# Nature of the Laws of Nature

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Fermilab Society of Philosophy, 2014

# The problem

- Physics is looking for the laws of nature, the logical structure of the Universe.
- When theories that exhaust phenomena are formulated and logically unified into a single theory of everything (TOE), the task of fundamental science is over.
- Although humanity does not now and may possibly never have such a theory in its fullness, many of its limit cases are known.
- Why the world is defined by any mathematical structure at all? Why this structure is so simple that it is **discoverable**?
- While it is thinkable for a universe to be structured by any logically consistent system, out of this infinite set of structures only one determines our universe. Why this structure and not another? Who or what singled it out and on what ground?
- In this way the laws of nature become a problem, though not in the usual scientific context of searching them out, but as something that requires its own explanation.

# What can be the Terminus?

- The illusory nature of an explanation that does not go beyond natural laws was pointed out by Ludwig Wittgenstein (1889-1951) ("Tractatus", 1922):

- "The whole modern conception of the world is founded on the illusion that the so-called laws of nature are the explanations of natural phenomena. Thus people today stop at the laws of nature, treating them as something inviolable, just as God and Fate were treated in past ages. And in fact both are right and both wrong: though the view of the ancients is clearer in so far as they have a clear and acknowledged terminus, while the modern system tries to make it look as if everything were explained."

# Absurd as a Ground of Reason?

- One of the reactions to the problem of terminus is to reject a reasonable ground for this questioning.

- Such explanation barred from further questioning is an affirmation of unreasonableness of its ground, it is an acceptance of absurdity as the ultimate foundation of existence. Such superstition destroys the meaning of fundamental science by undermining the importance of reason, subjected by this superstition to the absurd.

- What can be the answers concerning the source of the laws of nature? Is there any way of choosing or rejecting one or another?

# The Fine Tuning

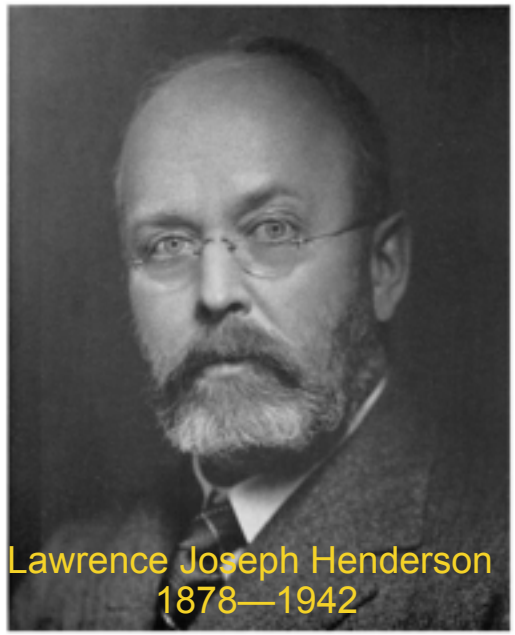
- "…the whole evolutionary process, both cosmic and organic, is one, and the biologist may now rightly regard the universe in its very essence as biocentric" (L.J..Henderson, "The Fitness of the Environment",1913)

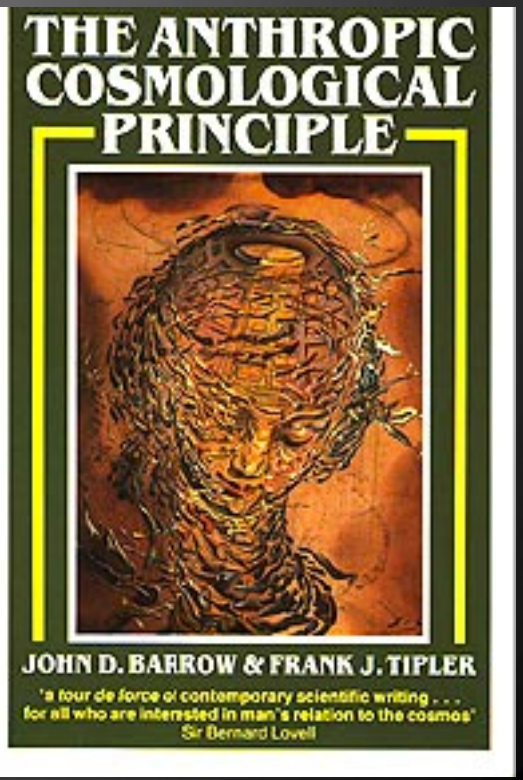
- "The laws of science, as we know them at present, contain many fundamental numbers, like the size of the electric charge of the electron [fine structure constant] and the ratio of the masses of the proton and the electron. ... The remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life." (S. Hawking)

