A Perfect World

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"The world was without form and void"… a part of the description of the beginning of all things, drawn from Biblical philosophy and repeated in our ceremonies. The world of physics does not entirely disagree.

Hubble's Law is a mathematical relation describing the motion of galaxies in an expanding universe; played backwards in time, like a movie in reverse, and Hubble's Law describes a point in time some 13.7 billion years ago, at which all things must come together in a single point, where time and space have no meaning.

"The Big Bang" is now a familiar term and part of our cultural lexicon. We can intuitively grasp the idea of a massive explosion, but the sheer scale and speed boggle the mind. Consider this: existence went from nothing to a whole lot of something in $10^{-35}$ seconds – that's a decimal point followed by 35 zeroes and then a one. How much 'something' was there? – possibly a smooth patch of space nearly one-tenth the size of the current known universe, composed of nature's invisible building blocks: leptons, quarks, bozons and gluons. Attempting to describe what those things are, or how they behave, is still well within the realm of theory and much scientific debate.

But then something interesting happens to the nascent universe at the ripe old age of $10^{-11}$ seconds: matter gets the upper hand over anti-matter. There is an apparent imbalance; the universe is not uniform, not perfectly smooth, after all. Nuclei emerge when the universe is a tenth of a second old: helium, lithium and heavy hydrogen are formed from protons and neutrons. Gravity amplifies the differences in density of the gases that fill space. The temperature and radiation levels making their

birth possible are at perfect levels to support the event. Expansion slows and gravity begins to clump matter together.

“And darkness was upon the face of the deep”… computer simulations show that the formation of stars and galaxies would not have occurred until 300 million years after the instant of Creation. Prior to that point, the universe was a soup of mostly dark matter and dark energy, hydrogen, and helium - a pitch-black, lightless place. This is called the ‘dark ages’ by cosmologists, the furthest point back in time that our most sensitive instruments can peer. Light-based instruments such as telescopes can see back only to around one billion years post-Big Bang. Beyond that era lies the CMB, or Cosmic Microwave Background, itself no more than a grainy snapshot of radiation emitted by the earliest atoms which formed some 380,000 years after the Bang itself.

The universe, it turns out, may be rather lumpy – expansion was not equal in all directions. What vexes physicists and cosmologists the most are the nature and origins of the imbalance that gave us a non-smooth universe in the first place. Theoretically, it is suspiciously precise and non-random. The mathematics behind it is brain-cracking, but it suffices to say that just the tiniest variation in any direction - plus or minus - given to the forces, fields, dimensions, and energies calculated to have existed at the instant of Creation, and the likelihood of our existence – even that of our entire galaxy – drops to incredibly low levels of probability.

“And the spirit of god moved upon the face of the waters, and God said Let There Be Light”… I don’t want to dwell on the grander cosmological mysteries for too long, as fascinating as the topic is, because the subject simply is too big. I’ll refer you instead to the work of physicist A. Garret Lisi, a researcher who is probably closer to giving science a full Theory of Everything than anyone before. Boiled down, the universe emerges from an enormously complex mathematical structure when symmetry breaks, and this breakage is ascribed to the Higgs Boson, the now-famous so-called “God Particle” (which may be

justifiably named). When the Higgs field becomes non-zero, when it has a value that does not cancel out against all the other forces and fields, time-space comes into being -with a Bang. The dawn of time, then, was the breaking of perfect symmetry, and in a particular direction. Why that particular direction? What causes a minus-sign to enter the equation and cause the collapse of the perfect symmetry? Both the philosopher and the physicist can only shrug and say: “God only knows”.

Skipping ahead a little now, to eight billion years in our cosmic movie: our galaxy, the Milky Way, comes into being and the solar system we call home congeals at around nine billion years. At the core of the Milky Way lies a super-massive black hole, weighing as much as 4.5 million Suns. It is just the right size to produce a galaxy of the size and shape of our own. The spiral arm in which our solar system resides is just far enough from the center not be sterilized by the seething energy emanating from the bulging cluster of stars at the center, yet not so far away that the heavy elements forged in the hearts of giant stars couldn’t reach us, when they collapsed and subsequently exploded into supernovas.

