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A New Science of Mysticism: *Pythagoras in 1999*

Christian Wertenbaker



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What would Pythagoras have thought of our modern ideas about the world? Let us imagine that a time machine transported him to 1989, and he then studied the developments in mathematics, music, philosophy, and physical science of the last 2500 years. Now, ten years later, PARABOLA has had the opportunity to interview him.

CHRISTIAN WERTENBAKER: Well, sir, are you finding our modern civilization congenial?

PYTHAGORAS: Of course, your technological inventions are absolutely phenomenal and some are quite wonderful. And you have, at least in some places, developed the ideas of democracy and human rights that originated in my country over two thousand years ago. But your life is so hectic! What about the right to contemplate an idea for a long time, or to have an uninterrupted conversation? But we didn't come together to talk about that; you wanted to ask me about my scientific and mathematical ideas, and whether they make sense nowadays.

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P: Let's take those two separately, although they are obviously related, and then we can also talk about what has not changed, which is what I find most interesting. First, the biggest change in science is pointed out in all your textbooks: it is the clarification of, and adherence to, what you call the scientific method--that everything must be tested by experiment; speculation and logic are not enough. Of course, I did experiments with vibrating strings and other bodies, and we made careful observations of planetary motions, but back then experiment was not considered as important, nor did we have the sophisticated experimental tools that you have developed, the microscopes, telescopes, atom smashers, and so on. The precision of logic has also improved, mostly through the work of

mathematicians. So, everything is more rigorous.

On the other hand, you could say--and many contemporary people believe this--that the soul or feeling has gone out of science. It's like your modern capitalism: making money is the priority, and quality, beauty, fulfillment, empathy are all secondary. Similarly, in science, producing facts has become paramount; the sense of meaning, of the nature and purpose of life, the sense of communion with a living conscious universe, has gone out of the enterprise. We regarded numbers as divine principles, and connected with them not only through thought but also through a higher feeling.

But this view--although there's some truth to it--is somewhat superficial. Many great scientists of your civilization were and are mystics, although they might not admit it. Newton spent more time on alchemy than he did on gravitation and the calculus. Einstein made statements like "I want to know how God created this world. I am not interested in this or that phenomenon. I want to know His thoughts, the rest are details." And: "The creative principle resides in mathematics. In a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed."⁽¹⁾ Many contemporary mathematicians and physicists feel, as Einstein did, that a mathematical theory can't be true unless it is also beautiful.

CW: Do you think that now we suffer from too much information?

P: Yes, no one can understand even all of mathematics, and the mathematics is so complicated that it takes years to get a feel for it. In my day, an intelligent man could study all the knowledge there was. Now one has to rely on experts to understand the meaning of some scientific theories, and the experts may not grasp the meaning themselves. No one really understands the meaning of quantum theory, though some have tried very hard. For a long time--and still now to some extent--the view prevailed among physicists that it was pointless to try to understand the meaning; that's not what science is about. But humans can't help but look for meaning; it's their most compelling need. Much of modern physical and mathematical theory is contrary to the commonsense intuitions we develop living on the earth. Relativity and quantum theory, the cornerstones of modern physics, just don't make sense to us. But the truth of these theories, even if incomplete, can't be denied, and you all happily use your transistors, laser CDs, and atomic energy plants, none of which would exist if these theories weren't at least partially true and understood.

CW: It's interesting that now knowledge is disseminated freely--some would say too freely, given some of the horrors that science has produced--yet it remains hidden to many because of its complexity. In your day, knowledge was kept secret, even though it was more comprehensible.

P: Well, in a way it was more comprehensible. But again, this analysis is somewhat superficial. The mystical knowledge which has existed since very ancient times has always been, in part, contrary to ordinary common sense and inaccessible to the ordinary mind. Not that modern science and mysticism are the same thing. Their methods are very different. Science regards knowledge as external, in a sense: it has to be demonstrable by manipulations of the external world. Mysticism regards true knowledge as graspable from within, by a specially trained, more inclusive, higher consciousness. This presupposes that we humans can be in tune with the essence of the cosmos. For many scientists this is an unproved fantasy, and certainly people can claim all kinds of revelations which are demonstrably hallucinatory. So scientists demand external verification. But, in both cases, special training is needed, and when you get right down to it, faith in logic and observation also presupposes a kind of being in tune with the universe. In my more optimistic moments, I think that science came about in its present form in order to bring a different kind of rigor to mystical knowledge, and that the two kinds of knowing are destined to join together.