- There is now broad agreement among physicists and cosmologists that the universe is in several respects 'fine-tuned' for life." (P. Davis)

- Who or what tuned the universe so fine? A pure scientific approach required finding an objective answer: not "somebody" but "something" as the cause of tuning.

- This "something" can be only the totality of Chaos, Nothingness.

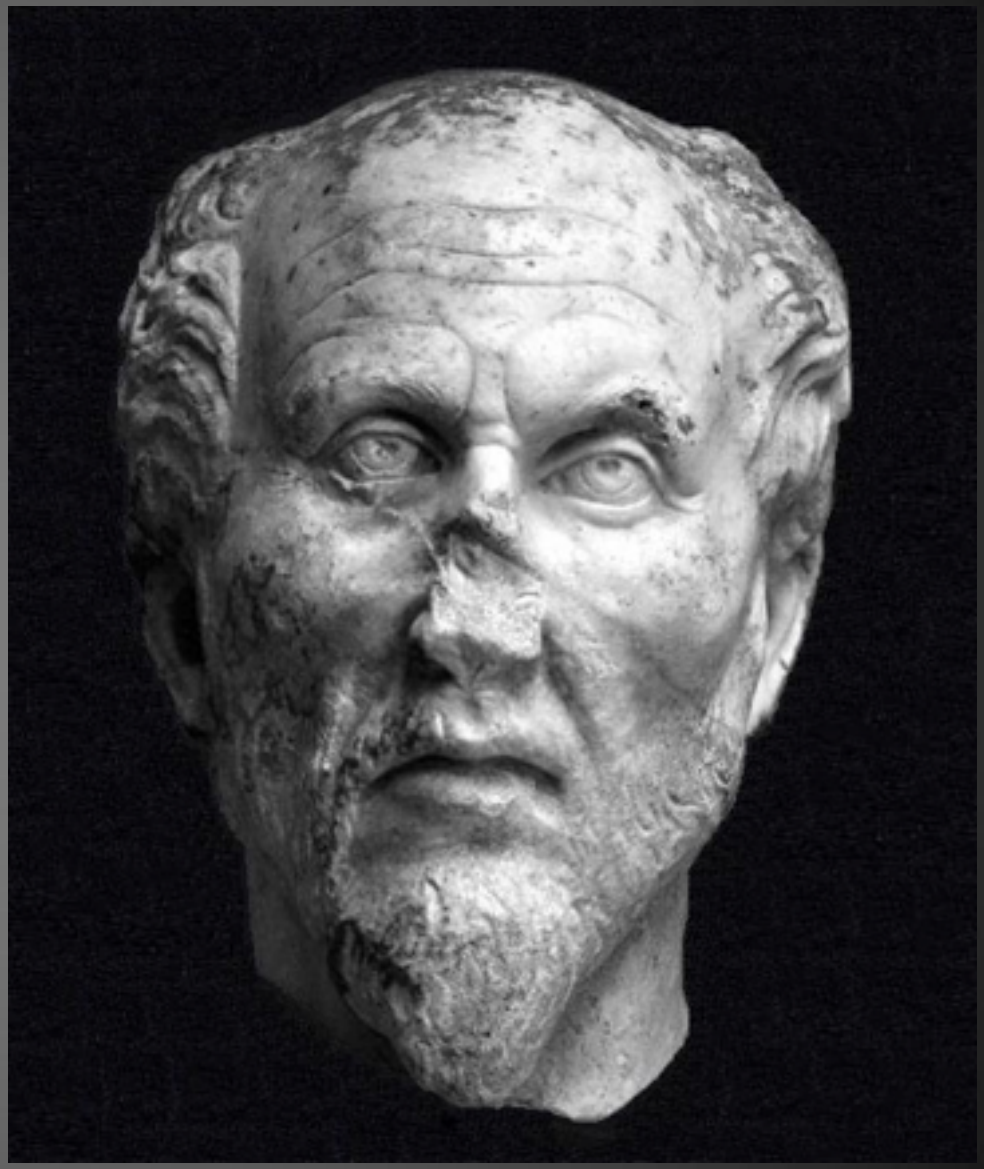

Lawrence Joseph Henderson
1878—1942



# Order from Chaos

- The only way to solve this problem totally in the framework of science is to show a possibility of appearance of being from nothing, or chaosogenesis (CG), the appearance of order from chaos.

- The idea of CG is not new. “Any attempt to derive order, reason, or the directing soul from the unordered motion of atoms or elements is absurd and impossible.” (Plotinus, c. 250 AD)




Max Tegmark suggested his own solution to the "embarrassing" question: **"mathematical democracy"**

"If the TOE [theory of everything] exists and is one day discovered, then an embarrassing question remains, as emphasized by John Archibald Wheeler: Why these particular equations, not others? Could there really be a fundamental, unexplained ontological asymmetry built into the very heart of reality, splitting mathematical structures into two classes, those with and without physical existence? After all, a mathematical structure is not "created" and doesn't exist "somewhere". It just