Entsegu honek zirkuluaren (eta erlazionatutako esfera eta zilindro irudien) diziplina anitzeko azterketa bati eskainia dago Naturan, Arteen eta Zientzietan. Irudiak lehenik Euklidear Geometriaren terminoetan definitzen dira. Ondoren, gorputz zerutarren eta Unibertsoaren beraren formak eta Kopernikar kosmosaren eta Bohr-en egitura atomikoaren arteko paralelismo formala aztertzen dira. Zirkuluaren garrantzia mistikan, erlijioan eta para-zientzietan eztabaidatzen da. Atal espezifikoak Mekanikan, Artean, Arkitekturan eta Biologian zirkuluari eskainita daude. Adibide grafiko ugari eskaintzen dira. Amaierako eztabaida batek forma sinple hauek gizakiek mendeetan zehar sentitu duten erakargarritasun nabarmena modu arrazionalean azaltzeko zailtasunak aztertzen ditu.

Giltza-Hitzak: Zirkulua. Euklidear geometria. Kosmologia. Fisika. Biologia. Artea. Arkitektura. Mistika.

Este ensayo está dedicado a un análisis multidisciplinar del círculo (y las figuras afines esfera y cilindro) en la Naturaleza, las Artes y las Ciencias. Las figuras se definen primero en términos de Geometría Euclidiana. A continuación, se examinan históricamente las formas de los cuerpos celestes y del propio Universo, así como el sorprendente paralelismo formal entre el cosmos copernicano y la estructura atómica de Bohr. Se analiza la relevancia del círculo en la mística, la religión y las paraciencias. Se dedican secciones específicas al círculo en la Mecánica, el Arte, la Arquitectura y la Biología. Se ofrecen abundantes ejemplos gráficos. Por último, se abordan las dificultades para explicar de forma racional la evidente atracción que han sentido los seres humanos a lo largo de la historia por estas formas engañosamente simples.

Palabras Clave: Círculo. Geometría euclidiana. Cosmología. Física. Biología. Arte. Arquitectura. Misticismo.

Cet essai est consacré à une analyse multidisciplinaire du cercle (et des figures apparentées que sont la sphère et le cylindre) dans la nature, les arts et les sciences. Les figures sont d'abord définies en termes de géométrie euclidienne. Suit une étude historique des formes des corps célestes et de l'univers lui-même, ainsi que le surprenant parallélisme formel entre le cosmos copernicien et la structure atomique de Bohr. L'importance du cercle dans la mystique, la religion et les para-sciences est discutée. Des sections spécifiques sont consacrées au cercle dans la Mécanique, l'Art, l'Architecture et la Biologie. De nombreux exemples graphiques sont fournis. Une discussion finale aborde les difficultés à expliquer de manière rationnelle l'attirance évidente ressentie par les humains à travers les âges pour ces formes d'une simplicité trompeuse.

Mots clés : Cercle. Géométrie euclidienne. Cosmologie. Physique. Biologie. Art. Architecture. Mysticisme.

The circle game

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"And the seasons they go round and round
And the painted ponies go up and down
We're captive on the carousel of time
We can't return we can only look
Behind from where we came
And go round and round and round
In the circle game."

The lyrics of Joni Mitchell's celebrated song "The circle game" give its name to the current contribution, and they also provide a beautiful starting point for our trans-historical and trans-methodological essay on the sphere, and on its projection on the plane, the circle.

Circle and sphere in Euclid

The circle has been known since before the beginning of recorded history, perhaps influenced by the shape of the solar disk, or of the full moon. Prehistoric humans made stone and timber circles, and circular elements are common in petroglyphs and cave paintings[1]. Megalithic monuments called *cromlechs* can be found in many parts of Western Europe, including the Basque Country, in which stones are organized in circles[2]. The circular (spherical) shape of the Earth may have been mentioned in the 5th century BC[3].

The circle (and the sphere) were described in geometrical terms by Euclid of Alexandria (c. 325 BC – c. 265 BC), the most prominent mathematician of antiquity, best known for his treatise on mathematics "*Στοιχεῖα*", or "The Elements"[4]. This work was unsurpassed in logical rigor until the 19th century, and is presumed to be the most influential textbook ever written.

The circle is defined in Euclid's Elements, Book 1, Definition 15, as follows: "*A* circle *is a plane figure contained by one line such that all the straight lines falling upon it from one point among those lying within the figure equal one another*[4]." *Circle* is derived from Latin *circulus*, diminutive of Latin *circus*, from Greek *κίρκος,* a metathesis of Homeric Greek *κρίκος,* meaning *hoop* or *ring*.

Definition 16 states: "*And the point is called the center of the circle*." *Center* derives from Latin *centrum*, and the latter, from ancient Greek *κέντρον*. The original meaning of *κέντρον* is *sting,* or *awl,* it has been borrowed by Geometry to mean the spike of a compass, thus the center is the point where the spike is located when a compass is used to draw a circle.

The sphere is defined in Book 11, Definition 14: "*When a semicircle with fixed diameter is carried round and restored again to the same position from which it began to be moved, the figure so comprehended is a sphere*[4]." Euclid then follows: (Definition 15) "The *axis* of the sphere is the straight line which remains fixed and about which the semicircle is turned", and (Definition 16) "The *center* of the sphere is the same as that of the semicircle".

An additional circle-related figure described by Euclid is the (right, circular) *cylinder*[4]. Book 11, Definitions 21-23 read, consecutively:

> "When a rectangular parallelogram with one side of those about the right angle remains fixed is carried round and restored again to the same position from which it began to be moved, the figure so comprehended is a cylinder"; "The axis of the cylinder is the straight line which remains fixed and about which the parallelogram

is turned"; "And the bases are the circles described by the two sides opposite to one another which are carried round".

Physics and Astronomy

The spherical shape, and its circular projection on the plane, have fascinated the scientists since the earliest stages of philosophical and scientific endeavour. In early Mesopotamian mythology (1st millennium BC), the world was portrayed as a disk floating in the ocean with a hemispherical sky-dome above[5].

Anaximander of Miletus (c. 610 – c. 546 BC) taught that the celestial bodies orbit at different distances and that the earth floats unsupported in space. The Earth's shape was that of a cylinder[6] with a height one-third of its diameter. The flat top formed the inhabited world. Anaximander's views inaugurated modern cosmology[7]. Anaxagoras of Clazomenae (c. 500 – c. 428 BC), the first person to propose the current theory of the lunar and solar eclipses[8], still thought that the Earth was a thin, flat disk at the center of the cosmos. The transition from the disk (or cylinder) idea to the spherical hypothesis took place in the next generation.

Plato (c. 427 – c. 347 BC) in *Phaedo* (108e-109a, 110b ff.) and in *Timaeus* (40b-c, 62d ff.) thought of the Earth as of a spherical body[9]. His disciple Aristotle (c. 384 – c. 322 BC) was perhaps the first to specifically recognize the fact of our planet being a round sphere[10,11]. He observed lunar eclipses and noticed that only a round sphere could imply a circular shadow. This astronomical observation was confirmed by general observations made at sea. When a ship sails away from the coast, it seems to disappear gradually behind the horizon. Aristotle's universe was also spherical, with the Earth taking the central place, and, in contrast to the celestial bodies, always at rest. Also, a perfect sphere was the natural shape of heavenly bodies and uniform rotation in circles was the natural state of their motion. Indeed, primary motion was derived from the outermost sphere, the seat of the unchangeable stars and of divine power (Fig. 1).

