Principle are *only* coincidences or that the universe was indeed tailor-made for life. I will leave it to the theologians to ascertain the identity of the tailor!

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FROM SCIENTIFIC COSMOLOGY TO A CREATED UNIVERSE

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Almost exactly a hundred years ago, in 1885, Berthelot, a leading French scientist, declared that owing to the progress of science the world became free of mysteries. Then came a rash of unexpected discoveries: cathode-rays, X-rays, electrons, radioactivity and quanta. The world suddenly looked so mysterious that even politicians took note. On January 21, 1910, Jean Jaurès, a leader of the French socialist party, told the Chambre des Députés: "The admirable scientist who once wrote that the world is without a mystery seems to me to have uttered a naiveté as great as his genius". Twenty years later there appeared the most successful high-level popularization of science published so far, the *Mysterious Universe* by James Jeans. The universe seemed to the famed British astronomer so mysterious that he was even willing to see beyond it a God, a sort of super-mathematician. A few years later Etienne Gilson wondered aloud why scientists should take any satisfaction in the apparent mysteriousness of the universe. Most Christian readers of the book seemed satisfied. Belief in God, the greatest mystery, often appeared safer when God's handiwork, the universe, also looked mysterious. Unfortunately, true mysteries were often seen in mere gaps of scientific knowledge, gaps which as a rule are rapidly filled as science progresses.

Even if by mysteries Berthelot meant such gaps, his really scientific bungle was not that he saw all mysteries, that is, gaps in scientific knowledge, being filled at least potentially, although this was enough of a bungle. In 1885 there was not even an inkling of the true explanation of spectral lines which by then had been measured by the tens of thousands and held the key to an atomic realm defying all scientific prognostication. Berthelot misread science most as he spoke of the universe without hinting at its scientifically problematic character. He should have known that in 1885 it was not yet possible to speak in a scientifically unobjectionable way about the universe, the totality of consistently interacting things. Scientific cosmology was still to be born in spite of the fact that throughout the 19th century scientists spoke more and more often of the universe, a topic which had largely been the preserve of philosophers and of a few philosophically inclined scientists. That during the 19th century and before, scientists spoke of the universe in the sense of doing cosmology, was not in itself completely unscientific. One ought to speak of a problem one cannot solve if that problem is ever to be solved. The universe was for 19th-century science, or for Newtonian science, a huge problem, but, and this was scientifically reprehensible, scientists preferred not to speak of this, rather, they tried to talk away the problem.

The problem was the alleged Euclidean infinity of the universe. Such a universe was largely the product of 19th-century thinking. Newton himself believed the material universe to be finite in an infinite space. This idea was endorsed and propagated, as something most conformable to reason and to God, by no less publicists than Addison and Voltaire. But with the early 19th century there came a radical shift. Thus the astronomer Olbers declared in 1823, with a reference to Kant's authority, that the universe of stars had to be infinite. The context spoke for itself. Olbers wanted to save the infinity of the universe from the paradox of the darkness of the night sky. If the number of stars was infinite and homogeneously distributed, it followed, if one did not take into account the average lifespan of stars, that the intensity of starlight should be equal at any point to the brightness of the surface of a typical star, such as the Sun.

Whatever the loopholes in the optical paradox, which had already been discussed by Halley and intimated by Kepler, there were no loopholes in its gravitational counterpart. Here too the story goes back well beyond the 19th century. As early as 1692 Bentley called attention to the gravitational paradox in his famous Boyle lectures and also privately in his letters to Newton. After Green formulated in 1827 the theory of potential, the gravitational paradox could have been given a rigorous formulation. This did not happen until 1871 when Zöllner, professor of astrophysics in Leipzig, showed that in an infinite homogeneous universe any force obeying the inverse square law should produce an infinitely large potential at any point. At the same time Zöllner also suggested that Riemann's four-dimensional space-time manifold could provide a way out, provided the total mass of the universe was taken to be finite. Two years later, W. K. Clifford, professor of applied mathematics at University College in London, stated that Riemann's geometry made the universe a scientifically valid notion, the very basis of the possibility of a scientific cosmology.