exists. As a way out of this philosophical conundrum, I have suggested that complete **mathematical democracy** holds: that mathematical existence and physical existence are equivalent, so that all mathematical structures have the same ontological status." ("The Mathematical Universe", Foundations of Physics, 2007)

# Accidental laws, selected by AP

- A possibility for the structure of the fundamental laws of nature to be accidental was expressed by Steven Weinberg : "…we have to keep in mind the possibility that what we now call the laws of nature and the constants of nature are accidental features of the big bang in which we happen to find ourselves, though constrained (as is the distance of the Earth from the Sun) by the requirement that they have to be in a range that allows the appearance of beings that can ask why they are what they are. " ("Lake views", 2011)

- The same, by Andrei Linde: "the inflationary multiverse consists of myriads of 'universes' with all possible laws of physics and mathematics operating in each of them. We can only live in those universes where the laws of physics allow our existence, which requires making reliable predictions." ("Why Is Our World Comprehensible?", 2012)

# Anthropic Principle

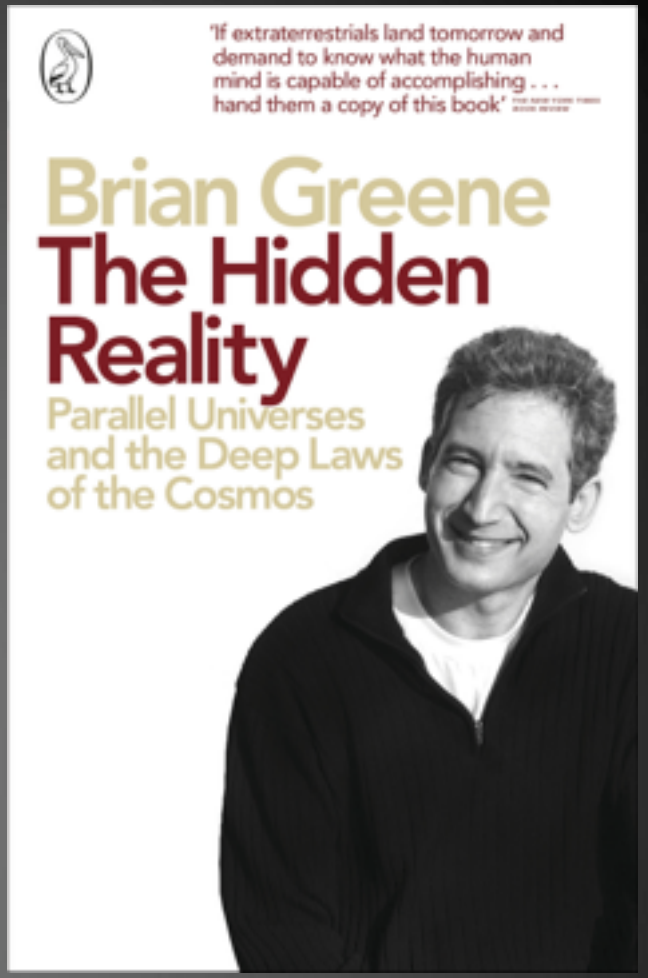
- Strong Anthropic Principle (SAP): The Universe is fine-tuned because it is compelled, in some sense, to eventually have conscious and sapient life emerge within it.

