Anthropic Principle

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Giuseppe Tanzella-Nitti [1]

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One of the most important changes that characterized the transition from the Medieval epoch to the Modern Age was the progressive displacement of the human being from a central position in the cosmos, and the consequent loss of many philosophical privileges that this central status had entailed. This change of perspective had a major impact on theology, though more in its cultural and philosophical context than in its dogmatic content. Even in our days, the idea that science has finally demonstrated that the human being and its small host planet occupy a very minor role in the universe at large, is considered by many to have removed any theological illusion about the cosmic relevance of human life. For this reason, the intriguing suggestion that contemporary cosmology has made in the recent decades, that the existence of intelligent life seems to be highly entangled with the structure and evolution of the universe from the very beginning, has aroused the interest of religion, including Christian theology, supplying fresh matter to the debate between science and theology.

From the Copernican revolution onwards, responsible for such a decentralization have been, in the first place, the natural sciences, primarily physics, due to the development of observational astronomy, and then biology, due to the discovery of the evolution [2] of species, and later on modern and contemporary cosmology [3], due to the discovery of the large-scale structure of the Milky Way and of the extragalactic cosmos as a whole. Starting from the 17th century, the new perspectives caused by the loss of the observer's cosmic central position were certainly in tune with the demands for objectivity and impersonal

analysis required by the birth of scientific method, by then recognized as one of the pillars of the new scientific epistemology. From the second half of the 20th century, however, the set of observations and reflections known as “the Anthropic Principle” stand now as the first attempt, since the beginning of the Modern Age, to show that ascribing a more central role to humankind can unexpectedly result in a better scientific understanding of the universe, of its properties and evolution.

The fact that the attempt to restore the significance of the presence of humanity within the cosmos comes from results alleged by the natural sciences, and not simply on the basis of considerations developed in the domains of psychology or cognitive science, has offered elements of dialogue and debate with respect to philosophy and religion. Just second to the so-called “problem of the origins,” the debate about the significance of the Anthropic Principle constitutes a major issue for interdisciplinary discussion between science, philosophy and theology. Although the Anthropic Principle regards mainly the field of cosmology, its suggestions extend into the field of biology, where they meet some recent demands for overcoming the Darwinian paradigm, flowing into that new, overall outlook on nature and life, that some authors have labelled “Intelligent design”. We soon realize that we are dealing here with reflections made in the domains of science, but that enter into an open terrain of confrontation with philosophy and religion.

I. From the Copernican Principle to the Anthropic Principle

It is usual to refer to the name of Nicholas Copernicus (1473-1543) to indicate the beginning of the cosmological and philosophical decentralization of the human being that occurred in the Modern Age. Nevertheless, such a loss of centrality showed non-univocal aspects and had a non-linear historical development, especially if it is evaluated over the background of its implications for religious thought. A writer such as Nicholas of Cusa (1401-1464), for instance, had no difficulty in maintaining a non-geocentric, philosophical and cosmological position, without any contrast for theology. It was not the same for a thinker such as Giordano Bruno (1548-1600), who did not find a way for a non-controversial synthesis. In the Modern Age, the progressive emancipation of humankind and nature from God also was, in part, an unwanted outcome of a process that had one of its principal roots in humanistic anthropocentrism, a movement whose first purpose was not to refuse or overcome theology. The humanists of the Renaissance did not pursue any anti-religious program when re-evaluating all of the human world, although part of 16th and 17th-century philosophy ended by placing between parentheses the bond between humankind, and its moral life, and God (Machiavelli, Montaigne, van Groot, Hobbes). The author who summarizes in himself the double soul, and therefore the genetic ambiguity, of the anthropocentrism of the beginning of the Modern Age was, without doubt, René Descartes (1596-1650). His gnoseology wanted to remain theist, but, choosing as its starting point the human psyche, he was laying the foundation for a future understanding of the world without God [4]. Finally, it should be remembered that the scientists who were protagonists of the Copernican cosmological revolution, from Copernicus to Galileo, from Kepler to Newton, were far from interpreting this revolution in an anti-religious manner.

After the Copernican Principle had declared how the Earth would no longer occupy a privileged observational position, the scientific method began to emphasize the so-called “Principle of covariance,” according to which the laws of nature [5] and the principles of the experimental sciences must be valid for all observers. This implied the methodical recognition, and the consequent removal, of any privileged conditions owned by the one making an experiment or some scientific observation. Soon science understood how important it was to deal with reproducible phenomena, that is, phenomena that anyone could verify and whose measurements could be the object of inter-subjective communication. Science

was then concerned with refining more and more the formulation of protocols to regulate an ever more objective and impersonal knowledge. The involvement and the implication of the observer within scientific activity came to light only in the 20th century: in the field of physics with quantum mechanics [6]; in epistemology [7] with the introduction of the mutual, critical implications between theory and observation; and lastly in the field of gnoseology, with the rediscovery of personal, implicit, and heuristic factors, tacitly present in all scientific knowledge.