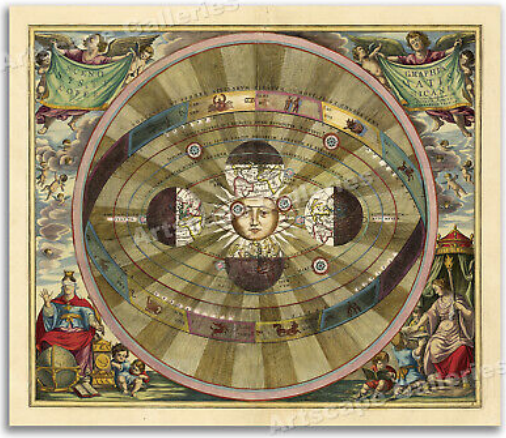
Fig. 1. The Aristotelian cosmos, a Medieval view (www.alamy.com)

The next scientific step, directly measuring the circumference of our planet, was carried out by Eratosthenes of Cyrene (c. 276 – c. 194 BC), from measurements in Alexandria and in today's Aswan. He obtained a result of 250,000 stadia, which, because the actual value of the stadium is not known with certainty, may contain an error between 0.5% to 7% of the currently accepted value[12].

The spherical representation of the cosmos, inaugurated by the ancient Greeks, and famously adopted by the astronomer and geographer Ptolemy (c. 100 – c. 170 AD), has pervaded all cosmological studies until the 20th century. 18 centuries after Aristotle, the Western world conceived the cosmos as a spherical entity, often one in which the various elements (water, earth, air) existed separately (Fig. 2). Even the Copernican revolution did not change the global shape of the universe, or of the celestial bodies, although it put the spherical Sun at the center of the spherical cosmos (Fig. 3)[13,14].

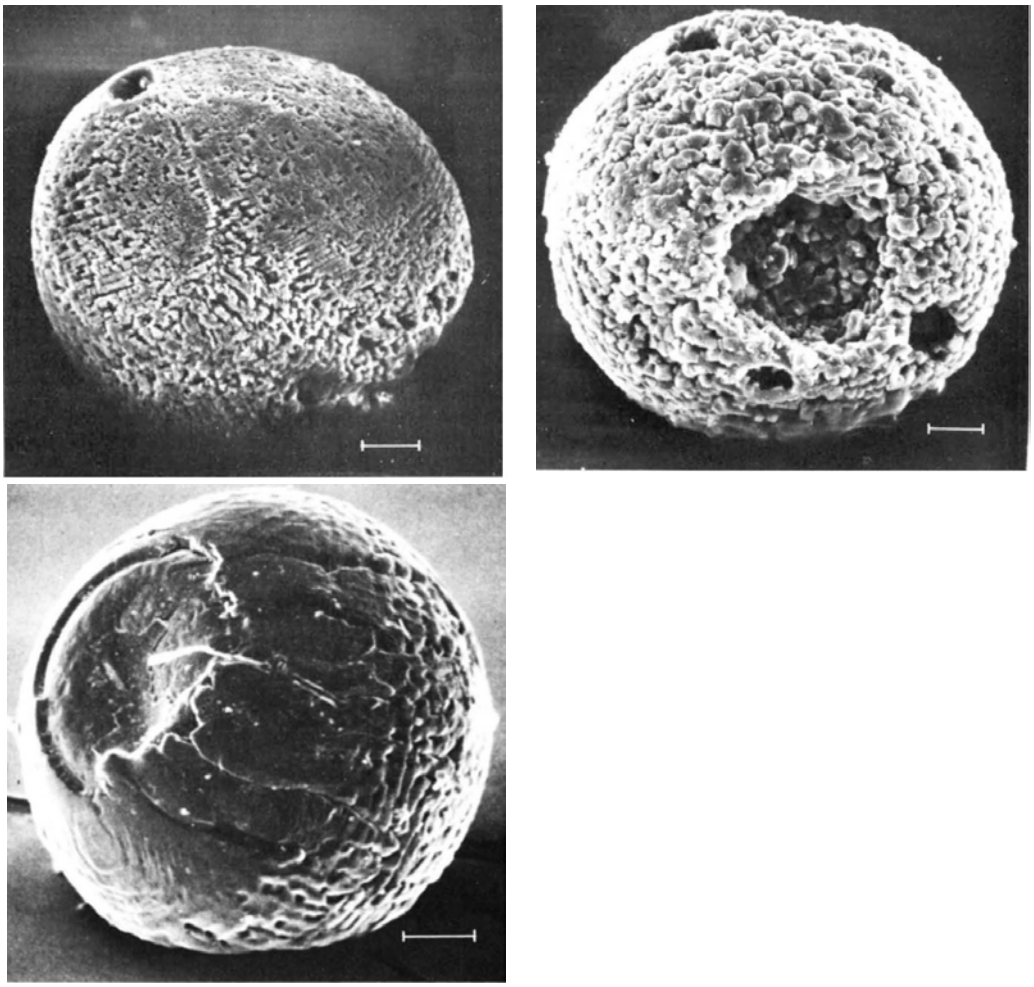
Fig. 2. A medieval artistic representation of the world: a sphere with compartments representing earth, air, and water. Detail from a portrait of John Gower. The picture is from Glasgow Univ. Lib., MS Hunter 59 (T.2.17), dated c. 1400.

Fig. 3. The Copernican universe. Andreas Cellarius, *Harmonia Macrocosmica,* 1660.



The sphere does not only represent the shape of the massive heavenly bodies. Little known to the layperson, tons of the so-called "cosmic dust" fall daily upon the Earth, the particle size is of the order of micrometers (i.e. like the cell's), and the shape is spherical (Fig. 4). David W. Parkin, the main explorer of this phenomenon, described the particles as *spherules.* Long thought to be the result of asteroidal collisions in the atmosphere, Parkin demonstrated that cosmic spherules existed as such in the outer space[15].

Fig. 4. Cosmic spherules as described by Parkin [15]. Bars are 20 μm (top left), or 10 μm (top right and bottom)

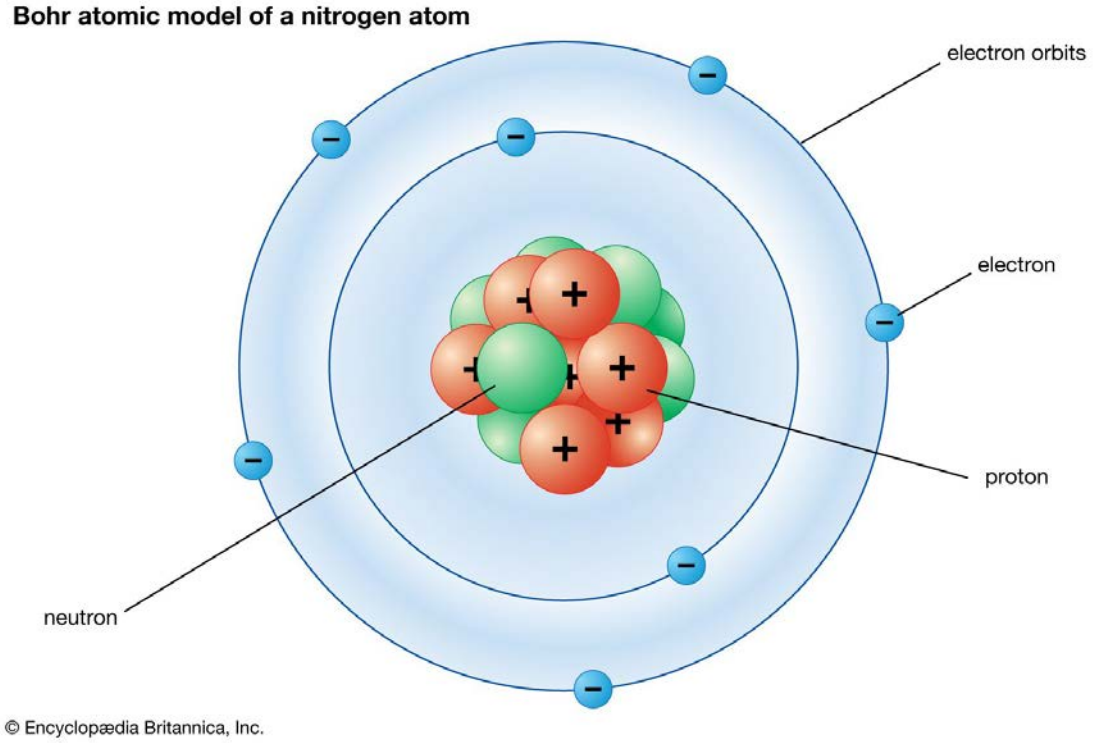


The sphere and the circle as the essential shapes of the universe found their correspondence in tools devoted to astronomical studies, namely the astrolabe (essentially a circle), and the armillary sphere (Fig. 5). They were both developed in antiquity, and remained in use well into the Modern Era. The *armillary sphere* is a model of objects in the celestial sphere, consisting of a spherical framework of rings, centered on Earth or the Sun, that represent lines of celestial longitude and latitude and other astronomically important features, such as the ecliptic. It was invented separately, in China (4th century BC) and Greece (3rd century BC).