- Weak Anthropic Principle (WAP): In the infinite multiverse, only those universes can be observed where observers can appear, which selects a narrow class of fine-tuned universes. Though our universe is thought of in this Darwinian approach as ultimately generated by chaos, its fine tuning apparently receives a scientific explanation. Although in the infinite megaverse only a tiny portion of universes is fine-tuned for life and consciousness, the probability for any observer to see the universe as fine-tuned is 100%.

- Nothing seemingly contradicts the assumption that our universe is a random representative of anthropic-selected subset of Tegmark's multiverse, but is that really so? Does the universe indeed have no clear signature excluding any possibility of it having been **randomly** selected from this totality of all possible mathematical structures? Is the concept of chaosogenesis irrefutable by any thinkable observation, i. e. is it not a scientific hypothesis? Apparently, it is considered as irrefutable by some leading experts.

# Is Tegmark's Hypothesis Scientific?

- For instance, Brian Greene clearly says that: "I draw the line at ideas that have no possibility of being confronted meaningfully by experiment or observation, not because of human frailty or technological hurdles, but because of the proposals' inherent nature. Of the multiverses we've considered, only the full-blown version of the Ultimate Multiverse falls into this netherland. If absolutely every possible universe is included, then no matter what we measure or observe, the Ultimate Multiverse [i.e. Tegmark's one] will nod and embrace our result." ("The Hidden Reality: Parallel Universes and the Deep Laws of the Cosmos", 2011)




Contrary to B. Greene, we are showing that Tegmark's hypothesis runs counter to certain observations, so it fails, and fails as a scientific theory.

# **Dual** Fine Tuning

- "Observers" in WAP are not specified; it is not taken into account what it is namely they do observe.

- In fact, the observers silently assumed by WAP are **minimal**: they are supposed to have enough consciousness to ask the question—why the world is so specific that we are able to live in? This question is permanently asked since ancient time, being reflected by many ancient myths.

- **Cosmic observers**, instead, are discovering theories of big cosmos, seeing their universe both at extremely large and extremely small scales, far exceeding the scale of immediate life support. To become cosmic observers, minimal ones must live in a very specific world: it has to be theoretically comprehensible on a big cosmic scale, it has to be **theoretizable**.

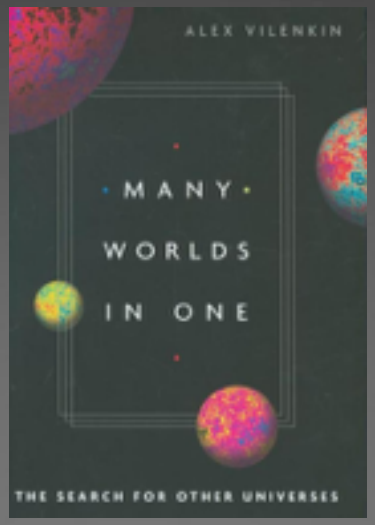
- Contemporary humanity is indeed a cosmic observer. For today, our scale of scientific cognition is described by an enormous dimensionless parameter **~10^45;** that big is the ratio of the sizes of largest object of physics, the universe, **~10^26m**, to the smallest ones, the top quark and the Higgs boson, corresponding to **~10^-19m**.

