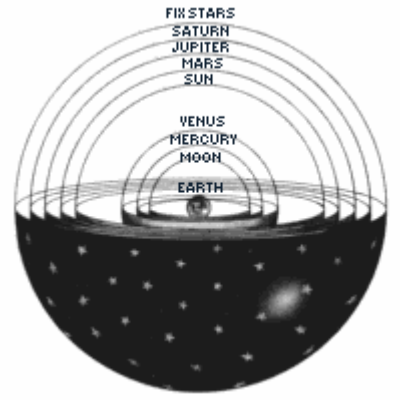
COSMOLOGY TIME LINE; BROPHY

550 BC - Pythagoras believed earth in motion; knew of periodic numerical relations of planets, moon, and sun. Celestial spheres of planets were thought to produce harmony; music of the spheres.

350 BC - Aristotle rotating spheres carried Moon, Sun, planets, and stars around a stationary Earth. Finite universe.

280 BC - Aristarchus of Samos. Heliocentric model. Deduced planets in correct order from the Sun.

200 AD - Ptolemaic system. Earth centered Universe. Perfect circular motion around Earth. Mathematics supported epicycles.



1514 – Copernicus - In 1514 the Polish astronomer Nicolaus Copernicus (1473-1543) put forward an alternative model, referred to as the heliocentric system, in which the Sun is at the centre of the universe, and all planets, including Earth, revolve around it. The further apart a planet is from the Sun, the longer it takes to complete a revolution. Copernicus said that the ostensible movement of the Sun is caused by the Earth rotating around its north-to-south axis. The heliocentric system got rid of Ptolemy's obscure epicycles, whose main weakness was that they did neither account for the observed backward motion of Mars, Jupiter, and Saturn, nor for the fact that Mercury and Venus never moved more than a certain distance from the Sun. Unfortunately, the Copernican system was not inherently simpler than the geocentric system; and it did not immediately render more accurate calculations of the planet's motion.

1584 - Giordano Bruno proposes a non-hierarchical cosmology, wherein the Copernican solar system is a relatively insignificant star system, amongst an infinite multitude of others. A universe which, like **Plotinus**' in 3rd century A.D., or **Blaise Pascal's** a century after Bruno, had its center everywhere and its circumference nowhere.
Dominican Friar. Burned at Stake for defending Arianism: if God the Father begat God the Son, then the Son had a beginning. Proponent of Acentrism?

1600 - Tycho Brahe
1609 - Johannes Kepler -
1609 - Galileo Galilei

1760- Immanuel Kant: The question of whether the universe has boundaries in time and space has captivated the imagination of mankind since early times. Some would say the universe had existed forever, while others would say that the universe was created and thus had a beginning in time and space. The second thesis immediately raises the question **what exists beyond its temporal and spatial bounds. Could it be nothingness?** But then, what is nothingness?
The absence of matter, or the absence of space and time itself? The German philosopher Immanuel Kant (1724-1804) dealt intensively with this question. In his book Critique of Pure Reason he came to the conclusion that the **question cannot be answered reliably within the limits of human knowledge, since thesis and antithesis are equally valid**. Kant thought instead of **time and space as fundamental aspects of human perception.**

1687 - Newton: 1720 - Edmund Halley puts forth an early form of **Olbers' paradox**
1744 - Jean-Philippe de Cheseaux 1791 - Erasmus Darwin 1826 - Heinrich Wilhelm Olbers
1848 - Edgar Allan 1900 –
Friedrich Bessel

1900 – Static Universe: A **static universe** or "Einstein universe" is one in which space is neither expanding nor contracting. Edwin Hubble that the universe is in fact not static, but expanding; Einstein to declare this cosmological model, and especially the introduction of the cosmological constant, his "biggest blunder".[1]

Even after Hubble's observations, Fritz Zwicky proposed that a static universe could still be viable if there was an alternative explanation of redshift due to a mechanism that would cause light to lose energy as it traveled through space, a concept that would come to be known as "tired light

1905 - Albert Einstein - Special Theory of Relativity, positing space and time are not separate continuums.
1915 - Albert Einstein - General Theory of Relativity which requires a finite spherical universe (it cannot be infinite because of **Mach's Principle**, with which Einstein strongly agreed, that the mass of a body is finite, is determined by all other matter in the universe, thus all other matter in universe must be finite).
1922 - Alexander Friedmann, Russian, realized that Einstein equations could describe an expanding universe. Einstein was reluctant - believing in a static (non-expanding universe).