Fig. 5. Astrolabe (top) and armillary sphere (bottom). Modern replicas of Medieval instruments

In a remarkable twist of the Ptolemaic-Copernican cosmological ideas, the 20th century witnessed the development of a spherical, solar-system like, model for the atom. The Irish scientist Joseph Larmor had proposed in 1897 the so-called 'Solar System atom model', but it was in 1913, with the publication of the atomic model by Niels Bohr and Ernest Rutherford, that the microcosmos and the macrocosmos appeared linked by a surprisingly similar common structure (see, e.g., Fig. 6). Indeed our current views of the universe, and of the atom, are more complicated than the simple circular motions and shapes just described. And yet very few, if any, abstractions of the physical world have enjoyed like the sphere the favor of scientists and philosophers along so many centuries.

Fig. 6. Bohr's model of a nitrogen atom (1913), with 7 protons + 7 neutrons, forming the nucleus, and 7 orbiting electrons (Britannica)



Mystical and religious experience

The term "mysticism" has Ancient Greek origins with various historically determined meanings. It derives from the Greek word *μύω (múō),* meaning "to conceal" and its derivative *μυστικός (mystikos),* meaning 'an initiate'. The New Testament uses the related noun *μυστήριον (mystḗrion),* or "mystery". Until the sixth century, the Greek term θεωρία (theoria), Latin *contemplatio*, was used for the mystical interpretation of the Bible[16] and the vision of God. In the Christian tradition, the link between mysticism and the vision of the Divine was introduced by the early Church Fathers.

According to the *Macmillan Encyclopedia of Religion*, mysticism is "*the doctrine that special mental states or events allow an understanding of ultimate truths*"[17]. Parsons warns that "what might at times seem to be a straightforward phenomenon exhibiting an unambiguous commonality has become, at least within the academic study of religion, opaque and controversial on multiple levels"[18].

Closely related to mysticism is spirituality, commonly understood as the recognition of a feeling or sense or belief that there is something greater than ourselves, something more to being human than sensory experience, and that the greater whole of which we are part is cosmic or divine in nature. According to Waaijman, the traditional meaning of spirituality is a process of re-formation which

> "aims to recover the original shape of man, the image of God. To accomplish this, the re-formation is oriented at a mold, which represents the original shape: in Judaism the Torah, in Christianity Christ, in Buddhism Buddha, in the Islam Muhammad"[19].

Waaijman points out that "spirituality" is only one term of a range of words which denote the praxis of spirituality. Some other terms are "Hasidism, contemplation, kabbala, asceticism, mysticism, perfection, devotion and piety"[19].

The circle is an important element in Islam's inner and mystical dimension encapsulated in Sufism[20]. A practitioner of this tradition is nowadays known as a *ṣūfī*, or, in earlier usage, a dervish. Sufis generally belong to a *halaqa*, a circle or group, led by a Sheikh or Murshid. Sufi circles are generally a part of a *Tariqa* which is the Sufi order. Sufi practice involves, among others, *Sama*, devotional music and ritual movements, akin to dance, to further enhance the experiential nearness to God they are seeking. This practice is most commonly associated today with the Mevlevi Sufi order's Dervishes of Turkey, often referred to as the "Whirling Dervishes".

A circular object, namely the wheel (see below) has also become a strong cultural and spiritual metaphor for a cycle or regular repetition (see, e.g., Mircea Eliade's Myth of the Eternal Return)[21]. The wheel of time is also an important symbol in Jainism. Also, the Ashoka Chakra, a 24-spoke wheel, occupies the center of the Indian flag. Moreover, even if wheeled vehicles were forbidden in Tibet, the so-called prayer wheels or *mani* wheels, cylindrical wheels for Buddhist recitation, have been used since the 4th century there[22]. Examples could be added to extenuation.

In the contemporary usage "mysticism" has become an umbrella term for all sorts of non-rational world views, parapsychology and pseudoscience included[18,23]. It has been affirmed that mysticism has become "a catch-all for religious weirdness"[24]. It does not come as a surprise, then, that the sphere has attracted the most widespread attention of all kinds of contemporary "mystics". To mention but a few examples, worth mentioning for aesthetic rather than rational reasons, Ila Bonczek has published in *Vision Times*, a newspaper, an article whose title is already a proclamation of the author's views: "*Spheres: Exploring the Mystery and Mysticism of Nature's Most Perfect Form*"[25]. Bonczek considers that "*As a symbol of harmony, unity, and infinity, spheres are often connected with spirituality, and man-made spheres have been used for everything from divination and healing to sport.*" The author examines, and shows beautiful images of virtually perfect spheres consisting of: soap bubbles, water drops, human egg cells, plant gall tumors, and even the mysterious man-made giant stone balls, of pre-Columbian origin, discovered a century ago in Costa Rica (Fig. 7). A large number of examples of spherical objects found in Nature are also mentioned: from fruits, like oranges, or concord grapes, to eggs from many species, e.g. many fish, turtles, owls, etc.

Fig. 7. Hundreds of stone spheres, apparently man-made, were uncovered in Costa Rica about a century ago

(Image: DRVMX via Flickr CC BY 2.0)

"Spheres and the supernormal" constitute an important part of Bonczek's contribution[25]. It reads: "*Spiritually, spheres of light may be used to represent an aura — or energy field— around the head or body of an enlightened being. Although religious art generally depicts them as a circular halo…*" Sphere and circle again! In this context, spheres are also mentioned as an instrument for divination, apparently introduced by Druids. Moving a step forward in the scale of credulity, crystal spheres are also presented as healing aids: "An expression of balance, integrity and unity, the perfect sphere radiates energy in all directions, and can help clear negative energy to improve one's mental and physical state." The paper ends on a more realistic, and likeable, note, stating that "Spheres are fun". Indeed, from marbles to bowling, and to basket balls, spheres provide entertainment to children, adults and pets alike, while moving, in some cases, enormous sums of money all over the world (Fig. 8).

Fig. 8. Old and new soccer balls

The Web offers, under "magic spheres" and "mystic spheres", together with a good amount of "information" ranging from the absurd to the idiotic, the work of a few artists that have produced nice pieces, consisting of variations on the circle/sphere motif, usually in video format. A few examples can be found in references[26,27].

Mechanics: The wheel, and the ball bearings

The wheel and the ball bearings constitute the most typical technological applications respectively of the circle and the sphere, the wheel predating, of course, the ball bearings by several millennia. A *wheel* is a rotating component that is intended to turn on an axle bearing. The wheel alone is not a machine, but when attached to an axle in conjunction with bearing, it forms the "wheel and axle", one of the simple machines. Even if the Mesopotamian civilization has been credited with the invention of the wheel, the contemporary consensus view is that it was invented independently in different parts of the globe, around the 5th millennium BC (late Neolithic)[28]. It is interesting that several millennia may have elapsed between

the invention of pottery and that of the potter's wheel. Solid wooden wheels were first used, both in pottery and in vehicles, while the spoked wheel had to wait for a further two millennia (middle Bronze Age)[29] (Fig. 9a, b). The *rim* is the "outer edge of a wheel, holding the tire", thus an additional circular structure. In the 1st millennium BC an iron rim was introduced around the wooden wheels of chariots.