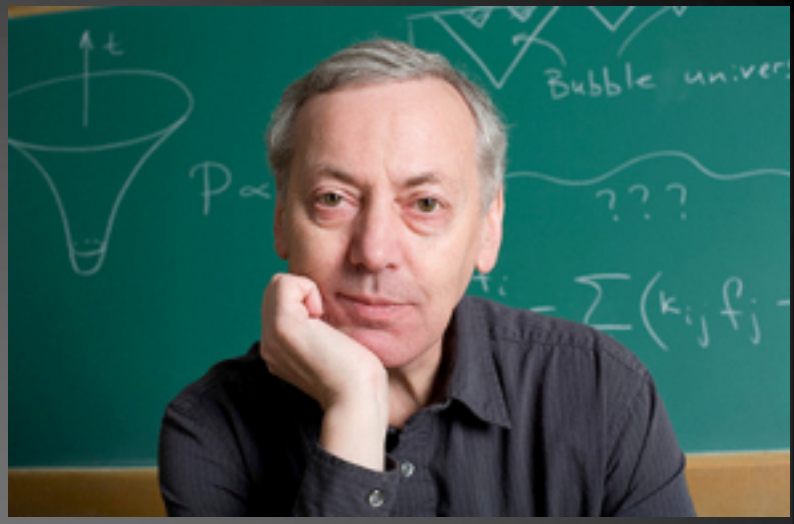
- Thus, the **laws of nature are fine-tune doubly**: they are both anthropic and discoverable.

# Discoverability Is not a Coincidence

- Can the discoverability of the laws of nature be coincidental to their anthropness? What if our discoverable laws are the only anthropic ones?
- No, they are not.
- The anthropness selects the entire infinite family of laws within the relative width of ~0.001 (like Mp/Mn), or wider.
- Only a few of that infinite family are discoverable outside their common level of ~0.001. Thus, were the laws selected anthropically only, they would not be discoverable outside their anthropic width.
- However, the accuracy of QED and General Relativity are 12 and 14 digits—far outside of the 3 digits.
- By that, the coincidental discoverability is refuted as a zero probability case.
- Thus, Weinberg-Linde-Tegmark chaosogenesis ("mathematical democracy") is refuted on the ground of extremely high accuracy and cosmic range of the simple laws of nature.

# Primacy of Mind




- This contradiction of Tegmark's "mathematical democracy" with the aristocratic reality of simple laws was noted by Alex Vilenkin: "Tegmark's proposal, however, faces a formidable problem. The number of mathematical structures increases with increasing complexity, suggesting that "typical" structures should be horrendously large and cumbersome. This seems to be in conflict with the simplicity and beauty of the theories describing our world." ("Many Worlds in One: The Search for Other Universes", 2006)

- "… the laws should be "there" even prior to the universe itself. Does this mean that the laws are not mere descriptions of reality and can have an independent existence of their own? In the absence of space, time, and matter, what tablets could they be written upon? The laws are expressed in the form of mathematical equations. If the medium of mathematics is the mind, does this mean that mind should predate the universe? " (ibid)

# Are the Laws Minimal?

- Since the laws of our universe are not picked randomly, they can only be purposefully chosen. Our universe is special not only because it is populated by living and conscious beings but also because it is theoretizable by means of elegant mathematical forms, both rather simple in presentation and extremely rich in consequences. To allow life and consciousness, the mathematical structure of laws has to be complex enough so as to be able to generate rich families of material structures. From the other side, the laws have to be simple enough to be discoverable by the appearing conscious beings. To satisfy these opposing requirements, the laws must be just right.

