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In the Beginning: a Scientific and Philosophical Inquiry

As far back as history can take us, mankind has been trying to understand the world around him, trying to find answers to the questions that have never ceased to fascinate countless inquisitive minds: where did we come from and why are we here? Cosmologists try to answer these questions. The word *cosmology* derives from two Greek words: *kosmos* (universe) and *logos* (account). Cosmology, then, seeks to develop an account (or theory) of the universe that both describes it and explains its origins, while still interfacing with the rest of scientific thought. Until the 20th century, speculations about the origin of the universe (or lack thereof) were largely restricted to the domain of philosophy, but cosmologists have made striking discoveries since the development of Einstein's Theory of General Relativity, particularly owing to the massive technological advances that have enabled scientists to probe deeper into the universe. These timeless philosophical questions have become contemporary scientific questions; the abstract has now become concrete. For age, philosophers and theologians have firmly held the belief that the universe had a beginning in the finite past, but only on the basis of religious conviction and logical argumentation. Today, the expanding field of cosmological theory provides significant evidence in support of roughly the same idea, namely that the universe had a beginning. The prevailing theory in cosmology today is commonly called the Big Bang Theory.

In order to put modern cosmology in context, it may be helpful to survey how the western concept of the universe had developed up to Einstein. The general trend has been from a concept of a steady, unchanging universe to a dynamic, expanding one. The ancient Greeks championed a geocentric model of the universe, observing that the stars seemed to rotate the earth daily. “The alternative proposal—that this effect is produced by a rotation of the earth rather than that of the starry sphere” as Timothy Ferris puts it in his book *The Whole Shebang*, “was to encounter objections that were insurmountable at the time” (23). The obvious objection is this: if the earth is rotating rapidly, then why isn't there a perpetual trade wind, and why “does a man who jumps straight up land in his footprints [...]” (24)? It was not until Galileo (1564-1642) that this misunderstanding of inertia was corrected; whereas Aristotle (4th century BC) had posited that objects tend towards being at rest, Galileo observed that objects already set in motion tend to stay in motion, until they are prevented by opposing forces, such as friction (28). Nicolaus Copernicus (1473-1543) had made an important step away from the geocentric model by assuming that the planets were orbiting around the sun, but his theory failed to accurately predict the movements of the heavenly bodies on account of his false supposition that the planets moved in circular orbits. Johannes Kepler (1571-1630) corrected this assumption, working on the astronomical observations of Tycho Brahe (1456-1601) that indicated that the planets revolved around the sun elliptically. Ferris quotes Einstein in lauding both Kepler and Galileo for realizing that mathematical and philosophical reasoning were not sufficient for drawing conclusions about the universe, but must be founded upon empirical observation (28). The work of Galileo and Kepler was were solidified by Isaac Newton (1647-1727), whose Three Laws of Motion accurately described the motion of bodies in the universe for hundreds of years, until Einstein and the 20th century.

Newtonian physics, however, assumed a steady-state universe. Both astronomical observations and Einstein's Theory of General Relativity rather unanimously pointed to the fact that the universe was expanding, an idea that even Einstein was hesitant to accept. According to Ferris, “Einstein at first resisted this odd idea, but soon found himself obliged to accept the validity of the mathematical reasoning involved” (32). Einstein compensated for this implication, “regarding [it] as a flaw,” by introducing the *cosmological constant* to balance out the expansion. Einstein was corrected by the Russian physicist and mathematician, Alexander Friedmann, who had conclusively shown that “the universe of relativity was a dynamic universe” (43). Friedmann's conclusions were later corroborated by the Belgian Georges Lemaître, Howard P. Robertson, and American, and the British Arthur G. Walker (43), hence the eponymous Friedmann-Lemaître-Robertson-Walker solution to Einstein's field equations.

