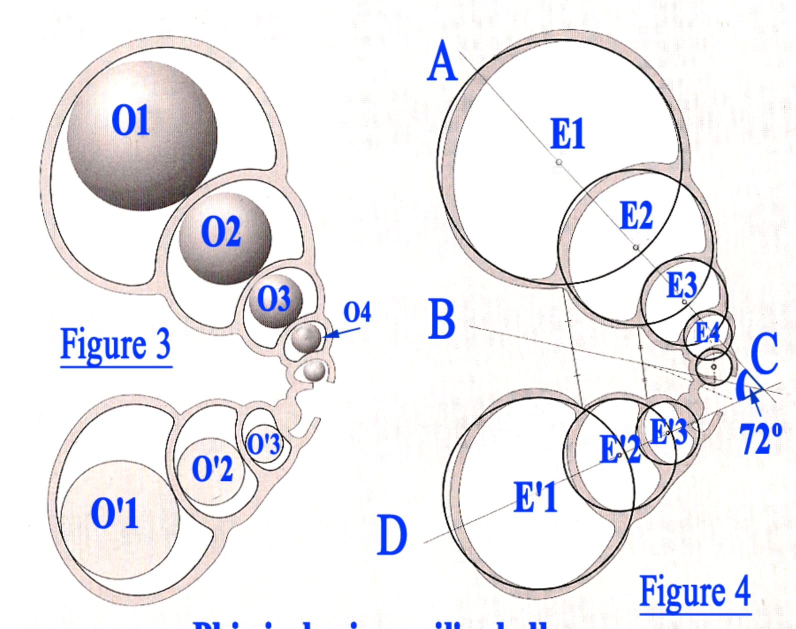


← Arbelos

↑ The snail studied by R. Chalavoux.



Cross section of a snail's shell



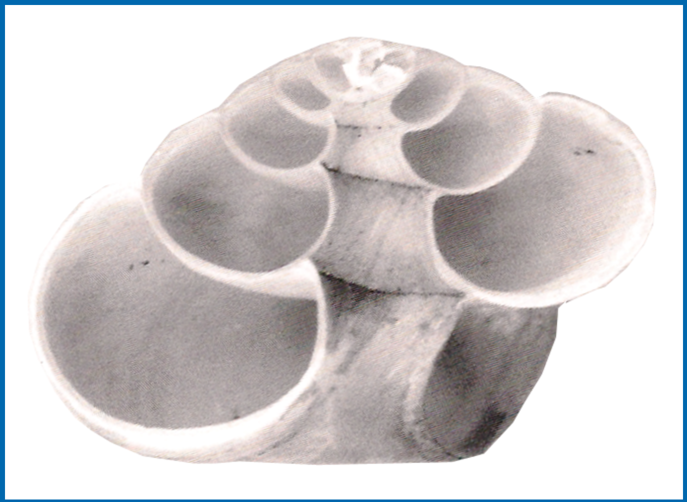
Phi circles in snail's shell

Figure 1. Cross section of the shell.
Figure 2. Re-tracing of the inner cavities.
Figure 3. The smaller circles inscribed in the successive cavities O1, O2, O3, O4 are in Phi ratio: O1 / O2 = O2 / O3 = Φ
• We also have: O'1 / O'2 = O'2 / O'3 = Φ

Figure 4. The larger circles circumscribed to the cavities are also in Phi ratio: E1 / E2 = E2 / E3 = Φ
• The circumscribed circle E2 = the inscribed circle O1. The two series of circles (inscribed & circumscribed) are in Phi ratio.
• The angle ACD = 72º (remember the Golden Triangle with base = unit 1 and side = Phi = 1.618… and angles of 72º, 72º and 36º).
[◆SG106.2]

SG205B.9.10.2 The Snail Shell (2) Flowform Design

The cross section of the snail shell analyzed by Robert Chalavoux suddenly jumped up and morphed into a flow form fountain! It is the same design & dynamics of gnomonic growth, based on fractal increments of the Golden Ratio or harmonics thereof. Whether water, body or consciousness, evolution might just be a process of golden fractal expansion spiraling from vessel to vessel, across the dimensions and magnitudes.



🡅 The same snail shell seen with the vertical axis up looks like a series of flow-form bowls.

🡅 Flow form fountain in Darmstadt, Germany.

[More on flow forms ◆SG105.5]

The flow form ➔ cascade in the park of PKS, Bad Ischl, Austria.

The PKS Institute (Pythagoras Kepler System) is pursuing the work of Viktor Schauberger [◆SG203B]

SG205B.9.11.1 The Nautilus (1) Introduction

↑ The Nautilus Golden spiral takes a whole turn before it moves a factor of Phi (1.618…) from the center. It is a function of Phi[4].

The *pearly* or *chambered Nautilus* is the sole survivor of a stock that flourished 200 million years ago. The logarithmic spiral shell consists of a series of chambers partitioned by *septa*. The animal lives in the largest and newest chamber, with a tubular elongation of its body extending through the septa to the apex of the shell… i.e. a "tail" or energy line that reaches through its successive "past lives" all the way through its "root"…

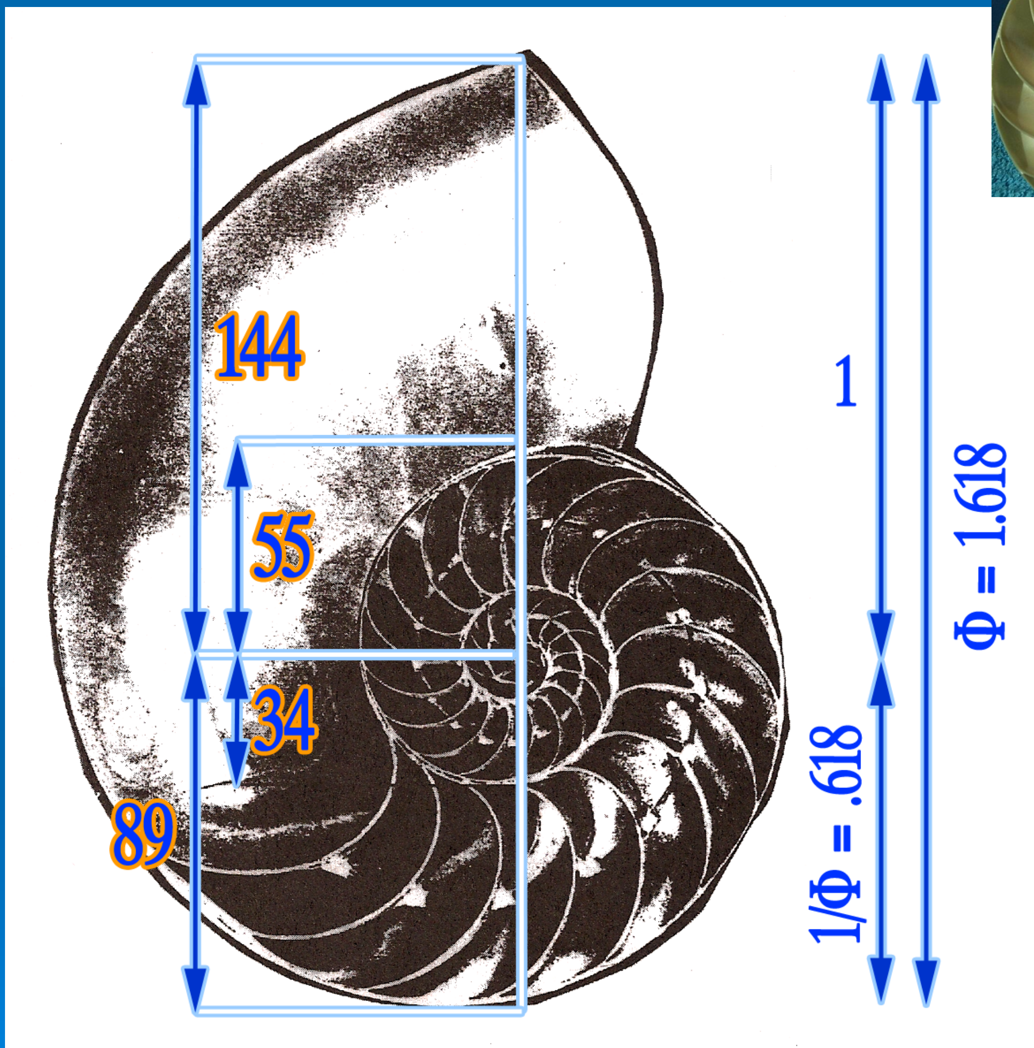
↑ Having survived relatively unchanged for millions of years, nautiluses represent the only living members of the subclass *Nautiloidea*, and are often considered to be 'living fossils'.

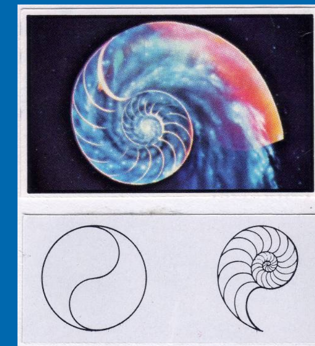
- The name comes from the Greek *nautilos* = sailor.

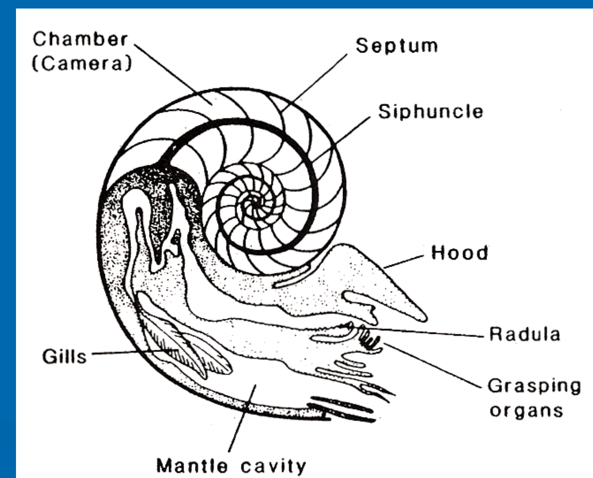
- Nautiluses live in deep water, down to several 1,000 feet but come up at night to feed.

- Nautilus populations are on the decline due to the harvesting of their shells. Because of this, export of the shells has been banned in many countries throughout the world.

SG205B.9.11.2 Nautilus (2) Fibo Geometry







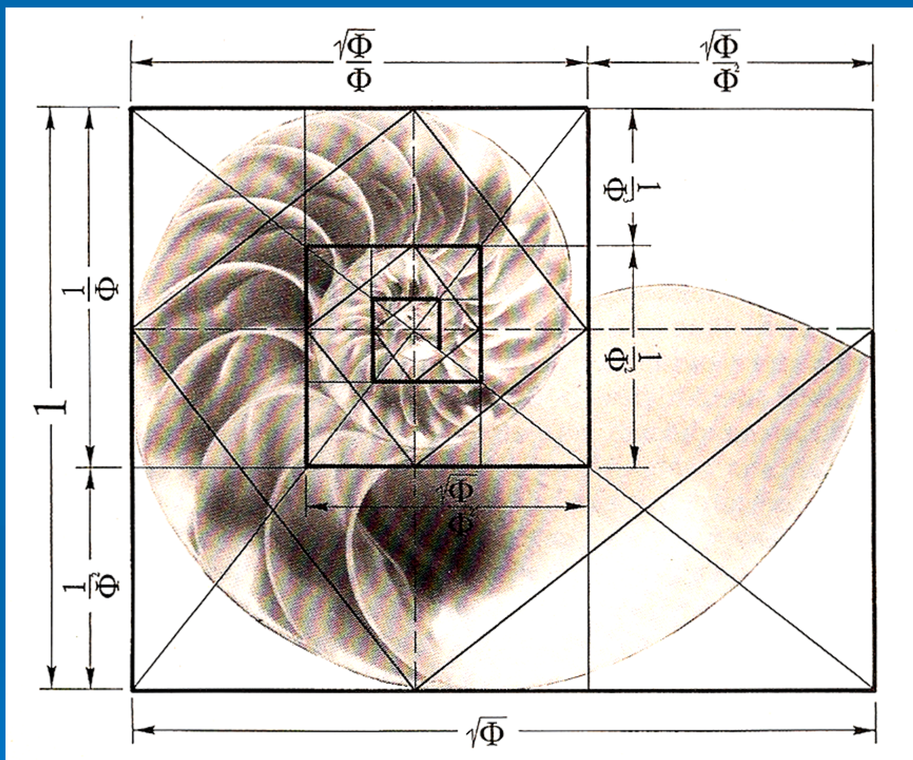
Nautilus - Cross section

More geometric aspects of the Nautilus log spiral:
◆SG105.4 and a full discussion:
www.goldennumber.net/nautilus-spiral-golden-ratio/

(Redrawn from J. C. Perez *"L'ADN Décrypté"*. Resurgence. 1997).

SG205B.9.11.3 The Nautilus (3) Design

//dooleymath.com



↑ **Proportional study of a Nautilus by Rachel Fletcher.**
(In *The Power of Place*. Anthology by James Swan. 1991)

"A rectangle of 1 x √ Φ encloses the shell as a whole, while the nautilus spiral proceeds along equally spaced axes whose lengths progress in 1 : √ Φ ratio."

