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Pythagoras: We are all Pythagoreans

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Plut. Quaest. conv. 720A) ἔστι γὰρ ἐν τοῖς γεωμετρικωτάτοις θεωρήμασιν, μᾶλλον δὲ προβλήμασι, τὸ δυεῖν εἰδῶν δοθέντων ἄλλο τρίτον παραβάλλειν τῷ μὲν ἴσον τῷ δ' ὅμοιον·ἐφ' ᾧ καί φασιν ἐξευρεθέντι θῦσαι τὸν Πυθαγόραν·πολὺ γὰρ ἀμέλει γλαφυρώτερον τοῦτο καὶ μουσικώτερον ἐκείνου τοῦ θεωρήματος, ὃ τὴν ὑποτείνουσαν ἀπέδειξεν ταῖς περὶ τὴν ὀρθὴν ἴσον δυναμένην.

"Among the most geometrical theorems—or rather problems—there is one which, when two figures are given, seeks to find a third figure that is equal to one and similar to the other. They say that, upon discovering this, Pythagoras offered a sacrifice; for this is, to be sure, far more elegant and more musical (harmonious) than that theorem which proved that the hypotenuse is equal in power to the sides about the right angle."[1]

[1] The Geometric Problem: Plutarch is describing a well-known geometric problem: Given two figures, find a third which is equal in area to one and similar in shape to the other. This is an advanced problem of proportion and similarity, later appearing in Euclid, Book VI (Props. 25–26).
It's not about measurement, but about the relationship between form and quantity — the synthesis of equality and similarity.

Pythagoras. [2]

[2] Line engraving by D. Cunego, 1782, after R. Mengs after Raphael. Raphael, 1483-1520., Date: 1782 Reference: 8008i, R. Burgess, Portraits of doctors & scientists in the Wellcome Institute, London 1973, no. 2404.6

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Pythagoras engraving, based on a coin. Detail. Portrait de Pythagore d'après l'antique. Maréchal del. Dambrun scul. Greek lettering on medallion: Pythagoras Samion, Wellcome Collection 8006i

ABSTRACT:

Modern science is the natural continuation of Pythagorean view of nature based on mathematics, as commands Pythagoras philosophy. Pythagoras, considering that numbers, symmetries and harmonies are the *first principles* of nature, laid the foundations of scientific thought, continuing the work of Thales. Pythagoras is not just an ancient philosopher, but the first to grasp the deeper idea that nature is not simply described by mathematics—it is mathematics in itself.

This worldview is expressed in modern physics with the theories of symmetry and the search for fundamental laws. Just as the Pythagoreans saw in the ratio 1:2 or 2:3 the harmony of the universe, so physicists today recognize in the symmetries of the fields SU(2), SU(3), U(1) the harmonious structure of the microcosm. The mathematical equations that govern the universe are the modern expression of Pythagoras' "music of the spheres". Even the search for the *Theory of Everything* (a greek term, Θεωρία Παντός) is nothing more than the attempt to discover the perfect cosmic agreement, the one and harmonious law that unites everything, as expected in modern physics.

For the Pythagoreans, beauty, simplicity, and symmetry were criteria of truth and beauty. The same happens in modern science, where the most successful theories are distinguished by their elegance. The world, therefore, is presented as a mathematical and musical instrument, where every phenomenon is a note of a universal rhythm. Thus, the Pythagorean idea of numerical harmony remains alive: nature is number and order, and we, in search of its mathematical essence, are all Pythagoreans. It is quite normal that Pythagoras was transformed from a philosopher into a legendary and semi-divine figure already in ancient and late antiquity. Proportions such as 2:1 (octave), 3:2 (fifth), 4:3 (fourth) become metaphors for cosmic relationships. Pythagorean-Platonic emphasis on number to argue that harmony in music mirrors harmony in the heavens and within the soul.[3]

Key Words: Pythagorean Cosmology, Pythagorean Philosophy, Mathematics, Symmetry and Natural Laws, Music of the Spheres, Pythagoreanism in Modern Physics

Introduction

Pythagoras is one of the most important, as well as legentary, people who influenced and continue to influence human civilization.

We will deal with them in an organized way, based exclusively on ancient texts, which we analyze and are led to conclusions. We attempt philosophically, with precision, to attribute to Pythagoras and the Pythagoreans with respect and clarity, without secrets. We connect with modern science, because this connection restores the historical continuity of philosophical intellect, science, and technology.

Today we will not just talk about the great philosopher, but about an idea that permeated the centuries, changed the way we see and comprehend the world and still lives inside us. It affects culture even where we don't imagine it. We are talking about Pythagoras. Today's civilization is based exclusively on the principles of Pythagoras and the Pythagoreans.

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[3] Youvan, D.C., 2024. The Cosmic Symphony: Exploring the Legacy of the Music of the Spheres in Science, Philosophy, and Spirituality. DO - 10.13140/RG.2.2.34182.18243

What are the principles of Pythagoras? Let us see how the so-called Pseudoplutarch presents them. He writes: "Again, from another authority, Pythagoras Mnesarchus of Samos, the first to address philosophy in this way , the beginnings of the numbers and the symmetries of these things, which and of harmony he calls, the fourth of the two composite elements, called dthe geometric", i.e., "Starting again from another principle, Pythagoras, son of Mnesarchus of Samos, the first to call this thing "philosophy", considered as principles the numbers and symmetries that exist in them — which he also calls harmonies — both together the composite elements, which are called geometrical".[4] For Pythagoras, numbers are not just measures, but the principles on which the study of understanding and predicting nature is based. These relationships are how the world, nature, is described. Symmetries in nature are present everywhere, visible or often hidden. Symmetries and harmonies often help to find and formulate more simply and more generally the laws of nature that determine how phenomena occur, how they relate and evolve. With them we discovered most of the so-called elementary particles.

One manifestation of these principles was the concept of cosmic harmony and the music of the spheres — the movements of celestial bodies are expressions of numerical harmonies.[5] The cosmos is structured by musical-ratios and harmonies, linking the motions of the celestial spheres, the human soul's emotional life, and audible music. He claims these correspondences inspired art, architecture and scientific thought, so that harmonious proportions underlie temples, paintings and scientific theories. In art and architecture, this meant employing numerical ratios and cosmic symbolism to reflect divine order. In science, the notion of universal harmony helped shape cosmological and astronomical frameworks. The "music of the spheres" becomes a metaphor for linking micro- and macro-worlds, art , mathematics, science and uniting humanity and the human *gnosiosphere* with the one and only cosmic order.[6]

The "music of the spheres" endures primarily as a symbolic and heuristic idea rather than a literal physical phenomenon. Historically rooted in Pythagorean thought, the harmony metaphor encouraged generations of thinkers to seek mathematical order in the heavens; but modern astronomy demonstrates that planetary motions do not produce audible harmonies in any conventional sense. The essay stresses two complementary legacies: intellectual and cultural. Intellectually, the harmony motif fostered an expectation that celestial motion should be expressible in simple numerical ratios, a belief that propelled work from medieval cosmology through Kepler's *harmonices* toward the mathematization of planetary motion.[7] Culturally, the motif persisted as a powerful image in art and architecture, motivating designers and artists to embody cosmic proportions and to use harmonic ratios as organizing principles. Gaizauskas therefore frames the harmony of the spheres as a productive metaphor that shaped scientific questions and enriched aesthetic practice, even though its literal cosmological claims have been superseded by empirical astronomy.

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[4] On Philosophical Dogmas, I, 2 = Diels–Kranz 58 B1

[5] James, J., 1995. The music of the spheres: Music, science, and the natural order of the universe. Springer Science & Business Media.

[6] Voss, Angela, 1998. The Music of the Spheres; Marsilio Ficino and Renaissance Harmonia. Culture and Cosmos. A Journal of the History of Astrology and Cultural Astronomy, 2(2).

[7] Gaizauskas, B.R., 1974. The harmony of the spheres. *Journal of the Royal Astronomical Society of Canada, Vol. 68, p. 146*, *68*, p.146.

We are Pythagoreans

For Pythagoras was the first to see that the laws of nature are mathematical. When we say today that energy is conserved, that the equations of physics are symmetrical, that whenever a law is generalized it gives many more and more important results, when we say that laws are simple and universal, we are actually expressing the Pythagorean principle: Nature in numbers and harmonies is — Nature is made of numbers and contains harmonies. The phrase of Pseudoplutarch is one of the clearest and most concise testimonies to the first principles of Pythagoras which are applied everywhere today.