Modern cosmology [3], whose object of study in now the physical universe [8] in its totality, has implemented a definite extension of the Copernican principle and of the Principle of covariance through the formulation of the "Cosmological principle." According to the Cosmological principle, we must consider as a non-privileged position not only the position of any scientific observer on Earth, or that of Earth itself within the solar system, but also any observational position in the whole universe. Perhaps an interesting anticipation of such a principle could be found in Nicholas of Cusa, when he affirmed that the universe has no fixed center, rather, every point is its center (cf. *De docta ignorantia*, book II, ch. XI). In other words, according to the Cosmological principle, every point of the universe is an adequate position to describe the physical universe, its structure and its laws, in a universally valid fashion. Nevertheless, such a principle is entirely valid only for a certain cosmological "model," namely the one corresponding to a homogeneous and isotropic universe, in which the study of space-time on a medium and a large scale, can legitimately leave out of consideration possible dishomogeneities and non-uniformity on a small and local scale. A number of facts show that dishomogeneities on small and intermediate scales are not so relevant as to contradict the homogeneity of the universe on a large scale, i.e. on a "cosmological" scale, thus permitting the cosmological principle to work. They are, for instance: the result that the same laws of nature [5] discovered on the Earth are true also for larger distances within the solar system and in the Milky Way galaxy, and even on an extra-galactic scale; the isotropy and symmetry of the background microwave thermal radiation; the morphological structure of the clusters of galaxies. The Cosmological principle works indeed also within an expanding universe. In fact, it is easy to demonstrate that no point of the universe is privileged within a regime of isotropic expansion (i.e., an expansion whose properties are identical in all directions), and that the expansion can be equivalently described from every point in the universe. A "perfect Cosmological principle," a radicalization of the Cosmological principle, claims that all the magnitudes and properties of the universe should be identical if observed not only from any spatial point, but also in any instant of time. However, a perfect Cosmological principle does not seem to work. We know that many parameters of the universe (density, radius or temperature, for example) vary according to time-dependent laws, even though such temporal variations and the laws that describe them are the same in every point of the universe in which they are measured. A perfect Cosmological principle would require the expansion of the universe to be counter-balanced by the continual creation of new matter and energy, in a way that assures the constancy in time of the global parameters of the universe, such as its overall structure or the distribution of the matter it contains. This hypothesis of continual creation, however, is a conjecture that present observations rule out with a good level of confidence.

Prior to now, it has never been claimed that the presence of humankind could play any relevant role in this process of understanding the cosmos and its history. Humankind certainly belongs to the "cosmic system," i.e. the subject matter of cosmology, but the slight consistency of our cosmic coordinates —geometric, chemical and biological— do not seem to possess any influence on the structure and evolution of the universe in its entirety, especially if the space and time scales of the Earth, and that of the life that it hosts, are evaluated against the background of the great and vast cosmological scale of the whole physical universe. It has been in the last decades of the 20th century when some new reflections, rising from within scientific research, have suggested something profoundly different. If it remains always true that human beings do not occupy any "central" position (geometrically or physically) within the cosmos, they do however seem to occupy a "privileged" position. What, then, would this privilege consist of? It has

been discovered that the fundamental physical parameters that determined both the structure and the physical-chemical laws of the universe, like the delicate dependence of its evolutionary phases upon each other, responsible for having progressively supplied adequate chemical abundances and regulated the formation of stars and planets, have been precisely *also* those parameters necessary to host life, and eventually intelligent observers. And, what is more, many of these delicate conditions did not occur so much in the course of the temporal development of the cosmos as they did during the very early moments of its primeval formation and of its subsequent accelerated expansion. This ensemble of scientific results and observations, that I will examine in more detail below (see section II), has prompted some authors, mainly coming from the scientific, astronomical community, to propose the formulation of what is today known as the "Anthropic Principle."

Collecting some suggestions of Dirac (1937), who pointed out some interesting numerical coincidences existing between the relevant values for the global properties of the cosmos (for example the relationships between the total number of photons and barions, the intensity of the electrical and gravitational forces, the age and dimensions of the universe expressed in atomic units), and reminding himself of the indication of Dicke (1961), who emphasized that the presence of life strongly conditions the value assumed by some cosmological "observed" magnitudes, which cannot be very different from the real measured ones, it was Brandon Carter (1974) who first proposed a coherent presentation of such observations employing the expression Anthropic Principle. As he specified later, his intentions were to place the accent on the human being "as observer," without wanting to make any consideration of a strictly philosophical value. Carter introduced the formulation of his Anthropic Principle with two different variations, *weak* and *strong*. The "weak" formulation states that the values of some specific cosmological parameters can only be those that are compatible with the existence of observers in the universe; the "strong" formulation of the Anthropic Principle affirms that the universe must possess only those properties and parameters which determine, in some stage of its development, the birth and then the presence of observers. Carter emphasized the "novelty" of this perspective underlining that the introduction of the Principle in a scientific context was legitimated by its capacity of predictability, analogously to what happens for other principles or theories commonly used in physics or astrophysics.

Some years later, John Barrow and Frank Tipler, authors of their ponderous work *The Anthropic Cosmological Principle* (1986) have theorized the Anthropic Principle in a broader and more systematic way, proposing three precise versions, that, in fact, have conditioned nearly all the following debates regarding the theme. According to their formulation of the *Weak Anthropic Principle* (WAP), "The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so." (Barrow and Tipler, 1986, p. 16). The use of a *Strong Anthropic Principle* (SAP) indicated instead that "The Universe must have those properties which allow life to develop within it at some stage in its history." (*ibidem*, p 21). To this last formulation can correspond one that includes the perspective of quantum cosmology (*Participatory Anthropic Principle*); in this case, the "necessity" of the observer is stated in order that our present universe is selected from an ensemble of possible universes (different quantum states), and then comes into being (actual state) . In the systematization given by Barrow and Tipler, the Strong Anthropic Principle would finally lead, as its extreme consequence, to a *Final Anthropic Principle* (FAP), according to which "Intelligent information-processing must come into existence in the Universe, and, once it comes into existence, it will never die out." (*ibidem*, p. 23).

Prior to analyzing the philosophy brought along with the Anthropic Principle and its possible theological resonances, it is not superfluous to elucidate that both the denomination of "principle," and its qualification to be "anthropic," do not appear obvious. If no supplementary explanations are provided, an

approach to its formulation (strong or weak) shows a certain tautological character of the Principle. It says that, for one or more conclusions in the astrophysical or cosmological domain to be true, they must be compatible with the observations, and among these observations we have to include also the existence of the observer itself (cf. Swinburne, 1990). Regarding the adjective "anthropic," in the strong formulation, the Principle emphasizes first the observer, since he or she is the "receptor of the information of the universe," and only secondarily the conditions of being human. In the "weak" form, instead, the Principle underlines the necessity of the existence of conditions able to produce chemical-biological niches adequate for the appearance of life, though not necessarily human life. To qualify it as "anthropic" assumes an implicit, non-obvious link, between the appearance of life and human life, considering this last to be the "natural" outlet for the cosmic evolutionary process, whether it is physical or chemical-biological.