The Nautilus House in Mexico City.
(For more images of this home ◆SG207)
www.newhouseofart.com

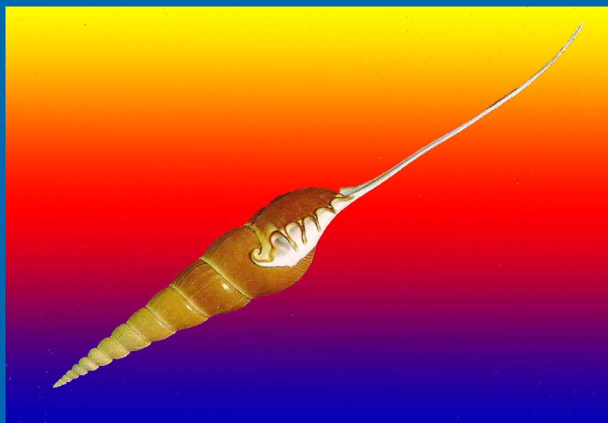
SG205B.9.12.1 Shell Gallery (1)

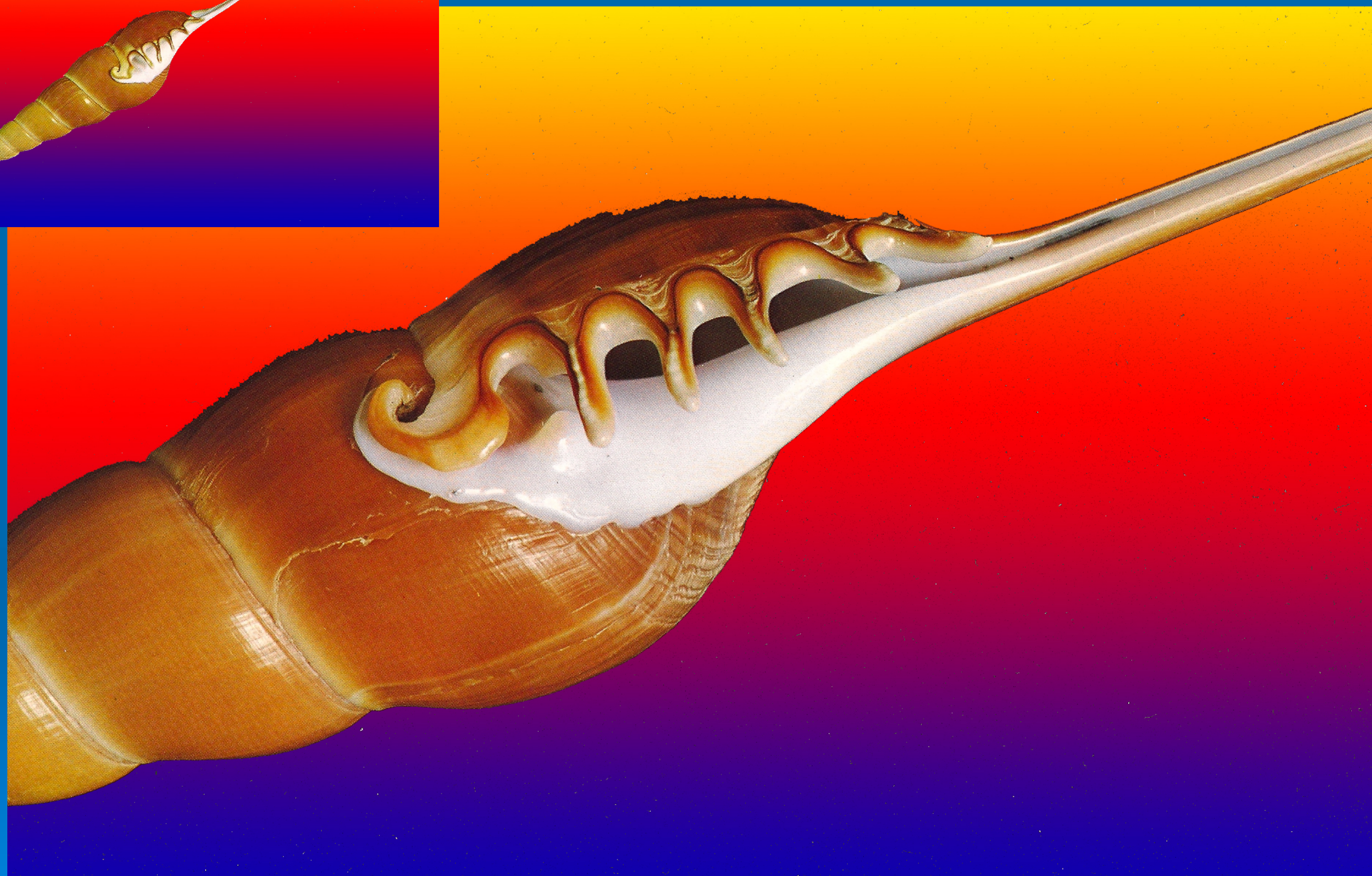
We are now visiting some shells with extraordinary and beautiful shapes, for the pure pleasure of delighting in nature's creations.

↑ Conch shell. (Image credit)

↑ *Epitonium scalare.* (Image credit)

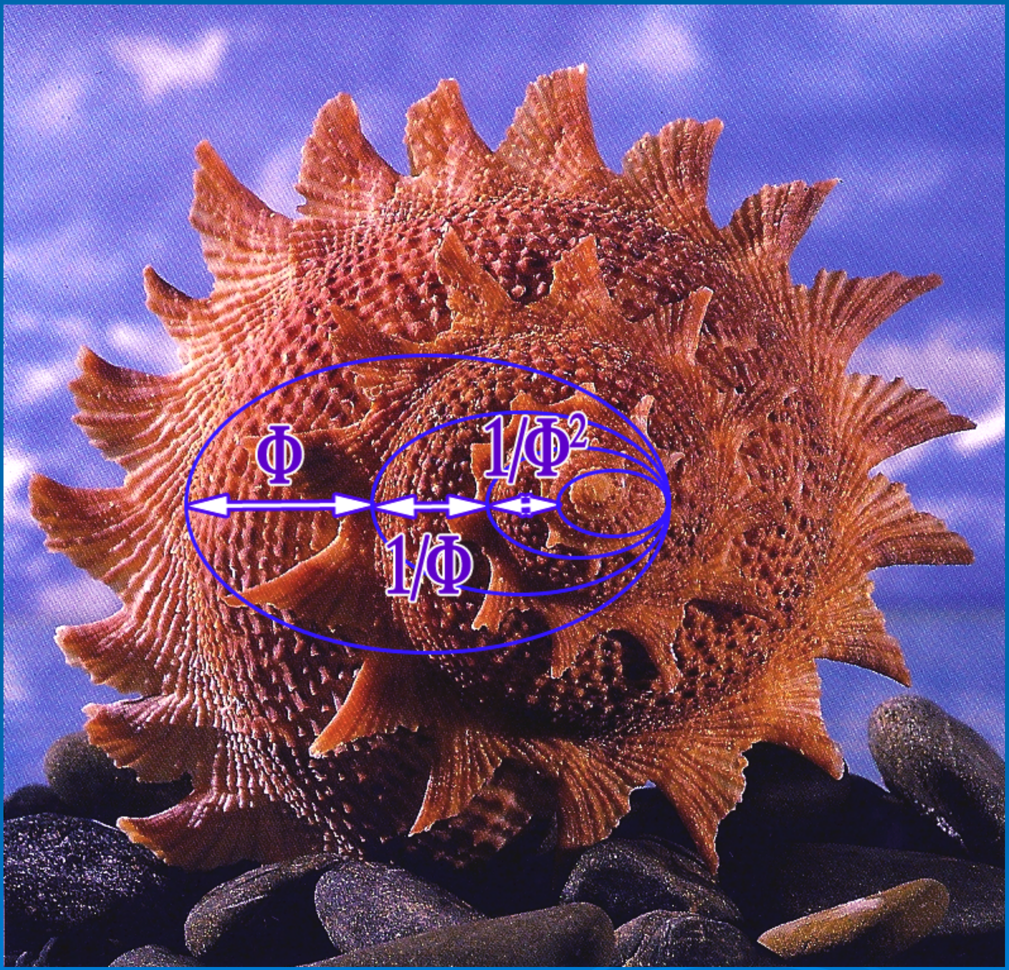
SG205B.9.12.2 Shells Gallery (2)





↑↑ *Tibia fusus* or "Spindle Tibia" belongs to the family Strombidae. To me, this shell is a marine hummingbird.
(Image: H. & M. Stix. *The Shell*.)

SG205B.9.12.3 Shells Gallery (3)

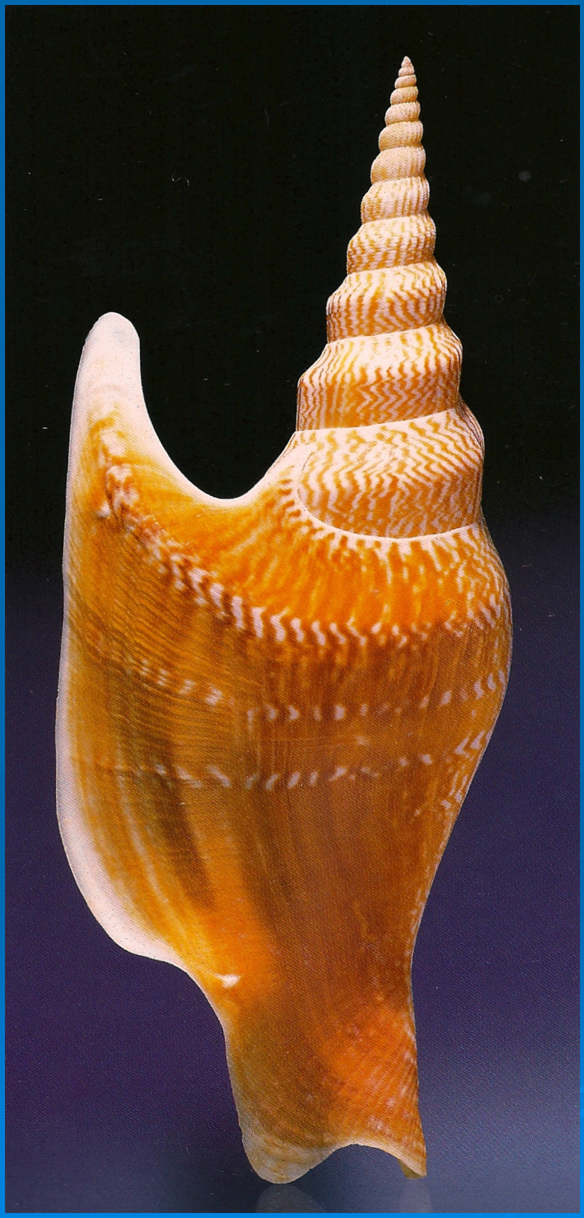


↑ *Astraea heliotropium* or "Sunburst Star Turban". Family Turbinidae. (Image: L. Hill & P. Carmihael. *The World's Most Beautiful Seashells*. 2004).

"The spectacular StarTurban was the talk of European collectors when the first specimen was displayed in 1773. Captain Cook's fleet returned to England that year with many shells from its Pacific explorations, but this species drew special attention…"

(Quote from *The World's Most Beautiful Seashells*. By L. Hill & P. Carmihael).

(Wikipedia).



SG205B.9.12.4
Shells Gallery (4)

🡐 *Strombus listeri* or "Lister Conch". Family Strombidae.

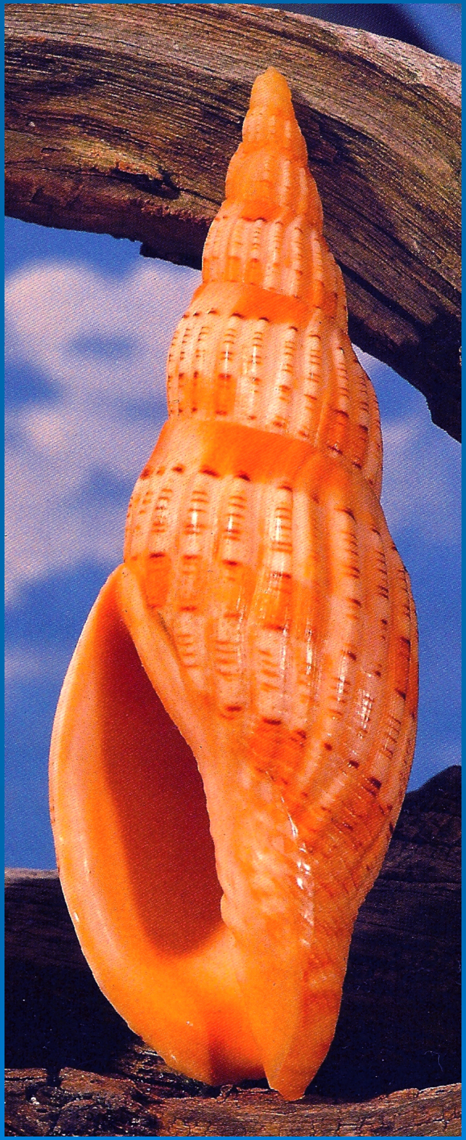
Some cape-draped being in a hieratic mudra gesture of greeting and welcoming.

Yes, the head is unusual but this is because this shell being has made visible the cascading levels of its crown chakra <smile>.

***Cochlespira pulchella* 🡒 or "Pagoda shell". Family Turridae.**

(Images: L. Hill & P. Carmihael. *The World's Most Beautiful Seashells*. 2004).

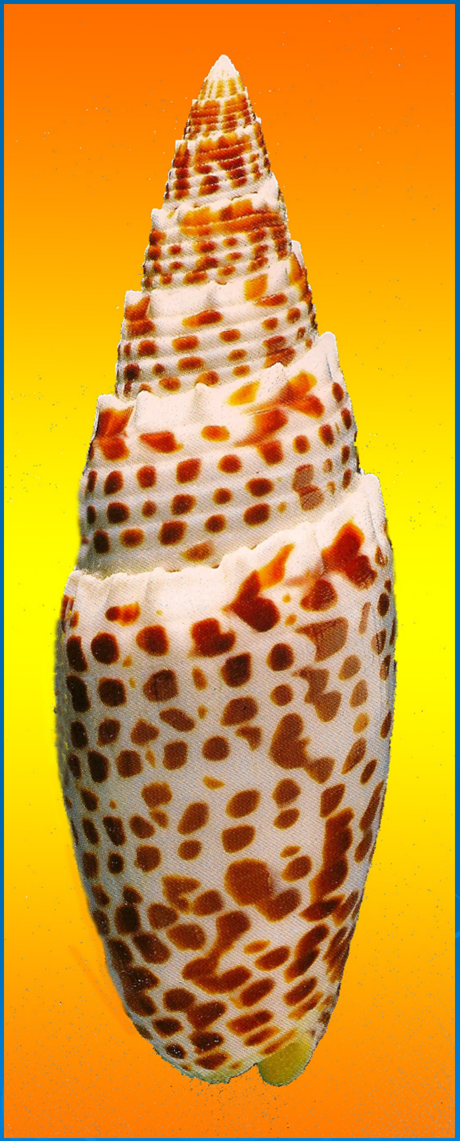
SG205B.9.12.5
Shells Gallery (5)



← *Lyria lyraeformis.*

Family Volutae.

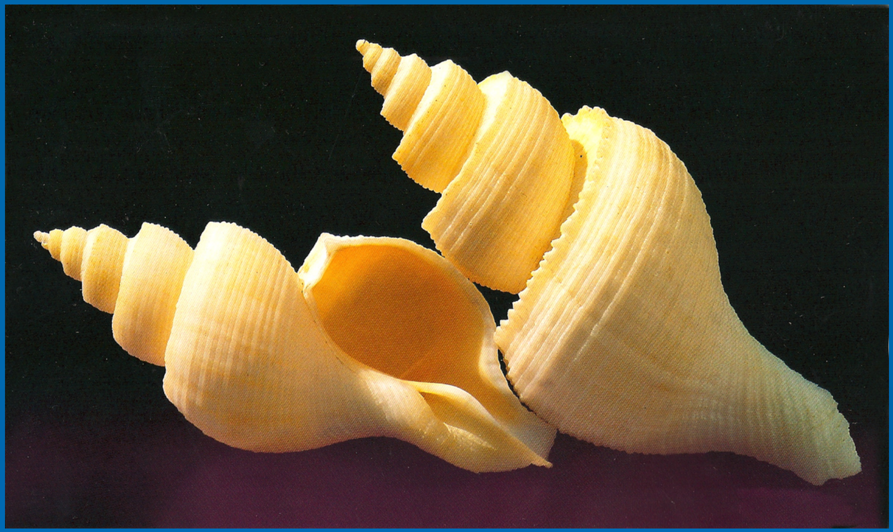
↑ *Amoria kawamurai*
Family Volutidae.



↑ *Mitra papalis*
Family Mitridae

(Images: L. Hill & P. Carmihael. *The World's Most Beautiful Seashells*. 2004).