Why are we Pythagoreans? Because we necessarily adhere to the scientific principles, which are the principles of the Pythagoreans and indeed of nature. When I gave the first lesson to the Physics students at the University of Athens, I told them. You will become more Pythagorean than Pythagoras himself. Of course they didn't understand me, but I explained to them immediately: From today you will see the Cosmos with the scientific principles of Pythagoras, that is, that nature is described with mathematics, with the mathematics that expresses the laws of physics, as we formulate them every era. In the next four years, the students were transformed into Pythagoreans.

Therefore, Einstein is not right when he expresses his concern about the fact that we can and do study the universe. Einstein on this paradox highlights the unexpected harmony between human knowledge and the universe. In his 1936 essay "Physics and Reality," he wrote: "The eternal mystery of the world is its comprehension... The fact that he is understood is a miracle." He marveled at how human thought could unravel the mysteries of the universe, suggesting a deep-rooted connection between the mind and the universe.[8] Of course he knows that this is not a paradox, because he knows better than anyone the value of the laws of physics.

If you were to ask a citizen of antiquity what the world is, you might be answered by chaos. Hesiod says that the Cosmos began from chaos, in the sense of infinite space, of space and not of disorderly and mixed material, since before the Cosmos there was no material.

Pythagoras allows us to understand how this chaos changed and the Cosmos was created. This is what science ultimately attempts with determinism and the laws of physics, as according to our history, Pythagoras was the first to formulate.

What was Pythagoras based on? In the laws of physics that are expressed with the appropriate mathematics. Simplicity, harmony and symmetries lead to comprehensible and utilitarian forms of the laws of nature.

Pythagoras and the Laws of Nature

Pythagoras didn't just talk about numbers; He talked about laws. Numbers, for him, were not symbols of invention, but principles of reality. The analogies (1:2, 2:3, 3:4) that govern musical harmony were not only aesthetically pleasing; they revealed the natural order — the way nature structures energy, movement, and matter. In essence, Pythagoras invented the mathematization of natural laws. That is, that nature is not simply described by mathematics, it is mathematics in action. What Galileo later formulated — "the book of nature is written in the language of

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[8] Einstein's reflection on this paradox highlights the unexpected harmony between human cognition and the cosmos. In his 1936 essay "Physics and Reality," he wrote, "The eternal mystery of the world is its comprehensibility… The fact that it is comprehensible is a miracle." He marveled at how human thought could unravel the universe's mysteries, suggesting a deep-seated connection between the mind and the cosmos.

mathematics" — is Pythagorean doctrine in its pure form. And what Einstein described as "the most incomprehensible thing in the world is that the world is intelligible", is precisely the expression of the Pythagorean principle: nature obeys simplicity, symmetries and reasons.

Simplicity and Symmetry: the Pythagorean Key. For Pythagoras, the law of nature is the one that combines: Simplicity, that is, the minimum number of principles, the simplest mathematical relationships. It combines these with symmetry, i.e. the balance of opposites. This triptych reappears at every stage of natural science. Maxwell's equations are symmetric. That matter is oscillating harmony — a purely Pythagorean idea.

Mathematics, Simplicity, and Symmetry: The Pythagorean Key to Elementary Particle Physics

Pythagoras did not just look for numbers; he sought the form of truth in the apparent chaos of the phenomenon. Where most people see complex movements, Pythagoras discerned harmony and relationships. Where others heard noise, he heard harmony. From the oscillation of strings to the movement of planets, from the geometry of shapes to the structure of matter we know today, the same principle resonates: what is simple and symmetrical is true. This Pythagorean axiom—that nature expresses itself through pure numerical relations—is the foundation of modern physics. Particle theories, from the Standard Model to the search beyond it, are based precisely on this Pythagorean vision: symmetry gives birth to particles. Physicists today are not just looking for what exists, but what symmetry allows it to exist.

The theory of the Lie groups, the symmetries SU(2), SU(3), and U(1) that describe the fundamental forces, is nothing more than the modern form of the Pythagorean harmonies 1:2, 2:3, 3:4. Like the strings of a lyre, particles pulsate within the field of symmetries, forming spectra—energetic, photonic, musical.

Many particles, such as the Higgs boson, were not discovered by chance. It was predicted by symmetry and simplicity. The same mathematical simplicity that led Pythagoras to see the universe as a musical sphere led Dirac to write the equation of the electron in antiparticles and Higgs to predict the field that gives mass to the particles.

Nature, it seems, loves pure relationships: beauty is the criterion of truth. Almost all the elementary particles of the Standard Model were predicted before they were discovered experimentally, by the mathematical requirement of symmetry. Let's look at them briefly and clearly, to show how Pythagorean the logic behind modern physics is.

The elementary particles that symmetry "gave birth" to

1. The positron (antielectron) with prediction: 1928 by Paul Dirac, through the Dirac equation based on the principle of symmetry: symmetry of matter – antimatter (fundamental solution of the equation). The discovery was made in 1932 by Carl Anderson. Blackett and Occialini had detected and recorded them in detail earlier. The positron is the first particle to be predicted exclusively by mathematical symmetry.

2. Neutrinos were detected by a prediction made in 1930 by Wolfgang Pauli and confirmed in 1956. The prediction was based on the principle of symmetry: conservation of energy and angular momentum in β-decays. Their role was to complement the triads of leptons (e, m, t) and maintain the SU(2) symmetries of weak interactions.

3. Another form of symmetry led to quarks which were not predicted because they were "seen", but because they were missing from symmetry. Quarks were predicted in 1964 by Murray Gell-

Mann and George Zweig. The prediction was based on the principle of symmetry: SU(3) symmetry of the "octet" of hadrons — octets and tens of particles are derived like harmonics from a basic sound. The discovery was made in 1968 in SLAC, USA.

4. Tier bosons (force carriers)

The principle of symmetry with Gauge theory led to group symmetries in theoretical physics.

U(1) → photon (electromagnetism)

SU(2) → W^{+}, W^{-}, Z^{0} (weak power)

SU(3) → Gluons (Strong Power)

TABLE: PYTHAGORAS' PRINCIPLES AND MODERN SCIENCE

Pythagorean Authority	Text / Term	Meaning in Pythagorean Philosophy	Equivalent in Modern Science	**Remark / Comment**
1. Number	"The Beginning of the Numbers"	Numbers are the fundamental principles of all things. Everything that exists can be expressed in numerical relationships.	Mathematical laws of nature (Physics, Cosmology, Field Theory)	Equations describe the universe with mathematics, as predicted by the Pythagoreans.
2. Symmetry (harmony)	"the symmetries that are in them, which he also calls harmony"	Nature is organized in harmony, in balanced proportions.	Principles of symmetry – conservation laws (energy, momentum, charge, electromagnetism, time–space symmetry, elementary particles	Harmony and symmetries are the fundamental qualities of nature that make the universe Cosmos and understandable.
3. Composite Elements (Geometric)	"The D of both composite elements, and they are called geometrical"	From numbers and harmonies arise forms, structures and bodies – the material world.	Geometry of space – Theory of Relativity, Crystallography, Morphogenesis	Matter is structure and form — geometry describes space, time, and matter.
4. Harmony of the World	(synopsis of the Pythagoreans, "order in heaven")	The universe is a living, numerically, harmoniously, often symmetrically, organized order.	Cosmic Symmetry – Music of the Spheres → Quantum Frequencies / Cosmic Music	From the motion of the planets to the oscillations of the particles, everything obeys rhythms and numbers.

The discoveries of W and Z (1983, CERN), Gluonia (1979) were made by applying Pythagorean principles. Each force arises as a "harmonic note" of an internal symmetry.

5. The Higgs boson

With the Pythagorean principles, we were led to predictions of new particles in 1964 (Higgs, Englert, Brout, etc.). Deviations from the principle of symmetry also led to the perception of the Mechanism of spontaneous symmetry breaking and to new discoveries in 2012 (CERN). The Higgs particle was found to be the "regulator" of harmony – it gives mass to the other particles, just as the string regulates the pitch of sound.

6. The top quark was predicted in 1973, as necessary to maintain the symmetry of the "three generations". The discovery was made in 1995 (Fermilab). It had to exist, otherwise the music of symmetry would "break".