In any case, a philosophical discussion of the Principle should always be preceded by an analysis of the scientific data on which it is based (Section II), in order to evaluate its independence from further philosophical paradigms, especially of an aprioristic kind, and to clarify the real philosophical implications that this data can generate (Section III); this is particularly crucial if we want to point out and clarify possible links with the perspectives of natural theology and Christian Revelation (Sections IV and V). It is worthwhile noting that the interdisciplinary debate that the Anthropic Principle has provoked and continues to provoke, witnesses an important hermeneutic and epistemological turning-point. The reflection of the sciences on the cosmos seems obliged to call into question once again the role of the knowing subject; and this does not happen in the context of a simple theory of measurement, or in the context of a generic subject/object interaction; it happens now within the framework of a global inquiry regarding the nature and the significance of the cosmos in its entirety. I willingly endorse the remark made by J. Merleau-Ponty (1984), according to whom the Anthropic Principle represents a significant epistemological turning-point in the philosophy of 20th century science, thanks to its capacity to re-open the discussion with respect to the non-accidental role that humankind plays within the physical understanding of the universe. Physical cosmology is obliged to review some of its principles because they are recognized to be interlaced with questions of a metaphysical character, re-opening the way to a new possible integration of the natural and human sciences.

II. The Scientific Observations at the basis of the Anthropic Principle

There exist many works providing valuable presentations of the scientific data at the basis of the Anthropic Principle. Many of them have a synthetic and popular-science character, others are extensive specialized books (cf. Barrow and Tipler, 1986; Leslie, 1989; Gribbin and Rees, 1989; Demaret and Lambert, 1994), or scientific review articles (cf. Leslie, 1988). There also exists a high number of collected essays and articles published as Proceedings of Conferences (cf. for example Bertola and Curi, 1993). The essential original works containing the kernel of observations which suggested the introduction of the Principle, are the scientific articles of Dicke (1961), Carter (1974), Carr and Rees (1979), and the huge amount of data offered by the previously cited book of Barrow and Tipler (1986).

The reflections start off by noting the importance and the delicacy of the values of the four natural constants that regulate the intensity of the interaction of the four fundamental forces, respectively $?_g$ (gravitational), $?$ (electromagnetic), $?_w$ (electro-weak nuclear), and $?_s$ (strong nuclear), demonstrating how the structure of each body —elementary particles, biological molecules, the different sizes of living beings, up until the planets, stars and galaxies— has a dimensional structure (size and mass) that sensitively depends upon these constants. In particular, the mass M or the dimension R of any physical

body can be expressed as a function of a typical mass and radius multiplied by the four natural constants to the power of a certain exponent. It allows that each natural structure lies within the diagram *log R – log M*, inside a strict, well defined band. Such a result does not shed any light on the particular "anthropic" conditions, but simply indicates the importance that the four natural constants have regarding the structuring of the cosmos. It can be observed that these four constants are adimensional, that is, they do not depend upon any particular system of measurement we choose, being pure numbers. The value of the ratio between two of these constants expresses the ratio of the intensities between the two corresponding forces, regulating the way in which, varying the distance between two bodies, one prevails with respect to the other (remember that they can act in a competitive fashion, as happens for example, with the positive protons in an atomic nucleus: the electromagnetic force tends to drive back the protons because they are charges of the same sign, while strong nuclear force, on a very short scale, tends to attract the protons). The mathematical formulas that express the value of the four constants of nature depend upon other mathematical (such as ?) or physical (non-adimensional) constants, like the mass of the proton *mp*, the charge on the electron *e*, the universal constant of gravitation *G*, Planck's constant *h*, and the velocity of light in the vacuum *c*.

The values of the natural constants are in a certain way "congenital" to the coming into being of the universe. We ignore which kind of physics is apt to describe the universe prior to Planck's era, when its dimensions were smaller than 10^{-33} cm, and the time from the beginning of its expansion was less than 10^{-43} sec. What we know is that when the fundamental forces separated by means of progressive "breaks of symmetry", their corresponding constants remained "fixed." This happened within the first 10^{-6} sec, that is, the epoch starting from which the first components of matter (quarks and anti-quarks) and of radiation (photons) quickly gave origin, well inside the first second of the "life" of the universe, to the elementary particles that are known today.

Such constants (we could also reasonably add the adimensional ratio of the proton/electron mass) are associated with a number of important and delicate conditions that will determine the "possibility" that, along the course of cosmic evolution, the universe takes one way instead of another. Not all the ways can bring about the physical-chemical conditions necessary for life, but only those corresponding to some specific and very limited "numerical windows." Among all these conditions, I will summarize here those which seem to be the most important.

After about 1 sec of time from the beginning of the expansion (*Big Bang*), neutrinos decoupled from the rest of matter, thus "freezing" the ratio between the number of protons and the neutrons that until that moment were subject to continuing transformation *p* <—> *n*. Such a frozen ratio depends very sensitively upon the modality of the expansion (that is, upon $?_g$) and on the intensity of the weak interaction, that regulated the decay of the neutron (that is, upon $?_w$). The formation of "cosmological" helium (that is, helium originated during the *Big Bang*, not in stars) strongly depends upon the relationship between the total number of protons and neutrons and, therefore, upon the value of the ratio $?_g/?_w$. If this ratio had been slightly more, all the hydrogen (protons) would be transformed into nuclei of helium, with easily imaginable consequences, among them the impossibility to have water, which is composed of hydrogen. If it had been slightly less, we would not have any cosmological helium, causing strong negative repercussions for the subsequent thermodynamic evolution of the stars; in fact, without any percentage of cosmological helium, the evolving times of stars would be extremely rapid, in a way that their lifetime becomes incompatible with the time requested for the development of life on the planets. The value of $?_g$ also regulated the initial rate of expansion of the universe: if its value had been just a little bit higher than the actual value, it would have implicated the collapse of the whole universe on itself, more or less immediately, therefore preventing any further "development of the facts;" on the other hand, a value just

a little bit lower, would have prevented the subsequent formation of any gravitational aggregation of matter, thereby inhibiting the formation of galaxies and stars and, *a fortiori*, of planets.