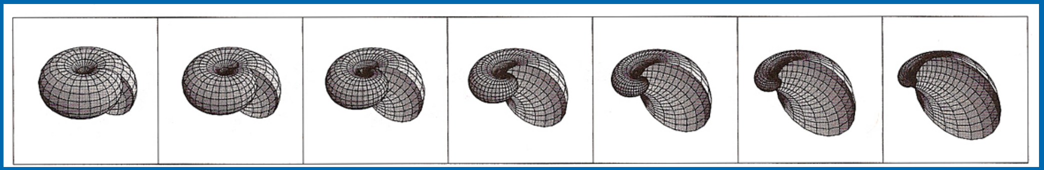
SG205B.9.12.6
Shells Gallery (6)



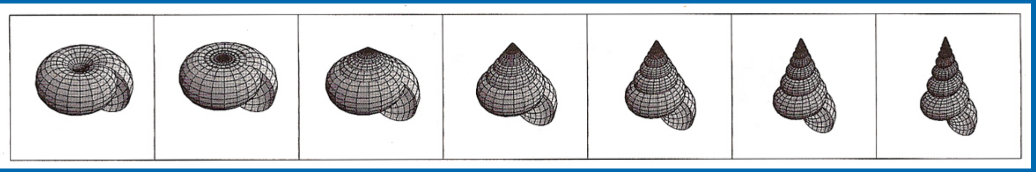
↑ ***Neptunea tabulata.*** **Family Bucchinidae.**
(L. Hill & P. Carmihael. *The World's Most Beautiful Seashells*. 2004).

↑ ***Tatcheria mirabilis*. Family Turridae.**
Image credit

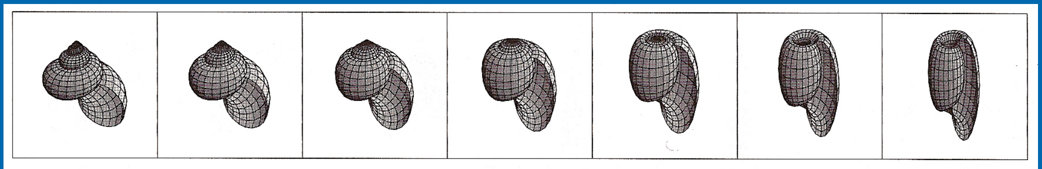
Interlude 6a. Computer Modeling of Shells (1) Simple Rules



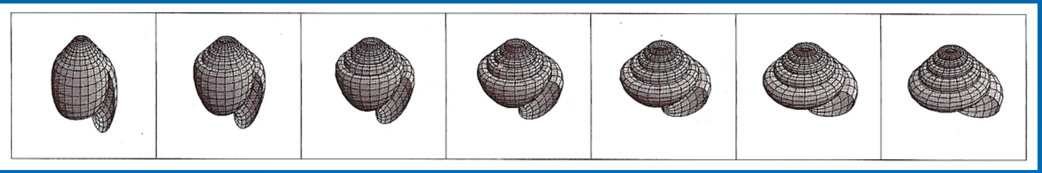
↑ Varying the overall factor by which the size increases in the course of each evolution.



↑ Varying the relative amount by which the opening is displaced downward at each revolution.



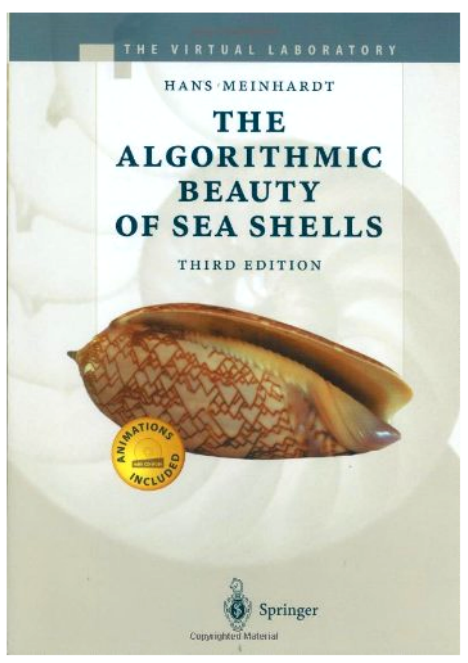
↑ Varying the elongation of the opening.



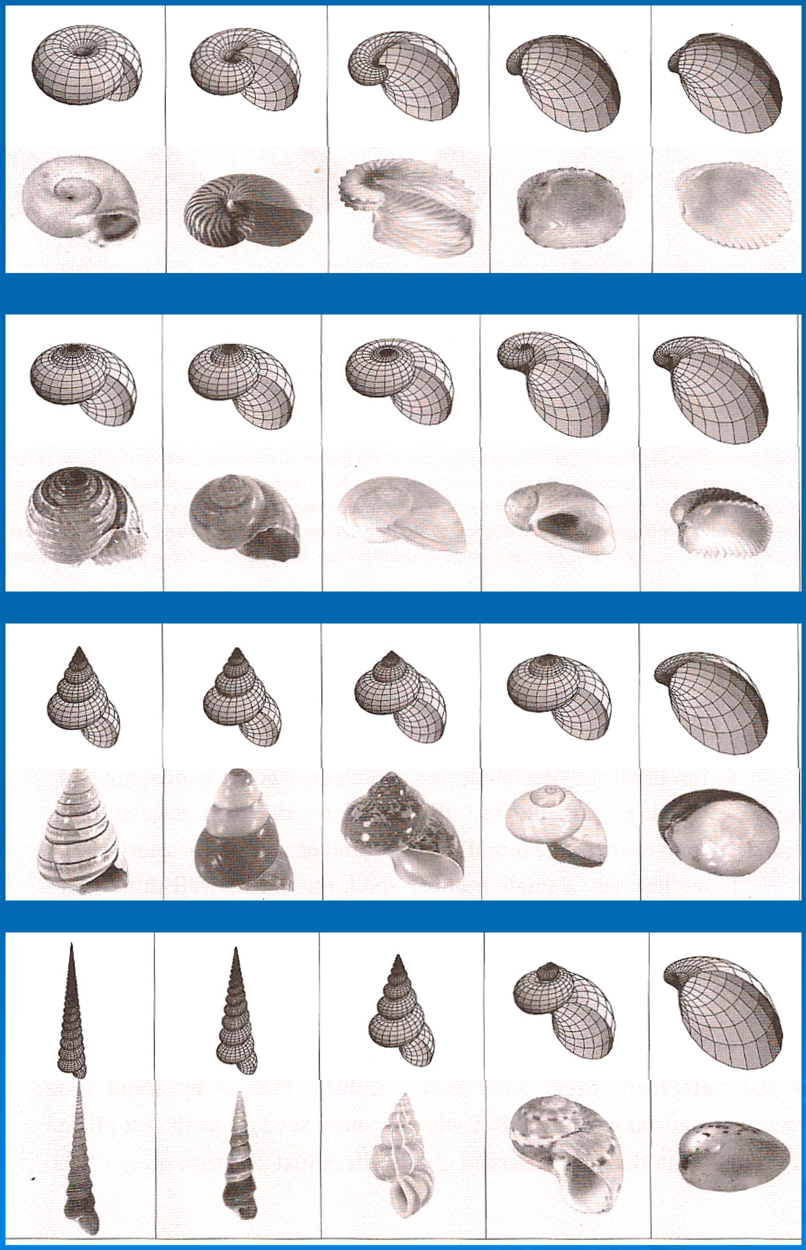
↑ Varying the orientation of elongation in the opening.

↑ A simple model for the growth of mollusk shells.
Stephen Wolfram in his "A New Kind of Science" illustrates the effects of varying simple features of the growth rates.

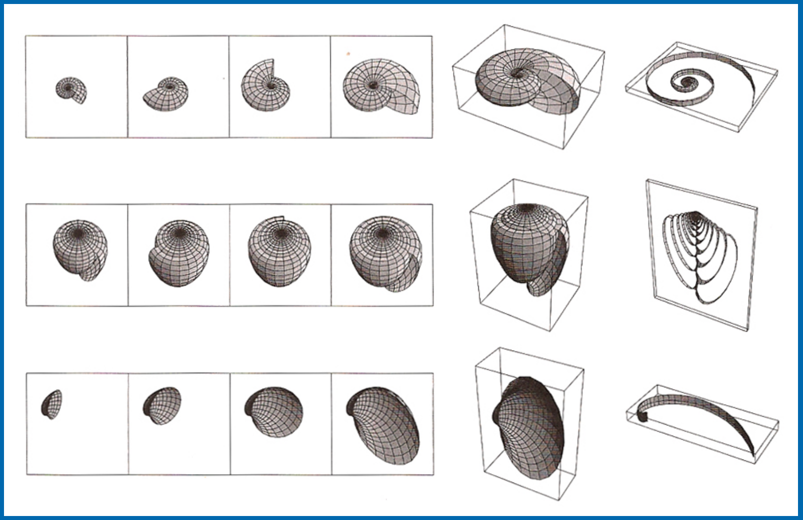
"It takes only very simple rules to produce highly complex behavior", says Wolfram. We ask: could the Phi ratio be the SIMPLEST rule there is in the universe?



↑ A classic primer on shell modeling by Hans Meinhardt, based on "local non-linear self-activation".
First published in 1995.
4th edition, 2009.



Interlude 6b. Computer Modeling of Shells (2)

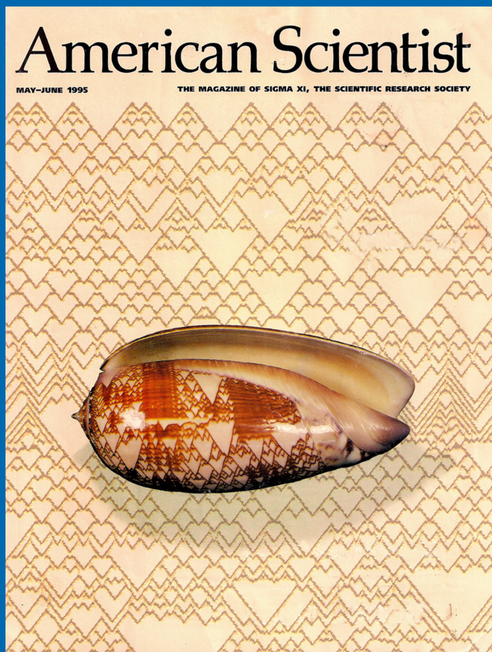


↑ In this model (by Stephen Wolfram) "new shell material is progressively added at the open end of the shell… All shells produced by adding material according to (such) fixed rules have the property that throughout their growth they maintain the same overall shape."

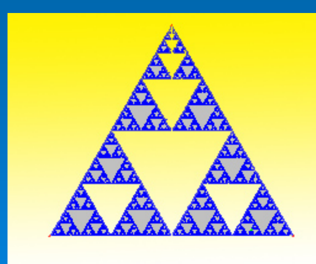
← Comparison between shell shapes generated by Wolfram's simple model and corresponding shapes of actual shells in nature.
"The remarkable fact is that all the shapes generated by varying growth rates are found in some kind of mollusk or another".

All images: Stephen Wolfram. *A New Kind of Science*. 2002

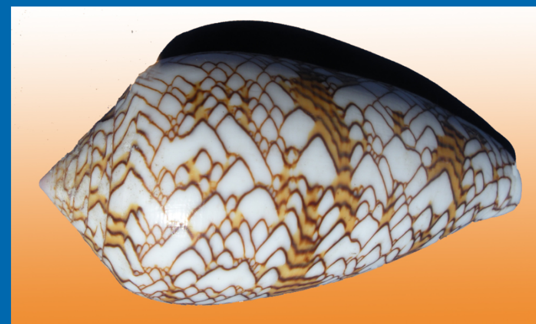
Interlude 6c. Shells & Fractal Markings



↑ Biologists & mathematicians have been trying to model the fractal-like patterns on some shells. One of the challenges is that the branch points are often correlated over long distances: when one line branches, others will also branch at the same time, thus pointing to a "master oscillator".



↑ The Sierpinski Triangle, a fractal [◆SG203A]



↑ Textile cone (*Conus textile*)

↑ Volute shell (*Cymbiola nobilis*)

↑ *Oliva porphyria.* Image: H. & M. Stix. *The Shell.*

Interlude 6d. Computer Shells & Neural Nets

A trio of scientists (Boettiger, Oster and Ermentrout) has created a "Neural Net" computer program able to generate the complex patterns of seashells using simple principles developed to explain how the brain works and how memories are stored.

The model explains how mollusks build their seashells based on the finding that the mollusk's tongue-like mantle, which overlaps the edge of the growing shell, senses or "tastes" the calcium carbonate layer laid down the day before in order to generate a new layer.

"The pattern on a seashell is the mollusk's memories," said Oster, a professor of environmental science, policy and management and of molecular and cell biology. "The shell is laid down in layers, so the mantle is sensing the history of the mollusk's 'thoughts' and extrapolating to the next layer, just like our brains project into the future."

The studies may help neuroscientists understand how neural networks work in the brain and throughout the body, where neural nets cover our skin and all internal organs.

The researchers' computer model reproduces nearly all known shell shapes, ranging from scallops to whelks. "The model gives us a remarkable ability to explain much of the dramatic diversity of both shape and pattern that we see in the natural world," Boettiger said.

🡅 In each of the pairs of pictures above, the right picture is generated by the new neural net seashell program. (ScienceDaily).

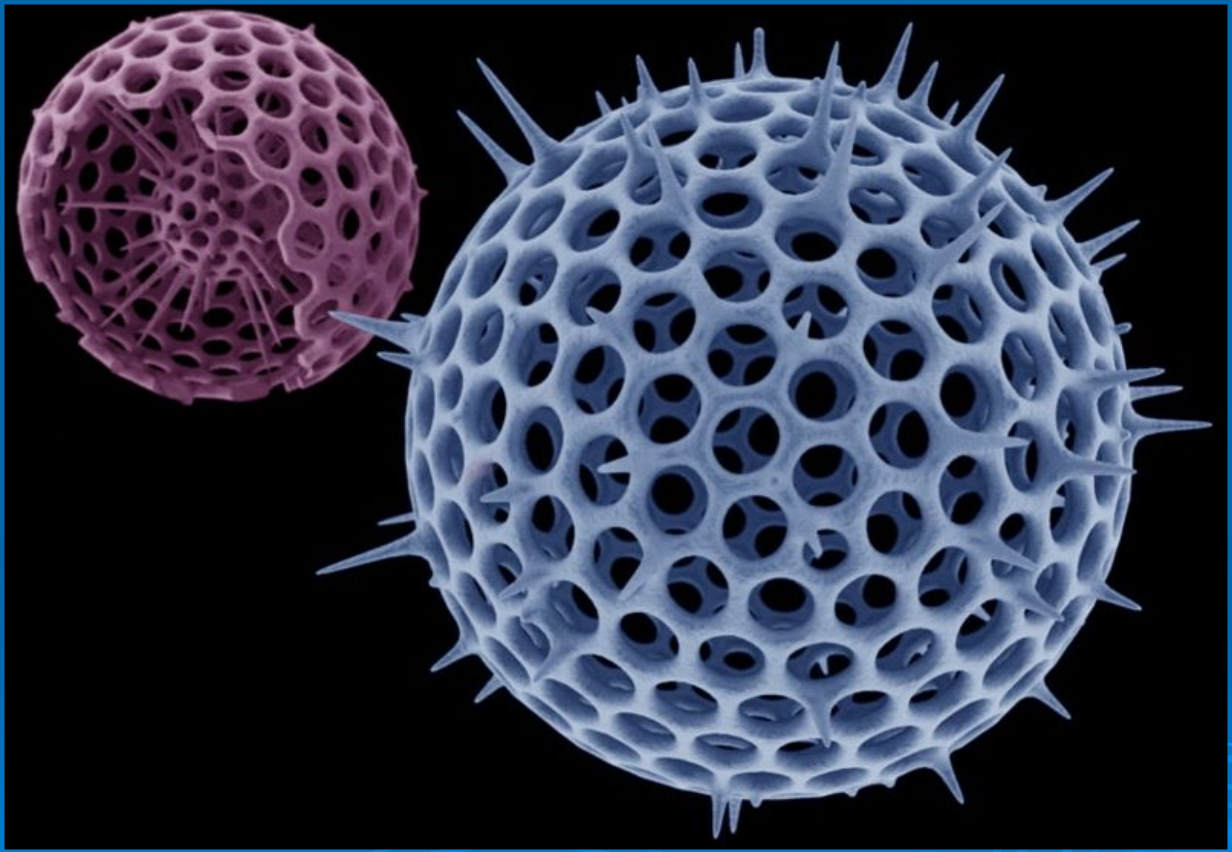
To build their model, the UC Berkeley scientists first studied electron microscope images of mollusk mantles in order to understand the network of neurons connecting the sensing cells in the mantle with the secretory cells that produce calcium carbonate and proteins - many of them colored pigments - incorporated into the growing shell. Different rates of calcium carbonate secretion determine the shape of the spiral, while different amounts of pigment secretion create a pattern unique to each species.