Edwin Hubble (1889-1953) popularized an important discovery that have been made previously by other astronomers and corroborated by his own observations, a discovery that fit nicely within this theoretical framework. In 1929 Hubble formulated his Redshift Law, which states that there is an observed “red-shift” in the spectral analysis of celestial bodies that increases linearly with distance. Spectrum analysis breaks down energy emitted by matter into certain frequencies of light. Different elements radiate energy producing different spectra. What Hubble's Redshift Law means, then, is that for a given light source, the frequencies shown in the spectrum analysis of that source are redder (lower frequency) than expected. This result is attributed to the Doppler Effect, which can be illustrated by a simple example from everyday life. Whenever you hear the siren of an ambulance, the pitch always seems to be either rising or falling. If the ambulance is approaching, then the pitch appears to be rising; if it is receding, the pitch appears to drop. Pitch is nothing other than frequency, so the siren emitted by the receding ambulance can be said to be "red-shifted," or shifted to a lower frequency; by virtue of the same principle, the approaching siren appears to be "blue-shifted," with an augmented frequency. Timothy Ferris explains this phenomenon quite intuitively with the following example:

> Think of a drummer, standing on a railroad car, who hits a kettledrum once every second. Now let the train speed away. As the train accelerates, ever-greater amounts of space intervene between each striking of the drum, so that the intervals you measure back at the station increase to one and a half seconds, two seconds, and so fort. The drummer will seem to be beating more slowly, and the sound will deepen in pitch. (43-4)

When the sound analogy is carried over to light waves, instead of the pitch being perceived higher or lower, the light is perceived as redder or bluer. To run the experiment backwards, then, if a listener hears a descending ambulance siren, it is logical for him to conclude that the ambulance is retreating. Therefore, if an astronomer on earth perceives that light from distant galaxies is red-shifted, it is reasonable for him to conclude that those galaxies are likewise receding. Moreover, the linear regression of this red-shift data from galaxies of varying distance further confirms this theory. If the universe has always been expanding at a rate equal to the present rate of expansion indicated by the observed red-shifts—it is almost certain that it has not been, but let us set this aside for a moment—then the universe is approximately 15 billion years old, a period of time also known as a *Hubble period* (Harrison 220). This evidence, then, confirmed the theoretical conclusion that the universe is expanding, and according to Timothy Ferris, "the Hubble law [...] put flesh on the bones of the theories" (48).

So if the universe is expanding, two obvious questions arise: *into what* and *from where* is it expanding? The first question is really nonsensical, since if space itself is expanding, it is not expanding into anything, but rather the very fabric of space-time is being stretched out. The second question had led cosmologists to the formulation of the Big Bang theory. Basically, if space is expanding and has always been expanding, then it must have begun as a single point "in space" (really, all of space was a single point) in the finite past. Somehow, something—or everything—came from nothing. As Edward Harrison writes in his book *Cosmology,*

> The universe expands; we naturally therefore suppose that in the past it was in a more congested state than at present. If we could journey back in time we would notice the universe becoming steadily more and more dense; eventually we would arrive at the high-density state referred to as the big bang. **This conclusion seems unavoidable** [emphasis added]. (346)

Because of that fact that up to the 20th century the standard model of the universe had been a static universe, this new hypothesis was earth-shattering. Now, for such a space-time explosion, there are three possible scenarios. Space is attracted to itself gravitationally, so as space expands, it is necessarily being slowed down by gravity. Consider a rocket shot from the surface of the earth. Initially the rocket accelerates upwards, but the earth's gravity is working against it. If the force of gravity exceeds the thrust of the rocket, then it will fall back to the earth. Or, if the rocket's thrust is sustained and exceeds that of the force of the earth's gravity, then the rocket will escape the earth's gravitational field and continue to speed into space. A third scenario is possible, however, in which the rocket's booster gives out just as it escapes the earth's gravitational field, so that the rocket continues into space but maintains its velocity.

Although the universe is much larger and more complicated than a rocket, the concept is essentially the same. Basically, instead of two point masses pulling on each other as in the rocket example, there are an infinite number of point masses all pulling on each other. If the force initiated by the Big Bang that is causing the universe to expand is less than space's gravitational attraction to itself, then the universe will eventually collapse on itself, terminating in a "big crunch." If gravity is weaker, then it will continue to stretch out faster and faster, ending in a cold "heat death." Or, if the forces are roughly equal, then the universe will continue to expand at it's "escape velocity." The Greek letter Ω denotes the *density parameter* of the universe, which is determined by the average matter density of the universe. The previous three scenarios, in terms of Ω are as follows: if $\Omega > 1$, then the universe will collapse (spherical geometry), if $\Omega < 1$, then it will continue to expand increasingly quickly (saddle-geometry), and if $\Omega = 1$, then it will reach a terminal velocity of expansion (flat geometry). Currently, most cosmologists are convinced that $\Omega < 1$, meaning that the universe will eventually fizzle out in a cold "heat death." An immediate corollary of this positive curvature is that the universe is less than 15 billion years old, which was predicted by the Hubble period in a universe of constant expansion.