Although both Zöllner and Clifford were prominent figures, scientists paid little if any attention. Some, like Seeliger in Munich, tried to change slightly the inverse square law to save the infinite homogeneous universe; others took the Milky Way for all the universe that was investigable. The infinitely large part beyond the Milky Way was declared by Kelvin, among others, to be forever beyond the reach of science. Such a solution was not science, but a schizophrenic thinking which split the universe into two parts: one finite (the Milky Way), the other infinite (everything beyond). Thus was the universe rid of its mysteries. So much in a way of commentary on the real scientific blunder which Berthelot made in speaking of the universe. Assuming as he did that the universe was infinite in the Euclidean sense, he had no right to speak of it as if it had no mysteries, that is, scientifically debilitating problems.

The first chapter in a scientifically rigorous cosmology came only in 1917 with Einstein's memoir on the cosmological consequences of General Relativity. There Einstein showed that the gravitational interaction of all material bodies could be given a formulation free from the gravitational paradox which plagued the so-called

Newtonian universe. This was not, however, the most important aspect of that memoir which was the last in a series published by Einstein between 1915 and 1917 on General Relativity. The most important point was a formula which stated that from the values of the average density of matter and of the gravitational constant one could infer the value of the total mass of the universe and its overall radius of curvature produced by that mass. Such an inference was not a mere play with formulas. The inference was based on a broad theory, General Relativity, which already at that time provided three experimentally verifiable predictions, each independent of the other: the gravitational red-shift, the gravitational bending of light, and the advance of the perihelion of planetary orbits (readily observable in the case of Mercury). While the early verifications of these effects were not altogether convincing, today the margin of error in measuring them is too small to permit real doubt. During the last half a century several other predictions of General Relativity have been submitted to observational tests which further confirmed its reliability. No less valuable confirmation of General Relativity is the increasingly vaster field of study: scientific cosmology. All branches and further developments of that study are based on the conviction that it is scientifically meaningful to discuss the consistent interaction of the totality of matter, a totality which is the universe.

Such a conviction is further strengthened by the fact that in modern scientific cosmology the study of galaxies and other large-scale celestial objects is closely united with the atomic, nuclear, and subnuclear studies, that is, the study of the smallest material objects. That scientific cosmology deals with the totality of consistently interacting matter is strikingly shown by the expansion of the universe. This large-scale motion to which all matter is subject was first a mere prediction by Abbé Lemaitre on the basis of General Relativity before it obtained observational proof in the red-shift of the spectrum of galaxies. That shift can be explained only if galaxies have a recessional velocity with respect to one another which is the greater the farther they are from one another. This, however, entitles one to follow the motion of galaxies backward in time to a moment where all matter was condensed within a relatively small space.

Scientific cosmology gives so far an account only of the gravitational interaction of matter. Other interactions, electromagnetic and nuclear, are incorporated only in part in that picture. A Unified Field Theory valid for all these forces (to say nothing of some forces still to be discovered) is still to be formulated. Such a theory is the most coveted prize for leading scientists today, in proof that in their eyes the notion of the universe is a truly valid and not merely a regulative idea. They are encouraged by the success achieved so far by General Relativity. Twentieth-century science provides indeed powerful support on behalf of the validity of the notion of the universe, a validity which since Kant's *Critique of Pure Reason* has been largely dismissed in philosophical circles (and even in some theological realms which should know better). Kant's ultimate purpose with the *Critique* was, it is well to recall, to provide a rigorous basis for man's autonomy or independence. In that strategy an all-important step was the presentation of the universe as a bastard product of the metaphysical cravings of the intellect. If the universe was not a valid notion, then it could no longer function as a reliable basis of inference to the existence of the Creator, the only Independent Being. In the absence of such trustworthy inference man's autonomy seemed to be fully secured.

The really dangerous part in Kant's strategy was that he largely succeeded in creating the impression that his reasoning was in the spirit of exact, that is, Newtonian science. Now, if he had been well informed and really perceptive in matters scientific, he should have realized that his antinomy about the finiteness versus infinity of the universe had no scientific merit. The so-called Newtonian infinity, which he had in mind, had no scientific validity and therefore could not be used as an alternative to the possible finiteness of the universe. Twentieth-century science or cosmology has shown that it is meaningful to speak about the infinity of the universe as well as about its finiteness, without being thrown back thereby into the hold of Kant's first antinomy. That modern scientific cosmology restores confidence in the validity of the notion of the universe should seem no small bonus for those who see the universe as a jumping board to its Creator. The same cosmology does something even more important in that respect. The universe as described in that cosmology strikes us as a truly existing thing. Scientific cosmology provides this impression not by philosophical arguments, however valid and precious they may be about existence. Rather, it does so by its portrayal of the universe as a most specific, most peculiar, most particular and at the same time fully consistent entity.