Fig. 9a. Solid wheel with axle found in Ljubljana Marshes, perhaps the oldest wooden wheel yet discovered (Copper Age, c. 3130 BC)

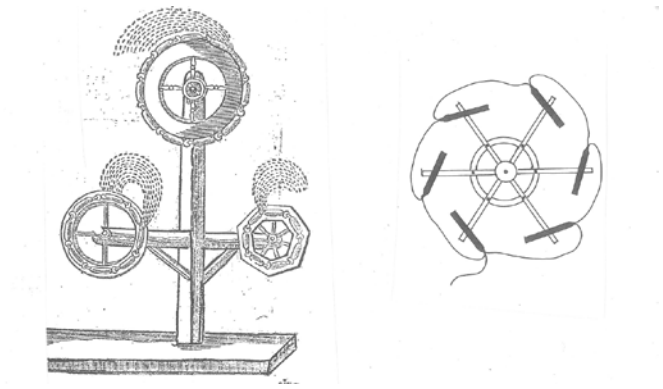
Picture by Petar Milošević

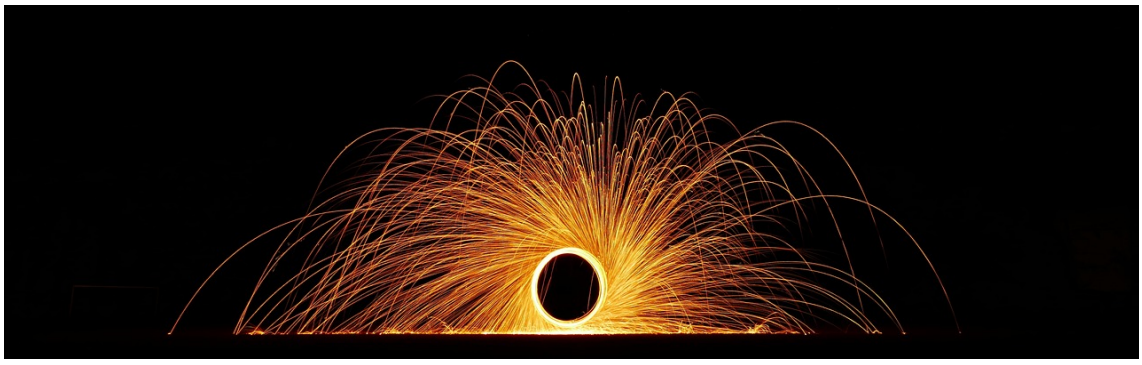
Fig. 9b. Spoked wheel, 2nd millennium BC

National Museum of Iran, Tehran.

A very specialized use of the wheel, among dozens of others, is the the firework piece known in English-speaking countries as Catherine wheels. Saint Catherine of Alexandria was tortured on a wheel by the Emperor Maxentius for refusing to renounce her Christian faith. The wheel miraculously broke and Catherine was eventually beheaded instead. Her martyrdom is remembered (implicitly, one might say) with this pyrotechnic piece, once popular in public displays, and today limited, in small-size versions, to private use. The piece consists of a wheel, in wood or cardboard, with a hub, or simply a small hole in its center[30]. Several rockets are fixed in its periphery, and usually matched so that the end of one of the rockets passes the fire to the next one. The rockets drive the rapid spinning of the wheel. Fig. 10 shows a few examples of the wheel and its night effect. Sometimes, a Catherine wheel is mounted on a horizontal wheel, itself spinning rapidly, producing the effect of a fire globe, or sphere.

Fig. 10. Catherine wheels, before and after ignition. The two top drawings are taken from[31], left, and from[32], right.





The *ball bearing* has been defined as "a type of rolling-element bearing that uses balls to maintain the separation between the bearing races" (Fig. 11). Note that the spherical elements are the balls, while the races are circular. Its purpose is to reduce friction between a stationary and a rotating component[33]. Developed in the late 18th century in Britain, they are currently in use in a variety of devices, from skateboards to aircraft, yo-yos and watches[33].

Fig. 11. A ball bearing for skateboard wheels with a plastic cage

(Wikipedia Commons)

Architecture and the plastic arts

Circle, sphere and cylinder are so commonly found in the plastic arts that a mere enunciation of examples would be beyond the scope of this contribution. Just a few notes on the subject are given below. The cylinder must be considered in a class of its own, as the basic geometric element of many columns. Columns must have originally consisted of tree logs, stone being the result of much later developments. Perhaps the Spanish "*fuste de columna*", equivalent to the English "column shaft", refers to the vegetal origin of pillars, "*fusta*" being today used in Catalan for "wood".

The sphere has found widespread application in architecture in the form of *hemisphere,* the traditional shape of domes. The basis of the dome, seen from the inside of the building, appears as a circle. See Fig. 12 for the combination of hemispheric and circular geometric elements, in the relatively unknown *San Francisco el Grande* church, in Madrid, one of the largest domes in Christendom.

Fig. 12. Dome of *San Francisco el Grande* church in Madrid, Spain's largest and fourth largest in the world. (Top) outside view. (Bottom) inside view, showing the circle corresponding to the circumference of the hemisphere

A different example of the use of circles in architecture is given by the rose windows. The name may refer to any circular window, but it is used more specifically to denote those found in Gothic cathedrals, defined by moulded stone mullions, and intricate tracery (Fig. 13, top).

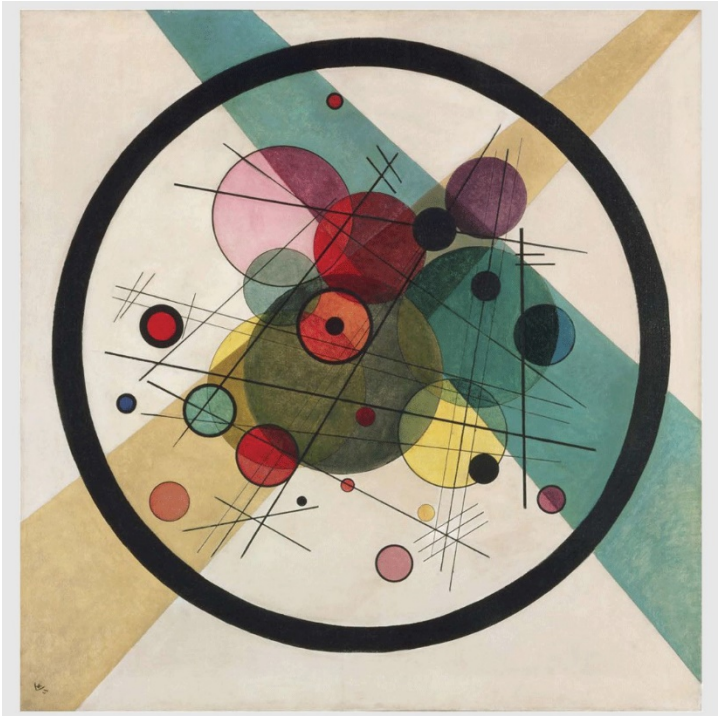
Fig. 13 top. Round windows. Interior of the rose at Strasbourg cathedral

Fig. 13 Bottom. James Turrell's LED installation at the Guggenheim Museum, New York.

Contemporary plastic arts are full of examples of circular shapes, often in "abstract" works (Fig. 14, 15). In fact, the attraction exerted by the circular or spherical shapes even on non-figurative artists is a remarkable phenomenon, which will be briefly discussed at the end of this article. Wassily Kandinsky's "Concentric circles", or "Circles in a circle Wall Art", Diane Wisehart's "Circles abstract", Robert Delauney's "Le premier disque", or a number of serigraphies by Eusebio Sempere are just a few representative examples. James Turrell is a singular example of an artist interested in circular/ovoidal shapes built of light; he has collaborated with the Guggenheim Museums since the 80's of the last century (Fig. 13, bottom)[34].