They then modeled the size of the excitatory and inhibitory regions surrounding the secretory cells and the cells' firing thresholds - nine parameters in all - as a neural network that determines how much calcium and pigment is secreted.

Based solely on these nine parameters, Boettiger, Oster and Ermentrout were able to reproduce the shapes and patterns of almost every known sea mollusk.

Credit: University of California - Berkeley.
"Mollusks Taste Memories To Build Shells." *ScienceDaily*, 2 Apr. 2009. Web. 4 Jul. 2011.

SG205B. Chapter 10. The Jewels of the Sea



🡡 Radiolarian. Reconstructed image by Michael Spaw. Credit.

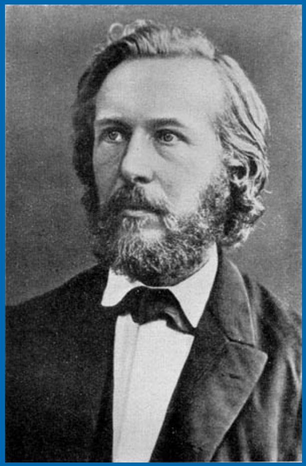
SG205B.10.1 Meet Ernst Haeckel

Ernst Haeckel (1834 -1919) was a biologist, an accomplished artist & illustrator and a flamboyant scientist who discovered thousands of new species and coined many terms in biology. He left magnificently illustrated atlases of animals and sea creatures which made *radiolaria* and *diatoms* public names.

With the eye of an artist, Haeckel was interested in the geometry & symmetries of biological forms. According to Olaf Breidbach: "In his volume *General Morphology of Organisms* (1866), Haeckel developed the idea that the evolution of the blueprints of the different species ought to be understood as the gradual development of increasingly complex symmetrical relations. In this way, he developed a kind of 'organic crystallography'. (Preface to *Art Forms From The Ocean*.)

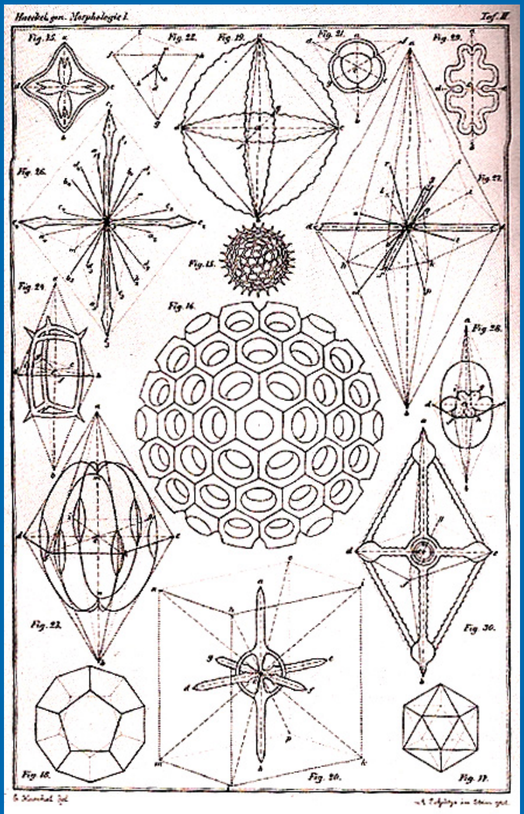
With the eye of a philosopher and a poet, Haeckel described a world in which "all forms are presented as the ornaments of a universal design framework". [Note: remember from SG101, "*cosmos*", in the Greek language, means order & beauty and refers to a universe conceived as
a divine ornament.]

The popularity of Haeckel's deep-sea creatures was such that architect René Binet modeled the gateway of the Paris World Fair of 1900 after one of Haeckel's radiolorians enlarged to gigantic proportions.

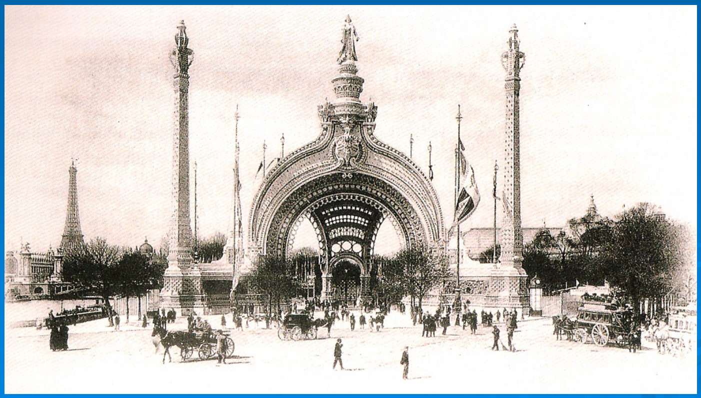


↑ Haeckel at age 26.

↑ Haeckel's microscope.



↑ Plate 2 of Ernst Haeckel's General Morphology of Organisms.
This plate shows "polyaxonal and homopolar organic forms".



← The gateway to the Paris World Fair (1900) was modeled after a radiolarian drawing by Haeckel.

SG205B.10.2 Radiolarians

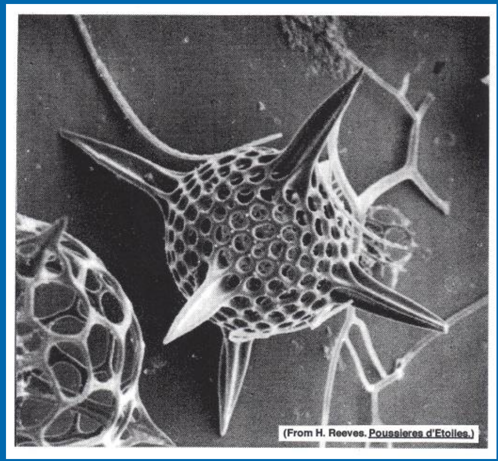
Radiolarian (from Latin *radiolus* = small sunbeam).

Radiolarians are any of 3 classes (Acantharia, Polycystina, and Phaedoria) of usually spherical marine protozoa having radiating needlelike pseudopodia. Radiolarians produce intricate mineral skeletons.

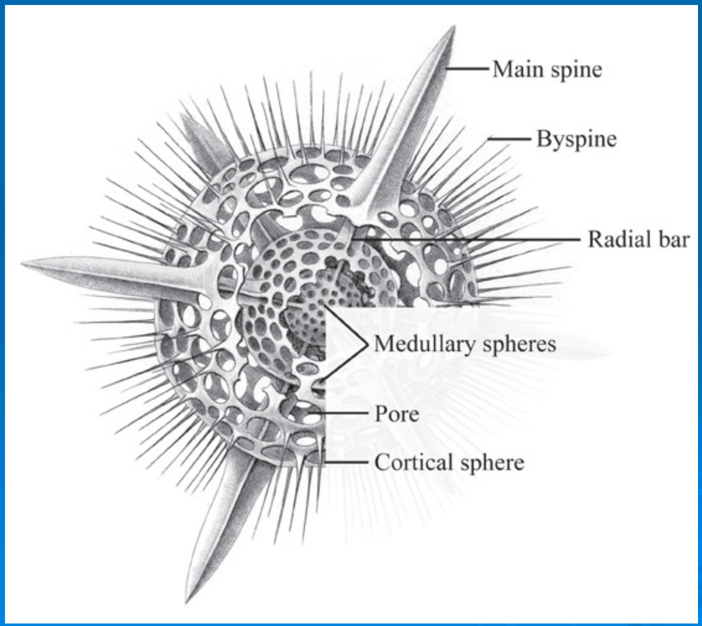
Radiolarians are commonly called the *"living jewels of the sea".* These tiny single-celled organisms drift among the plankton of the oceans. Their fossil (skeletal) remains cover large portions of the ocean floor.

Radiolarians make their skeletons from silica (the basic material of sand). The skeleton of the radiolarian encloses the nucleus of the cell, and the rest of the cell material flows round, streaming out trough the geometric-shaped openings in long filaments of sticky protoplasm which traps other species of plankton.

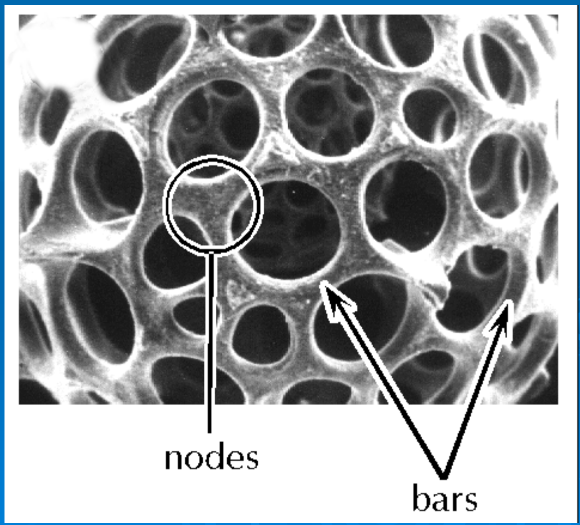
The fossil remains of radiolarians are beautiful examples of micro-jewelry in nature, some of them exhibiting startlingly precise geometric shapes. *"Some radiolarians are known for their resemblance to regular polyhedra"*. (Wikipedia) [see next page]. It has been said that, under the microscope, a group of radiolarians looks like *"a cluster of stars in the oceanic universe"*.



↑ (From H. Reeves. *Poussières d'Etoiles.*)



← Structure of a radiolarian (*Spumellaria*). Original image by Haeckel. Modified by J. Dolven. //tolweb.org

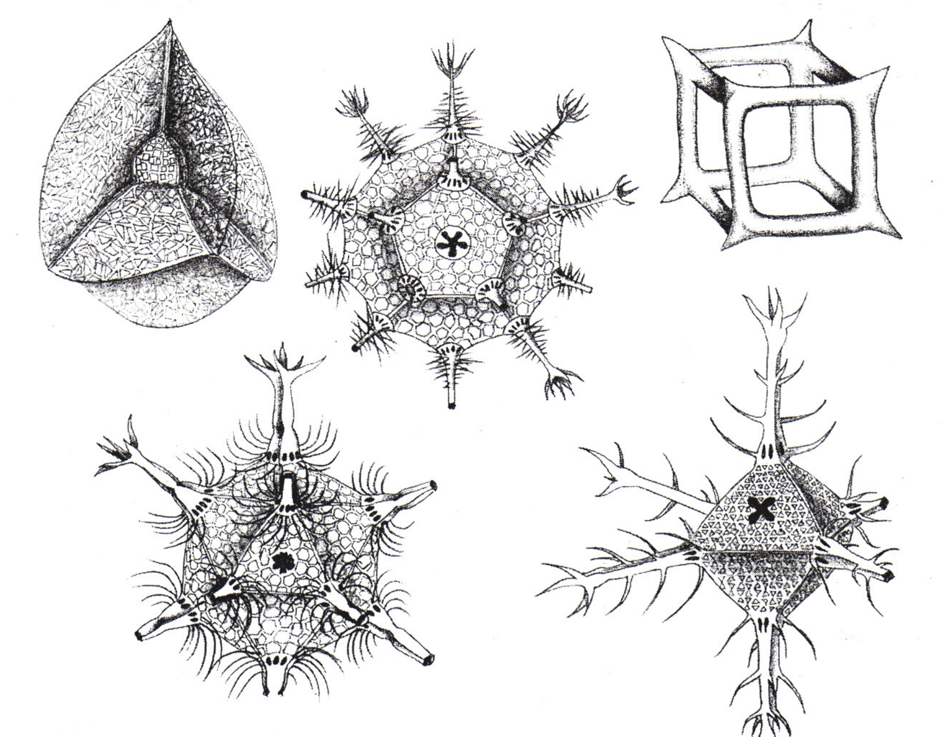


//palaeo-electronica.org

SG205B.10.3.1 Radiolarians by Ernst Haeckel (1)

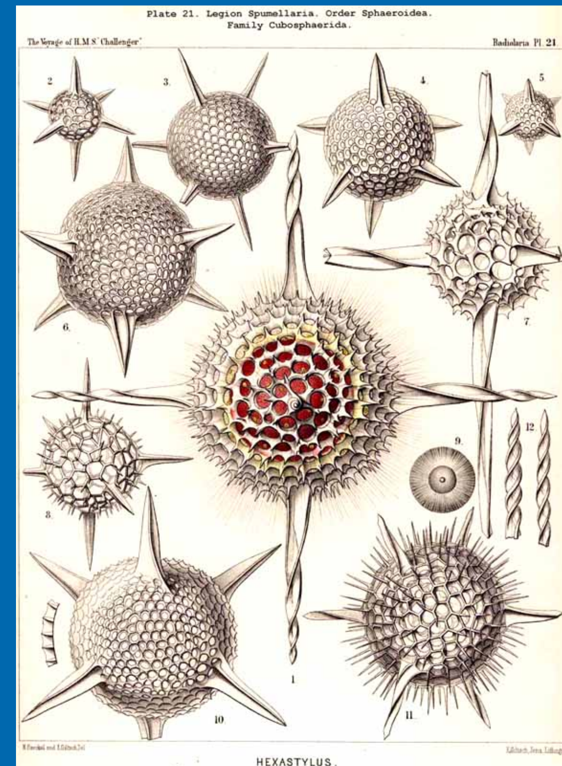
"The happiest day of my whole life was when I set out early as ever with my fine net to fish, and I caught no less than 12 new species (of radiolarians); the most charming creatures were among them! A lucky catch that made me half demented with joy. I knelt down in front of my microscope and cried my heartfelt thanks to the blue sea…"

(Ernst Haeckel. Letter, February 16th, 1860).