Also the ratio $?_s/?$ is rather critical for the development of a chemistry adequate for life. The strong nuclear force, driven by $?_s$, and the electromagnetic force, driven by $?$, act in opposite directions (respectively attracting and repelling) in the atomic nuclei composed of protons. This equilibrium, with the prevailing strong nuclear force in interactions at a very short range, makes possible the existence and stability of atomic nuclei, and allows for the formation of a "periodic table" of chemical elements, such as we observe today. If $?$ had been just a little bit larger, or $?_s$ a little bit smaller, even the lightest nuclei would not have been stable. The role played by this critical ratio also reflects on the sensitivity of the value of the elementary electrical charge *e*.

In the formation of the proto-stellar masses from the interstellar gas clouds, in order for them to become true stars irradiating energy by thermonuclear fusion, it is necessary for the gravitational collapse which will lead to the birth of a new star to be interrupted by the burst of nuclear reactions. This can happen only thanks to the favorable relationship between the value of $?_g$ and the other physical constants involved in the phenomenon of the gravitational collapse. Surprisingly, it happens that the temperature, which constantly increases during the phase of contraction, reaches the threshold necessary for the nuclear reactions just before a collapse, which would drive the proto-star towards an irreversible equilibrium of degenerate gas, as happens in the final evolutionary states of white dwarfs or of neutron stars (around which no planets can support life). If such a threshold of temperature were not reached in time, the universe would be populated by an extremely large number of "failed" stars, but not a single energetically active star.

Another delicate condition regards the relationships among the constants of gravitational interaction $?_g$, of electromagnetic interaction $?$, and the ratio between the proton and the electron mass. The adimensional values of these three constants make them such that the phases of stellar formation allow the proto-stars to give origin, within the Temperature – Luminosity diagram (the so-called Hertzsprung-Russell diagram), to an ordered sequence of dwarf stars called "main sequence". The stars slowly depart from this main sequence, as their energetic and thermonuclear evolution proceeds. Those same constants also cause the main sequence to be formed by some stars having radiative equilibrium (in which the thermal energy is transported by radiation from the nucleus towards the external layers), and by other stars having convective equilibrium (where such a transport takes place, instead, by convection). The first ones, hot and energetic, evolve more rapidly and supply the interstellar medium with heavy chemical elements (including carbon, nitrogen and oxygen) synthesized in their nuclei; the second ones, are less bright and have a longer life, assuring the possibility that planets, eventually formed around them, have lifetimes long enough to allow life to develop and evolve. Life cannot appear on planets orbiting around radiative stars because their surfaces are too hot and bright; however, without these stars, life could not originate elsewhere, since the interstellar medium would not be supplied with chemical elements adequate for life. In fact, in order for the biological molecules upon which life is based to originate, the interstellar space had to be enriched with heavy chemical elements produced in the nuclei of stars. In order to render such elements available in the interstellar medium so that new stars and planets might form from such chemically-enriched gas clouds, it is necessary to have an efficient machinery to eject chemical elements from the stars into the interstellar space. This machinery is provided if, in the final phases of stellar evolution, the outer star layers become unstable and are expelled into space, without collapsing in on themselves. In other words, we need a significant number of stars in each galaxy to die as *supernovae*, and not as white dwarfs or neutron stars. For that to happen, again, new delicate numerical constraints

must be imposed on the values of $?_g$ and $?_w$. It is in fact required that the many neutrinos produced in the phase immediately preceding gravitational collapse caused by the star's instability, can interact with the gaseous layers of the star, pushing them violently towards outer space, an event that occurs only if the rate of interaction and the rate of collapse, governed by the two constants above, are constructively compatible with each other.

We could append other additional observations to the various "conditions for life" summarized above, in which the numerical constraints can be expressed in terms of rigorous mathematical equations. Though not directly linked to the values of the constants of nature, they also point out how "critical" many circumstances are in order to allow the formation of a chemistry adequate for life. One of them is the delicacy of the nuclear reactions which form carbon, through beryllium and helium ($Be^8 + He^4 \text{—>} C^{12}$), and oxygen, through the capture of new helium nuclei ($C^{12} + He^4 \text{—>} O^{16}$). In the first case, the existence of an opportune energy level of the excited carbon (7,65 Mev) close to the sum of the energy levels of beryllium and helium (7,37 Mev), turns out to be unexpectedly propitious for carbon synthesis, since the beryllium-helium reaction has a very small cross section. In the second case, if the energy level of the oxygen (7,12 Mev) were not a slightly lower than the sum of the energy levels of the two nuclei that produce it (7,16 Mev), almost all the carbon would be completely burnt to produce oxygen, preventing the development of carbon-based life. Luckily for us, the beryllium, less important for life, is lost, and a good quantity of carbon, without which all of biology would not be possible, is conserved. The formation of crystals and the stability of macromolecules are, moreover, also linked to the critical values of the ratio between the proton and electron masses and of the electrical charge *e*. Finally, it must not be forgotten that water, so important for life, can be abundantly present at the liquid phase because the average temperature of the biosphere on the Earth's surface actually falls within the tight interval between its freezing and boiling points (0-100 °C). The inventory of the delicate physical and chemical conditions considered "anthropic" could be even larger: Barrow and Tipler (1986) and Demaret and Lambert (1994) recorded various dozens of them.

To sum up what we have rapidly sketched, these results indicate that a light variation of the numerical values of the constants of nature would have (hypothetically) given origin to a universe with a structure, distribution of the chemical-physical morphologies, and laws of nature, all dramatically different from the current ones. This would have also interrupted the critical sequence of phenomena that, starting from the initial *Big Bang,* led to the existence of a physics (planets around stars with a convective equilibrium) and a chemistry (elements and molecules of biological interest) necessary for life. Such a sequence of phenomena appears moreover to depend, in an equally critical manner, upon numerous other conditions having a more structural, rather than evolutionary character, that involves the properties of elementary particles, atomic energy levels, chemical bonds and the major physical constants. Finally, a remarkable result is that the numerical values of the constants of the four fundamental interactions are all already fixed within a time of about 10-6sec from the horizon of the *Big Bang*; that is, at the time in which the electromagnetic force differentiates itself from the three remaining forces, and the properties of the protons and of the neutrons remain established once for all. The "ensemble" of the above considerations is often summarized, and efficaciously expressed, by saying that the essential characteristics of our universe appear *finely tuned*, that is accurately "regulated," for the appearance of life.