Fig. 14. Robert Delaunay, 1912–13, *Le Premier Disque*

Fig. 15. Wassily Kandinsky, 1923, *Circles in a circle*



Coins, and coin minting, are on the borderline of art and technology (Fig. 16). Remote precedents of modern coins are the "currency" systems of the Late Bronze Age, when various cultures used standard-sized ingots to store and transfer value. Cyrus the Great introduced circular coins to the Persian Empire after 546 BC, following his conquest of Lydia and the defeat of its king Croesus, who had put in place the first coinage in history. Nowadays, coins (together with jewelry rings) are perhaps the most common circular objects in everyday life. In addition to their practical use as a medium of exchange, they have become collectors items, as well as creative media of expression.

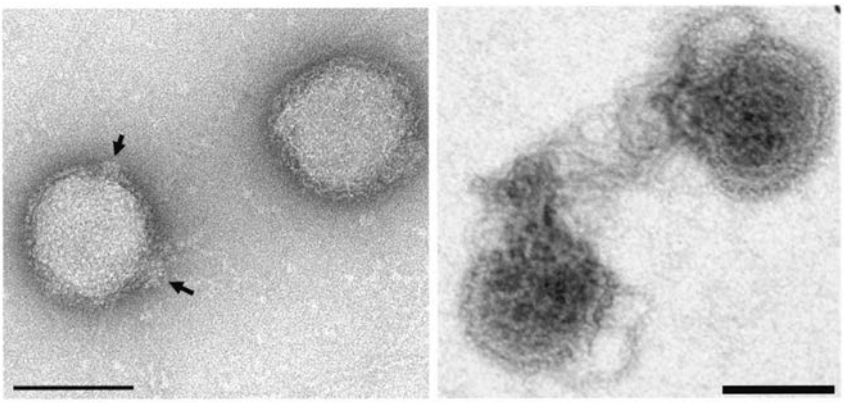
Fig. 16. (Top) A Swiss ten-cent coin from 1879, similar to the oldest coins still in official use today. (Bottom) Alexander the Great Tetradrachm from the Temnos Mint, c. 188–170 BC

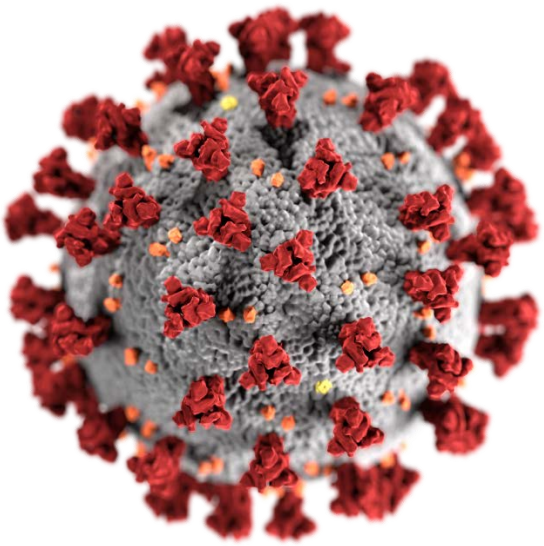
Biology

The realm of Biology offers abundant examples of natural and man-made spherical forms. A few examples were mentioned above, see pictures in[25]. Biological spheres are found in viruses, cells, and eggs from various organisms, apart from specialized organs, e.g. the eye. The reason for the pervasive circular shape in Biology is that the sphere corresponds to the maximum volume/surface ratio, thus holding up more material in a minimum of space.

Many viruses appear spherical in shape (although, strictly speaking, they are often icosahedral), including Human Immunodeficiency Virus (HIV), herpes virus, poliovirus, coronavirus, or adenovirus, the latter responsible for influenzal infections or for conjunctivitis. In many instances the spherical surface contains spikes[35]. Selected examples are shown in Fig. 17.

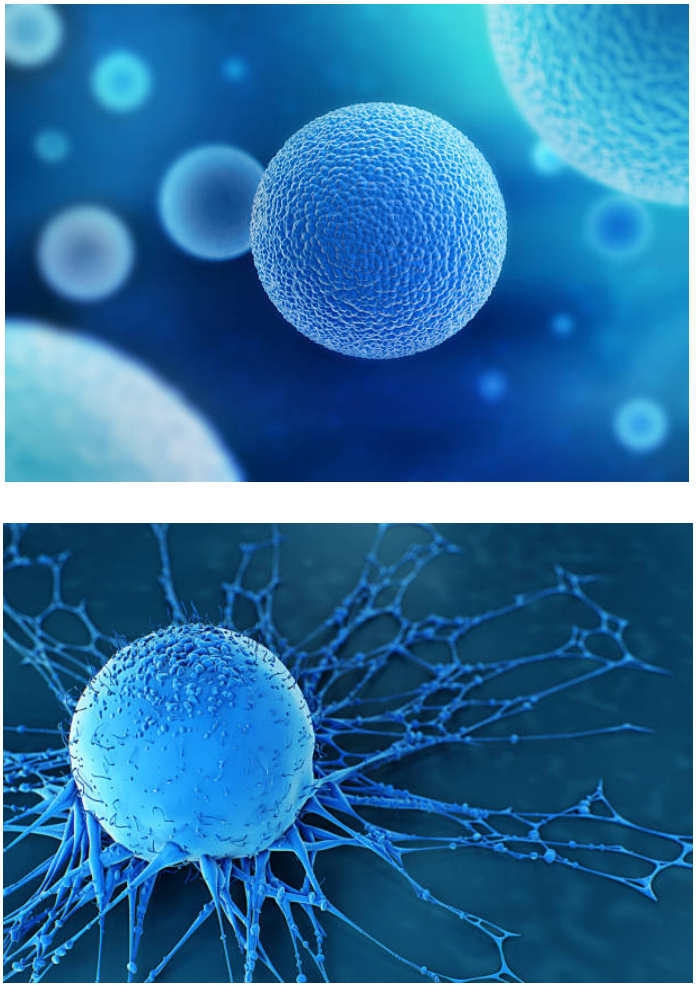
Fig. 17. (Top) Electron micrograph of *Pyrobaculum* spherical virus. Scale bar 0.1 μm (D. Prangishvili). (Bottom) SARS-CoV-2, a spherical virus, computed-assisted image starting from electron micrographs. Diameter ≈ 0.08 μm (Alissa Eckert, MS; Dan Higgins, MAM, Public domain, via Wikimedia Commons)





Animal cells suspended in liquid are usually round. They acquire flat or elongated shapes when they are attached to a rigid surface, or when they associate giving rise to tissues. When animal cells become malignant, as in cancer, they tend to get more spherical. Plant, fungal or bacterial cells have defined shapes, sometimes round but mostly otherwise, imposed by their rigid cell walls. Fig. 18 shows examples of a spherical bacterium, and of a malignant cell, which has adopted a rounded shape in the process of malignisation. Note the different sizes of viruses, bacteria and animal cells as stated in the legends to Fig. 17 and 18.

Fig. 18. (Top) A spherical bacterium (C. Ventrella, iStock). Diameter ≈ 1 µm. (Bottom) A spherical cancer cell, with filaments facilitating adherence (Luis M. Molina, Getty Images). Diameter ≈ 20 µm.

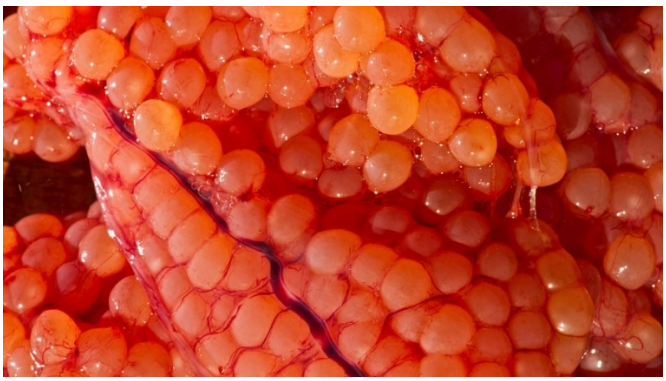


Plant galls are abnormal growths that occur on leaves, twigs, roots, or flowers of many plants. Most galls are caused by irritation and/or stimulation of plant cells due to feeding or egg-laying by insects[36]. Galls may appear as balls, as well as in other shapes (Fig. 19). In general, galls provide a home for the insect, where it can feed, lay eggs, and develop.