Here again a recall of the historical background against which this development should be seen may be very helpful. A hundred years ago Herbert Spencer rode the crest of the wave with his *First Principles,* a cosmic philosophy. Like Kant, Spencer too succeeded in presenting his philosophy as steeped in science. Spencer first made a name for himself with his account of Laplace's nebular hypothesis in which the solar system, and ultimately all solar systems and celestial bodies, were the products of an evolution which started with a nebulous, that is, most homogeneous state of matter and ended with a most specific or inhomogeneous form of it. The effort was a somersault both philosophically and scientifically, worthy of a philosopher who did not have proper scientific training and who prided himself that never in his life was he surprised by anything. Yet, because Spencer's scientific bungle was not perceived, his philosophical bungle too was readily overlooked. The scientific bungle was tied to the lack of any information about the nebulous state, the presumed starting point of cosmic evolution. The pale whiteness of nebulae was simply taken by scientists for a homogeneous fluid for no real reason whatsoever. Scientific unanimity based on wishful inference fully reassured Spencer that his starting point was correct and reliable. For all that, it remained thoroughly incorrect for him to assume that complete homogeneity would ultimately give rise to a high degree of inhomogeneity. As one would expect, Spencer assumed a "very slight imbalance" in that original state, but the significance of this proviso was largely lost on him and on his readers, among them Charles Darwin who naively took Spencer for one of the greatest intellects of all times. Spencer, as is well known, took that homogeneous, nondescript, unspecified entity for the starting point of the natural form of existence. It was a matching counterpart to the perceptual non-specificity of Euclidean infinity which in the eyes of many served as a natural frame of existence which needed no further, let alone metaphysical, explanation.

A hundred years after Spencer the farthest point in the past to which scientific cosmology carries us is the very opposite of non-specificity. With the discovery in 1965 of the 2.7 K cosmic background radiation, a proof was served on behalf of earlier theories about the genesis of chemical elements, at a time when the universe was in a highly condensed state. Chemical elements, as ranged in the Mendeleev table, are not only very specific in themselves (Mendeleev himself was so impressed by their specificity as to take all of them for irreducible primordial entities). Their relative abundances are no less specific. Such a compound specificity could arise from a cosmic soup comprising all matter in which for each proton, neutron, and electron there were almost exactly 40 million photons at a very specific temperature and pressure. Only under such conditions could the interaction between those particles yield hydrogen and helium in their actual and very specific proportion and make thereby the genesis of heavier elements possible.

On looking at a proportion of 1 versus 40 million, no sane mind would be tempted to take it as a natural or, rather, exclusive state of affairs. The same lesson is on hand when one follows modern scientific cosmology beyond the baryon state of the cosmos (described by Dr. Carr above) to states which modern scientific cosmology calls lepton, hadron, and quantum states. Beyond those states is the matter-antimatter state where things appear dizzyingly specific. Nothing would be more natural than to see that state as comprising an equal amount of matter and antimatter. But interaction between equal amounts of matter and antimatter would yield only sheer radiation. In order that our ordinary matter and world may arise, scientific cosmology must resort to a most "unnatural" assumption, according to which there had to be an original imbalance of one part in 10 billion in favour of ordinary matter. Such is not a mere speculation. Its reasonability is implied in the finding by Fitch and Cronin of a slight asymmetry in the decay of K_2 mesons, a finding which earned them the Nobel Prize in 1980.

Clearly, there is an immense contrast between the primordial state of matter as described by Spencer and as described by scientific cosmology, a contrast which should provoke the utmost surprise. The difference is not merely a difference between studied vagueness and a study steeped in scientific precision. The real difference is that a most specific entity may strike even a philosophically desensitized mind with the fact of existence. While the queer specificity of everyday things can easily be lost on us, such is hardly the case when one is forced to face up to cosmic specificity, described and verified in all details by science. About the universe scientific cosmology states not only that it is a valid notion, but also powerfully suggests that it does exist—a most welcome contribution in an age in which philosophizing is stranded on the shallows of idealism and logicism, two skilful guides to solipsism and sheer wilfulness.