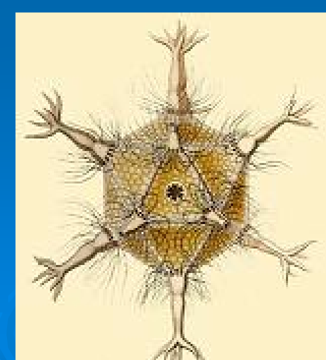


The 5 Platonic Solids are well represented in the Radiolarian world.
(From Lawrence Blair. Rhythms of Vision. 1975.)
Note: The drawings were originally done by Ernst Haeckel. 1904.

↑ This most famous collage of five drawings of radiolarians by Ernst Haeckel has appeared in many Sacred Geometry books.

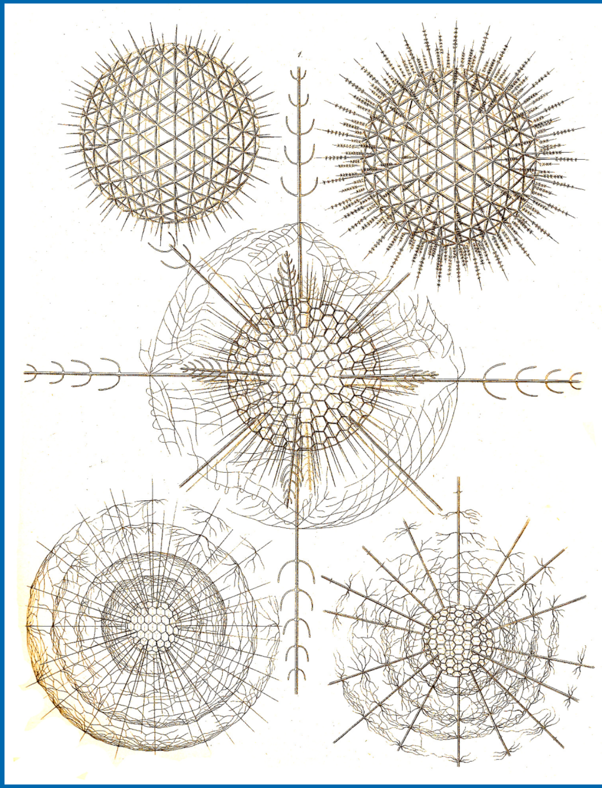


↑ "Challenger" Plate #21 By Haeckel.

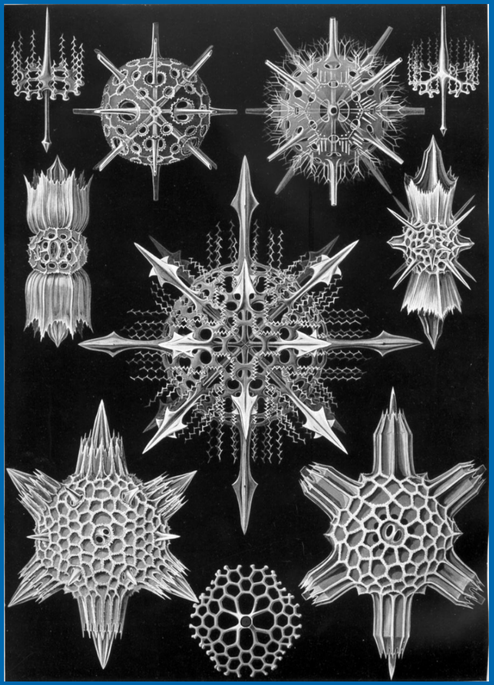


← *Circogonia icosahedra*, a species of Radiolaria, shaped like a regular icosahedron. (Wikipedia)

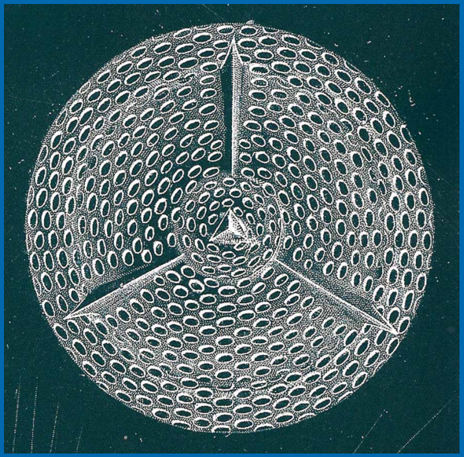
SG205B.10.3.2 Radiolarians by Ernst Haeckel (2)



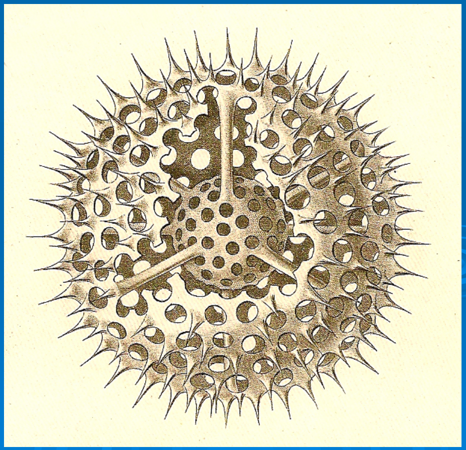
↑ Plate X. *Arts Forms from the Ocean*.



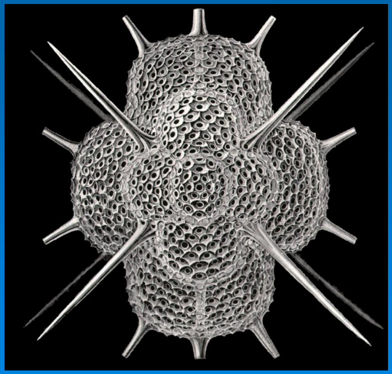
↑ Plate 41. *Art Forms in Nature.*



↑ ***Eucyrtidium carinatum***
Plate VII. ***Art Forms from the Ocean.***

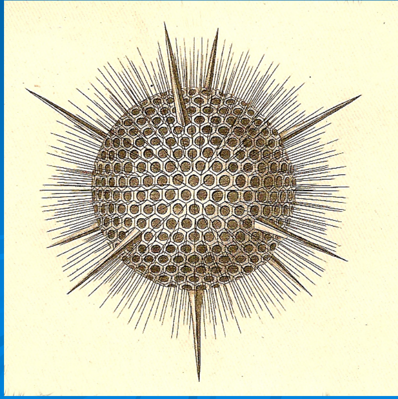


↑ ***Haliomma castenea***

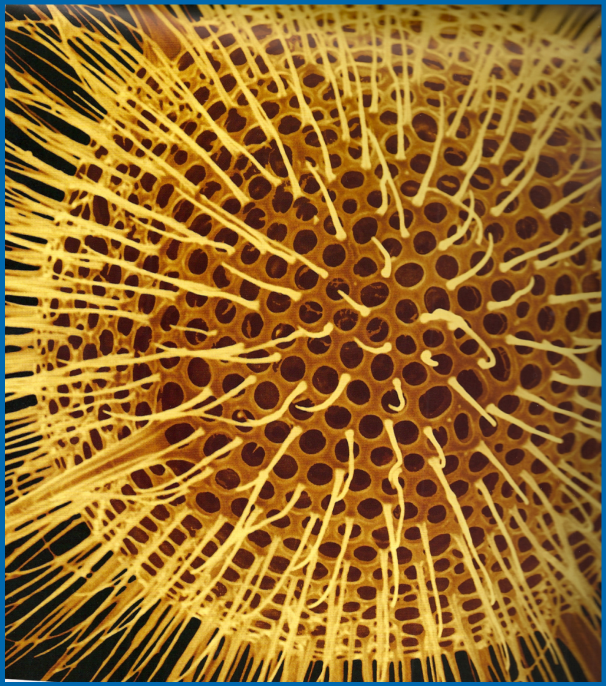


← ***Tholoma metallasson***

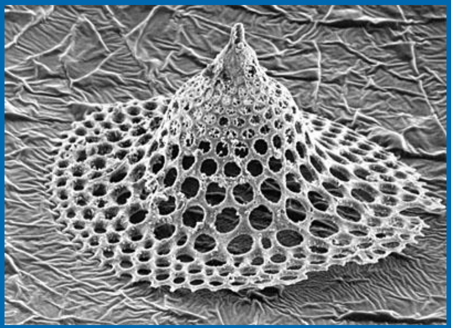
→ ***Haliomma echinaster***



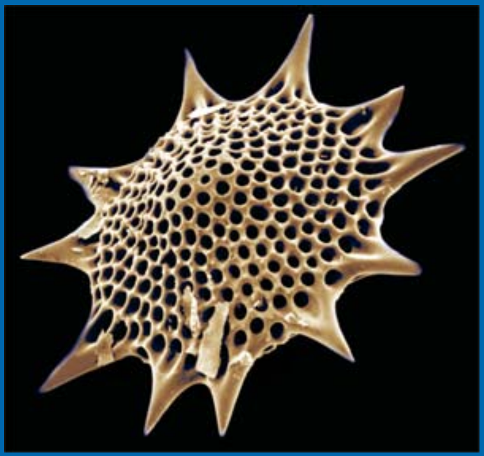
(←↑ Plate XXIV.
***Art Forms from the Ocean*).**



SG205B.10.4.1 More Radiolarians (1)



www.gns.cri.nz

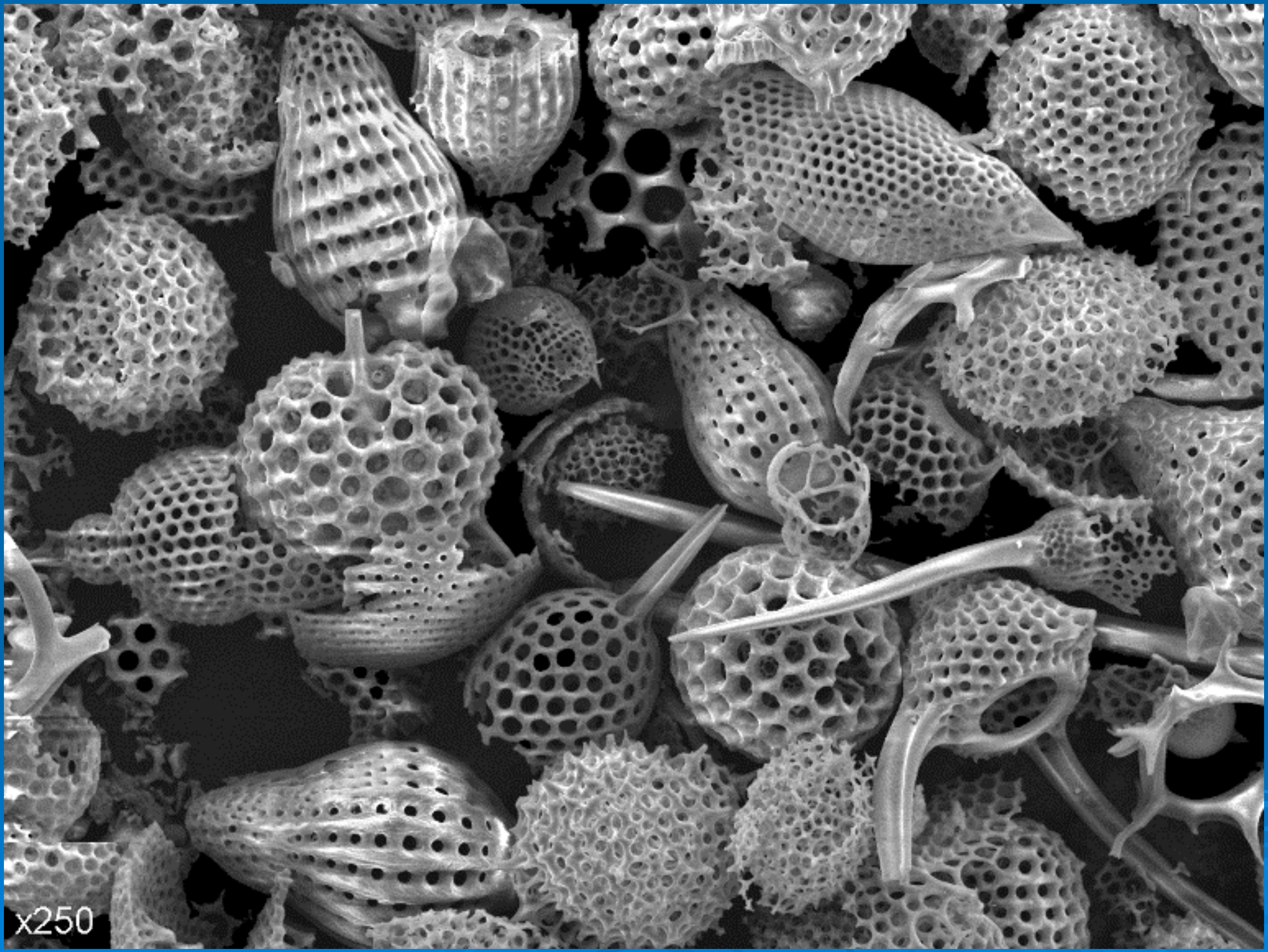


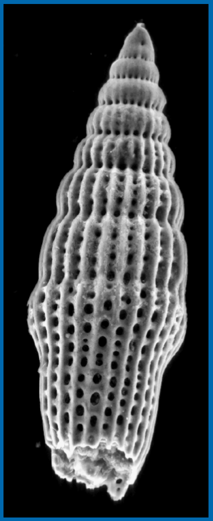
↑ //incrediblebeings.wordpress.com

psmicrographs.co.uk

www.biol.tsukuba.ac.jp

SG205B.10.4.2 More Radiolarians (2)

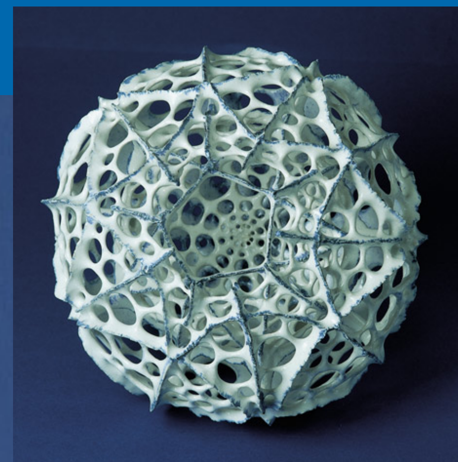


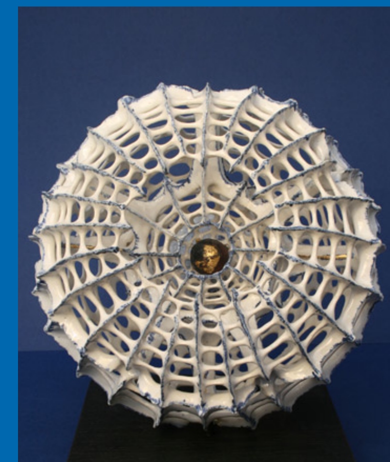


www.ucmp.
berkeley.edu

www.nestlaboratory.com

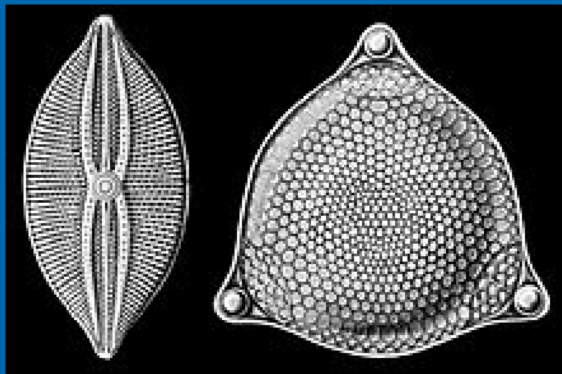
SG205B.10.5 Radiolarian Art





Art by German ceramicist Gehard Lutz.
www.lutz-tonkunst.de

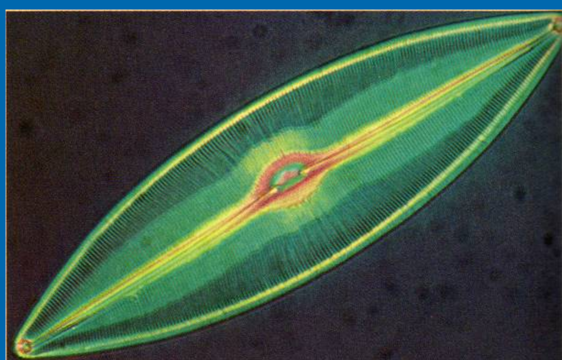
SG205B.10.6.1 Diatoms (1)