From Music to Cosmology

Music was for Pythagoras the first physics laboratory. The sound of the string revealed that nature "thinks" with ratios: 1:2, 2:3, 3:4. The same mathematical logic he had found with his disciples in the heavens. Cosmic harmony was highlighted. This shows that the music of the spheres is not a myth, it is an aesthetic physical theory that the movements, spectra and frequencies of the universe obey laws of harmony.

Modern interpretation is very instructive. Today's physics — from the symmetry of conservation laws to superstring theory — confirms Pythagorean intuition. The universe is dominated by resonances, and this can be understood through harmonic relationships and simple mathematical symmetries. Pythagoras, without knowing the equations, understood the essentials. Nature may be complex, complex, but its complexity stems from the simplicity of its principles by which it can be understood, interpreted and in many its manifestations predicted.

In conclusion, Pythagoras did not prophesy only the music of the spheres. He prophesied and imposed the music of the laws of physics. The search for simplicity and symmetry is the continuation of the Pythagorean tradition in modern science.

Every time a physicist looks for the most "elegant" law, every time a mathematician speaks of the "beauty of an equation", every time an astronomer sees in the orbits of the planets a mathematical consequence — there, the soul of Pythagoras breathes.

The phrase "We are all Pythagoreans" is not just a philosophical slogan; it is a statement about the nature of human rationality. All Western (and not only) civilization—from science to music, from astronomy to geometry, from harmony to ethics—is imbued with the Pythagorean idea that the *world is numerous, reason, harmony*.

From the moment we measured the rhythm of our heart, the frequency of a sound, or the period of an orbit, we became—consciously or not—Pythagoras' disciples. For Pythagoras did not just look for numbers; he looked for reasons, mathematical relationships, equations that explain how it is given, what it is, how it is born, why the light shines. Similar because the sound fascinates, because the soul pulsates. Today, physics interprets everything from elementary particles to the structure of the whole world and DNA. Science based on the principles of Pythagoras interprets the universe, makes our phones, our computers, all the technology.

The world on all scales pulsates in harmonious rhythms. When Pythagoras spoke of the harmony of the spheres, he was not speaking metaphorically; He described a natural phenomenon that we are only now beginning to understand. The planets move at rhythms that form ratios: 1:2, 2:3, 3:4 — the same proportions that determine musical symphonies. Kepler, nineteen centuries later, wrote in his book that the periods of the planets and their resonances are similar to musical intervals. Saturn and Jupiter sing a fifth; the Earth and Venus one ton.

In Harmonices Mundi (1619), Kepler calculates the velocity difference between perihelium and aphelion and compares it to musical intervals, such as tones, thirds, and fifths. The entire 5th book is dedicated to the music of the spheres. The most important parts are: Chapter 7: Musical Proportions of Planetary Motions, Chapter 8: Planetary Velocities and Musical Tones. Chapter 9–10: Relationship between orbital geometry and musical symphony. The approach is quantitative and mathematical: musical notes and intervals are tools for understanding the laws of planetary motion. The motion of the planets is no longer considered an invisible sound, but a measurable numerical harmony, leading to the laws of elliptical orbit and Kepler's 3rd law (ratio of circle and velocity). Pythagoras sees harmony as a philosophical and cosmological principle, a secret of the world embodied in planets and sounds. Kepler turns the same idea into a scientific tool: the numerical relationships of planetary velocities become "musical intervals", which help to discover the laws of nature. The two perceptions emphasize that the universe is organized by numbers and harmony.

The Byzantine philosopher Ioannis Laurentios of Lydia, another Pythagorean, in his work *On the Months*, reminds us that "All that is the movement of the planets is happening." And he continues, attributing to every planet a musical way and vowel:

Saturn — Doric, Κρόνος — Δωρικός (ι),

Jupiter — Phrygian, Δίας — Φρυγικός (ω),

Mars — Lydicus, Άρης — Λυδικός (ο),

Sun, Ήλιος — (η),

Venus, Αφροδίτη — (ε),

Mercury, Ερμής — (α),

Moon Σελήνη — (υ).

Kepler, with the sensitivity of Ioannis Lydos and the mathematical precision of Pythagoras, translates these voices into numbers. Pythagoras saw and measured the relations; Lydos praised it; Kepler proved it.

We are all Pythagoreans: From Ancient Greece to modern physics laboratories, the same pattern is coming back. Order is harmony, music, the law of nature is the Logos, beauty is the result of the laws of nature expressed in mathematics, the principles of understanding the Cosmos are numbers.

The world, the cosmos, is not chaos. It is the world — that is, order, harmony, Logos, with symmetries. And here we have the first great miracle: The word "κόσμος" in ancient times meant ornament.

Reason, Mind, Fate and Laws of Nature

Pythagoras and the Pythagoreans were the first to say: In nature there is causality. There is a reason (of Heraclitus). The word "LOGOS, λόγος" does not simply mean speech, word; It mainly means logic and the resulting determinism. It means the law of nature. This Pythagorean idea later founded mathematics, physics, science, cosmology, philosophy.

In Greek philosophy, the terms Logos, Nous,Eimmenis are often associated with the idea of a "law of nature", but each term has specific nuances. Let's look at them in detail.

Logos (logos) in the classical use of the term by Heraclitus (6th–5th century BC) means the causal principle that governs the universe. It is the law of nature that governs and interprets motion, the order that maintains unity in the constant flow of things. Nature is constantly changing, but according to fixed rules – these are the Logos.

The Mind (νοῦς) is mainly mentioned by Anaxagoras and to the Stoics. In the Anaxagoras, the Mind is the imaginary cause of the order in the world. The Mind directs the seeds (admittedly tiny elements) and organizes matter. According to the Stoics, the Mind is the cosmic logical force that shapes the world according to natural laws. A modern interpretation is that the Mind is the natural laws that determine motion and from the Stoics. order and therefore the structure of the universe.

In the Greek intelligentsia (e.g. Stoics, Orphics, Plato) it has the same meaning according to my interpretation. Ε ἱμαρμενη is the necessity or 'fate' that determines the processes of nature and the course of things, ultimately as a result of the laws of physics. The meaning in many texts is what will inevitably become in a system, that the "natural order" imposed on all beings and natural systems as a result of the laws of nature cannot be changed. If we leave a stone it will fall. Its orbit is determined by the starting position and initial velocity. In the Stoics:Eimmenis is associated with Reason and Mind as an inviolable natural law. Of course, all this is determined by Pythagoras' principles, numbers.

A modern Pythagorean Perspective

Particle physics works like a Pythagoras lyre: Symmetries are the strings, Particles are their harmonic oscillations, Interactions are the intervals that connect sounds. When a symmetry "breaks", new "notes" appear — new particles. When symmetry is "restored," the universe returns to its harmony.

Next step: supersymmetry (SUSY), which has not yet been accepted, is based on the same principle: Every fermion has a symmetric boson. If confirmed, it will be the most complete Pythagorean symphony of nature. Pythagoras taught us that the universe is not a machine, but an instrument — and the laws of the natural world are the notes of a cosmic composition.

From light waves (optical harmony) to probability waves (quantum harmony), everything obeys rhythms and reasons that he could have carved out himself at his School in Croton.

The physics of elementary particles is nothing more than the new Pythagorean Harmony — written no longer with sounds, but with equations.

The search for the *Theory of Everything* is essentially the search for the perfect agreement between matter, energy, space and time.

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As Pythagoras said, "everything is made by number." And if there's one thing the Higgs' discovery has taught us, it's that even the most invisible particle obeys the same principle that governs spheres, colors, and sounds: nature is harmonious. And we, its researchers, are—after all—all Pythagoreans.

Richard Feynman, renowned for his contributions to quantum electrodynamics and his charismatic teaching style, often reflected on the profound relationship between mathematics and nature, a theme rooted in Pythagorean philosophy. Feynman admired the idea that the universe operates according to simple, elegant mathematical laws, echoing Pythagoras' conviction that numbers and ratios govern cosmic harmony. He frequently emphasized that understanding the patterns and symmetries in physical phenomena is central to scientific inquiry. While not directly referencing Pythagoras in most of his technical work, Feynman's intuitive appreciation for the mathematical order of the universe—from quantum mechanics to path integrals—resonates strongly with the Pythagorean vision of a cosmos structured through numerical relationships. In this sense, Feynman can be seen as a modern scientific heir to the Pythagorean belief in the intrinsic harmony and intelligibility of nature.