III. The Interpretation of Scientific Data and the Most Significant Philosophical Key-Points

1. The Distinction between WAP and SAP. A first reflection prompted by the data is the need to clarify

the distinction between the weak (WAP) and the strong (SAP) versions of the Anthropic Principle. Various authors have rightly pointed out that the WAP appears to be a scientifically founded, but philosophically inconsequential, Principle (they emphasize the tautological character of the Principle, or simply the fact that it formulates a *status de facto*), while the SAP seems to be a scientifically groundless Principle with very strong philosophical content. This distinction looks particularly useful both on the level of analysis of science and on the level of logical inference, although it is understandable that, on more general contexts of reflection, some authors consider the weak and the strong formulations to have a certain continuity. That the distinction between WAP and SAP must be maintained, at least along its general lines, is also suggested by the acknowledgement that in strictly scientific terms the weak formulation of the Principle asserts that the conditions and the observed coincidences are *conditions that are necessary but not sufficient* for the appearance of life, while the strong formulation states that we deal with *conditions that are both necessary and sufficient*. This last implication cannot be founded on the scientific level (scientific weakness of the strong formulation) simply because we do not know *all* the conditions and processes that, starting from the existence of a physics and a chemistry adequately tuned for hosting life in the universe (necessary conditions), might lead us to always and necessarily conclude that life effectively makes its appearance (sufficient conditions). In other words, the discovery of those delicate conditions, or the discovery of some physical-mathematical rule which justifies their existence, is not equivalent to offering the reason why life exists or an explanation of what life is.

A second reflection is that a use of the WAP could not be associated, in reality, to the adjective "anthropic," since the physical-chemical conditions it refers to do not involve humankind any more than they do a daisy or an amoeba: they deal with conditions necessary for an organic, carbon-based chemistry, and an adequate biology. A universe possessing the anthropic conditions indicated by the WAP, but without intelligent life, would be fully conceivable, with the only difference that it would not have an observer. On the contrary, the SAP presents itself with an undoubted philosophical charge, linking in a bi-univocal way the existence of the universe to that of humankind (as an intelligent observer). The universe must exist with precisely the characteristics that allow it to have intelligent observers somewhere. In other words, *if* the universe exists, *then* humankind exists (the reverse proposition, of an idealistic type, is after all obvious). In the SAP formulation the finalistic dimension could not be explicit, while its determinist dimension certainly is.

It would be worthwhile to clarify for a moment the emphasis placed by Carter, in his original proposal for a SAP, on humankind *as an observer*: "The Universe, and hence the fundamental parameters on which it depends, must be such as to admit the creation of observers within it at some stage. To paraphrase Descartes, 'cogito ergo mundus talis est'." (Carter, 1974, p. 294). At this level, when the emphasis is placed on the *observer*, the SAP puts itself into continuity with the WAP: after all it takes its predicting value (and therefore its scientific value) from it, treating the presence of the observer as one of the observed data with which the structure of the cosmos must be consistent. The presence of an observer is, in fact, implicitly assumed also in the formulation of a simple WAP; and it could not be otherwise for any scientific observation. Things change if the SAP is philosophically read as having strong implications on the fact that the universe must be such as to *necessarily* have the presence of human beings.

To arrive at such a conclusion starting from only scientific data, does not seem compulsory. By itself, the scientific method is incapable of giving an account for and justifing all the sufficient conditions for the appearance of humankind; this would mean to have the power to define and determine, in an exhaustive way, the ultimate reasons for all of human phenomenology (including knowledge and self-reflection). In doing so, science would implicitly endorse a highly reductive anthropological vision: understanding the human being would be the same as knowing the reasons for its *soma*, i.e. its material body, while ignoring the transcendence or emergence of the human *psyche* from matter. I am afraid that, once understood in

this way, the Strong Anthropic Principle is nothing but a monistic (materialistic) solution of the mind-body relationship [9] formulated in the frame of cosmic evolution. We deal here with an omni-comprehensive vision of reality, a vision claimed with absolute and universal necessity (and therefore on a metaphysical level), but directly extrapolated from reflections made with a relative, non absolute, necessity (on the level of physical sciences). Such interpretation was probably not Carter's original understanding, but has ended up to imposing itself as a dominant idea in the debate that followed his original claims, especially through the influx brought about by the reflections reported in the concluding chapter of Barrow and Tipler' (1986, cf. ch. 10).

2. Objections to the Anthropic Principle and their Philosophical Value. Objections regarding the true significance of the Principle have been raised from both scientific and philosophical positions, and possible "solutions" of the Principle have been proposed accordingly. In the following discussion, I will refer to the "core" of the Principle, that is, to the coincidences and to the delicate conditions (*fine tuning*) pointed out by the scientific observations, abstracting for the moment from their diverse possible usage (weak or strong). I am commenting on three main critiques: a) the supposed tautological value of the Principle; b) the existence of a general law of nature from which we can deduce the existence of the various anthropic coincidences (or biotic, if you prefer); and finally c) the resort to cosmological models, including quantum cosmology models, that predict a multiplicity of many or infinite universes (*many worlds models*), in order to deprive *our* universe of significance. These three "solutions" are very often presented as arguments which rule out any "finalistic" usage of the Principle (see finalism [10]), a use that —as we have seen— does not necessarily follow (at least in a scientific position) from the simple presentation of the data, but is implicitly (and perhaps unconsciously) associated with the Anthropic Principle in many interdisciplinary debates.