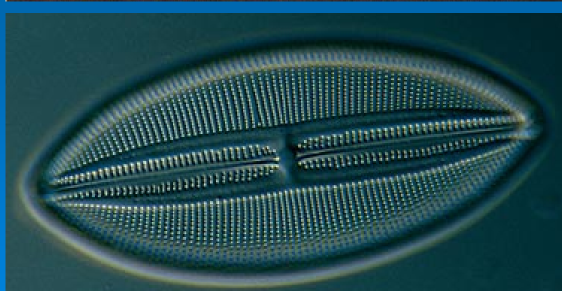


🡅 Selections from Ernst Haeckel's Art Forms of Nature (1904), showing pennate (left) and centric (right) frustules. (Wikipedia)

Diatoms are photosynthesizing algae and one of the most common types of phytoplankton. They form the base of the marine life food chain by contributing up to 45% of the total oceanic production of organic compounds. There are more than 200 genera (the next level up above species) of living diatoms, and it is estimated that there are approximately 100,000 extant species. Diatoms also provide a major portion of earth's oxygen supply.

Diatoms generally range in size from ca. 2-200 µm. Most diatoms are unicellular, although they can exist as colonies. A characteristic feature of diatom cells is that they are encased within a unique cell wall made of silica. This wall, called a *frustule*, is highly differentiated. It consists of two large beautifully sculptured units called *valves* with a split between them (hence the group name: "*dia*" = two + "*tome*" = to cut). There are also linking structures termed *girdle elements*. Each species is characterized by a particular shape and geometric decoration of the valves. Diatoms are traditionally divided into two orders: centric diatoms (*Centrales*), which are radially symmetric, and pennate diatoms (*Pennales*), which are bilaterally symmetric.



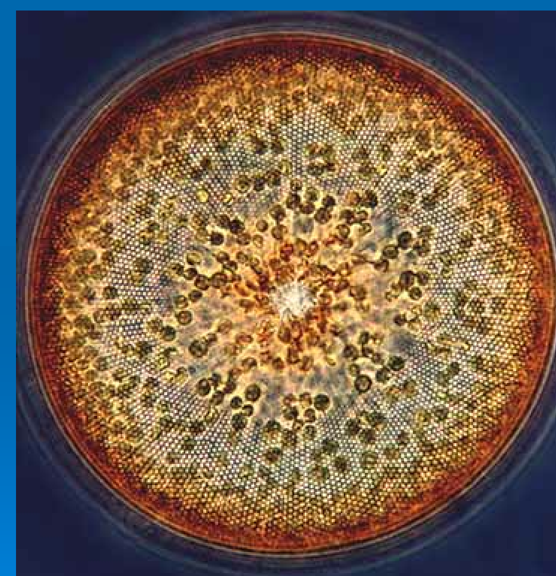


🡄 Two examples of pennate diatoms.

www.microscopy-uk.org.uk

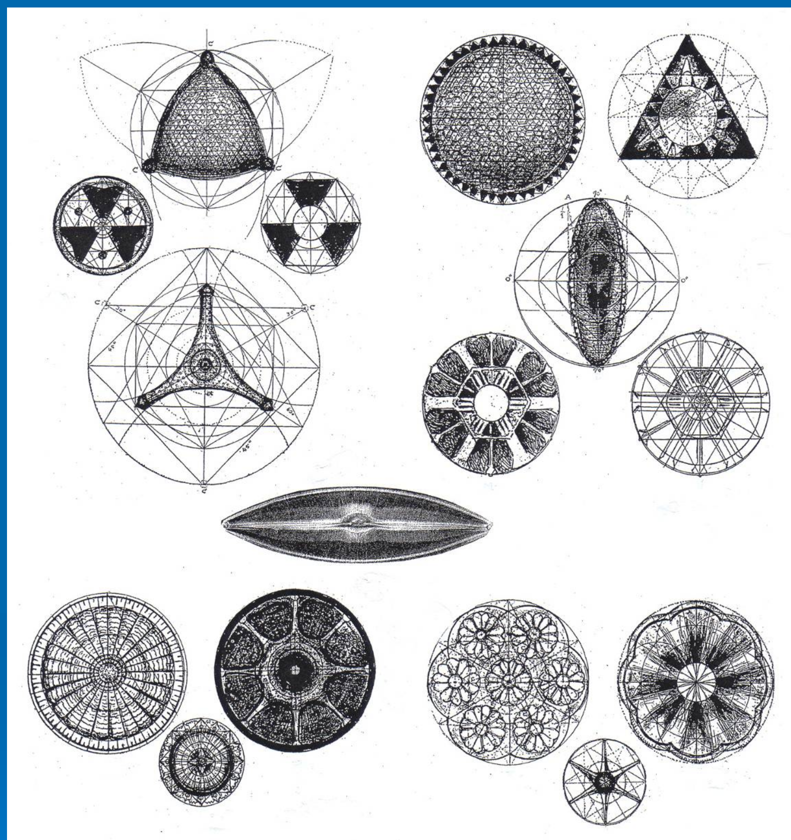
🡆 top view of a large centric diatom (*Coscinodiscus*), a marine species that can just be seen with the naked eye.

Clearly visible is the fine net-like structure of the siliceous cell wall.

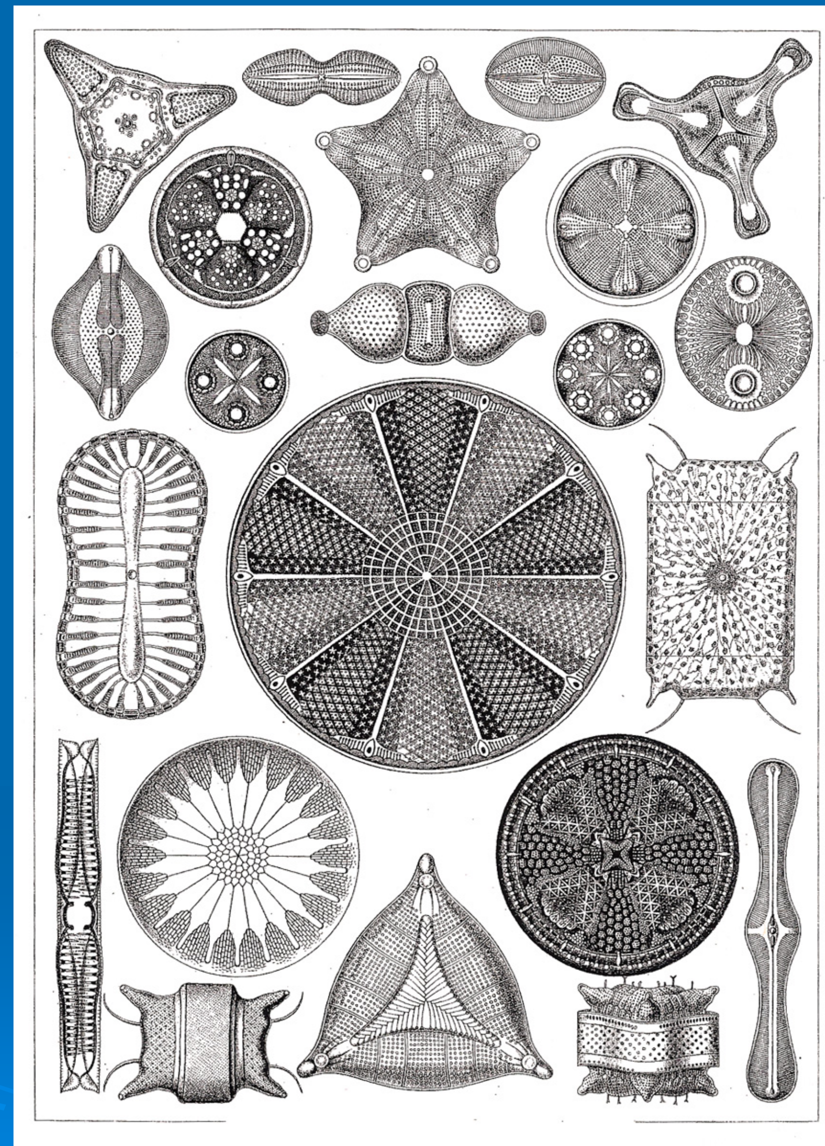


www.microscopy-uk.org.uk

SG205B.10.6.2 Diatoms (2)
Early Renditions



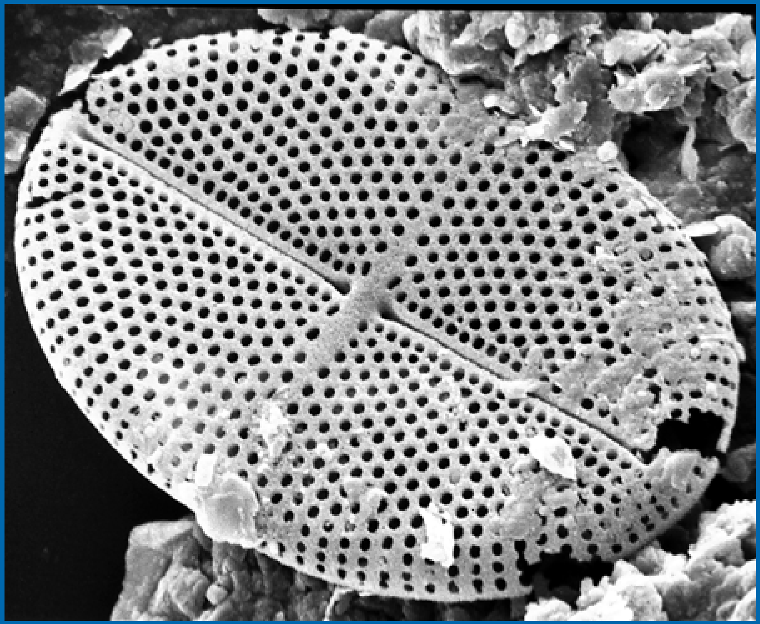
Early geometric renditions of diatoms.
Samuel Colman, 1911)



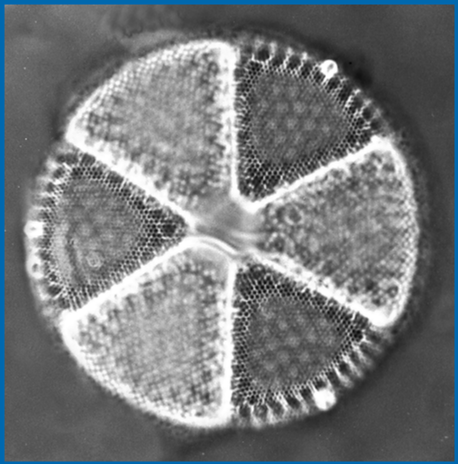
↑ Plate 4 of *Arts Forms in Nature* by Ernst Haeckel. 1904.

SG205B.10.7 Diatom Geometries

Diatoms come in various geometries.

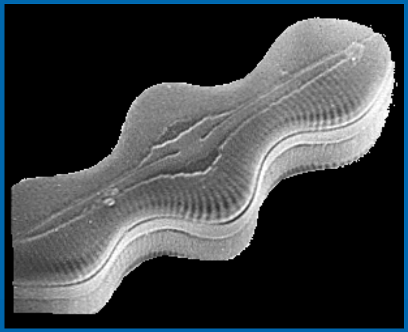


🡩 *Cocconeis molesta var. crucifera* Grunow SEM micrograph. www.ucl.ac.uk



***Actinoptychus senarius* Ehrenberg 🡪 www.ucl.ac.uk**

🡨 SEM micrograph of *Cyclotella stelligera* www.indiana.edu

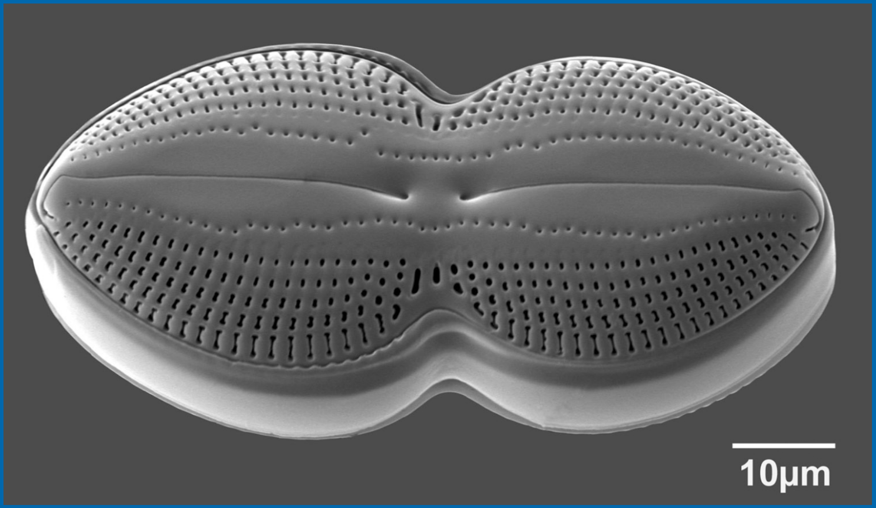


🡩 *Caloneis* species www.bgsu.edu

🡨 *Synedra* species. www.bgsu.edu

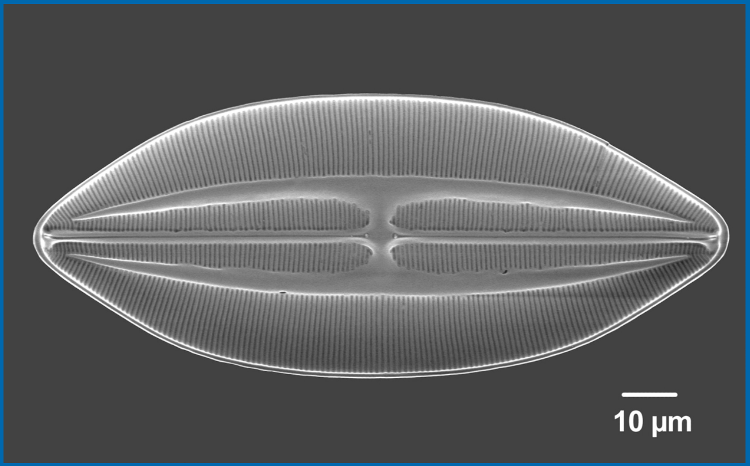
SG205B.10.8.1 Diatom Loir Gallery (1)