To grasp all this requires no familiarity with that elaborate mathematics which is an integral part of scientific cosmology. Because of its mathematical aspect, scientific cosmology is subject to Gödel's incompleteness theorem, according to which no set of non-trivial arithmetical propositions can have its proof of consistency within itself. This means that all scientific efforts aimed at an account for the universe, which would show that the universe can only be what it is and cannot be anything else, are doomed to failure. Eddington was not the only major scientist in our century who seriously devoted himself to such an undertaking. Einstein himself would have loved to construct a Unified Theory such that, as he put it half seriously, "even the good Lord would not be able to improve on it". In the past two decades several Nobel laureates admitted that their work was motivated by some such aim. Of course, it is not absolutely beyond the realm of possibility that a scientist should be fortunate enough to hit upon a mathematical formalism which would fit the quantitative aspect of all material processes. In that case there would remain no mysteries or unsolved problems with respect to the physical universe where, let us not forget, God "disposed everything according to measure, number, and weight". Such a fortunate theory would account not only for all data on hand but also for data still to be gathered in the future, however distant.

Yet even such a theory could not claim to itself intrinsic consistency. Its proof of consistency would, in virtue of Gödel's theorem, lie in a set of considerations not included in it. In other words, scientific cosmology, because of Gödel's theorem, can never pose a threat to that cosmic contingency which is intimated in the scientific portrayal of the specificity of the universe. A universe which is contingent is the very opposite of cosmic necessitarianism, the age-old refuge of materialists, pantheists and atheists, all of whom, with Nietzsche in the lead, consider the dogma of creation as the most pernicious error man can espouse.

The final and most striking pointer of scientific cosmology to the createdness of the universe is a sequel to the contingency of the universe. The contingency meant here is not its confused sense equivalent to an undefined indeterminacy. Contingency here means the utter dependence of something on something else. The actual specificity of the universe is a striking reminder of such a dependence. Precisely because the actual cosmos is so specific, it should be easy to see the possibility of an immensely large number of other specificities. The actual specificity of the universe, which cannot be necessary, reveals therefore its dependence on a choice beyond the universe. Since the specificity of the universe is highly understandable, the choice underlying that specificity, a choice which also gives the universe its actual existence, must involve an intelligence and power which is supercosmic, that is, beyond that cosmos which for science is the totality of consistently interacting things. Things, even worlds, which do not interact consistently are, it is well to recall, irrelevant for science. Nor is relevant for science that spurious philosophy which is often equated with quantum mechanics, the probabilistic method to account for atomic and subatomic phenomena. The radical inconsistency or purely chance character which is attributed by that philosophy (Copenhagen theory) to atomic processes, is a consequence of the radical rejection by that philosophy of any question about being (ontology). Typically, such a philosophy is not consistent to the point of recognizing the fact that it therefore has no right to ask, let alone to answer, the question: What *is* chance?

Is it reasonable to assume that an Intelligence which produced a universe, a totality of consistently interacting things, is not consistent to the point of acting for a purpose? To speak of purpose may seem, since Darwin, the most reprehensible procedure before the tribunal of science. Bafflingly enough, it is science in its most advanced and comprehensive form—scientific cosmology—which reinstates today references to purpose into scientific discourse. Shortly after the discovery of the 2.7 K radiation cosmologists began to wonder at the extremely narrow margin allowed for cosmic evolution. The universe began to appear to them more and more as if placed on an extremely narrow track, a track laid down so that ultimately man may appear on the scene. For if that cosmic soup had been slightly different, not only the chemical elements, of which all organic bodies are made, would have failed to be formed. Inert matter would have also been subject to an interaction different from the one required for the coagulation of large lumps of matter, such as protostars and proto-solar systems.

Yet the solar system ultimately emerged and with it that curious planet, the Earth, which if placed at a slightly different distance from the Sun, would have undergone a very different evolutionary process on its surface. At any rate, the emergence of life on earth is, from the purely scientific viewpoint, an outcome of immense improbability. No wonder that in view of this quite a few cosmologists, who are unwilling to sacrifice forever at the altar of blind chance, began to speak of the anthropic principle. Recognition of that principle was prompted by the nagging suspicion that the universe may have after all been specifically tailored for the sake of man.