The Laws of Physics in the Orphic Hymns

In the ancient Greek tradition, the Orphic Hymns were not just religious texts; they were also cosmological hymns that reflected the perception of order, the Law and the harmony of the world. The Law, as expressed in the hymns, is not abstract but is incorporated into the very nature and movements of the celestial bodies. Every planet, satellite or asteroid moves within a framework of strict numerical and geometric relationships, which the Orphics identify with the cosmic Law (NOMOS, νόμος).[9]

Hymns often describe the world as a dance of gods and celestial bodies, where each participation follows a rhythm and harmony that cannot be disturbed. This corresponds to the Pythagorean idea of the Music of the Spheres (Musica Universalis): the planets do not move randomly, but according to proportions that produce arithmetic and harmonic order. The Law described in the Orphic Hymns makes this harmony inviolable — the celestial movements are bound to specific periods and cycles, such as the Eight Years, the Meton cycle, and the Saros we discovered in the Antikythera Mechanism.[10]

In Orphic cosmology, harmony is not limited to the planets but runs through the entire universe, as indeed happens. The Hymn to the Sun, for example, describes the movements of the Sun and Moon as rhythmic and regular, while the other planets and celestial bodies are integrated into coordinated patterns. The Law of Hymns suggests that no body can deviate from the cosmic dance without disturbing the harmony of the universe, a fact linked to the idea of necessity in the movements of the planets, as later described by the Pythagoreans and Plato in the Timaeon.

Even satellites and smaller asteroids are considered part of this dance. Their movement is not random, but depends on numerical ratios and periodicities that have been analyzed by ancient

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[9] Papathanasiou Maro, 1978 and 2nd edition 2016 Cosmological and cosmogenic concepts in Greece during the 2nd millennium BC, Doctoral thesis, University of Athens. Cosmosware Publishing, ISBN 978-960-7596-18-5, Athens.
Papathanasiou Maro, 2017 Orphics. Orphism - Hymns of Orpheus, by K. S. Hasapi, Cosmosware Publishing, ISBN 978-960-7596-24-6, Athens.

[10] Moussas, X., 2014. Early Greek astrophysics: the foundations of modern science and technology. *American Journal of Space Science, 1(2),* p.129.

astronomers and are confirmed today with modern astronomy. Celestial bodies move in normal, repetitive orbits, where any deviation would compromise the cosmic balance.

In conclusion, the Orphic Hymns, combined with the Pythagorean perceptions, show us that the universe functions as a great dance of numbers, harmonies and laws, in which the planets, satellites and asteroids participate invariably. This cosmic order, the necessity and the resonances described, are the foundation for the modern scientific understanding of astronomy and physics, proving that the harmony of numbers and laws is not an abstract philosophy but a practical reality of the celestial bodies.

Pythagoras according to Aristotle

Aristotle points out that this approach represents a metaphysical conception of nature, where the concept of number takes on a central role as a cause and measure of order in the world.

Aristotle presents the Pythagoreans as a School of Philosophy that studies and interprets nature and ethics with numbers of which he considers as principles. He considers the One and the Infinite as primary principles. He considers physical bodies and their relations to be a manifestation of numerical proportions. Aristotle considers that the Pythagoreans do not strictly separate number from real matter. but he sees a numerical order in all beings in nature.[11] Literal translation: "The order that exists in the heavens and which the Pythagoreans established through numbers, is mentioned in the second book On the Pythagorean Glory." refers to the order in the heavens, to the Pythagorean idea that the universe is organized according to harmony and numerical relationships. The Pythagoreans believed that celestial bodies and their movements can be expressed through proportions and numbers, That is, through the laws of physics expressed by mathematics. "which they made of numbers" – established through numbers. He emphasizes that Pythagorean cosmology is grounded in mathematics, with numbers not just as tools, but as principles of understanding the cosmic order.

Reference to the On the Pythagorean Glory. This is a work (probably one of the works that summarizes the Pythagorean teachings and which has been lost) that deals with Pythagorean cosmology and the importance of numbers [laws of physics] in the universe. The passage acknowledges that the Pythagoreans study the heavens with mathematics and harmoniously structured. This perception influenced Greek and modern philosophy, from Plato and the Stoics from Galileo, Kepler, Newton to modern science. It is also an important source linking the Pythagoreans to the notion that the harmony of numbers governs the movements of the planets.

Aristotle says that the Pythagoreans associated the trinity with the heavenly planes (e.g., earth–world–heaven) or with musical harmonies (such as 1:2, 2:3, 3:4).[12] Aristotle recognizes the Pythagorean doctrine of number as the beginning of the world, explains why the trinity is considered the measure of everything, and connects mathematical harmony with the physical and cosmic order. The trias is the number of completeness. For the Pythagoreans, three (3) is the first

[11] Category 5, treatise title 30, fragment 202, line 3 metaphys. (1, 8) p. 56, 9 Bon.: and the order of the heavens in which the Pythagoreans made numbers, mentions in the second on the Pythagorean glory. The passage says: "And of the order in heaven which the Pythagoreans made of numbers, he mentions in the second about the Pythagorean glory.

[12] Aristotle et Corpus Aristotelicum Phil., De caelo, Bekker page 268a, line 11 For as the Pythagoreans also do, everything and everything are defined by the three; for the last and the middle and the beginning have the number of all, and these things have the number of the trinity

perfect number; It has a beginning, a middle and an end. Anything that has these three elements is considered perfect and complete. The trinity symbolizes the fullness of existence and the order of the world, "all and all" – the universe and all beings. Aristotle here analyzes the theory of the Pythagoreans, which is based on the fundamental principle that the structure of the universe is arithmetic and even triadic. For he writes "the last and the middle and the beginning". The phrase indicates the order and harmony that governs the world; Nothing is anarchic or imperfect—everything has a beginning, a middle, and an end, just like every musical phrase or any natural process. This concept of the trinity as a secular principle passed into Platonic and Neoplatonic thought (e.g. ἕν-νοῦς-soul), but also into the theological tradition, where the trinity becomes a symbol of divine perfection.

Let's see more metaphors.

Referring to the theory of numbers and nature, he writes again that The Pythagoreans believe that the nature of the world can be explained through numbers.[13] Physical bodies seem to have weight and lightness, while units (numbers) are not bodies nor do they have physical characteristics and indirectly rejects the Pythagorean perception of the correspondence of numbers and beings. Comment: Aristotle notes that the Pythagoreans attempt a metaphysical reduction of nature to numbers, without identifying number and material substance.

Aristotle in Ethics[14] refers to ethics and virtues and comments that Pythagoras tried to connect virtues with numbers, but his theory of virtues was not correct, because virtues are not numbers. Aristotle rejects the view that the Pythagoreans have of reducing moral issues to numbers, which he considers inappropriate. Aristotle comments[15] on the moral dimension of Pythagorean thought, pointing out that Pythagoras tried to reduce the virtues to numerical proportions. This effort is not considered correct, as the virtues cannot be considered numbers or measured as such. The connection of the moral order with the number shows the tendency of the school to apply numerical thinking to every field of knowledge, but Aristotle emphasizes the limits of this approach. The Pythagorean method in ethics was more symbolic and proportional than strictly scientific, while their error, according to Aristotle, lies in the fact that the nature of virtues does not obey numerical rules.

Aristotle in Metaphysics[16] again refers negatively to the Pythagorean principles and matter. The Pythagoreans consider the One and the Infinite as basic principles, and that the essence of everything is number. The concept of participation (communion) is used differently in Plato and the Pythagoreans. The Pythagoreans have an arithmetic cosmology: everything follows from arithmetic principles. A number is not just a magnitude, but an entity that manifests the nature of things. The concept of communion (participation) used by Plato differs from theirs, as the Pythagoreans do not consider numbers to participate in things in the Platonic way; On the contrary, things are numerical manifestations, where each element of the world can be reduced to an analogy or a ten.

Aristotle[17] again writes that the Pythagoreans consider physical bodies and magnitudes to arise from numbers, not as separate objects but as a manifestation of numerical order. The void is also

[13] De Caelo 300a17:
[14] Magna Moralia 1.1.6
[15] Magna Moralia (1.1.6),
[16] Metaphysica 987a-b:
[17] Metaphysica 1080b-1090a

considered a numerical principle for them. Aristotle explains that the Pythagoreans do not separate the numerical from the physical, but see the physical bodies as "embedded" in numerical relationships.