See the beautiful diatom gallery assembled by Maurice Loir, a French biologist.
http://www.diatomloir.eu

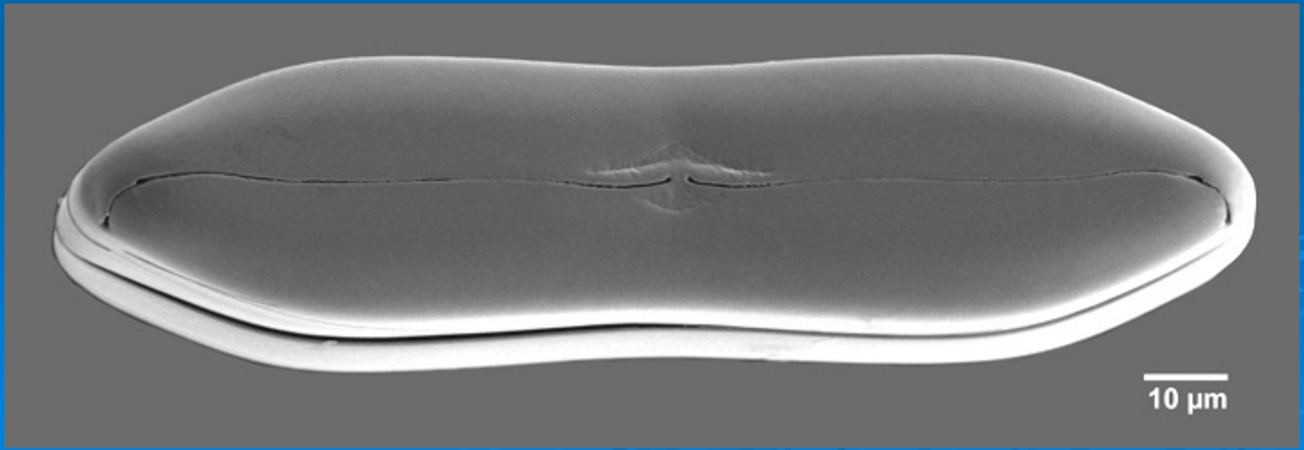


🡅 Diplobombus

http://www.diatomloir.eu

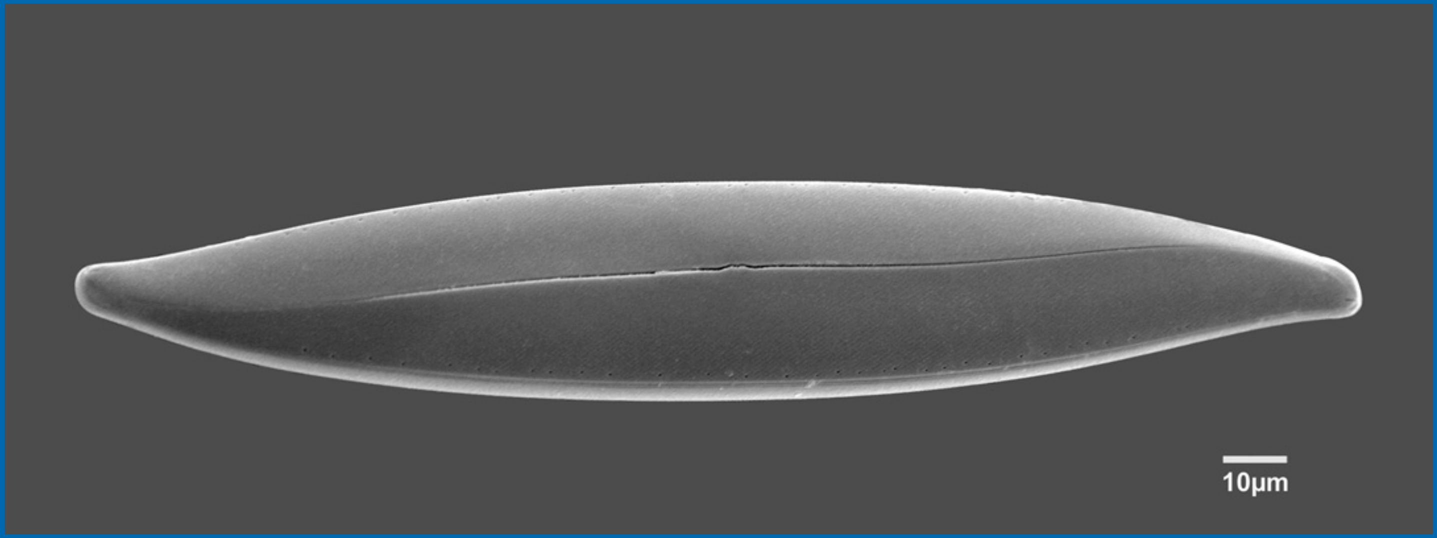


🡅 Lyrella



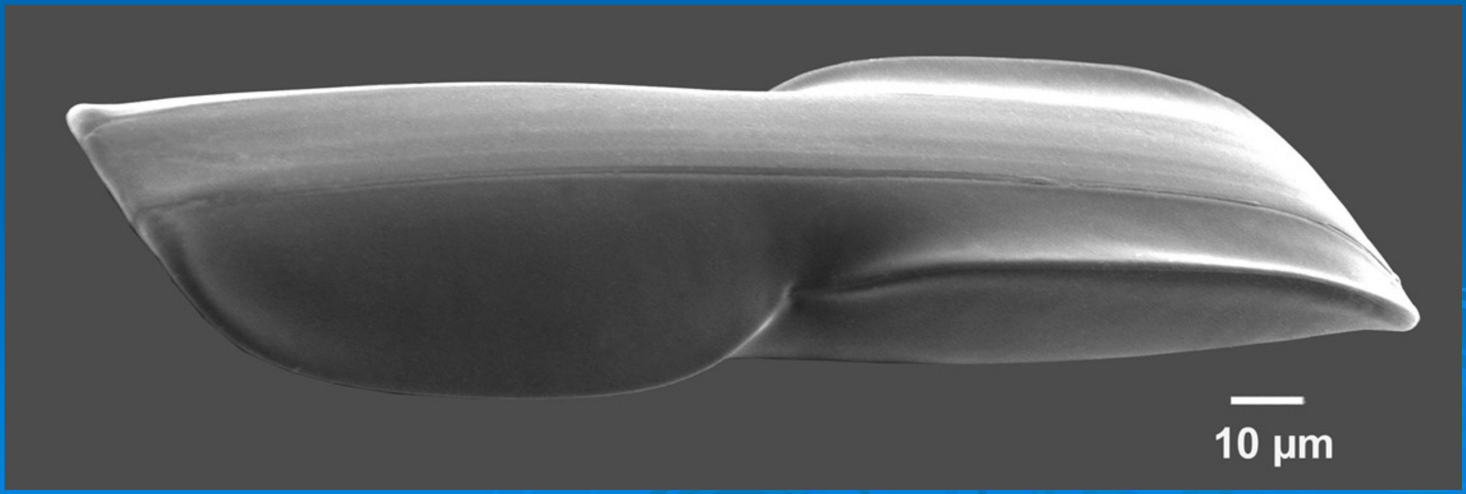
🡄 Caloneis

SG205B. 10.8.2. Diatom Loir Gallery (2)



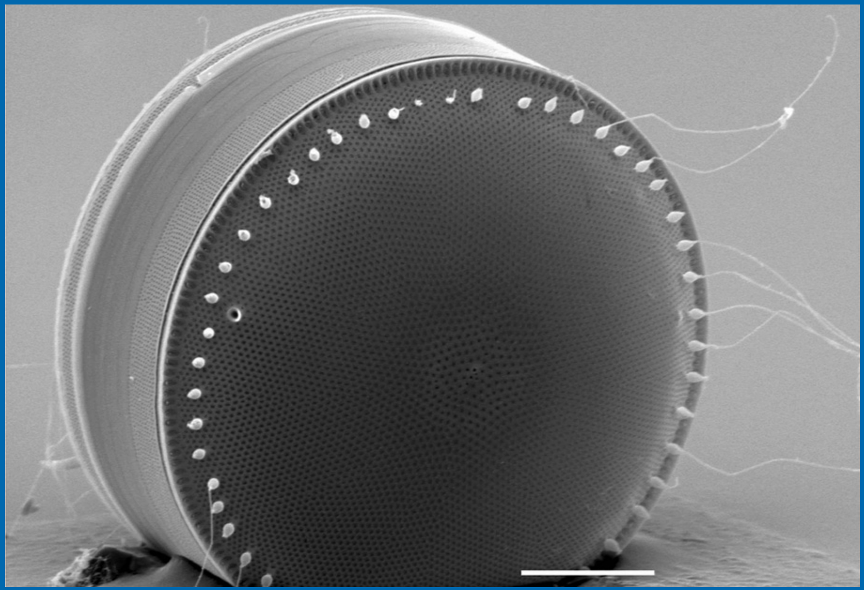
↑ Pleurosigma

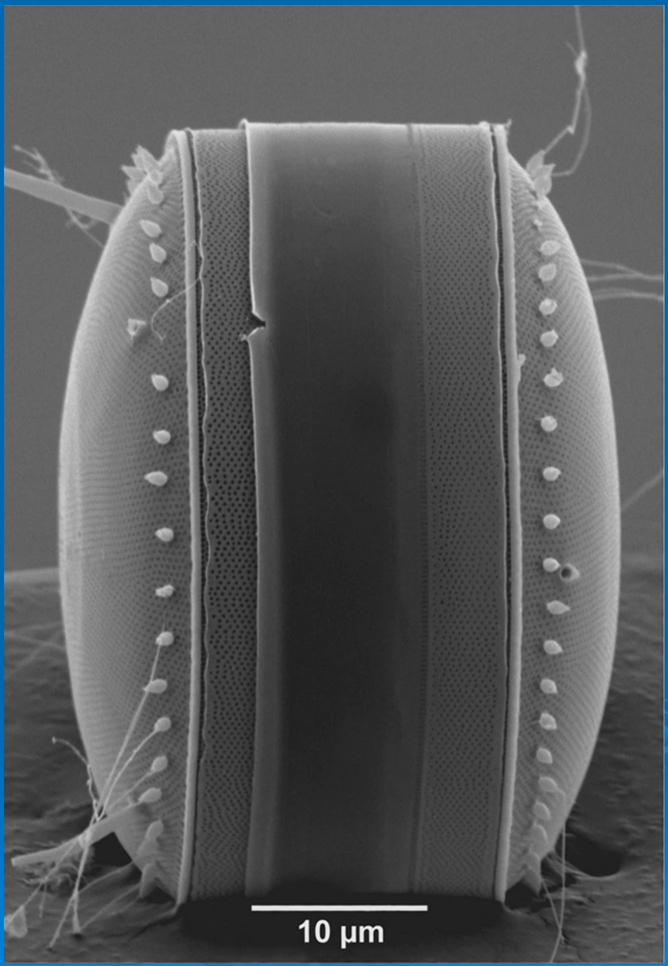
http://www.diatomloir.eu



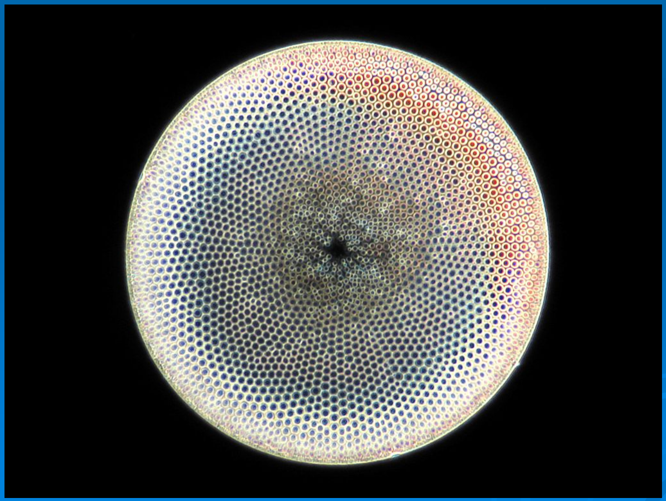
← Donkinia

SG205B.10.8.3 Diatom Loir Gallery (3)





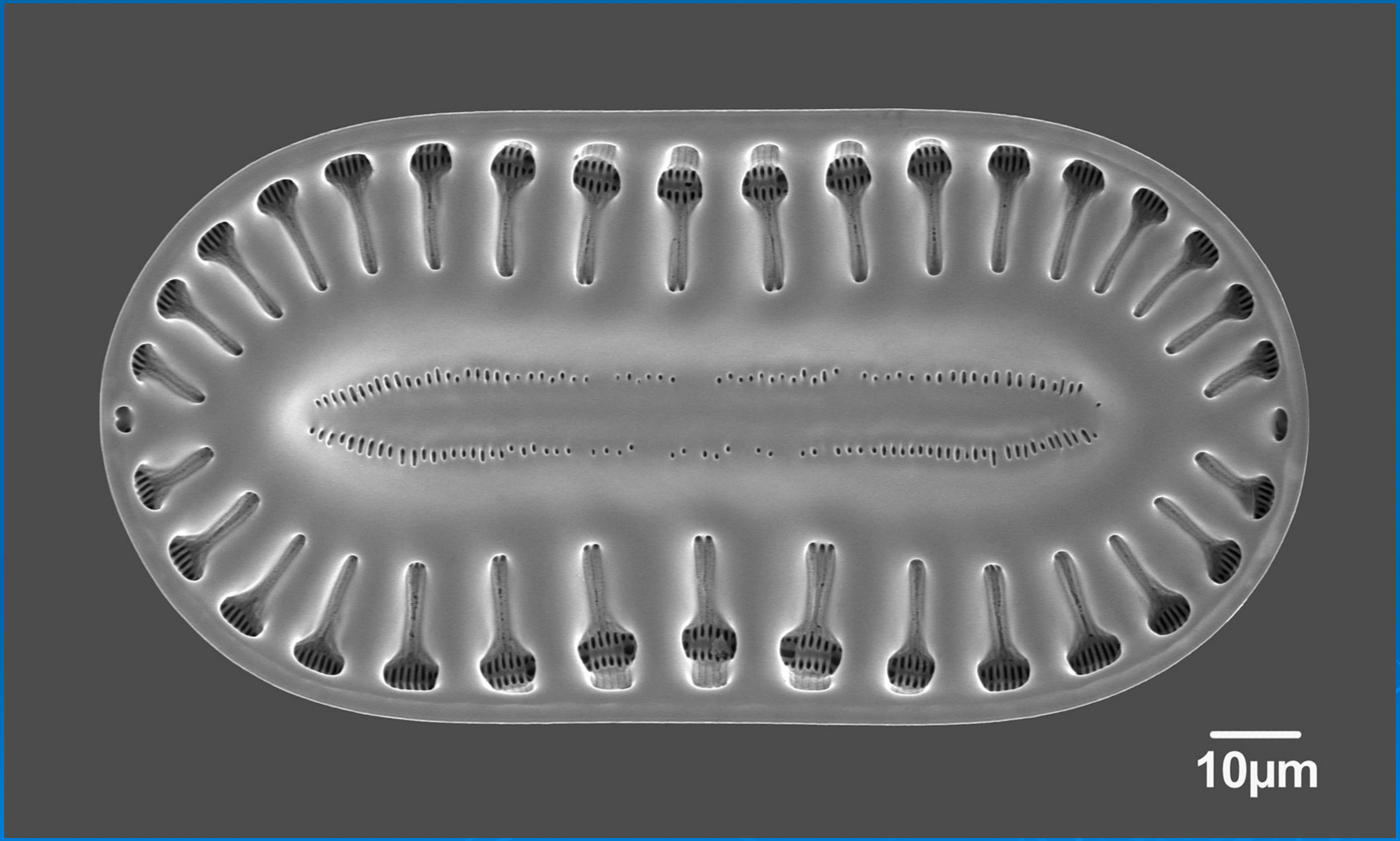
↑→ Coscinodiscus thalassiosira punctigera