CW: Some think that quantum theory is closely related to mystical truths.

P: Yes. In quantum theory the kind of observation made determines whether an electron, or any of the other small building blocks of which things are composed, looks like a wave or a particle. One can interpret this as indicative of the inextricable role of consciousness in the universe. Many scientists would deny this interpretation, but some great ones, like von Neumann, came to just this conclusion. So maybe the end result of your modern science will be to confirm, from a different point of view, great, ancient mystical truths--though there is a long way to go certainly--and get rid of some of the nonsense promoted in the name of mysticism. For that matter, I could do without some of the concoctions made out of my own ideas over the centuries.

I think the real difference between modern science and true mysticism is that the scientist deliberately tries to ignore the role of the subject in understanding the world. But no understanding exists except within a conscious being; the understanding does not exist on paper, in the formulas and diagrams. Science also does not consider differing capacities for understanding, dependent not just on intellectual training but on an even more rigorous development of a higher capacity for consciousness--the aim of the mystical teachings.

CW: What about mathematics? How has it changed? As you said, there is a lot more of it now, much of it completely obscure to most people.

P: The changes have been enormous, of course. It's like the difference between one of your Mercedes and an ancient Greek chariot. The basic principle of a moving conveyance on wheels, however, remains the same. In the case of mathematics, our saying, "everything is number," seems more true than ever. The amazing applicability of mathematical constructs to the physical world has been noted again and again. Now you have more kinds of numbers than we did. We didn't like to use even negative numbers, or zero, and were puzzled by what you now call irrational numbers, numbers like the square root of two, or pi, which we were aware of because of geometry, but didn't really consider to be numbers because they couldn't be expressed as exact ratios. Now all of these kinds of numbers, as well as complex numbers, involving the square root of minus 1, have been integrated into mathematics, with wonderful results. And it seems that there are no more kinds of numbers to find, so the process is complete. One of the most successful discoveries is the calculus, which makes it possible to deal with smoothly changing processes, such as motion, by having a method of handling infinitesimally small changes. It gets around some of the paradoxes we came up with in ancient Greece, now known as Zeno's paradoxes. For instance, Zeno argued that motion was impossible because in order to get from point A to point B, it's first necessary to get to point C, in between the two, and before one can get to point C, one has to get to point D, between A and C, and so on, so that one can't actually ever get started. The calculus makes it possible to handle motion mathematically, including wave motion, which we understood only qualitatively.

CW: But hasn't mathematics gotten away from what some regard as primitive notions of the applicability of simple whole numbers--one, two, three, etc.--to the workings of the universe?

P: Ah, no, you see it has merely added to these basic truths. There are still three dimensions of space, at least on our macroscopic scale, and this determines many things. It still takes a minimum of two points to determine a line, three to determine a plane figure like a triangle, and four to specify a solid, like a tetrahedron. These four numbers arranged in a triangle, and their sum, ten, were our holy tetraktys.

This tetraktys, by the way, is identical in its basic pattern to the ten components of Riemann's metric tensor, an essential part of the mathematics of Einstein's general theory of relativity.(2) I find this absolutely amazing.

The universe is still one whole. Your modern idea of everything beginning as a singularity which exploded in the Big Bang (you do have some amusing terms for things) means that everything is interconnected, although your science still does not have the view that the whole universe is alive.

Many processes depend on two opposite forces interacting; it is this ever-perpetuating dynamic tension between opposites that creates the infinite multiplicity of phenomena. There are force and inertia, positive and negative charges, male and female. But it takes three forces or things interacting to produce an event or a phenomenon: all of your significant equations have three terms--force = mass x acceleration, energy = mass x the speed of light squared, electrical current = voltage / resistance--and if there are more terms in an equation, often the extra ones are constants. And look, there are three constituents of atoms: protons, neutrons, and electrons. There are three quarks in a proton or neutron, and quarks come in three "colors" and three pairs of "flavors". There are three notes in a basic chord, and three primary colors can mix to form any color. We have three internal modes of cognition: sensation, emotion, and intellect.