Objection "a" regards the obviousness and triviality of the Principle, something that could not be otherwise: that which exists, does so only because it can exist. In other words, it would not make sense, for an apple on the branch of a tree, to ask why the tree on which it has originated possesses those physical and biochemical laws that make the apple-tree to be as it is. It is clear that *only those laws* allow the apple, if it had a voice, to raise such an "question." I believe that this objection, though correct, does not remove *all* of the Principle's significance. As pointed out since the time of Wittgenstein, every logical or mathematical affirmation is, on its own, tautological in character, insofar as we accept a number of axioms and non-demonstrable propositions that make possible the beginning of the reasoning process. But in a certain sense it is no longer so when a logical sentence helps to better understand (with cognitive progress) the implications and the relations existing among the various elements of the whole, though it adds no new knowledge to the individual elements themselves (cf. Zycinski, 2001). The conditions and the coincidences represented by the *fine tuning* have a mathematical nature (and therefore they are tautological in part), but they also point to observable physical facts (to the world of facts, to employ a Wittgensteinean vocabulary). The many relations that the fine tuning expresses add a new knowledge to physics and to the properties of the cosmos, just as a tautological relation of identity *?* = *?*' allows new meanings and results to emerge when we deepen the empirical contents of *?* (the whole of the anthropic conditions) and of *?*' (the presence of the observer). To think that the existence of these conditions does not call for any "explanations" and must be taken as "mere facts," without ever asking for a successive deepening in understanding, would be equivalent, for example, to deny any significance to the affirmation "the sky at night is dark," considering it an obvious statement; today, we know instead that the nocturnal dark is not due to the absence of the sun, but to the expansion of the universe, in particular to the *redshift* associated with such expansion, that makes the light of all the stars in the sky weaker and not constructively integrated. Were it so, the nocturnal sky would have a lot more brightness than the sky illuminated by the sun (Olber's paradox). The motive of an observation that in the past was considered obvious, was in reality the action of a physical law that, once known, has increased the comprehension of

a phenomenon previously accepted as something simply given. The fresh knowledge we have now acquired thanks to the "anthropic coincidences," is that the universe is much more "one" and coherent in itself than previously expected.

The second critique "b" of the significance of the *fine tuning* claims that what appears today to be a coincidence or a set of exceptional conditions, may later turn out to be the necessary outcome of a much more general physical law. Presently, such a law is still unknown in all its consistency, but the various anthropic conditions would follow from it as its physical consequence or one of its logical-numerical corollaries. In a sense, this would lead the weak Anthropic Principle to be "absorbed" by the strong formulation, which could now be expressed by saying that "the universe must have only the characteristics that bring about the presence of humankind, because there is a 'general physical law' that actually implies this." This looks legitimate, because part of the work of science is to understand local properties and particular formulations in light of more global and general interpretations. But when such a process of generalization arrives at its extreme limits, i.e. when it tries to understand the reason for all the properties and characteristics of the whole of reality, then physical cosmology once more faces to the "problem of the whole," a problem that is meta-physical and not scientific in character, a problem that the scientific method cannot formalize in a complete and exhaustive way. The situation is analogous to what happens when science tries to tackle the "problem of origins": when cosmology attempts to give an account of the "ultimate why" —in the present case, the ultimate cause of all reality— it abandons the experimental method in order to switch to conclusions that imply a major level of abstraction, proper to philosophy and metaphysics. In a few words, it is very possible that many of the anthropic conditions are necessary effects of broader and more general laws, but if we wish to formulate an "omni-comprehensive cosmic super-law," that is, a final and all-encompassing explanation for the whole of existence, this no longer belongs, *ipso facto*, to the domain of the natural sciences.

The third suggestion "c" invoked to "solve" the Anthropic Principle concerns the formulation of cosmological models that make use multiple universes. Some of the solutions that describe the state of the universe when passing from Planck's era to its following transitions, foresee the production of an extraordinarily large number of independent regions of space-time during a rapid phase of inflation. Each of these regions would give origin to a universe with an actual *set* of values for the constants of nature, but only that universe (or those universes) with the "right" values would allow the development of life and eventually the presence of intelligent observers. Instead of "parallel" histories, a many-worlds model could even allow for many universes, chronologically successive one after another, having a new *Big Bang* every time the preceding universe has concluded its history by collapsing into a *Big Crunch*. This theoretical option corresponds to one of the possible solutions for the standard Big Bang cosmological models, and it is known as the "cyclical universe" model. Today, such solutions do not receive particular interest, both because the observations seem to indicate that our universe is open (and therefore does not identify itself with one cycle among many), and because the number of possible "cycles" has an upper limit, and therefore such phenomenology cannot be reiterated to infinity or to whatever number one wishes. The multiple universe solution works in the sense of removing significance from the anthropic coincidences, not because life has occurred by chance in our universe, but because our universe would be, by chance, one among many. A similar solution is possible in the domain of quantum mechanics [6]. Once the whole universe is understood as a quantum object, according to what its very early stage might suggest, it could be interpreted as super-positions of a multiplicity of quantum states, of which one only would be "actualized" by the observation of an intelligent observer. Although from the mathematical point of view the solution of many (space-time or quantum) universes is formally correct, it presents two problems: the first is, once again, the problem of the whole; the second is the artifice of responding with a non-verifiable solution (or non-falsifiable, if you prefer) to a verified physical question. In both cases we deal with solutions taken from the philosophical realm, and no longer from the experimental-scientific

field. Moreover, many authors have pointed out that the solution which appeals to the *many-worlds model* seems to violate "Ockham's razor," as it would multiply the entities not strictly necessary to resolve a question that could have simpler philosophical solutions.