← Coscinodiscus Oculus Iridis

http://www.diatomloir.eu

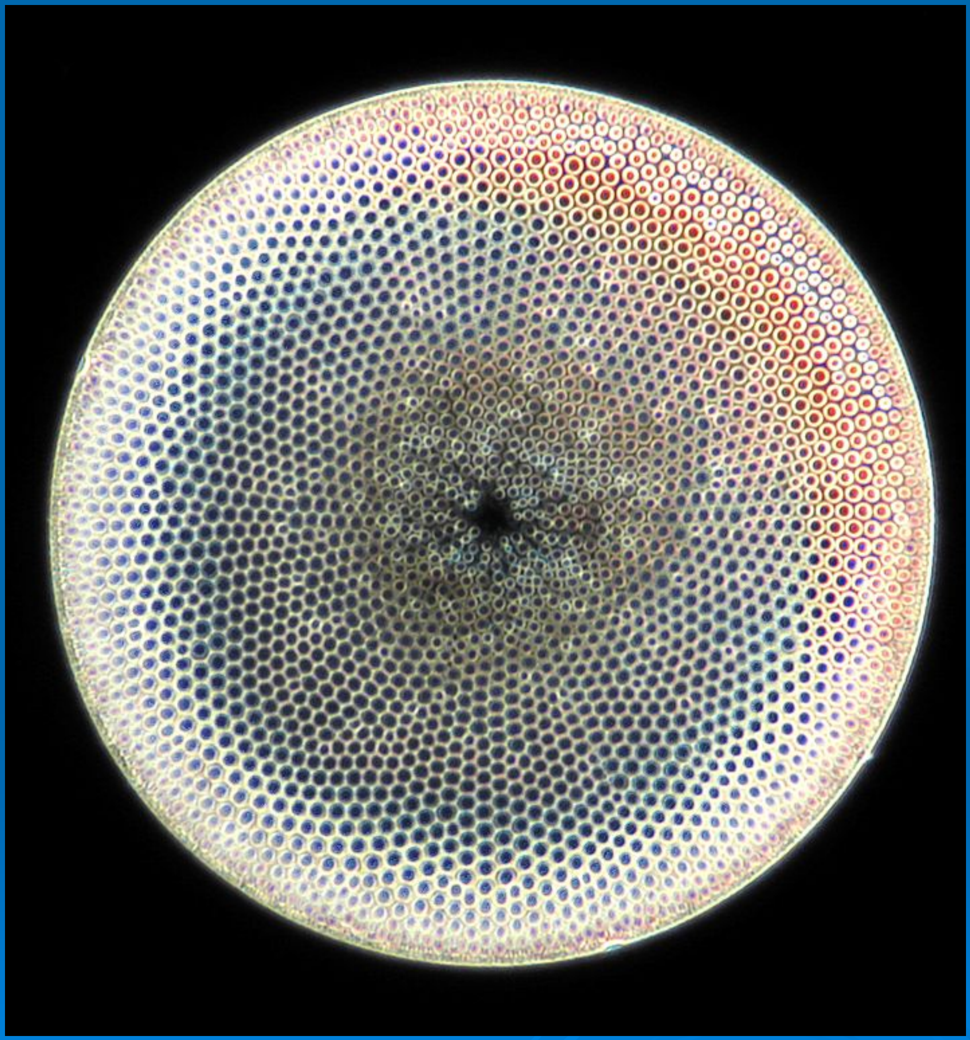
SG205B.10.8.4 Diatom Loir Gallery (4)

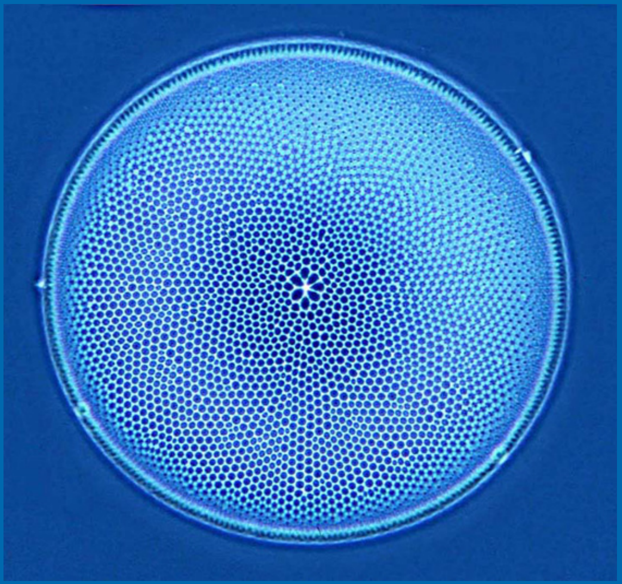


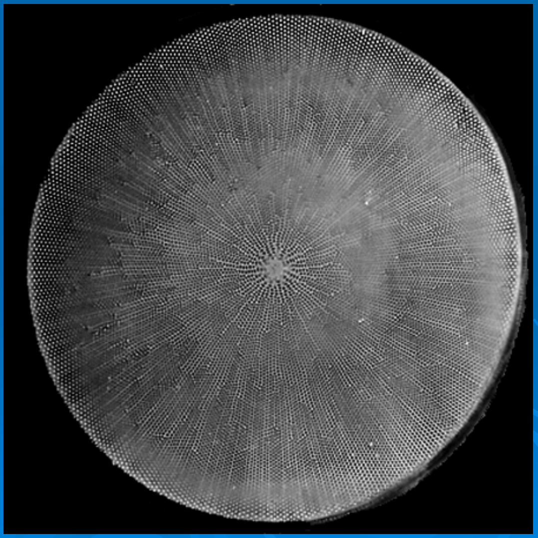
↑ Suricella

http://www.diatomloir.eu

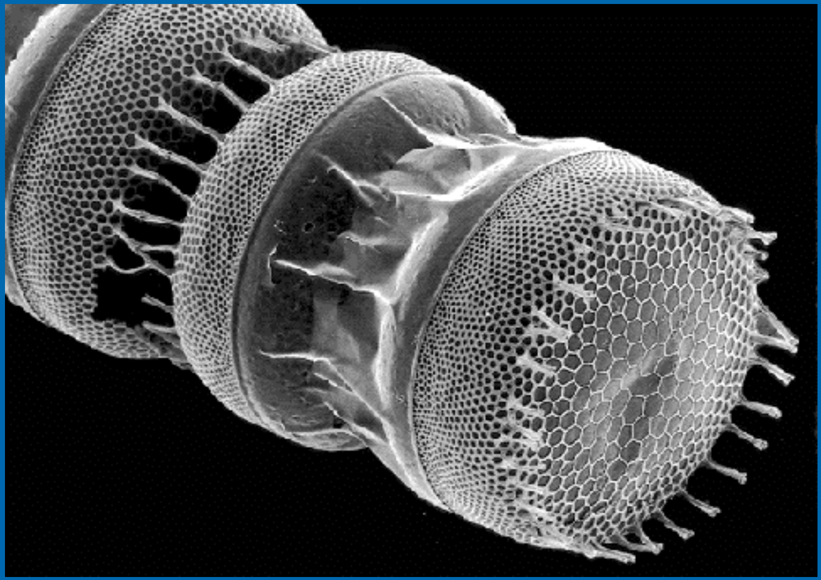
SG205B.10.9 More Coscinodiscus



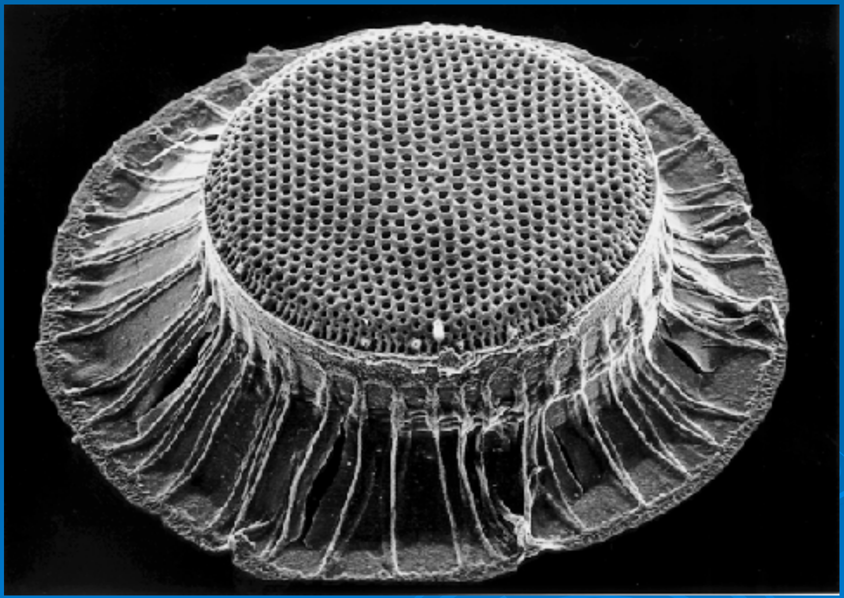




SG205B.10.10 Diatom Encounters (1)



🡅 *Stephano Stephanopyxis palmeriana*.



🡅 *Planktoniella sol*

Both images: Tamotsu Nagumo
Nippon Dental University
//www.biol.tsukuba.ac.jp

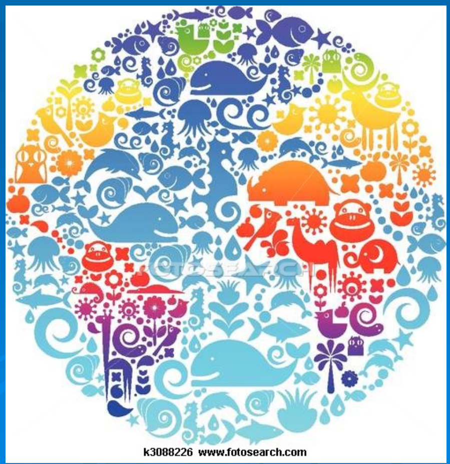
SG205B.Ca Conclusion - The SG of Nature

In SG205A & SG205B, we have briefly explored the existing evidence for the presence of a Golden Harmony (Golden Ratio proportions & relationships) in the realms of nature as we know them on planet Earth: the plants, the animals and the minerals. Sometimes, the evidence was simply the feeling of beauty and elegance evoked by immersion in nature, whether encountered directly or through macro/micro technology. Or the unexplainable insight that the *Web of Life* is the home in which we are able to experience the human adventure.

We are plainly aware that we have barely touched the surface of the subject - yet, we know a lot more now than we knew even 30 years ago, with the multiplication of new scientific discoveries and the emergence of a new science paradigm giving priority to whole systems, non-local inter-connectedness, fractal self-similarity, global scaling and spontaneous coherence: all these aspects are profusely displayed by nature and we now have tools to understand them better.

Our aim was also to enter new territories by raising questions of harmonic import, pointing to new directions of research, creating bridges between yet separate areas of research and share the extraordinary & exquisite perfection of the phenomenal world. Basically we aimed at inspiring a larger, more unified understanding of the universe in view of a possible Phi-based constant or "oscillator" synchronizing all levels of what we like to call the Golden Fractal Cosmos and Sacred Geometry has traditionally called Universal Harmony.

This Golden quest is at its very beginning in terms of a knowledge of observation and measurement. But it is a timeless and immediate quest in terms of the inner sensitivity and awareness of spirit communion with the generative powers of consciousness accessed by mystics. Wherever we are coming from, the same source is embraced again. Welcome to you as nature and the universe!



SG205B.Cb Cosmic Nature

"We are creators & creatures for each other and for ourselves."

(image: oil painting by Diana Bryer)

SG205B.Cc 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

SG205B.Cd 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**

SG205B.Ce StarWheel Blessing

SW#109. Li-La-Nai". www.starwheels.com

SG205B.Cf
Contact Info

Sedona School of Sacred Geometry
www.schoolofsacredgeometry.org
phi@schoolofsacredgeometry.org
PO Box 3714, Sedona, AZ 86340

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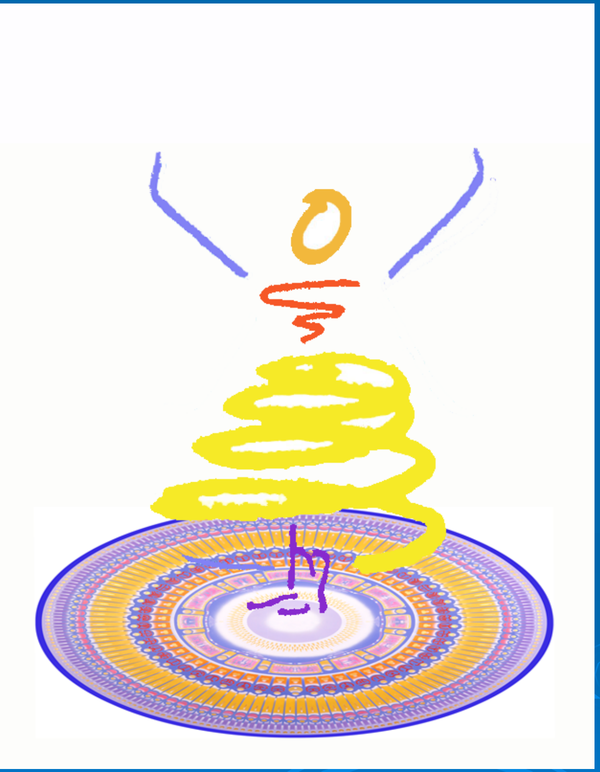
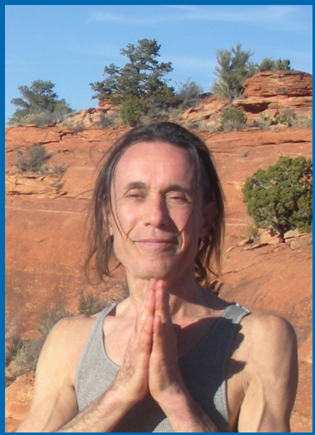
www.starwheelmandalas.com/index.php?p=wisdomcards
www.starwheelmandalas.com/index.php?p=deck1

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



Φ celebration



SG205B.Cg 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!