1929 - Edwin Hubble discovered distant galaxies comparable in size to our Milky Way. **Discovers the red shift with distance as evidence the universe is expanding**. Einstein, swayed by this argument, changed his mind - thus his comment 'My biggest blunder' referring to the Cosmological Constant.

1946 – Steady State Theory (also known as the **Infinite Universe theory** or **continuous creation**) is a model developed in 1948 by Fred Hoyle, Thomas Gold, Hermann Bondi

1950 - Fred Hoyle coins the "Big Bang." The Universe was created at just one instant.

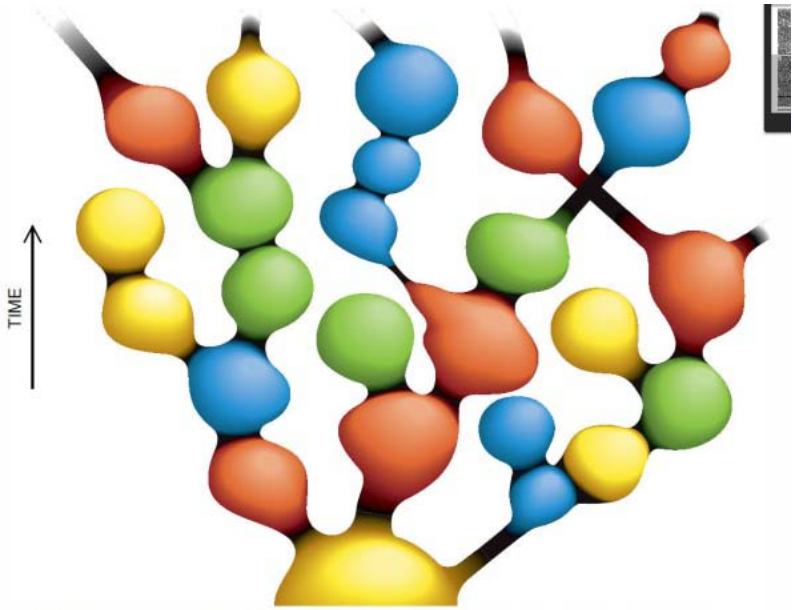
1955 – Pierre de Chardin SJ: *The Phenomenon of Man*. Written in 1930, prohibited by the Catholic Church, published posthumously. Introduced the Noosphere (nous Greek for mind). The noosphere is the collective consciousness of humanity, the networks of thought and emotion in which all are immersed. Coined the term “complexification.” Used as support for the concept of a “Conscious Universe.” Supported in various forms by many world class thinkers, including Freeman Dyson, Roger Penrose, Stuart Hammeroff.

1957 – Hugh Everett publish his doctoral dissertation while at Princeton about **Parallel Universes**.

1965 – Arno Penzias and Robert Woodrow Wilson discovered cosmic background radiation; the faint afterglow of the intense radiation of a Hot Big Bang, which had been predicted

1981 – Alan Guth: introduced Cosmic Inflation Theory, to solve **four troublesome issues** with the standard model. The flatness problem [one in 10^16] arises because Ω must have been highly fine-tuned in the past to give an approximately flat Universe today, the smoothness problem [one in 100,000] deals with trying to understand how the Universe can be so smooth if different parts of it were never in contact or in communication, the inhomogeneity problem [not lumpy enough] is how the appropriate density fluctuations are generated at various scales to produce the astronomical structures that are observed, and the magnetic monopole problem, [none found] which only arises in grand unified gauge theories, is why magnetic monopoles have never been detected. Guth proposed that, when the Universe was less than a billionth of a trillionth of a trillionth of a second old, that it underwent a tremendous expansion in which space was stretched by an enormous factor greater than **10^50**. A more recent estimate, Scientific American is **10^(10^12).**

1994 – Andrei Linde: one of the originators of inflationary theory. The Self Reproducing Inflationary Universe. Link to PDF document.



SELF-REPRODUCING COSMOS appears as an extended branching of inflationary bubbles. Changes in color represent "mutations" in the laws of physics from parent universes. The properties of space in each bubble do not depend on the time when the bubble formed. In this sense, the universe as a whole may be stationary, even though the interior of each bubble is described by the big bang theory.

1998 – Saul Permutter: In 1995-96, measurements of type Ia supernovae began that would suggest an astonishing result. A sufficient number of type Ia supernovae had been observed to conclude that the expansion of the Universe was **accelerating**. This came as a complete surprise since cosmologists thought that the expansion rate should be slowing. Science Magazine called the result "The Breakthrough of the Year."