Aristotle, in the same works, points to the Pythagorean view that physical bodies and quantities arise from numbers, but not as separate objects. Numbers are the means of creating and maintaining order in the world. In particular, he notes[18] that nature and physical properties, such as lightness and weight, are not inherent in arithmetic units. but they arise from the organization of numbers. Therefore, numerical theory is not simply mathematical, but metaphysical, since it determines the structure of the world and phenomena.

Aristotle also writes[19] that the Pythagoreans categorize oppositions (good-bad, worst-better) into numerical arrays, using the ten as a basic tool. He emphasizes that there is a clear numerocratic methodology, where the moral order of the world and the harmony of things are reflected in numbers.

In his book Physics[20] Aristotle explains that the Pythagoreans considered the Infinite and the void to be arithmetic principles that determine the nature and arrangement of the world. The Infinity is associated with the concept of even and odd order in numbers, while the void determines the relationships between beings, allowing for the sequential arrangement of elements and their movement in the world. This metaphysical use of numerical concepts shows that for the Pythagoreans The mathematical classroom is not just a tool for description, but a principle of creation and maintenance of the world.

The Pythagoreans, Aristotle writes,[21] seem to believe that the whole world can be reduced to numbers, and even to specific proportions, as in the case of cubic numbers that form tens and sets. The ten functions symbolically, connecting every opposition (good-bad, better-worst) with a numerical array. This numerical symbolic approach shows the Pythagoreans' attempt to conceive harmony and justice in the world with mathematics means, seeking to unite moral, physical and cosmological order.

Aristotle's references to the Pythagoreans show the attempt of this school to interpret the world through numerical order and proportions. Already in his work On Heaven[22] , Aristotle notes that, according to some Pythagoreans, the nature of the world can be reduced to numbers. Physical bodies appear to have weight and lightness, whereas arithmetic units by themselves are not bodies nor do they possess physical characteristics. In other words, the Pythagoreans attempt to explain physical reality with abstract numerical principles, where bodies are manifestations of these principles and not independent entities with their own matter or properties.

In summary, Aristotle's references present the Pythagoreans as a school that attempts a holistic numerocratic approach. From cosmology and physics, to ethics and metaphysics, numbers are the foundation of every classroom. The physical bodies and the opposites of things are manifestations of this numerical order, while the One, the Infinite, and the void function as primary principles that determine the structure and dynamics of the world. Aristotle, while acknowledging the

[18] to 1080b-1090a
[19] Fragmenta varia 191 & 200
[20] Physica (203a, 213b),
[21] Problemata (910b)
[22] (300a17)

originality and coherence of this approach, observes its limits, particularly when applied to ethical issues or phenomena that cannot be reduced to numbers.

Symmetry and Harmony

Simplicity is not poverty or naivety, let alone incompetence. It is primarily important in the app, where simplicity is essential. Simplicity is a sign of maturity, understanding and true knowledge. Aristotle said that virtue lies in the middle; In the same way, simplicity is the golden mean between exaggeration, complexity and confusion. In practice, simplicity is not easy; it requires inspiration, understanding of the problem, analysis, solution, self-knowledge and spiritual discipline. When something is simple, it means that it has gotten rid of the superfluous, gone through the complexity, and kept only the essence. In science, in art, and in life, simplicity is not a constraint—it is the highest form of perfection.

Symmetry is not only a matter of aesthetics, it is not decorative; it is a tool of insight. Symmetry is not only a matter of aesthetics, nor just a decorative element; it is a fundamental tool for insight and understanding of nature. It expresses the inner order of the world, the harmony between contrasts, the logic of Being. From the Pythagorean music of spheres to the equations of modern physics, Symmetry acts as a bridge between the sensible and the intelligible, chaos and order. It doesn't just adorn the form; it reveals its deepest essence. Through symmetry, the mind sees not only beauty — it recognizes the general law that governs a natural phenomenon. Pythagoras defined number as the "beginning of everything", he meant exactly that: that reality is not chaotic, but organized according to simple and unchanging relations, the laws of physics and fields.

The harmony that Pythagoras discerned in the sounds of the hammers and strings of musical instruments and the Planets expressed in simple ratios of numbers, is not limited only to music or mathematical relations, but also becomes visible in the sky through the resonances of the planets and the celestial bodies. The Pythagoreans believed that numbers and proportions are not just abstract concepts, but the fundamental rules that determine the order and balance of the universe. Every numerical relationship, every symmetry, every harmony in the movement of bodies reflects the same cosmic order that governs everything from the smallest structures of nature to the orbits of the planets.

The confirmation of this cosmic mathematical order is strikingly displayed through the Antikythera Mechanism, this unique artifact from the 2nd century BC that connects technology with astronomy and arithmetic. The Mechanism revealed to the scholars the mathematical structure of the celestial periods, including the Octaeteris, the Eight-Year Period, the 19-Year *Metonic* Cycle, the 223-Month *Saros*, the 669-Month *Exeligmos* which are incredible resonances which are cosmic dances of the Earth, Sun and Moon in which the dancers dance not on one plane, but in three dimensions. One dancer (Venus) has to show her face to the other dancer, the Earth (New Moon, Full Moon, etc.) in certain phases in two of these dances (Octaetirida and Metonos). In two other dances of Saros (223 months) and Evolution (669 months) one dancer Moon as she ascends and descends above and below the level of the Earth's dance around the Sun, hides behind her or hides the Sun as she passes through the plane of the Earth's orbit. It is unbelievable that in the Antikythera Mechanism, even greater periodicities with a duration of 442 and 462 years are mentioned in the bronze manual of its use, which are cosmic dances of the entire Solar System.

These long-lasting harmonic periodicities are the Music of the Spheres. They owe the resonances of the planets and lunar phenomena, proving that the ancients did not just see random movements in the sky but perceived a "dance" of cosmic harmony, where each body participates in a greater rhythm that determines the functioning of the universe. The resonances, the dances of the planets take place always and everywhere in the Cosmos without deviations from this

Ancient philosophers such as Plato in Timaeon refer to the soul of the world, which moves the celestial spheres according to the same rhythm and harmony that governs the human soul and nature. Pythagoras goes a step further: he considers that the laws of numbers are not just abstract mathematical constructions, but the very laws of nature, the foundation of order and evolution. The rate at which the universe "breathes", the regularity of celestial phenomena, the harmony of planetary cycles — all this expresses the same rules that govern numerical relations in art, music and geometry.

The consciousness of this harmony is not merely theoretical. It has practical implications in science, astronomy, and the study of nature. The symmetries that the Pythagoreans identified in mathematics, proportions and forms are transferred to the way we understand today the fundamental physical norms, the movements of bodies, the balance of forces, and even the cyclical processes followed by the stars and planets. Pythagoras teaches us that nature is number and harmony — that everything that seems random obeys an inner rhythm that we can study, describe, and predict.

In other words, the cosmic harmony envisioned by Pythagoras, from the strings of musical instruments to the planets, is not only philosophical thought but also scientific observation. The Antikythera Mechanism is a monument to this realization, proving that the harmony of numbers and celestial bodies is one and the same, timeless and transcendent, leading us to understand the world through the rhythm, symmetry and perfection of numbers.

Islamic thinkers' engagement with Pythagoras and Pythagorean thought

Many Islamic philosophers, mathematicians, and scientists were deeply influenced by Pythagorean ideas concerning numerical harmony, proportion, and the mathematical order of the cosmos. Great philosophers as Al-Farabi, Al-Kindi, Al-Biruni, and Ibn Sina (Avicenna) studied Greek philosophy, including Pythagorean and Platonic works, often through Arabic translations of Neoplatonic commentaries. They embraced the Pythagorean notion that numbers and ratios underpin music, geometry, and the structure of the universe, integrating these principles into mathematics, astronomy, and metaphysics.

The influence of Pythagoras on Islamic thinkers highlights the deep interconnection between mathematics, philosophy, and empirical science in the medieval Islamic world. Al-Kindi, Al-Farabi, Ibn Sina, Al-Biruni and others illustrate how Pythagorean principles of harmony, proportion, and numerical order were adapted, expanded, and applied in diverse contexts. By engaging with Greek philosophy critically and creatively, these thinkers not only preserved Pythagorean ideas but also transformed them, ensuring their transmission to the European Renaissance. Their work exemplifies a sophisticated synthesis of numerical reasoning, philosophical reflection, and empirical investigation, demonstrating the enduring power of Pythagorean thought across cultures and centuries.