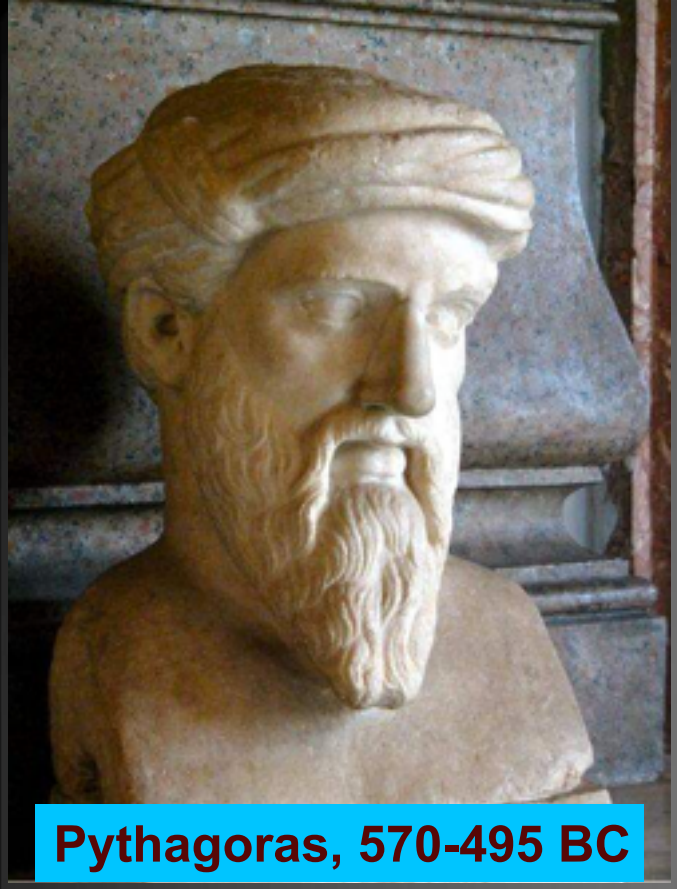
- The laws of nature are fine-tuned not only with respect to the anthropic principle but to be discoverable as well. It could be even that they are at their simplest within our sort of life. Would it be possible to take any part away from our existing theories without compromising forms of life as we know them?

- Such a special universe deserves a proper term, and we do not see a better choice than to call it Cosmos or to qualify it as Pythagorean, in honor of the originator of theoretical cognition, who coined such important words as cosmos (order), philosophy (love of wisdom), and theory (contemplation).