It may be helpful at this point to flesh out the current understanding of how this happened, that is, how the universe transformed from an infinitely dense point into the distinguishable galaxies and formations that exist today. In trying to understand the early states of the universe, Harrison gives us the following principle: “As a rough guide we use the rule of thumb that the average density of the universe is inversely proportional to the square of its age [...]” (347), which means that “each time the age [of the universe] is increased by a factor of 10, the density is reduced by 100” (348). Galaxies contract and stars disappear as one rewinds the tape of universal expansion back to an age of 5 billion years, when our Solar System was first formed (349). At around 1 billion years of age, the galaxies were “swelling into gigantic orbs of gas,” galaxies that were being formed over the previous 900 million years (from an age of 100 million years) (349). Recall that as the universe expands, it gets cooler and rarer, which means that as we rewind this cosmic tape, space is getting much hotter and much denser. According to Harrison, “at an age of 1 million years the universe has begun to glow red-hot. Its density is 100 hydrogen atoms per cubic centimeter and the temperature is just over 1000 degrees […]” (349). Earlier than 1 million years, there was a point when the gas was so hot that it was partially ionized, and the free atomic particles scatter light rights, which is what prevent us from viewing space at the most extreme distances (349). It was at approximately the same time that the density of matter and radiation were equivalent, although earlier than this point, for almost the first million years of the universe’s history, also known as the *radiation age*, radiation was denser than matter (349-50). The radiation age began after the first second of the universe’s existence at a temperature of 10 billion degrees and with an average density of 1 million grams per cubic centimeter (350). In the first few hundred seconds, one-quarter of the matter in the universe became helium, formed from decaying deuterons (350-1). Before the radiation era, in what is known as the *lepton era*, is when the universe began, in a singularity of infinite energy and density. This is the core of the Big Bang theory. From this singularity, the universe expanded rapidly, and as it cooled, molecules formed, then galaxies, stars, solar systems and planets, etc.

Well, the Big Bang makes for an interesting story, and it seems plausible, but is there any external evidence that helps to convince us that it is true? If it is, then scientific observations should corroborate with the theory, at least with any testable implications of the theory. One of the key pieces of evidence that helps to confirm the Big Bang Theory is Cosmic Background Radiation (CMB). If all of the energy in the universe originated from a point, then the universe's beginning must have been very hot. Given the law of conservation of energy, as the universe has expanded, that heat energy must have spread out, just as gas dissipates throughout a volume. Therefore, there should be a residual glow left-over from the Big Bang. Although cosmologists had speculated that there must be thermal residue, they had not yet found a way to detect it when Amo Penzias and Robert Wilson, working for Bell Telephone Laboratories, observed it unintentionally: “the radiation was acting as a source of excess noise in a radio receiver they were building” (WMAP). When cosmologists Robert Dicke and David Wilkinson of Princeton University learned of this experimental interference, “they realized that the CMB had been found” (WMAP). The CMB radiation is very cold (2.725º K), existing “primarily in the microwave portion of the electromagnetic spectrum,” and it is surprisingly uniform throughout the universe, “better than one part in a thousand” (WMAP). This cold uniformity fits nicely with the Big Bang Theory. How else would this energy have dissipated evenly throughout the universe? In the words of the NASA writers, “it would be very difficult to imagine a local source of radiation that was this uniform” (WMAP). It seems, then, that the Cosmic Background Radiation serves as excellent evidence in support of the Big Bang Theory.