That scientific cosmologists were forced by their own findings to formulate the anthropic principle may please some philosophers and theologians. In Aquinas' philosophy it was a central tenet that the universe was created for the sake of man. It must not however be forgotten that such a tenet, or the anthropic principle, can never be a part of scientific cosmology. Science is about quantitative correlations, not about purpose. Not that science as such is not a purposeful activity. As all truly human actions science too is for a purpose and to a very high degree. This is true even of those scientists who devote their whole lives to the purpose of proving that there is no purpose. Such scientists, as Whitehead once put it, constitute an interesting subject for study. And yet, no matter how deeply is the actual implementation of scientific method steeped in purpose and therefore steeped in metaphysics, it is very important to keep in mind the self-imposed limitations of that method. Otherwise one will expect from that method something it cannot deliver. Scientific cosmology can reassure the philosopher that science poses no threat to the validity of such notions as universe, existence, and contingency. Actually, scientific cosmology powerfully suggests these notions and indeed makes use of them on a vast scale. But a suggestion, however powerful, is one thing, philosophical demonstration is another. While science or scientific cosmology can be a powerful prompting for considering the createdness of the cosmos, it can never become a discourse about creation as such.

The importance of this distinction becomes obvious when creation in time is considered. If there is a theological theme, it is creation in time, the theme or dogma which supports all other Christian themes and dogmas. Whenever the meaning of creation in time is weakened, let alone eliminated, the meaning of all other tenets of the Christian creed become weakened or eliminated. Those tenets—Fall, Incarnation, redemption, the growth of the Kingdom of God, eschatology, final judgment—presuppose not only creation but also a creation in time because all those tenets refer to events in time which alone can constitute that sequence which is salvation history. When in 1215 the Fourth Lateran Council solemnly defined creation out of nothing and in time as a dogma, it merely confirmed a long-standing tradition. The continued strength of that tradition, which, by the way, was again reasserted by Vatican I, is so great as to evidence itself far beyond Christian realms. A case in point is the widespread custom of scientists and science writers to refer to the dating by science of the age of the universe. Few customs can become more unscientific. While science can assure us that it can carry its investigations 12 billion years back into cosmic past, there is no science whatever which can date the birth of the universe. There is no scientific value whatsoever in statements, often seen nowadays in print, that through the launching in 1985 of the Space Telescope man will have a glimpse of the moment of creation, because his farthest view into the universe will be increased from 2 to 20 billion light years. The reason for the absence of science in such statements is simple. Physical science or scientific cosmology is absolutely powerless to show that any stage of material interactions is not reducible to a previous state, however hypothetical. If science is impotent in this purely scientific respect, it is even more impotent with respect to a far deeper problem, a problem of very different nature, namely, that a given physical state must owe its existence to a direct creative act, which brought that physical state into being out of nothing.

Scientific cosmology has, however, made a very important contribution with respect to the existence of time, the very basis for making meaningful the phrase, creation in time. Scientific cosmology shows all too well that the universe carries on itself the stamp of time. Such a stamp is the expansion of the universe. In a very real sense the universe is ageing. It clearly burns up energy and by doing so it shows the signs of transitoriness. The force of that sign can best be judged by the frantic efforts of some cosmologists to erase that stamp from the face of the universe. The enthusiasm with which the steady-state theory was hailed thirty years ago is a case in point. The real aim of that theory was to secure for the universe that infinity along the parameter of time which it already lost along the parameter of mass and space. That the theory was indeed markedly antitheological in character could easily be gathered from the emphatic insistence of its proponents. They claimed that the continued emergence of hydrogen atoms, whereby the density of matter is kept steady in an expanding space, should be conceived as a creation out of nothing though without a creator. For the atheistic candor of those proponents one ought to be appreciative. It is hardly to be expected that they would be appreciative of the remark already made about the impossibility of physics to see *the* nothing beyond any given state of matter.