With about 4.7 billion years to go until our movie catches up with current events, the planet we call home coalesces from trillions of tons of dust and stellar debris. The in-falling matter that goes into its composition is rich in nickel and iron, the legacy of a nearby exploding star and whatever unlucky planets once orbited around it. Once again, not so far away as to under-supply our system with heavy elements, yet not so close as to blow away all the lighter matter that became our planet’s mantle and crust. Planet Earth glides through what is called the “Goldilocks Zone” in a solar system – neither too close nor too far from the star at the center, with neighbours small enough not to perturb its orbit over-much, protected from excessive cometary or asteroidal bombardment by much larger outer worlds. Other planets have now been located around other stars, orbiting in the Goldilocks zone, but none appear to have the distinctive signatures of atmosphere or ocean that astronomers hope to find. For that particular blessing, we owe our thanks to Jupiter and Saturn.

These two gas giants, it has been theorized, swapped orbits some four and a half billion years ago, the result of which was two-fold: they disturbed the orbit of Theiea, a hypothetically mars-sized companion planet of the Earth, causing a collision that formed our moon and set in motion the forces of plate tectonics. The place-swapping giants also perturbed the Oort cloud of icy bodies, causing our world to be bombarded by an in-falling of comets somewhere between 4.5 and 3.9 billion years ago. Being in the Goldilocks zone, not too hot and not too cold, we retained all that free water, methane and hydrocarbons, the essential stuff of life. Extra iron delivered by Theiea gave us a spinning, dense core of metals acting like a giant electro-magnet, creating the magnetosphere surrounding us and protecting us from the ravages of unchecked cosmic radiation. Mass and density in just the right proportions served to retain a gaseous envelope and liquid water. Internal heat, from both radioactive matter and that spinning core made the outer shell plastic, keeping the outer crust from locking solid – upwelling and sinking of crust acting in concert in the process of plate tectonics, recycling carbon and other essential elements and injecting them into the hot ocean above.

Precisely when the miracle we call life began is impossible to determine – the rocks and sediments that might have conveyed that information have long since been recycled. The oldest reliably-aged rock on the planet is sedimentary in origin (which means it was eroded from a solid parent material millions of years earlier), and it contains no traces of even the most simple of organic forms. For brevity's sake we will just have to accept that the building blocks of complex life, and its earliest known exemplars, the single-celled prokaryotes, are dated to around three and a half billion years old.

Ordovician–Silurian extinction events (End Ordovician or O-S): 450–440 Ma at the Ordovician-Silurian transition. Two events occurred that killed off 60% to 70% of all species

Late Devonian extinction: 375–360 Ma near the Devonian-Carboniferous transition. A prolonged series of extinctions eliminated about 70% of all species. This extinction event lasted perhaps as long as 20 Ma, and there is evidence for a series of extinction pulses within this period.

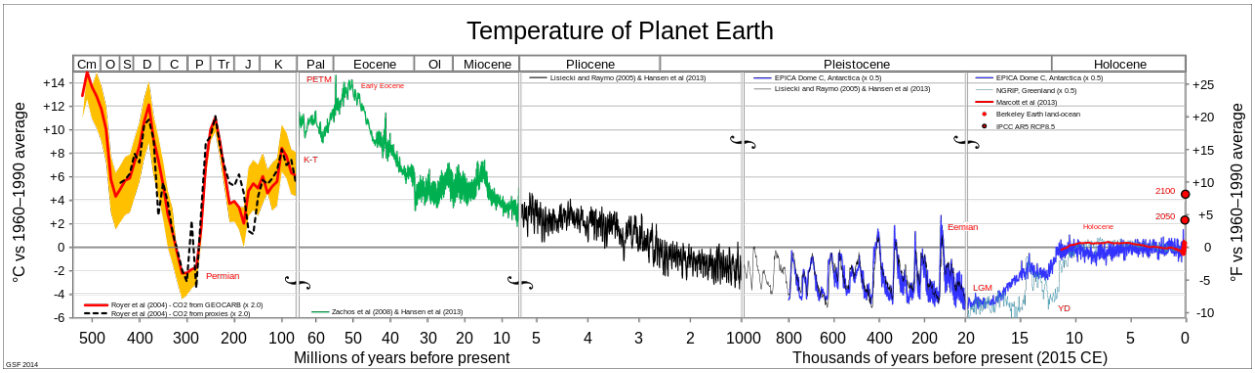
Permian–Triassic extinction event (End Permian): 251 Ma at the Permian-Triassic transition. Earth's largest extinction killed 90% to 96% of all species. About 96% of all marine species and an estimated 70% of land species, including insects, vanished. The "Great Dying" had enormous evolutionary significance: on land, it ended the primacy of mammal-like reptiles. The recovery of vertebrates took 30 million years but the vacant niches created the opportunity for archosaurs to become ascendant.