The Big Bang Theory could be rendered untenable—at least in its present formulation—if it could be shown that something has been around longer than the age of the universe projected by Big Bang cosmology. Current estimations are under 14 billion years old (WMAP, Age of the Universe). The oldest known star clusters date to approximately this same age. If the universe were significantly older than 15 billion years, then one would expect to find astronomical artifacts dating much further back in time. The fact that we do not observe older bodies also fits well with the theory. Another piece of evidence is the amount of helium in the universe. Recall that

> one second after the Big Bang, the temperature of the universe was roughly 10 billion degrees and was filled with a sea of neutrons, protons, electrons, anti-electrons (positrons), photons and neutrinos. As the universe cooled, the neutrons either decayed into protons and electrons or combined with protons to make deuterium (an isotope of hydrogen). During the first three minutes of the universe, most of the deuterium combined to make helium. (WMAP)

The Big Bang model predicts that roughly one-fourth of the matter in the early universe was transformed into helium, which agrees with modern scientific observations (WMAP). That the theory can be confirmed experimentally lends great strength to its credibility. The largest threat to the Big Bang theory, however, is the range of ages implied by different data, but this is generally attributed to experimental error. As we can see, not only does the Big Bang theory have a strong explanatory power (the dynamic universe necessitated by general relativity, why the universe is expanding, how the universe may have begun), it also meshes with independent observations (age of oldest celestial bodies, quantity of light elements, CMB, red-shift).

Cosmologists with their theories and astronomers with their observations have rendered the Big Bang theory probable, but what does this mean for us practically? Does the Big Bang model help us answer Leibniz's famous question: why is they something rather than nothing? Does this mean that there must be a God? Although not necessarily incompatible with Newton's steady-state universe, for centuries some philosophers have concluded that the universe must have begun at a point in the finite past for purely *a priori* reasons. The Big Bang model implies the same conclusion that the philosophers had already reached, so it seems logical to explore the independent philosophical reasoning that strengthens, and is equally strengthened by, the Big Bang model. Whereas some see no useful connection between these two topics, such as Timothy Ferris, who, when answering the question "what can cosmology tell us about God?" writes the following: "Sadly, but in all earnestness, I must report that the answer is this: Nothing. Cosmology presents us neither the face of God, nor the handwriting of God, nor such thoughts as may occupy the mind of God [...] cosmology offers no resolution to such questions" (304), I cannot help but ask Leibniz's question in a thousand different ways, and God, if he exists, would go a long way as to answering these inquiries. In this case, science sparks the imagination, and in order to journey further, beyond the lepton era, beyond time itself, the cosmologist must become a poet, and the physicist a philosopher.

The Cosmological Argument has been around for centuries and has been employed by Jews, Christians, Muslims and atheists alike. In his book *The Kalām Cosmological Argument*, William Lane Craig traces the history of the argument through the ranks of Muslim philosophers and theologians, where it developed significantly before rooting itself firmly within Christian philosophy. Although the argument has manifested itself in many forms, it is supported in primarily two ways, as given by Craig. The first supporting argument is one from the impossibility of an actual infinite. The implication of this premise is that if there can be no actual infinite, then there can be no infinite temporal regression, since that would require an actually infinite set of finite intervals of time. The second states that it is impossible to form an actual infinite by succession. As time passes, one moment is necessarily added to the previous. Therefore, all of time could not be infinite, because time is formed by successive addition. I will explore both of these supporting arguments in a moment, but for now, let us look at the general form of the Cosmological

Argument, as given by William Lane Craig:

(1) Everything that begins to exist has a cause of its existence.

(2) The universe began to exist.

(3) Therefore, the universe has a cause of its existence.

(*The Kalām Cosmological Argument* 63)

The first premise (1) is accepted by almost all by intuition. As Craig writes, "even Hume himself confessed that his academic denial of the principle's demonstrability could not eradicate his belief that it was nonetheless true" (141). According to our experience, things do not generally happen uncaused, or as in Hume's case, there is an extremely strong impulse in the human psyche to draw causal connections between temporally subsequent events. Things happen for a reason (that is a *cause*, not a purpose). The conclusion (3) follows logically from (1) and (2), so the main argument to be made is in support of premise (2).