An equally atheistic, or simply pagan, or at best agnostic, longing for the eternity of matter is beneath that jubilation which greets the periodic news about the finding of the so-called missing mass, a curiously countertheological counterpart of the still elusive missing link. If that extra mass should be found in cosmic spaces, then the present expansion would turn into a contraction, and possibly that contraction would be followed by another expansion. Yet, even in this case the process would not go on ad infinitum. There has not yet been found any physical process that would be exempt from the law of entropy. Indeed, more and more attention has been given recently to the rate at which subsequent cycles in an oscillating universe would be less and less energetic. It is indeed possible to calculate, however tentatively, the number of cycles which would bring us back in time to the point where the period of a cycle would be vanishingly small. To some sanguine souls and uninformed minds that vanishing point may appear the moment of creation which would then certainly vanish.

The idea of an oscillating universe presupposes the finiteness of matter. That finiteness, when cognizance was first taken of it in the early 1920s under the impact of Einstein's General Relativity, produced shock waves in scientific and philosophical circles in which the infinity of the universe had for some time played the role of a convenient ultimate entity, making God unnecessary. The shock waves were all the more telling because, as Einstein already pointed out in 1917, there were ways in which it is possible to assume the infinity of matter without running into contradictions. Yet, all those ways are such as to provide further evidence on behalf of the stunning specificity of the universe. A distribution of infinite matter which would give rise to paths of motion resembling a cylindrical helix is too specific to be taken for that natural and necessary form of existence for which Euclidean infinity could so readily pass. The same is true about a distribution of infinite matter which would permit motion only along the curving slopes of a saddle with no edges, corresponding to an infinite hyperbolic space. About none of these specific situations is it natural to say that they are such forms of existence which one would naturally expect to exist and exist necessarily at the necessary exclusion of all other possibilities.

So much, in broad strokes, about the contribution of scientific cosmology to the idea of a created universe. The suggestiveness of that contribution is anything but small. Long before the discovery of the 2.7 K cosmic background radiation filled the world of science with metaphysical puzzlement, there was plenty of it under the surface. Einstein indeed felt it necessary to reassure with the words, "I have not yet fallen in the hands of priests", a friend who worried that on account of his cosmology Einstein might become a believer.

Reluctance to face up to the fact that the universe has a message pointing beyond itself is an old story. All too often the reluctance issues in a patently antiscientific posture. John Stuart Mill, who saw in cosmology the stronghold of theists, did his utmost to discredit it. In the process he deprived the cosmos of its intrinsic rationality. He did so by peddling the idea that in some faraway regions two and two may not necessarily make four.

Since Mill the same story has been enriched with further and no less telling chapters. They are usually provided by those educated in a milieu in which "interest in the greatest problems that ever agitated man is successfully stifled". Such was Henry Adams' characterization of that intellectually high-powered milieux of Boston and Harvard where he was brought up. Bologna, Paris, Oxford, Cambridge, Göttingen, Uppsala, Basel, Leiden—to keep the historical order—and many other illustrious places of learning, would provide ample material for painting that milieu. What is stifled is not however extinguished. Henry Adams had to realize, fifty years after he left Harvard, that "if he were obliged to insist on a Universe, he seemed driven to the Church". So he opted for what he called the Multiverse. He did not suspect that his option for the countermetaphysics of multiworlds demanded a renouncing of science at its best. The coming of scientific cosmology was less than a decade away from the moment when Henry Adams looked for salvation in multiworlds which, precisely because they could not interact consistently, could not form a universe and were therefore useless for science.

Science and Universe form indeed a seamless garment, a thesis not falsifiable unless the principle of falsifiability is turned into a *petitio principii.* That all science is cosmology has been an old truth long before K. R. Popper, hardly suspect of metaphysics, earned the aura of originality by voicing that truth to an unsuspecting generation which failed to notice its exemptness, implied by him, to the unrestricted sweep of falsifiability. Science, philosophically and historically, is an ally, not of the Academy of agnostics but of that Church which, unlike some of her theologians, knows all too well why her creed starts with the words: "I believe in God, the Father Almighty, Maker of Heaven and Earth". The effort which tries to resolve conflicts between Christianity and science by stating that religion is about persons and not about the universe of things, should seem a very poor half truth. For God, at least the Christian God, is above all the Creator of the Universe. Thanks to science, that universe appears less and less mysterious, though at the same time more and more specific, and thereby an irrefragable pointer to God, the mysterious origin of all.

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