Fig. 19. (Top) Galls on a silver maple (The Morton Arboretum). A further example of parasitic galls (Наталія Гудюк via Wikimedia Commons CC BY 4.0)

In spite of the familiar hen egg shape, some birds, and most fish and reptiles lay round eggs. This appears to have been the case for dinosaurs (Fig. 20), and, as seen in caviar (when this delicacy is available), or in the more accessible salmon eggs.

Fig. 20. (Top) An extremely rare specimen of a spherical hen egg. (Mid) Dinosaur eggs from Qianshan, China, diameter ≈ 20 cm (He et al./Journal of Paleogeography). (Bottom) Salmon eggs, diameter ≈ 7 mm (The Meateater. Com).



Biology, and in particular the study of biological membranes, has been enormously helped by the use of semi-synthetic vesicles, composed of membrane lipids, with or without proteins. These structures, often called liposomes, mimic efficiently the cell membranes, although they have a much simpler composition, which makes them amenable to a variety of biophysical studies[37]. The size of these liposomes ranges from ≈ 40 nm to ≈ 20 μm, or even larger, the latter corresponding to the size of most mammalian cells (Fig. 21). These structures are almost invariably spherical, as is the case for the free suspended cells, because the lateral surface pressure exerted by the surface lipids favors a minimum surface/volume ratio, which is a property of spherical recipients.

Fig. 21. (Top) Fluorescence microscopy image of a semi-synthetic chemico-biological system. The round forms are beads prepared with a polysaccharide (sepharose). To their surface, a protein is chemically bound (ATG8). Small lipidic vesicles, about 50 nm in diameter (they are too small to be seen individually), containing a fluorescent probe, interact with the ATG8 protein, thus creating the red fluorescent halo around the sepharose beads. Bar = 50 μm.

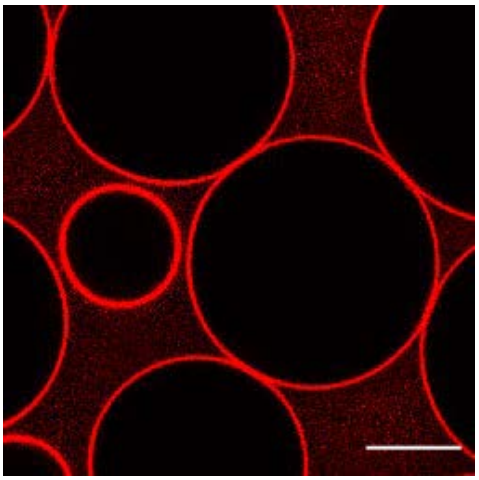
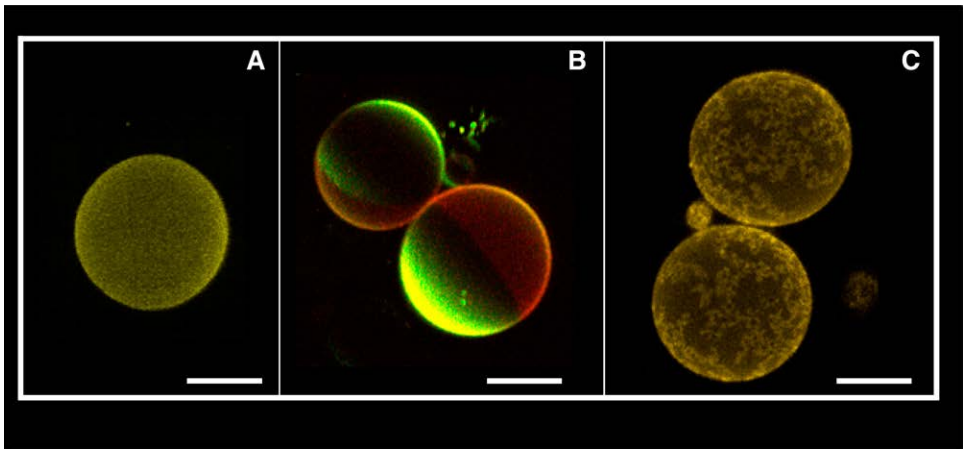


Image by Y.R. Varela, Instituto Biofisika, Leioa.

(Bottom) Fluorescence confocal microscopy: Cell-sized semi-synthetic vesicles, prepared with red blood cell membrane lipid extracts. Surface heterogeneities correspond to lipid domains in the membranes. Bars = 10 µm.



Images by L.R. Montes, Instituto Biofisika, Leioa

The manuscript found in Lisbon

While the present contribution was near completion, the authors became aware of an important manuscript recently discovered at the Gulbenkian Museum, Lisbon, and fully related to the subject of this essay. The manuscript is entitled "The Emperor's Gift: Circles of the Sciences and Tables of the Figures (*Tuḥfat al-Khāqān:Dawāʾir al-ʿulūm wa-jadāwil al-ruqūm*)"[38].

In 2021, a Gulbenkian Museum curator discovered an old box behind other works in the Museum storage. Inside, there were 88 pages of an unbound manuscript, full of curious circular diagrams. The work, never previously studied, is a graphic encyclopaedia of universal knowledge, compiled by the Persian scholar Mirza Muḥammad al-Akhbārī (c. 1764-1817). The Emperor's Gift is a wonderful visualization of three levels of information about Heaven, the World and Humanity, presented in 108 circular diagrams and tables. It seems that the text was considered mostly a talismanic work, combining sacred and scientific contents with the magic power of numbers through geometrical figures. From the Middle Ages, Islamic culture conceived the structure of the human soul and of the intellect as reflecting the spherical shape of the skies and of the heavenly motions. Also, Muslims believe that God does not have a beginning or an end, like the concept of infinity conveyed by the image of a circle.

The 108 circles and tables deal with topics as varied as Aristotle's conception of the cosmos, Avicenna's contribution to medicine, or the Zodiac Signs of Ancient Babylon. Indeed, The Emperor's Gift testifies to the wide circulation of natural knowledge beyond cultural boundaries, over nearly four thousand years. The main concepts dealt with in the manuscript are:

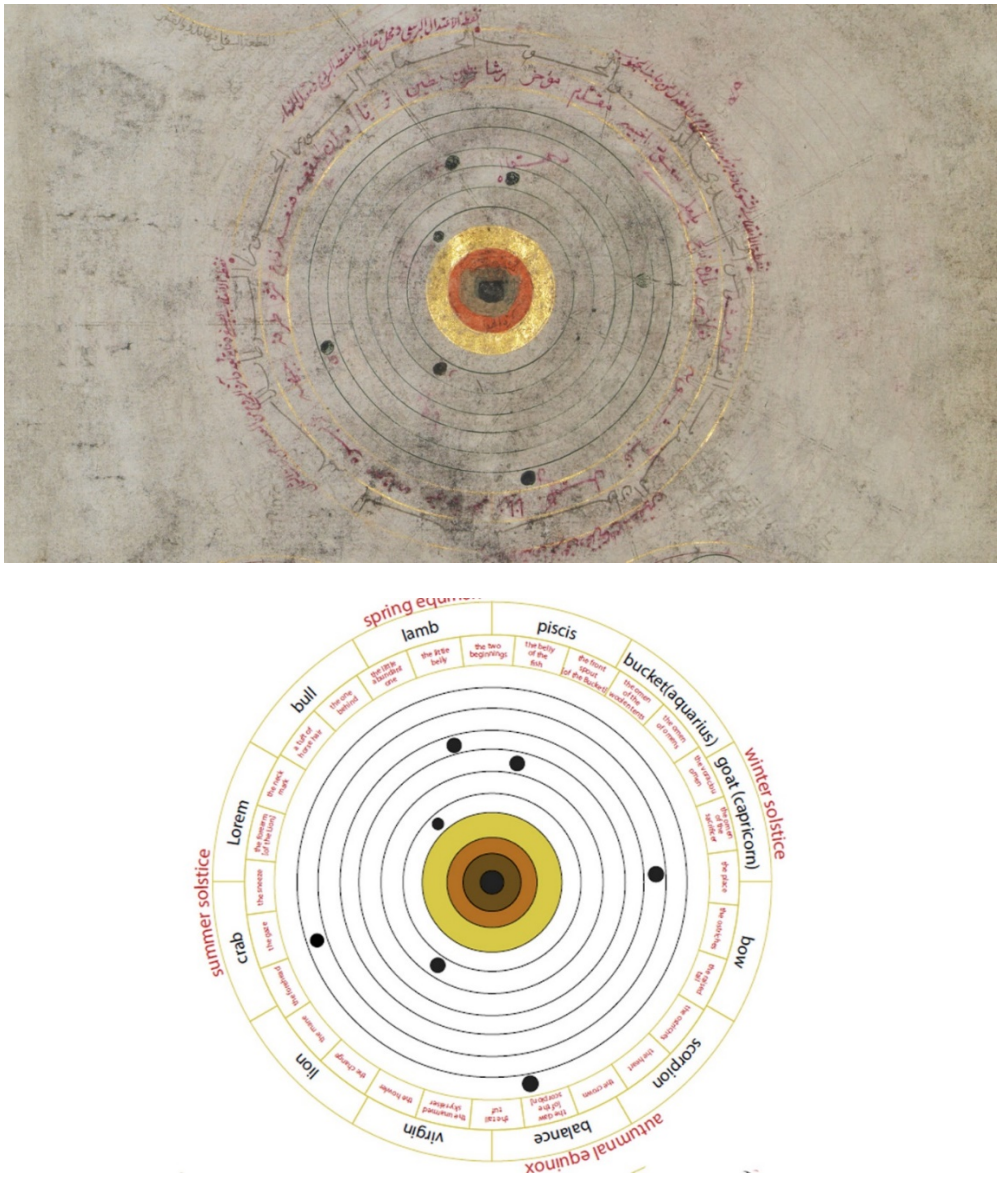
a) *Cosmogony*, or the First Light. From a central point of light, the whole universe is created, reverberating in rings, arising from the soul of the Prophet Muhammad and travelling through the 'veils and seas of existence'.

b) *The Five Lights*, this diagram in the Shia tradition (fol. 8v) has seven golden circles at its centre representing five members of the 'People of the House' (ahl al-bayt), each an aspect of knowledge: the Prophet Muhammad, his cousin and son in law 'Alī, his daughter Fatima, and his

grandchildren Ḥasan and Ḥusayn. The remaining two circles correspond to two moments in the Creation of the Universe.

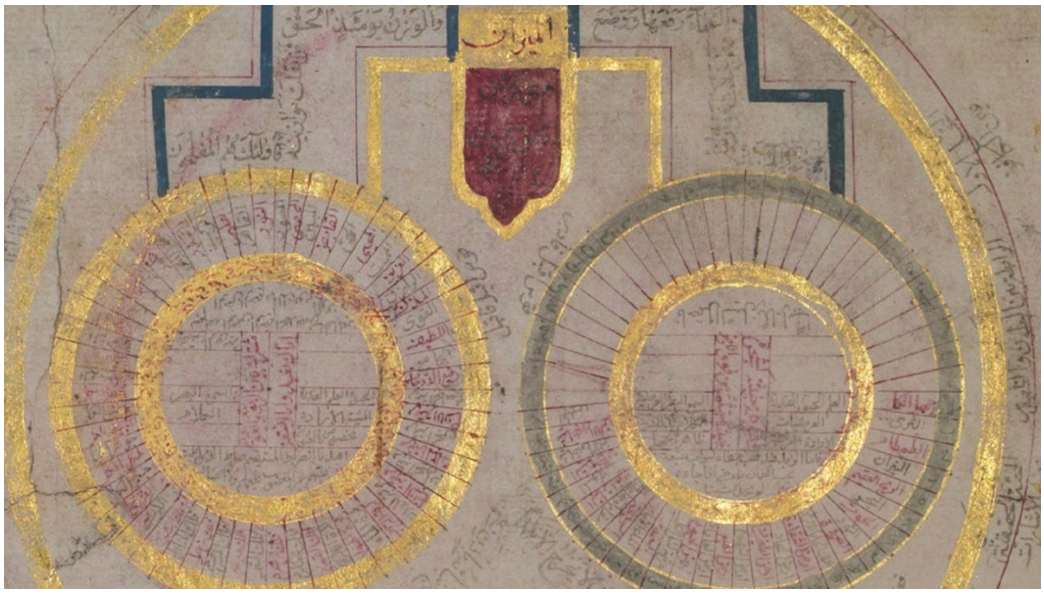
c) *The Cosmos*. Folio 20v represents a conception of the universe well known since Aristotle (Fig. 22; compare with Fig. 1).

Fig. 22. The Aristotelian view of the Universe, in the manuscript "The Emperor's Gift". (Top) Original figure. (Bottom) Modern transcription. Taken from [38]. Compare with Fig. 1, above.



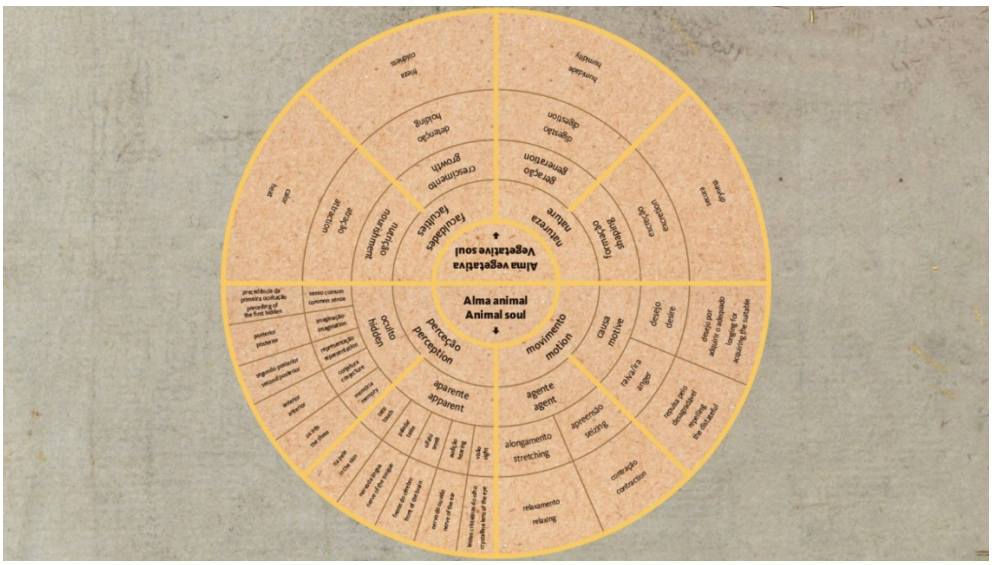
d) *The balance*. The gold plate (left) reflects the heavenly reality: planets, spheres, and layers of divine light. The silver plate (right), by contrast, is stained with ignorance, corruption, distress, and tyranny (Fig. 23).

Fig. 23. The Balance: A diagram from "The Emperor's Gift". One circle, one red axis, two pieces of blue string, two plates, gold (left) and silver (right). Taken from [38]. See main text for further details



e) *The soul.* This circle (folio 11 v.) arises from antique traditions of psychology and physiology, as studied by Greek philosophers and then by Jews, Christians, and Muslims throughout the Middle Ages. It is divided in two: the 'vegetative soul' concerns the simplest fundamental 'nature' and 'faculties' of all beings, while the 'animal soul' relates to 'movement' and 'perception' (Fig. 24).