It is not difficult to realize that the three main objections to the Anthropic Principle (except, perhaps, the first) are obliged to appeal to some *a priori* philosophical arguments, which operate on a level of understanding and abstraction exceeding the domain of experimental data, that is, the domain from which the Principle (at least as a question) takes its origin. A kind of proof of the *philosophical* character of the alleged solutions, comes from the pioneering article by Carter (1974), when he asserts that "*If* it were to turn out that strict limits could always be obtained in this way, while attempts to derive them from more fundamental mathematical structures failed, this would be able to be construed as evidence that the world ensemble philosophy should be taken seriously —even if one did not like it." (Carter, 1974, p. 298). It is not surprising, then, that solutions other than Carter's to the problem raised by the Anthropic Principle are almost always addressed on a philosophical, and no longer experimental level, for instance, that reported by John Leslie: "The fine tuning is evidence, genuine evidence, of the following fact: that God is real, and/or there are many and varied universes." (Leslie, 1989, p. 198).

Again, it is a philosophical perspective which presents the SAP as an expression of the evolutionary process caused by one general law, immanent within the cosmos, whose final consequence would be to generate intelligent life so that the universe "would finally become conscious of itself." Instead, one could object that what intelligent life reflects upon, as a personal subject flourishing in the universe, is much more profound than the simple "giving a voice" to cosmic evolution. As it has been rightly observed by Muratore, "the fundamental recognition that must be assigned to the human mind, is not that of a cosmos which demonstrates its intelligibility to itself, but rather the recognition of a contingent personal intelligence existing within a contingent universe. The condition of possibility of such recognition is that human beings open up a horizon of absolute transcendence which results in the recognition of their status as created beings, as well as that of the whole physical universe. It is nothing but to refer this contingent existence to a primary reality that is truly 'other,' a reality which provides all absolute foundation." (Muratore, 1993, pp. 159-160). Opposite this perspective there is the idealist position, that of conceiving a completely self-referential universe.

3. The True Scientific Significance of the Anthropic Principle. It would nevertheless be erroneous to believe that the difficulty in separating the scientific data from their philosophical interpretations would deprive the suggestions brought about from the Anthropic Principle of any scientific value. I suppose that such value could better emerge by abandoning the label "principle," limiting ourselves to simply offer the set of the physical-chemical conditions originally at the basis of the "weak" formulation. To call the WAP a "principle" appears ambiguous, and it precludes the reception of the scientific results involved therein. In reality, the WAP points to a series of facts, which do not depend upon the assumption of a particular philosophical perspective, just as the charge of the electron or of the mass of the proton do not. Instead of being classified under the form of an "Anthropic Principle," that specific set of observations could be more correctly presented as a number of "biotic conditions." The WAP is extraneous both to a deterministic bond with life (in fact it deals with necessary rather than sufficient conditions; cf. above, n. 1) and to any allusion to intelligent observers. Once they are presented in this way, such biotic conditions are evidence for a significant, non-tautological knowledge with regard to the universe and its cosmic evolution. I shall now try to recapitulate what are, in my opinion, the three most relevant contents of such knowledge.

Firstly, the evolution of the universe strongly manifests a character of unity and coherence. The four fundamental laws of interaction and their adimensional constants determine the physics of the universe

and its evolution in time, much more than all the individual events that accompany its development after the *Big Bang*. The universe is certainly not a deterministic machine, as it was believed in the 18th and 19th centuries. Contemporary physics has widely acquainted us with the mathematical unpredictability of a good part of its phenomena and the strong limits of methodological reductionism [11], especially with respect to the approach to complex phenomena in the field of chemistry, and above all in biology. On the other hand, the universe [8] presents itself neither as a whole of disconnected parts, extraneous to a unifying rationality, nor as remnants of a reality whose capacity for emergence and autopoiesis is the result of chance interactions that fortuitously drive its history. The scientific data at the basis of the "biotic conditions" (as derived from the Weak Anthropic Principle) show instead that the essential characteristics of the physics of the universe are conceptually determined, and that the creativity that accompanies the morphological novelties of complexity, even remaining open and mathematically unpredictable, turns out to be implicitly conditioned by a number of basic and grounded properties that are never contradicted. These fundamental properties originate within the primeval phenomenology that involved the formation of the space-time continuum, the radiation field, and finally matter, in its adronic and leptonic components.

Secondly, biology and human life strongly depend upon the whole history of the universe (I here employ the word "history" by analogy with the free human realm, in a somewhat inappropriate sense). In this history nothing seems to be superfluous. The very long times that separate us from the *Big Bang*, without which the stars would not have had the possibility to synthesize, and then release into space, the chemical elements indispensable for building organic molecules, have been necessary in order for us to be "here" and "now." In consequence, the dimensions of the universe and the enormous quantity of matter that it contains also appear to be in certain ways indispensable for the presence of life, even in the case that this would spring up only on the planet Earth. The radius of the universe is in fact proportional to the time of expansion, and all the quantity of matter that it contains depends upon the delicate equilibriums of the constants of nature (it could have contained much more, were not most of it transformed into radiation in the initial cosmological phases). Therefore, there is nothing superfluous in the cosmos; there exists only that which is strictly necessary for hosting life.

Thirdly, the conditions (necessary but not sufficient) that render life possible present themselves as "original or primeval conditions." In order for life to appear, the influence that a certain number of more or less casual events have had in the formation, for example, of our terrestrial *habitat*, has been less than the influence of the initial conditions associated with the *Big Bang*, when the values of the constants of nature and of the other fundamental physical constants were fixed once for all. What I want to emphasize is not the necessity of a particular *choice* of those values —that would unnecessarily change the level of the argumentation from efficient causality, proper to the analysis of science, to that of a finalistic intentionality— but rather their *original and non-evolutionary* character. This result is enough, on its own, to frame the issue of the origin of life and of the appearance of intelligent life in a way very different from the picture commonly assumed in many scientific circles, especially in scientific popularization, up to our days. Regarding a comparison with biological evolution, the "biotic conditions" suggest that the paradigm of natural selection and the capacity for adaptation to the environment cannot be the only criteria to have operated in the long chain of events that accompanied the evolution of life.

These are the observations that seem to stand out, independent from any particular philosophical or hermeneutic paradigm. Beginning with the original intuitions suggested by the Anthropic Principle, the natural sciences submit these observations as matter of reflection not only to philosophy, but also to religion.