The philosophy of Pythagoras emphasized that numbers, ratios, and mathematical relationships underlie the cosmos. His vision of harmony—whether in music, geometry, or the motions of celestial bodies—shaped centuries of intellectual inquiry. The Pythagorean idea that the universe is intelligible through numerical order not only influenced Greek thinkers such as Plato and

Aristotle but also profoundly impacted Islamic philosophers from the 9th to 11th centuries, who became crucial intermediaries in transmitting these ideas to medieval Europe.

For example, Al-Biruni applied Pythagorean concepts of proportion and harmony in his astronomical calculations, while Al-Farabi and Al-Kindi connected musical theory to cosmic order, reflecting the Pythagorean view of a mathematically structured cosmos. These thinkers transmitted and expanded Pythagorean ideas, blending them with Islamic metaphysics and empirical observation, thereby influencing both medieval European thought and the later development of modern science.

The philosophy of Pythagoras with its emphasis on numbers, harmony, and the mathematical structure of the cosmos, profoundly influenced later civilizations. Among these, Islamic thinkers from the 9th to 11th centuries engaged deeply with Pythagorean concepts, blending them with Greek, Neoplatonic, and Aristotelian thought. Through the translation and study of Greek texts, Muslim philosophers, mathematicians, and scientists absorbed the Pythagorean vision that the universe is intelligible through numerical relationships, applying it across fields as diverse as metaphysics, music, astronomy, and geometry.

Al-Kindi (c. 801–873), often called the "Philosopher of the Arabs," was a key figure in transmitting Greek philosophical ideas into the Islamic intellectual world. Drawing upon Plato, Aristotle, and Pythagoras, Al-Kindi emphasized the unity of existence and the underlying principles governing reality. In his treatise On First Philosophy, he writes: "The cause of the existence and continuance of everything is the True One."

This reflects the Pythagorean quest for an underlying numerical and harmonious principle governing reality. Al-Kindi's synthesis of Greek philosophy with Islamic thought laid the foundation for later European scholars to engage with these ideas.

Al-Farabi (c. 872–950) extended Pythagorean ideas into both philosophy and music. In his Kitab al-Musiqa al-Kabir (The Great Book of Music), he analyzed the mathematical foundations of musical intervals, echoing Pythagoras' exploration of the relationship between numbers and harmony. He writes: "Music is based on proportion, ratios, mirroring the cosmic order; its laws are mathematical in nature." Al-Farabi regarded music as a manifestation of cosmic order, illustrating the broader Pythagorean principle that numerical ratios govern both human experience and the cosmos. Yet he also critically examined some Pythagorean claims about celestial harmony, remarking that certain assertions about the stars were "plainly wrong," demonstrating the selective adaptation of Greek ideas within Islamic thought.

Ibn Sina (Avicenna, c. 980–1037) integrated Pythagorean concepts into his philosophical and scientific works. Influenced by Plato and Neoplatonism, Ibn Sina explored numerical ratios in metaphysics and music theory. Regarding music, he observed: "Music is a mathematical science, yet it must primarily concern the explanation of music as it is perceived by the ear." This illustrates a distinctive Islamic synthesis: Pythagorean ideas were valued not only for their metaphysical insights but also for their applicability to empirical and aesthetic understanding.

Al-Biruni (c. 973–1048) represents a further stage in the integration of Pythagorean principles into practical science. As a polymath in astronomy, mathematics, and geography, Al-Biruni applied the Pythagorean theorem and principles of numerical proportion to calculate distances, determine the Earth's radius, and develop precise astronomical models. He remarked in his works: "Mathematics is the key to understanding the order of creation, for through it the hidden measures of the universe are revealed." Al-Biruni applied Pythagorean mathematical principles to advance astronomy. He used proportional reasoning and the Pythagorean theorem to calculate distances and determine the Earth's radius. Al-Biruni demonstrates that Pythagorean harmony is not merely philosophical but also a practical tool for scientific investigation.

His work exemplifies the Pythagorean notion that mathematical order underlies the physical world, showing that ancient Greek ideas could be applied rigorously to empirical investigation.

Collectively, these Islamic thinkers demonstrate a pattern of engagement with Pythagorean philosophy that is both reverential and innovative. They absorbed the Pythagorean vision of a universe structured by numerical relationships and applied it to diverse domains—metaphysics, cosmology, music, and scientific computation. Yet they also critiqued, adapted, and extended these ideas to fit their own intellectual and cultural contexts. In doing so, they became vital conduits, transmitting Pythagorean concepts from the Greek tradition to later European thinkers during the Renaissance, thereby influencing the development of modern science and mathematics.

The enduring appeal of Pythagorean thought in the Islamic world lies in its combination of abstract mathematical reasoning with a philosophical understanding of cosmic order. From Al-Kindi's metaphysics to Al-Farabi's musical theory, Ibn Sina's integration of mathematics and perception, and Al-Biruni's empirical applications, numbers and proportion are consistently presented as keys to understanding the universe. This reflects a Pythagorean commitment to harmony, demonstrating that numerical relationships are not merely human inventions but intrinsic features of reality.

Through these scholars, Pythagorean thought was preserved and elaborated upon within the Islamic world. Their works, translated into Latin during the 12th century, formed a bridge to medieval Europe. Figures such as Thomas Aquinas, Robert Grosseteste, and later Kepler and Galileo encountered these ideas through Arabic commentaries, integrating Pythagorean numerology, harmony, and proportion into European philosophy, natural science, and music theory. Kepler, for instance, explicitly sought a "music of the spheres," echoing the Pythagorean belief in numerical order governing planetary motion.

The transmission of Pythagorean thought shows a remarkable continuity: from the abstract mathematical vision of Pythagoras, through the critical and empirical elaboration of Islamic philosophers, to the Renaissance revival of natural philosophy in Europe. This trajectory highlights three key features: the enduring importance of numerical harmony, the integration of philosophy and empirical observation, and the evolution of these ideas into modern science and mathematics.[23]

The legacy of Pythagoras extends far beyond ancient Greece. Through Islamic philosophers such as Al-Kindi, Al-Farabi, Ibn Sina, and Al-Biruni, Pythagorean principles of proportion, harmony, and numerical order were preserved, critiqued, and enriched. These ideas reached Europe, influencing the Renaissance and shaping the intellectual foundations of modern mathematics, astronomy, and physics. The journey from Pythagoras to Islamic thinkers and then to European

[23] Rashed, R., 2017. Problems of the transmission of Greek scientific thought into Arabic: examples from mathematics and optics. In *New Perspectives on the History of Islamic Science* (pp. 17-28). Routledge. Bhayro, S., 2017. On the Problem of Syriac "Influence" in the Transmission of Greek Science to the Arabs: The Cases of Astronomy, Philosophy, and Medicine. *Intellectual History of the Islamicate World*, *5*(3), pp.211-227. Shayegan, Y., 2013. The transmission of Greek philosophy to the Islamic world. In *History of Islamic philosophy* (pp. 89-104). Routledge. Abattouy, M., 2012. The Arabic-Latin intercultural transmission of scientific knowledge in pre-modern Europe: Historical context and case studies. In *The Role of the Arab-Islamic World in the Rise of the West: Implications for Contemporary Trans-Cultural Relations* (pp. 167-219). London: Palgrave Macmillan UK.

scholars demonstrates the enduring power of mathematical and philosophical harmony across cultures and centuries.

Isaac Newton and Pythagoreanism

Isaac Newton, while primarily a mathematician and physicist, was deeply influenced by the Pythagorean vision of a cosmos governed by mathematical harmony. He shared the Pythagorean conviction that numbers and ratios underline the structure of the universe, a belief that helped frame his laws of motion and universal gravitation. Newton saw the regularity and order of planetary orbits as evidence of a divinely ordered, mathematically intelligible cosmos—echoing the Pythagorean idea that the heavens reflect a harmonious, numerical order. His work bridged empirical observation with the search for underlying simplicity, reflecting the Pythagorean ideal that nature could be expressed through elegant mathematical principles.

Newton's integration of mathematics, physics, and metaphysical speculation demonstrates a direct intellectual line from Pythagorean harmony to the scientific revolution, showing how ancient philosophical ideas continued to shape modern scientific reasoning.