Fig. 24. The Soul: A diagram from "The Emperor's Gift". Upper half: the 'vegetative soul', it concerns the simplest fundamental 'nature' and 'faculties' of all beings. Lower half: the 'animal soul', which relates to 'movement' and 'perception'. Taken from [38].



f) *The Zodiac Signs*. The diagram of 'Zodiac Signs Pertaining to the Seven Planets' was badly damaged in the Gulbenkian manuscript, and has been studied with the help of another manuscript (Princeton University).

Concluding remarks

It has often been a source of perplexity for philosophers and psychologists the widely experienced attraction of humans towards the simplest geometrical shapes: the horizon straight line, the plane formed by the calm sea, or the full moon circle, to mention but a few. The above lines have provided abundant examples of the near-hypnotic attraction experienced by humans of all Ages for the circle (and its related figures, sphere and cylinder). What is the origin of such attraction? Probably a question without an answer. However, and just by way of a superficial, perhaps irrelevant observation, maybe humans get fatigued with the infinite sensitive aferences reaching the eye, thus the cortex, and instinctively try to get some rest by staring at the simplest discernible shapes, as idealized by Euclid and the classical Geometrists. The noted psychologist, and member of Jakiunde, Professor Enrique Echeburua wrote, at the request of these authors, the following:

> "I consider that circular shapes, by not having sharp corners, can be perceived and processed by the human eye as less threatening and safer. Our peripheral vision detects and follows smooth contours more easily than angular and discontinuous ones. Perhaps this is why, from a marketing perspective, people tend to prefer logos and products with rounded shapes over those with angular shapes. In general, curved design elements are more popular because they are perceived as friendlier and more accessible. Rounded shapes can evoke a feeling of security and comfort, are aesthetically pleasing, and are rooted in both our natural and cultural experiences and perceptions." (E. Echeburua, private communication).

Note that, for reasons of simplicity and of space constraints, we have limited our review to physical manifestations (e.g. drawings, pictures…) of the circle, even being aware of the literary correlates, among others, in literature (circular poems, ending with the same initial line) and in music (e.g. the canon and rondo forms). To partially amend these important omissions we close our contribution citing here the well-known lines by T.S. Eliot, evoking the essentially circular experience of human knowledge:

> "We shall not cease from exploration

And the end of all our exploring
Will be to arrive where we started
And know the place for the first time."[39]

Footnotes

[1] Simek, J. F.; Cressler, A.; Herrmann, N. P.; Sherwood, S. C. (2013). Sacred landscapes of the south-eastern USA: prehistoric rock and cave art in Tennessee. Antiquity. **87**, 430.

[2] Altuna, J.; Mariezkurrena, K; Armendariz, A.; Del Barrio, L.; Ugalde, Tx.; Peñalver, J. (1982). Carta Arqueológica de Guipúzcoa. Munibe, **34**, 1.

[3] Dicks, D.R. (1970). Early Greek Astronomy to Aristotle. Ithaca, N.Y.: Cornell University Press. p. 72.

[4] Euclid, The Elements, English version by Joyce, D.E. (1998). http://aleph0.clarku.edu/~djoyce/java/elements/elements.html

[5] Horowitz, W. (1998). Mesopotamian cosmic geography, Mesopotamian civilizations 8. University Park, PA: Eisenbrauns.

[6] "A column of stone", Aetius reports in *De Fide* (III, 7, 1), or "similar to a pillar-shaped stone", pseudo-Plutarch (III, 10).

[7] Neugebauer, O. E. (1975). A history of ancient mathematical astronomy. Basel: Birkhäuser. p. 577.

[8] Graham, D.W.; Hinz, E. (2007). Anaxagoras and the solar eclipse of 478 BC. Apeiron: A Journal for Ancient Philosophy and Science, **40**, 319.

[9] Baensch, O. (1903). Die Schilderung der Unterwelt in Platons Phaidon. Archiv für Geschichte der Philosophie **XVI**, 189.

[10] Dicks, D. R. (1970) Early Greek astronomy to Aristotle. London: Thames and Hudson.

[11] Couprie D. L. (2011). Heaven and earth in ancient Greek cosmology. From Thales to Heraclides Ponticus. Berlin: Springer.

[12] Fuentes González, P. P. (2000). "Ératosthène de Cyrène", in R. Goulet (ed.), *Dictionnaire des Philosophes Antiques*, vol. III, Paris: CNRS, p. 188.

[13] Koestler, A. (1989). The Sleepwalkers. London: Penguin Arkana.

[14] Kuhn, T. S. (1985). The Copernican revolution—Planetary astronomy in the development of Western thought. Cambridge: Harvard University Press.

[15] Parkin, D. W.; Hunter, W. (1959). Cosmic dust in the atmosphere. Nature 183, 732.

[16] Johnston, W. (1997). The inner eye of love: mysticism and religion. New York: HarperCollins.

[17] Moore, P. (2005). Mysticism (further considerations), in L. Jones, (ed.), MacMillan Encyclopedia of Religion. New York: MacMillan.

[18] Parsons, W. B. (2011). Teaching mysticism. Oxford: Oxford University Press.

[19] Waaijman, K. (2002). Spirituality: Forms, foundations, methods. Leuven: Peeters

[20] Zarruq, A.; Istrabadi, Z.; Hanson, H.Y. (2008).The principles of Sufism. Chicago, IL, Amal Press.

[21] Eliade, M. (2018).The myth of the eternal return: Cosmos and history. Princeton: Princeton University Press.

[22] Ladner, L. (2000). The wheel of great compassion: The practice of the prayer wheel in Tibetan Buddhism. Somerville, MA: Wisdom Publications.

[23] Ben-Shakhar, G.; Bar, M. (2018). The lying machine: Mysticism and pseudo-science in personality assessment and prediction. Abingdon: Taylor & Francis.

[24] Harmless, W. (2007). Mystics. Oxford: Oxford University Press.

[25] Bonczek, I. (2023). Spheres: Exploring the mystery and mysticism of Nature's most perfect form. Vision Times https://www.visiontimes.com/2023/01/17/spheres-mystery-and-mysticism.html

[26] https://www.youtube.com/watch?v=nEwdweindtI

[27] https://www.artstation.com/artwork/nYEARE

[28] Holm, H. J. J. G. (2019). The earliest wheel finds, their archaeology and Indo-European terminology in time and space, and early migrations around the Caucasus. Series Minor 43. Budapest: Archaeolingua.

[29] Anthony, D.A. (2007). The horse, the wheel, and language: how Bronze-Age riders from the Eurasian steppes shaped the modern world. Princeton, NJ: Princeton University Press.

[30] Goñi, F.M. (1999) Fuegos artificiales en Euskalherria. Pirotecnia y pirotécnicos. Bilbao: Laga.

[31] Bate, J. (1635) The second booke. Teaching most plainly, and withall most exactly, the composing of all manner of Fire-works for Tryumph and Recreation. London: Thomas Harper.

[32] Lancaster, R. (2005) Fireworks. Principles and practice (4th ed.). New York: Chemical Publishing Co.

[33] Brumbach, M.E.; Clade, J.A. (2003). Industrial Maintenance. Boston, MA: Cengage. p. 112.

[34] https://www.guggenheim.org/exhibition/james-turrell

[35] Rux, J.J.; Burnett, R.M. (1998) Spherical viruses. Current Opinion in Structural Biology **8**, 142.

[36] Raman, A. (2011). Morphogenesis of insect-induced plant galls: facts and questions. Flora - Morphology, Distribution, Functional Ecology of Plants. **206**, 517.

[37] Montes LR, Alonso A, Goñi FM, Bagatolli LA. (2007). Giant unilamellar vesicles electroformed from native membranes and organic lipid mixtures under physiological conditions. Biophysical Journal. **93**, 3548.

[38] Power of the Word V. https://gulbenkian.pt/museu/en/power-of-the-word-v/

[39] Eliot, T.S. 1944. “Little Gidding”, from “Four Quartets”. London: Faber and Faber.