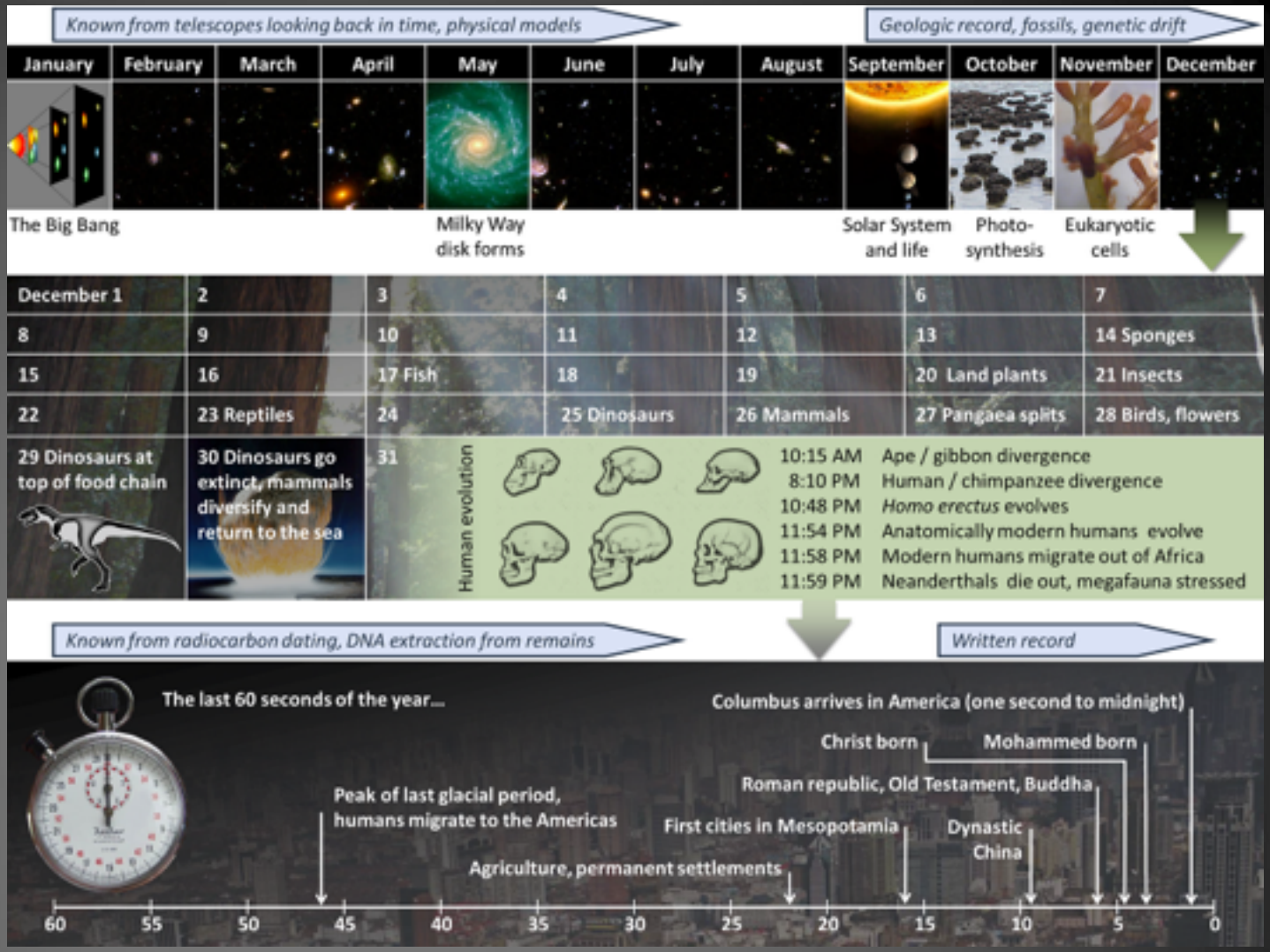
# Dual confirmation of the Pythagoreanism

- Starting with Pythagoras, it was a matter of faith for sparse groups of few people and lonely individuals that "fundamental laws of nature are described by beautiful equations." Theoretical science was conceived and nurtured by this very faith with its "cosmic religious feeling", which inspired scientific cognition for twenty-five centuries. Without any exaggeration, all great theories, from Copernicus, Kepler and Newton to Einstein and Dirac happened as guesses on the grounds of some fundamentally simple ideas like symmetry, conservation, or equivalence. The noted forty-five orders of magnitude of scientific cognition, with more than ten digits of precision reached in some experimental verifications, allow us to conclude about a scientific confirmation of what was considered a matter of faith for two and a half millennia: now it is a matter of fact that the universe is indeed Pythagorean. In other words, the existence of the Platonic world of elegant mathematical forms structuring the physical world is scientifically confirmed, and the accuracy of this confirmation is many orders of magnitude better than that of any specific statement of physics.

- **After two and a half millennia since its birth, fundamental science reached a grade of maturity allowing for a dual confirmation of its faith: the Pythagorean faith is confirmed as prophecy coming true and as a good tree that brings forth good fruit.**



Pythagoras, 570-495 BC




# GENESIS OF A PYTHAGOREAN UNIVERSE

*Alexey Burov and Lev Burov*

http://lss.fnal.gov/archive/2013/pub/fermilab-pub-13-533-ad.pdf

*Thank You!*

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