There are four dimensions, at least on our scale: three of space, and one of time. Events take place on a stage of four numbers. Five comes in with the golden section or golden mean, which interested us greatly. The formula for the golden ratio is $(\sqrt{5+1})/2$, and the golden section is found in the five-pointed star, in other figures with pentagonal symmetry, and is related to the Fibonacci numbers. These numbers and the golden ratio show up prominently in the patterns of living things, from the arrangements of leaves on a stem, to the patterns of sunflower seeds and cacti, to the spirals of marine shells.(3)

DNA, seen on end, has ten-sided symmetry. Five and ten also show up in modern "theories of everything," as well as in Riemann's metric tensor--in so-called SU(5) symmetry, and some of these new "string theories", with ten dimensions. Our idea that ten was the only right basis for a number system may turn out to be profoundly true when modern physics gets a clearer picture of a real fundamental theory.

I could go on with the other numbers we found important, showing you both the continuing validity of our concepts and the connection between them and modern discoveries. The idea of "magic numbers," simple whole numbers that keep showing up everywhere, is very much alive.

In fact, modern quantum physics can be seen partly as a return to simple numbers. The basic paradox of quantum theory is that elementary things behave both as waves and as particles, as continuous things and as discrete things. This is similar to the behavior of vibrating strings, to which I devoted so much attention. Strings vibrate in a wavelike fashion, but only in discrete tones, the fundamental tone and overtones of the string, determined by the constraint of the ends of the string, which must remain fixed. The string can only vibrate as a whole, in halves, in thirds, in fourths, etc, giving the fundamental tone, its octave, the fifth above that, the next octave, etc.

The description of atoms uses the same mathematical language: vibrating bodies with certain, now three-dimensional, overtones.

This creates your periodic table of the elements. Of course now you have over a hundred elements instead of the earth, water, air, fire and ether which we called elements--these concepts though are still valid as representing not elements, but states of matter: solid, liquid, gas, plasma or electromagnetic energy, and what you now call the vacuum, which isn't as empty as that word implies, but teeming with energy. But isn't it striking that the modern elements fall into groups based on the number of electron orbitals or vibratory modes, and that the orbitals can have, respectively, two times 1, 4, 9, and 16 electrons in them, the perfect squares, and these numbers in turn come from the simple whole numbers that determine the vibratory modes?

One thing is clear: everything vibrates, everything is in vibration, and the basic nature of the world is vibration. However abstract, complicated, and counterintuitive the modern theories become--whether it's ten or twenty-six dimensional strings vibrating, or abstract symmetry groups--this basic truth remains at the foundation of all of them. And the properties of vibrating things are determined by numbers, just as the musical tones are determined by numbers.

CW: But you felt that the musical scale, the simple notes represented by simple ratios:

1	9/8	5/4	4/3	3/2	5/3	15/8	2
do	re	mi	fa	sol	la	si	do

were the basic pattern on which the universe was built. Surely things are not so simple, according to modern ideas.

P: No, they're not. But I think they're getting simpler as your theories develop. Actually, that was not the scale we used. In our scale some notes had different, though still relatively simple, ratios. And it's this difficulty in determining the right scale to use which points out some most interesting aspects of the musical analogy.

Modern mathematical theories of the basic aspects of nature are based on the idea of symmetry. A symmetry exists when a property of a configuration of elements remains the same despite a manipulation of that configuration. For instance, if I rotate a hexagon a sixth of a turn, it still looks the same. If there were no symmetry, there would be no order, no predictability, no patterns, nothing recognizable could happen or exist. So there could be no intelligence either. The most important advance in modern mathematical physics has been in the generalization of the idea of symmetry. The fact that I don't turn into an alligator when I walk down the hall reflects a symmetry: the laws of the universe don't change from one location to another. A similar symmetry exists for time: I don't vanish from one moment to another. But these symmetries are not perfect, because everything is not quite the same when I walk down the hall, nor from one moment to another. If there were perfect symmetry, nothing much could happen or exist either. This is now called "broken symmetry." Symmetry and broken symmetry seem to underlie the basic organization of everything.(4)

CW: This seems to be more related to geometry than to number, or musical scales.

P: We regarded all of these areas as intimately related, and one of the beautiful aspects of modern mathematics is that it also has brought together many seemingly separate concepts. In fact, this is the antidote to the proliferation of information that we were talking about earlier. Numbers have a kind of symmetry. Some number systems form what are now called mathematical groups, which I won't go into all the details of. But the idea is that if you take, for instance, positive integers (1,2,3 etc), and perform an operation on them by adding them together (just like you perform an operation on a hexagon by rotating it), the addition produces another integer, not a rabbit. On the other hand, if you divide two integers, you may get another integer ($6/2=3$), or not ($2/3$ is not an integer). But $2/3$ is a rational number--it's expressible as a ratio of whole numbers--so if you have a different group, the rational numbers, then you can divide them and always get a rational number. There are other requirements for groups, but that's one of the main ideas. So things can be categorized into various groups, which have various symmetries. The notes of the musical scale, being produced by vibrations which are represented by simple ratios, have this kind of symmetry. If you go up a fifth (five notes in the scale, and $3/2$ the number of vibrations) from middle C, you get G, and if you go up a fourth from G ($4/3$ the number of vibrations), you get another C, an octave above the first one, because $3/2 \times 4/3 = 12/6 = 2$, and the octave is twice the number of vibrations. In