It is very useful to make the distinction between an actual and a potential infinite upfront. Mathematically, a potential infinite is meant by saying that as x approaches *infinity*, the limit of 1/x approaches zero, or to say that something could be divided into an infinite number of parts. A potential infinite, then, is a trend that can never be completed. A child can start counting 1, 2, 3 …, but regardless of how long or fast he counts, he can never reach a last number. A new, higher number always comes next. To say that the counting numbers proceed infinitely, is to say that they go on "forever," or as far as the imagination is willing to go. The trend toward infinity, however, is never complete, nor is it ever actual; it remains forever a potential infinite. A good concrete example of this is future time. No one knows how many seconds there are in the future, and it is certainly plausible that seconds *could* (potential) continue to tick away forever, but by *forever* we mean ceaselessly, in the sense that new seconds will continue to be added in a trend toward infinity. An actual infinite is not "the number infinity," which is meant by children who ask whether it is possible to count to infinity or not. Infinity is not a number, but an arbitrary mathematical definition, such as the set: {1, 2, 3 …}, which is defined all at once in a convenient mathematical notation. As Craig points out,

> prior to the revolutionary work of the mathematicians Bernard Bolzano (1781-1848), Richard Dedekind (1831-1916), and especially Georg Cantor (1845-1918), the only infinite considered possible by philosopher and mathematician alike was the potential infinite. (65)

Proofs and operations can be performed on such actual infinites, but they have no bearing on the real world, as we shall soon see.

Let us begin, then, with the first argument in support of premise (2): *the argument from the impossibility of the existence of an actual infinite*, which Craig thus formulates:

(a) An actual infinite cannot exist.

(b) An infinite temporal regress of events is an actual infinite.

(c) Therefore an infinite temporal regress of events cannot exist.

(*The Kalām Cosmological Argument* 69)

Although Cantor provided mathematics with a way of defining and comparing infinite sets, this does not, as Craig and others emphatically state, imply anything about the actual world. Moreover, the truth of this is fairly self-evident given the nature of absurdities that arise when trying to apply the axioms of Cantorian set-theory to the real world (72). For example, take the set: {**1**, **2**, **3** …} and then add it to itself again, so that we have {1, 2, 3, … 1, 2, 3 …}. Although we added an infinite number of members to the set, it has not grown in size, or cardinality. This can be shown by the fact that all of the odd numbers included in the original set can be mapped to the first part of the new set (**1**-1, **3**-2, **5**-3, **7**-4 …) while all of the even numbers of the original set can be mapped to the second part (**2**-1, **4**-2, **6**-3, **8**-4, …). Since a one-to-one correspondence between the two sets can be established, according to Cantor, they have the same cardinality. What is more astonishing is that the set of all real numbers has greater cardinality than the set of all rational numbers; that is to say that no one-to-one correspondence can be established between the two sets.

My favorite illustration of the absurdities of Cantorian set-theory, working on the same principle, comes from the mathematician David Hilbert (1862-1943) and is commonly referred to as "Hilbert's Hotel." A hotel manager, who happens to own a hotel with an actually infinite number of rooms, has turned on his "no-vacancy" sign, because all of the rooms are occupied. A weary traveler approaches the hotel, however, and asks if there are any rooms. Although the manager knows that all of the rooms are full, he comes up with a clever solution. The hotel rooms are numbered {1, 2, 3, …}, so he asks the occupant of room 1 to move to room 2, and 2 to move to 3, 3 to 4, *ad infinitum*. Then he puts the happy traveler into room 1, satisfied with all of the good business that he is bringing in. This is already troubling, since all the rooms were full, but the manager was able to create a vacancy somehow, but it only gets worse. Suppose an infinitely long bus with an infinite number of passengers arrives at Hilbert's Hotel. Should the manager turn them away in light of the “no-vacancy” sign, or not? Well, if he is clever, then he will ask each occupant to go to the room whose number is twice that of his own—1 will go to 2, 2 to 4, 3, to 6, etc. Then each person in the infinitely long bus should find an odd-numbered room to occupy—passenger 1 will go to room 1, passenger 2 to 3, 3 to 5, etc. It seems that the crafty manager has doubled the occupants of his hotel, but he has not even changed the “no-vacancy” sign. There is clearly something wrong with this tall-tale. It is not the set-theory that is flawed, but the fact that talking about infinite sets has no place in reality. Craig quotes Hilbert on this very principle: “… the infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought—a remarkable harmony between being and thought. …” (87). The very genius that can perform such mind-bending proofs in the Cantorian world acknowledges the fundamental problem with laying Cantor’s world on top of our own.