Isaac Newton regarded Archimedes as one of his most important intellectual predecessors. He deeply admired Archimedes' combination of rigorous mathematics with physical insight, particularly in mechanics and the study of motion. Newton built on Archimedean principles when formulating his laws of motion and universal gravitation, extending Archimedes' work on levers, centers of mass, and the mathematics of curves to the celestial scale. He famously claimed that he "stood on the shoulders of giants," and Archimedes was explicitly one of those giants, providing both methods and inspiration for Newton's analytical approach.

Archimedes' ability to merge geometric reasoning with practical problems of mechanics resonated with Newton's own synthesis of observation, experimentation, and mathematical abstraction. In this sense, Archimedes served as a bridge between Greek mathematical physics and the development of classical mechanics, directly informing Newton's revolutionary work on the laws governing both terrestrial and celestial bodies.

From Pythagoras to Newton and Leibniz: The Evolution of calculus, Integration and Mathematical Harmony

The history of mathematics and physics reveals a remarkable continuity of ideas stretching from ancient Greece to the birth of modern science. Central to this evolution is the concept of integration—the summation of infinitesimal contributions to determine areas, volumes, and motion. Four towering figures—Pythagoras, Archimedes, Johannes Kepler, Isaac Newton, and Gottfried Wilhelm Leibniz—illustrate this intellectual journey, tracing how philosophical intuition evolved into rigorous analytical methods.

Calculus, as developed by Newton and Leibniz, represents the culmination of a long intellectual lineage rooted in Pythagorean ideas of numerical harmony. Archimedes pioneered geometric integration through the method of exhaustion, summing infinitesimal contributions to compute areas and volumes. Kepler applied similar summation techniques empirically to planetary motion, reflecting a cosmic order inspired by Pythagoras. Newton formalized these methods analytically with fluxions and fluents, while Leibniz introduced symbolic notation and systematic manipulation of infinitesimals. Together, they transformed ancient geometric intuition and philosophical ideas of harmony into the rigorous, generalizable framework of modern calculus, underpinning both mathematics and physics.

The evolution of integration from Archimedes to Newton and Leibniz reflects a continuous development of mathematical ideas rooted in both geometry and simplicity. Archimedes pioneered the method of exhaustion, approximating areas and volumes by summing infinitely many inscribed and circumscribed shapes, anticipating the concept of infinitesimal summation. Kepler applied a simpler similar less vigorous approach empirically, dividing planetary orbits into narrow segments and summing their areas. Newton formalized these ideas through fluxions and fluents, providing a rigorous analytical framework, while Leibniz introduced symbolic notation and systematic manipulation of infinitesimals, making integration more general and versatile.

Across all four thinkers, integration involves the summation of continuous quantities, relies on approximations or limits, and is applied to physical or geometric problems. Philosophically, their work is guided by the belief in an underlying mathematical order, inspired by Pythagorean harmony. This continuity illustrates how geometric intuition evolved into the analytical calculus that forms the foundation of modern mathematics and physics.

Pythagoras (c. 570–495 BCE) introduced the revolutionary idea that numbers and ratios govern the universe, embedding the notion of cosmic harmony into the foundations of Greek thought. He emphasized numerical relationships in music, geometry, and astronomy, suggesting that the cosmos itself resonates according to mathematical laws. This vision of harmony and proportion profoundly influenced later thinkers, providing the philosophical grounding for Archimedes' geometric innovations and the analytical calculus of Newton and Leibniz.

Archimedes (c. 287–212 BCE) transformed Pythagorean principles into concrete mathematical practice. Using his method of exhaustion, Archimedes approximated areas and volumes of curves and solids by inscribing and circumscribing simpler geometric shapes, effectively summing infinitely many infinitesimal contributions. His computations of the area under a parabola or the volume of a sphere relied on the same Pythagorean intuition that the universe's structure could be discerned through number, proportion, and geometric reasoning. While expressed entirely in geometric terms, Archimedes' methods anticipated integral calculus and illustrated the power of numerical order in describing physical reality.

Johannes Kepler (1571–1630) applied this Pythagorean-inspired view of cosmic harmony to empirical astronomy. Observing planetary motion, he divided elliptical orbits into narrow segments and summed the areas swept by planets over time—a proto-integral method. Kepler's approach linked the mathematical ideal of proportional harmony with observational data, revealing that the planets move according to precise, measurable laws. In doing so, he combined the Pythagorean belief in cosmic order with Archimedes' geometric summation, bridging the gap between abstract mathematics and the physical universe.

Sir Isaac Newton (1642–1727) formalized these methods with the development of fluxions and fluents, introducing a symbolic framework for integration. His Fundamental Theorem of Calculus connected differentiation and integration, allowing precise calculation of areas, volumes, and trajectories. Newton's laws of motion and universal gravitation exemplify the culmination of the Pythagorean ideal: a mathematically harmonious cosmos whose motions can be expressed through elegant, unified principles. His work synthesized Archimedes' geometric insight and Kepler's empirical summation into a generalizable analytical method.

Gottfried Wilhelm Leibniz (1646–1716) independently developed calculus around the same time as Newton, introducing the differential and integral notation still used today. Leibniz emphasized the formal symbolic manipulation of infinitesimals, providing a systematic and flexible approach to integration. His notation and methods made the calculus more accessible and widely applicable, influencing generations of mathematicians and physicists. While Newton focused on motion and physical application, Leibniz highlighted the power of a rigorous symbolic language, creating a complementary path to modern analysis. Together, Newton and Leibniz solidified the foundation of calculus, transforming centuries of geometric and empirical techniques into a unified mathematical theory.

The intellectual lineage from Pythagoras through Archimedes, Kepler, Newton, and Leibniz illustrates the evolution of integration. Pythagoras' emphasis on numerical harmony inspired Archimedes' geometric rigor, Kepler's empirical summation of planetary motion, and the analytical methods of Newton and Leibniz. Each step reflects a shift from philosophical intuition to geometric reasoning, empirical approximation, and finally symbolic analysis, demonstrating how abstract principles can guide observation, theory, and calculation.

Science and mathmatics from Pythagoras to Newton and Leibniz exemplifies the continuous interplay between philosophy, mathematics, and physics. Pythagorean ideas of proportion and cosmic harmony set the stage for Archimedes' method of exhaustion, Kepler's summation of planetary motion, Newton's fluxions, and Leibniz's symbolic calculus. Together, they trace the development of integration and the birth of modern mathematics, highlighting how ancient philosophical insights into harmony and numbers continue to shape scientific understanding today.

Heisenberg on Greek Thought and Modern Physics

Werner Heisenberg is one of the founders of modern physics and science. He emphasized that modern physics is deeply rooted in the intellectual world opened by the ancient Greeks. He believed that the Greek language, with its philosophical precision and abstract capabilities, made possible the very development of concepts like logos (reason), kosmos (ordered universe), and harmony. Heisenberg wrote that the Greeks first saw the universe as an ordered harmonic structure governed by *rational principles*—an outlook that laid the metaphysical groundwork for physics. For example, he compared Pythagorean harmony in music with quantum harmonics, noting that both reveal nature as expressed through mathematical patterns.

Werner Heisenberg regarded the Pythagorean focus on numerical simplicity and cosmic harmony as a cornerstone of modern physics. He emphasized that the ancient belief in the "mathematical determinacy of harmony" provided a guiding principle that contemporary science inherited from antiquity.

Heisenberg saw the Pythagorean method—searching for nature's underlying order through simple ratios, symmetries, and mathematical patterns—not merely as historical insight but as a model for theory-building. He noted that a deep understanding of Greek natural philosophy was essential for progress in modern atomic physics.

For Heisenberg, the Pythagorean ideal of simplicity and harmony was more than aesthetic; it was epistemic. He believed that nature's fundamental laws reveal themselves through elegant mathematical structures, a perspective that shaped his approach to quantum mechanics, where conceptual clarity and symmetry were as vital as empirical accuracy.

In works like Physics and Philosophy,[24] Heisenberg claimed that concepts such as atoms, dynamics, and energy from Greek thought paved the avenue of physics and foreshadowed quantum theory. He argued that quantum physics returns us to a Greek vision of nature: reality as a dynamic interplay of potentialities seeking harmonic balance rather than fixed mechanical objects. For Heisenberg, modern physics does not abandon the Greek vision—it fulfills it, showing that the cosmos is both rationally ordered and harmonically structured in mathematical terms.