1997 – Max Tegmark. Classification of Multiverses

Level I: Beyond Our Cosmic Horizon

THE PARALLEL UNIVERSES of your alter egos constitute the Level I multiverse. It is the least controversial type. We all accept the existence of things that we cannot see but could see if we moved to a different vantage point or merely waited, like people watching for ships to come over the horizon. Objects beyond the cosmic horizon have a similar status. The observable universe grows by a light-year every year as light from farther away has time to reach us. An infinity lies out there, waiting to be seen. You will probably die long before your alter egos come into view, but in principle, and if cosmic expansion cooperates, your descendants could observe them through a sufficiently powerful telescope

Level II: Other Postinflation Bubbles

IF THE LEVEL I MULTIVERSE was hard to stomach, try imagining an infinite set of distinct Level I multiverses, some perhaps with different spacetime dimensionality and different physical constants. Those other multiverses—which constitute a Level II multiverse—are predicted by the currently popular theory of chaotic eternal inflation.

Level III: Quantum Many Worlds

THE LEVEL I AND LEVEL I I multiverses involve parallel worlds that are far away, beyond the domain even of astronomers. But the next level of multiverse is right around you.
It arises from the famous, and famously controversial, manyworlds interpretation of quantum mechanics—the idea that random quantum processes cause the universe to branch into multiple copies, one for each possible outcome.

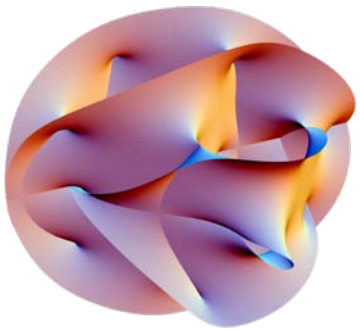
Level IV: Other Mathematical Structures

THE INITIAL CONDITIONS and physical constants in the Level I, Level II and Level III multiverses can vary, but the fundamental laws that govern nature remain the same. Why
stop there? Why not allow the laws themselves to vary? How about a universe that obeys the laws of classical physics, with no quantum effects? How about time that comes in discrete
steps, as for computers, instead of being continuous? How about a universe that is simply an empty dodecahedron? In the Level IV multiverse, all these alternative realities actually exist.

2003 – Max Tegmark. Mathematics suggests that Multiple Copies of us exist throughout the universe.

2008 - Terence Witt: ***Our Undiscovered Universe.*** Considered a crackpot theory; although Einstein and Max Zwicky may have liked it**.** ***Null Physics****:* Red shift occurs because photons get "tired" and lose energy along the way.

19xx – String Theory and offshoots:



Calabi-Yau 11 dimensional object

- **String Theory**: **String theory** is a developing branch of quantum mechanics and general relativity with the aim of merging and reconciling the two areas of physics into a quantum theory of gravity.[1] The strings of string theory are one-dimensional oscillating lines, but they are no longer

considered fundamental to the theory, which can be formulated in terms of points or surfaces too.

- **Multi-Universes**: The **multiverse** (or **meta-universe**, **metaverse**) is the hypothetical set of multiple possible universes (including our universe) that together comprise everything that physically exists: the entirety of space and time, all forms of matter, energy and momentum, and the physical laws and constants that govern them. The term was coined in 1895 by the American philosopher and psychologist William James.[1] The different universes within the multiverse are sometimes called **parallel universes**.

- **M-Theory**: n theoretical physics, **M-theory** is an extension of string theory in which 11 dimensions are identified. Because the dimensionality exceeds the dimensionality of five superstring theories in 10 dimensions, it is believed that the 11-dimensional theory unifies all string theories (and supersedes them). Though a full description of the theory is not yet known, the low-entropy dynamics are known to be supergravity interacting with 2- and 5-dimensional membranes.

- **Branes:** n theoretical physics, a **membrane**, **brane**, or ***p*-brane** is a spatially extended mathematical concept that appears in string theory and its relatives (M-theory and brane cosmology) that exists in a static number of dimensions.

  The variable *p* refers to the number of spatial dimensions of the brane. That is, a 0-brane is a zero-dimensional pointlike particle, a 1-brane is a string, that can either be open or closed, a 2-brane is a "membrane", etc. Every *p*-brane sweeps out a (*p*+1)-dimensional *world volume* as it propagates through spacetime.

- **Parallel Universes**: same as Multiverse: The **multiverse** (or **meta-universe**, **metaverse**) is the hypothetical set of multiple possible universes (including our universe) that together comprise everything that physically exists: the entirety of space and time, all forms of matter, energy and momentum, and the physical laws and constants that govern them. The term

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