Triassic–Jurassic extinction event (End Triassic): 200 Ma at the Triassic-Jurassic transition. About 70% to 75% of all species went extinct. Most non-dinosaurian archosaurs, and most of the large amphibians were eliminated, leaving dinosaurs with little terrestrial competition.

Cretaceous–Paleogene extinction event (End Cretaceous, K-T extinction, or K-Pg extinction): 66 Ma at the Cretaceous-Paleogene transition. About 75% of all species became extinct. All non-avian dinosaurs became extinct during that time. Mammals and birds emerged as dominant land vertebrates in the age of new life. The Mount –Everest-sized rock that struck our planet and delivered the final blow to the dinosaurs, seems to have also imparted a rapid wobble to the Earth’s rotation in space. This wobble has an interesting side-effect, in that it imparted a very precise, almost metronomic, swinging of the globe towards and away from the sun.

Another 60 million years would pass before the line of mammals that gave rise to our own species barely made it out of the most recent extinction event, which killed-off 70% of our competition - large predators, like sabre-tooth tigers and giant hyenas. This extinction was driven mainly by the most recent ice-age to lock the planet in a cold, arid glaciation that saw a drop in sea level of nearly 500 metres in places, and the growth of desertification which produced the Gobi, Sahara, and Kalahari landforms.

I was not until about 165,000 years ago, at the inception of the warm spell we currently enjoy, that our most modern ancestors could begin their spread over the face of the Earth.




At its coldest point, 20,000 years ago, global average temperatures were at some 20 degrees C lower than today. At this stage, Asia and North America may have been directly connected, and South America and Africa may have been separated by less than 800km of ocean. Almost immediately, temperatures began to rise and by 10,000 years ago reached the moderate levels we now enjoy. Nearly all of the oldest city-like settlements and the appearance of agriculture are dated to that period.

We all have a fairly good idea of what has occurred in the last ten millennia, so now I'll try to sum up and get to the point because you're probably wondering if I have one.

It is this:

From a state of perfect symmetry 13.7 billion years ago, a state we can only call nothingness because no *one* thing can be said to exist as all things *are*, simultaneously, and there is no time-space for any one thing to be discretely observed, a minus sign is introduced into the great equation and now something exists – call it the I Am, the Prime Mover, call it God if you will but we cannot say if it is a new thing or came before, since we have no way of describing 'before' or understanding it.

Complexity begins. Nine billion years pass and our solar system forms. Four and a half billion years ago, our planet takes shape and we acquire a moon. Two and a quarter billion years ago, single-cell life fills the oceans, photosynthesis begins and oxygen fills the atmosphere. One billion years ago, multi-cellular life arises and symbiosis of cooperative organisms gives rise to organelles, the nucleus, and mitochondria. 500 million years ago, the Cambrian explosion of life in the seas produces a vast array of new species of animals the planet has yet seen. 250 million years ago, 96% of everything living created so far is eliminated, making way for the dinosaurs, and the mammal-like reptiles. 125 million years ago, in the Lower Cretaceous, true mammals live alongside some of the largest dinosaurs ever to exist. 62 Million years ago, the planet recovers from a near-death blow from space and birds rule the air while mammals rule the ground. 30 million years ago, a new plant species called grass appears, and savannahs and prairies begin to replace forested areas as the planet enters a cooling phase. 15 million years ago, India collides with Asia, pushing up the Himalayan chain and altering weather across the globe, setting-off a cycle of glaciations which have a regular pulse of 100,000 years. 7.5 million years ago, and our ancestors have made the split from the branch of evolution we shared with the ancestors of the apes. 3.75 million years ago North and South America become joined, with major consequences to global temperatures, the Arctic cooling cycle begins and the Arctic gets a permanent ice cap. 1.8 million years ago, 30% of the Earth's surface is covered by ice. Mammoths, mastodons, saber-toothed cats, ground sloths, Irish elk, cave bears, and Neanderthals all vanish.

The ever-increasing pulse of complexity is self-evident, especially in our own times, and now the world and our lives seem to change on a daily, if not hourly, basis. The precision with which each of those events led seemingly inexorably to this one foal point – to us, in other words – is so far beyond mere chance it's mind-boggling. The odds of the exact same sequence of events occurring elsewhere in the universe, however vast it is, are so vanishingly small that the idea of intelligent life like our own appearing elsewhere loses credibility. This is, in essence, the perfect world for what we call Life to exist.