general, if you go up a certain number of notes in the scale, you get another note in the scale. But after a while there's a problem, which we saw long ago. For instance, if you go up 12 fifths:

C G D A E B F#
C# C# D# A# E# or F C

you get back to C, seven octaves above the first C. But this note is not quite the same as seven octaves, because $[(3/2).sup.12]-- 3/2$ multiplied by itself 12 times--equals $531441/4096 = 129.746$, whereas seven octaves is $[2.sup.7]= 128$. This difference, $129.746/128$, or $531441/524288$ [editor's note: which was named the Pythagorean comma], is still a rational number, but certainly not a ratio of small numbers, like the notes of the scale.

This problem led, a few hundred years ago, to your compromise scale, the tempered musical scale. And the problem exists because powers of 2 and powers of 3 never coincide exactly. So there you have a kind of imperfect symmetry, resulting simply from the properties of 2 and 3.

This slight difference between the twelfth fifth and the seventh octave, if they are played together, produces a slight dissonance, a tension, and creates another vibration. This can be regarded as a force between the two notes. I think this is analogous to the residual forces, resulting from imperfect symmetry, that create the different levels of interaction in the world. Let me quote from an article I read:

The electromagnetic force binds electrons and nuclei to make atoms. The atoms, although they are electrically neutral, interact through a residual electromagnetic force to form molecules. The strong force binds quarks to make protons, neutrons, and all other hadrons, and the residual strong force between protons and neutrons is the so-called nuclear force that binds them into nuclei.(5)

Now this is an analogy, not a direct correspondence. I don't claim that we anticipated the amazing advances that your civilization has made in discovering the mathematical underpinnings of the way the universe works. But the astonishing applicability of mathematics to the physical world is even more obvious now than it was then. And simple numbers and ratios still play a major part. It may be, as further developments occur, that the correspondences between ancient and modern thought in this regard will become more striking. Even now, I think your science is beginning to approach the realm of the ideal, the essence, that underlies all things, though it cannot be apprehended by science alone.

CW: What would you say is the major impediment to a more complete understanding?

P: The role of consciousness in the universe has to become part of your theories. Modern physics includes the fact that the way in which a phenomenon is observed is an essential, though still mysterious, determinant of how reality manifests itself. But consciousness has to be explicitly put into the theory, and the relationship between the inner world of conscious beings and the outer world has to be understood. A great effort to comprehend consciousness is just starting now among brain scientists; maybe this will help lead to insights as to how these two worlds fit together.

NOTES

(1.) Michio Kaku, *Hyperspace: A Scientific Odyssey through Parallel Universes, Time Warps, and the 10th Dimension* (New York: Oxford University Press, 1994).

(2.) Ibid., p. 41. The description of a curved space of four dimensions requires sixteen numbers:

[G.sub.11] [G.sub.12] [G.sub.13] [G.sub.14]
[G.sub.21] [G.sub.22] [G.sub.23] [G.sub.24]
[G.sub.31] [G.sub.32] [G.sub.33] [G.sub.34]
[G.sub.41] [G.sub.42] [G.sub.43] [G.sub.44]

six of which are redundant, leaving ten. See also Julian Schwinger, *Einstein's Legacy: The Unity of Space and Time* (New York: Scientific American Books, Inc., 1986).

(3.) There are many books on these matters. See particularly H. E. Huntley, *The Divine Proportion: A Study in Mathematical Beauty* (New York: Dover Publications, Inc., 1970).

(4.) See Christian Wertenbaker: "Nature's Patterns," *PARABOLA*, Vol. 24, Number 1, February 1999.

(5.) Howard E. Haber and Gordon L. Kane, "Is Nature Supersymmetric?" *Scientific American*, June 1986, p. 52.

CHRISTIAN WERTENBAKER is a neuro-ophthalmologist and a Senior Editor of *PARABOLA*.³

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