Premise (a), then, has been rendered probable, but (b) must be shown to be true: that an infinite temporal regress is an actual infinite. If we divide time up into discreet quantities, such as seconds, and time regresses backwards forever, then it seems fairly intuitive to conclude that there have been an actually infinite number of seconds in the history of time. This is unlike the example given earlier about time in the future. As Craig points out, there is an “important feature of past events that is not shared by future events, namely their actuality. For past events have really existed; they have taken place in the real world, while future events have not, since they have not occurred [...]” (96-7). One cannot, then, conceive of an infinite temporal regression as a mere potential infinite, since all of those discreet moments have actually existed, unlike the potential “next number” for the child trying to count to infinity. Craig gives a particularly insightful example taken from the philosopher and mathematician Bertrand Russell about

> Tristam Shandy, who, in the novel by Sterne, writes his autobiography so slowly that it takes him a whole year to record the events of a single day. Were he mortal, he would never finish, asserts Russell, but if he were immortal, then the entire book could be completed, since the method of correspondence each day would correspond to each year, and both are infinite [...] (97)

The problem with this story, however, is obvious. Tristam Shandy is always getting further and further behind. How could he possibly ever finish his autobiography? This is the kind of absurdity that arises when an actual infinite, such as the proposed infinite temporal regress, is supposed to exist. Since it seems that an infinite temporal regress *is*, in fact, an actual infinite, and since an actual infinite cannot exist, then there can be no infinite temporal regress of events. Therefore, time must have begun at some point in the finite past,

i. e. the universe began to exist.

Let us now turn to the second supporting argument that the universe began to exist: *the argument from the impossibility of the formation of an actual infinite by successive addition*, which Craig formalizes in the following way:

i. The temporal series of events is a collection formed by successive addition.

ii. A collection formed by successive addition cannot be an actual infinite.

iii. Therefore the temporal series of events cannot be an actual infinite.

(*The Kalām Cosmological Argument* 103)

Premise (ii) is straightforward enough, since a child can never count to infinity. To agree with this premise is essentially to understand that there is no "infinitieth" number. It is important to note that this impossibility does not arise from a lack of time or patience, but out of the fact that there is always higher number to be added to the list (104). William Lane Craig describes the series of temporal events as "a collection that is instantiated sequentially or *successively* in time, one event following upon the heels of another" (103). So to deny premise (i) is equivalent to denying the reality that "the collection of all past events grows progressively larger with each passing day," or at least to give it a rather unusual meaning (103). One of the interesting conceptual problems with an infinite temporal regression is this: if an infinite amount of time has passed, how is it that this moment is *this* very moment and not the one before it or after it, or how is it that this moment ever came to pass, since an actually infinite number of events necessarily preceded it? This concept is known as "traversing the infinite," and I think the most convincing formulation of this argument comes from the Jewish philosopher Saadia ben Joseph (882-942), whom Craig quotes:

> Now this same reason makes it impossible for existence to have traversed infinity in descending fashion so as to reach us. But if existence had not reached us, we would not have come into being. ... Since, however, I find that I do exist, I know that existence has traversed the whole length of time until it reached me and that, if it were not for the fact that time is finite, existence could not have traversed it. (39)

Saadia's argument is almost a strange reformulation of Descarte's famous *cogito ergo sum*, transforming it into "I think, therefore time began."

Now, these two supporting arguments, the one against the possibility of an actual infinite, and the other against the possibility of forming an actual infinite by succession, render premise (2) likely: the universe began to exist. The wonderful fact here, is that philosophy and science have reached the same conclusion. The one says that it is logically impossible for the universe to not have begun, and the other provides scientific theory and empirical evidence that nod in agreement. These two lines of argumentation, both philosophical and scientific, strengthen each other. The ultimate conclusion of the Cosmological Argument, however, that the universe must have had a cause, provides an extremely interesting starting point for discussion. Why did the Big Bang happen, or more generally, why is there something instead of nothing? Cosmologists and theologians have speculated about the answer to these questions. Although theories about what happened "before" the Big Bang seem entirely untestable, cosmology may nevertheless find a way to do it. It seems clear that philosophy and physics must work together to explore this further. Perhaps it is not insignificant that Joseph Silk writes near the end of his book, *The Infinite Cosmos*, the following words: "Physics, for good reason, was born, and still resides in some circles, as natural philosophy" (225). Philosophy and general human curiosity have once again pushed the ball back into the court of science.

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