Heisenberg's engagement with ancient Greek thought—including the works of Pythagoras, Plato, and Aristotle—shaped his approach to quantum mechanics. Djambov emphasizes that Heisenberg saw parallels between the indeterminacy of quantum theory and Aristotelian concepts of potentiality and actuality, while also drawing inspiration from the Pythagorean vision of a mathematically ordered cosmos. This blending of Greek philosophical ideas with modern physics highlights the lasting significance of these early thinkers in shaping contemporary scientific thought.

Djambov's analysis offers readers a sophisticated understanding of how Heisenberg's philosophical orientation informed his scientific work, creating a conceptual bridge between classical Greek philosophy and modern physics. The book serves as a valuable resource for those interested in the intersection of philosophy and science, illustrating how Pythagorean and broader Greek philosophical principles continue to resonate in the foundations of modern physics.

Heisenberg explicitly credits Greek thought as the origin of scientific reasoning: "The beginnings of scientific thought go back to the Greek philosophers... especially to Pythagoras and later Plato."[25] He links Greek metaphysics to quantum theory: "The concepts of dynamics (potentiality) and energeia (actuality), introduced by Aristotle, seem to be closer to the formulation of quantum theory than classical physics."[26] In his The Physicist's Conception of Nature he refers to modern physics as a return to a Greek-like view of nature: "Modern physics has, in a way, returned to the Greek view that nature is not a collection of material objects but is a structure of relations".[27] In his popular very influential article *Across the Frontiers*[28] (discusses Greek logos, harmony, and cosmos as foundational to Western science: "The idea of the world as a cosmos, a beautifully ordered harmony, has guided the development of science from its beginnings in Greece." In his essay The Meaning of Beauty in the Exact Sciences compares mathematics, harmony, and Greek inspiration: "The Pythagorean idea that mathematical harmony underlies the structure of reality finds surprising confirmation in atomic spectra."

Werner Heisenberg saw Pythagoras as a pioneer in showing the deep link between math and nature. He pointed out that Pythagoras discovered how equally tense strings produce harmonious sounds when their lengths are in simple numerical ratios. Heisenberg considered this one of the most important discoveries in history, showing how numbers and harmony are connected in nature. Heisenberg also valued simplicity and beauty in science, reflecting Pythagorean ideas. He believed nature often reveals simple and elegant mathematical patterns, which help us understand how the world truly works.

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[24] Heisenberg, W., 1958. *Physics and philosophy: The revolution in modern science*. Vladimir Djambov and Heisenberg W. and Paul Davies *Physics And Philosophy: The Revolution,* Modern Science Pb.
[25] Chapter 1: "The History of Quantum Theory"

[26] Chapter 4: "The Development of Philosophical Ideas since Descartes"
[27] Der Teil und das Ganze, 1969, in Conversations with Pauli, mid sections
[28] Heisenberg, W. and Casimir, H.B.G., 1974. Across the frontiers. *Physics Today*, *27*(8), pp.48-49.

Heisenberg, who learned Greek for early childhood from his father a professor of medieval and modern history, viewed Pythagoras as an early example of the idea that the universe follows harmonious mathematical rules and this influenced his life and work and modern physics. His own work in quantum mechanics continues this tradition, seeking clear and beautiful mathematical descriptions of nature. Heisenberg's engagement with Greek philosophy was not merely academic; he had been exposed to the language and ideas from an early age. His father, a professor of medieval and modern history, taught him Greek during his childhood, providing Heisenberg with direct access to the works of Pythagoras, Plato, and Aristotle. This early grounding helped shape his lifelong appreciation for the philosophical dimensions of science and informed his reflections on the conceptual foundations of quantum mechanics.

Schrödinger on Pythagoras and the Harmony of the Cosmos

Erwin Schrödinger, another father of quantum mechanics, admired Pythagoras for his vision of the cosmos as governed by mathematical order and harmony. He emphasized that the universe's underlying simplicity—the notion that natural phenomena could be expressed through numbers, ratios, and harmonious relationships—was central to scientific understanding. Schrödinger saw the Pythagorean idea of cosmic harmony not merely as a musical or mystical metaphor, but as an early recognition that the complexity of nature could emerge from simple, elegant principles. In his view, this pursuit of simplicity and numerical regularity in explaining the cosmos anticipates modern physics' search for unified laws, the Theory of Everything, *Η θεωρία του Παντός*.

Erwin Schrödinger demonstrated a lifelong fascination with Greek philosophy, which was reinforced by his study of the Greek language. He learned enough Greek to read original texts, allowing him to engage deeply with the writings of Pythagoras, Plato, and Aristotle. Schrödinger saw this linguistic and philosophical grounding as essential for understanding the conceptual and mathematical underpinnings of nature. In his view, familiarity with Greek thought was not just historical curiosity but a key to approaching questions of harmony, simplicity, and the structure of the cosmos. This direct engagement with the original language helped him appreciate subtleties in the Greek conception of natural order, proportion, and unity, which influenced his own scientific and philosophical reflections.

Erwin Schrödinger often reflected on the philosophical roots of mathematical thought. He admired the Pythagoreans for their deep engagement with numbers and their vision of the universe as governed by harmonious proportions. Schrödinger observed that even the seemingly simple concept of the square root of 2 posed significant challenges for Pythagoras and his followers, demonstrating their advanced mathematical intuition. As he noted, "We are told such a number as the square root of 2 worried Pythagoras and his school almost to exhaustion". For Schrödinger, this anecdote illustrated more than historical curiosity; it underscored the Pythagoreans' quest to uncover the numerical foundations of reality. Their pursuit of cosmic harmony and mathematical simplicity resonated with his own philosophical stance, in which the natural world is intelligible through elegant, unified principles. Schrödinger's reflections highlight the enduring influence of Pythagorean thought: the search for simplicity, proportion, and harmony remains central to both science and our understanding of the cosmos.

Erwin Schrödinger's *Nature and the Greeks* offers a profound exploration of the origins of Western scientific thought, tracing its roots back to ancient Greek philosophy. Schrödinger delves into the intellectual legacy of early Greek thinkers, examining how their inquiries into nature laid the groundwork for modern science. He emphasizes the Greeks' unique approach to understanding the natural world, highlighting their emphasis on observation, reason, and the pursuit of knowledge. Schrödinger discusses the contributions of key figures such as Pythagoras, Heraclitus, and Plato, illustrating how their ideas influenced the development of scientific concepts. Schrödinger's analysis underscores the continuity between ancient and modern scientific thought, suggesting that contemporary science owes much to the philosophical foundations established by the Greeks. He argues that the Greeks' integration of philosophy and science created a framework that continues to shape scientific inquiry today.

In summary, *Nature and the Greeks* serves as a testament to the enduring impact of Greek philosophy on the evolution of scientific thought, offering valuable insights into the intellectual heritage that underpins modern science.

The philosophical books of Heisenberg and Schrodinger are useful for all intellectuals.

Ethics, Education, Community

Pythagoras was not only interested in numbers, but also in ethos. The Pythagoreans lived in moderation, silence, contemplation and reflection. They believed in mental catharsis, in reincarnation (which I think they introduce so that we can all be good under the fear of being punished in the next life). At the same time, they cultivate the perception and practice that knowledge leads to self-awareness and virtue by reviewing the actions of the day every night, with the aim of improvement.

Theano, a student of Pythagoras (according to some mistakenly his wife)[29] his sons, Teleuge and Mnesarchus, and a philosopher who succeeded him along with his sons, wrote about the place of women in the family and in Constantinople — and is rightly considered one of the first female voices in the history of philosophy. Theano, a student of Pythagoras, was one of the first women philosophers of antiquity. Although her works have not survived in their entirety, excerpts and references to them have been preserved through other authors and works.

Pythagoreans today

Because today, when we learn a musical instrument, when we understand a geometric shape, when we talk about "laws of nature", when we respect harmony in ourselves and in the world, then **we are Pythagoreans**. We are heirs of that important intellect that brought order to chaos, light to darkness, meaning to Nature. It is our responsibility to continue.

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[29] Diogenes Laertius Biogr., Vitae philosophorum Book 8, section 42, line 1 Ἦν δὲ τῷ Πυθαγόρᾳ καὶ γυνή, Θεανὼ ὄνομα, Βροντίνου τοῦ Κροτωνιάτου θυγάτηρ· οἱ δέ, γυναῖκα μὲν εἶναι Βροντίνου, μαθήτριαν δὲ Πυθαγόρου.