IV. The Anthropic Principle between Science and Religion: is there any *Design* in the Cosmos?

After the date of publication of Barrow and Tipler's book *The Anthropic Cosmological Principle* (1986), there has been a notable increase in interdisciplinary literature on this topic. Also Catholic theology has registered a moderate but significant interest (cf. Muratore, 1992 and 1993). In the decade of the 1990, nearly all the books of scientific popularization which tackled the themes of the origin and evolution of the universe devoted at least one specific chapter to the Anthropic Principle. Implicit references to the Principle are also present in the recent debate regarding the so-called "Argument from design", or other holistic approaches to nature [12], that a few biologists seem today to prefer to better understand the morphogenesis of living beings. A possible correlation between some suggestions coming from the Anthropic Principle and the philosophical thought of Teilhard de Chardin also contributes today to keep this theme alive among scholars interested in the science-religion relationship. Because of the cosmological and biological contexts of the data that have brought about the formulation of the Principle, as well as the explanatory power it seems to possess, it is comprehensible that not a few authors have put the Anthropic Principle at the center of a debate in favor of or against the existence of purpose in nature. The question about purpose easily shifts towards a question about the existence of an intelligent cause, and therefore of a Creator.

1. Anthropic Principle and the "Argument from Design." The idea to recognize the presence of an intelligent design in nature as a proof for the existence of a Creator, has accompanied human thought for many centuries. This theme has known a complex historical path, due to the diversity of the epistemological context —scientific or philosophical— where it has been proposed, and because of the wide meanings that the term "design" (or other terms related to it), may assume or imply, including teleology, finalism [10], rationality, intelligence, etc. In this article I face only some of the aspects that are linked to the theme of purpose in nature: the reader can find more information in other entries of this Encyclopedia, such as God [4] and Universe [8], or in works that provide a thorough historical perspective of the theme (cf. Ward, 1961; Hulburtt, 1965; Craig, 1990; Barrow and Tipler, 1986, ch. 2; Harris, 1991, ch. 12).

Traditionally developed in philosophical contexts, as for example in the well-known "fifth way" of Thomas Aquinas that uses metaphysical arguments to ascend to God starting from the recognition of finalism in nature, the "argument from design" has been first linked to "scientific" observations in the English Anglican apologetics of the 17th and 18th centuries. This movement coined the expression "physical-theological proof for the existence of God [13]," employed for instance by William Derham in his *Boyle's Lectures* of 1711. This cultural and philosophical movement had a certain development above all in the field of biology, where the physico-theologians pointed out the remarkable organization among the functions and processes of living beings, and the unusual singular harmony existing between living beings (human beings included), and the *habitat* in which they live. In the domain of the natural sciences, the break will arrive with Darwin, who proposed a way, until then unknown, to achieve the observed concord between living beings and their *habitat* by resorting to a fight for survival and natural selection (progressive adaptation to the environment had been suggested earlier by Jean-Baptiste Lamarck). In the philosophical domain, the idea of recognizing a purpose in nature underwent a deep criticism in the Modern Age, first with David Hume, and immediately after, in a more severe way, by the thought of Immanuel Kant.

The double realm, philosophical and scientific, where the argument from design is debated, requires some clarification. An exclusively scientific foundation of the argument may be removed resorting to scientific reasoning. For instance, one may explain the coordination and the apparent purpose by means of the action of some observed efficient causes (efficient and not final causality, being the proper object of

science). On the other hand, the validity of a philosophical foundation of the argument cannot be removed by new scientific results, because the first depends upon the correctness of the inference properly developed within a philosophical context. In other words, an argumentation developed at the level of efficient causality cannot remove philosophical inferences made at the level of ontological or final causality. For such reasons, a demonstration utilizing only scientific data for or against the presence of Design in nature can never be apodictic, simply because science cannot have a complete comprehension "of the whole," nor can it give reasons for the existence of any "personal intention" acting above the level of observational data. Although "finalistic" principles exist in science and operate in mathematics, in physics or in biology, as they have a certain predicting value and favor the understanding of some particular phenomenology, they are nothing more than a kind of "finalistic strategy." For this reason, the Anthropic Principle, or the "biotic conditions" associated with it, only indicate the coherence, the co-ordination and the interrelations existing in the structure and in the evolution of the cosmos: one cannot employ the Principle, in a straight way and without any further reflections, as the proof of intelligent Design, nor can it demonstrate the existence of a necessary and absolute intentionality which drives the universe towards the appearance of life and human beings. It is not without interest that researchers such as Michael Behe and William Dembski, support the legitimacy of approaching the world of the living beings under the perspective of an *Intelligent design*, but without necessarily endorsing any kind of natural theology, since design is affirmed only as a cognitive strategy (cf. Dembski, 1998, 1999; Behe et al., 2000).

Another clarification regards the semantic width and the non-univocal meaning of the term *design.* Within the notion of "design" are contained at least three different (though interconnected) ideas: i) the existence of regularities or patterns that are thought to be non-casual; ii) the presence of a teleology understood as mere functional or organismic finalism; and, finally, iii) the idea of finalism in the strong sense, as something which refers to the presence of intentionality and intelligence (cf. Harris, 1991, pp. 162-163). In public debates it is easy for a criticism addressed to only one of those levels, to often end up by rejecting and disapproving the other two as well. However, this comes from (and generates) a kind of confusion, since we must remember the general rule of any teleological approach: the removal of a supposed scientific cause, when substituted by other scientific causes, cannot directly imply the removal of an ontological or metaphysical causality.

2. The Peculiarity of the Anthropic Principle among the Various Arguments from Design. The Anthropic Principle seems to possess a kind of "specificity" within the more general problem regarding "Arguments from design." Its peculiarity is the consequence of the cosmological and global context in which the Principle is raised, and deserves to be carefully considered. Different from other forms of order, organization or regularity that we observe in nature, the biotic conditions expressed by the WAP cannot be removed employing a mechanism similar to that by which Darwinism has removed, at least to some extent, the teleological interpretation of the harmony and agreement between the different biological forms and their *habitat*. The *fine tuning* of the constants of nature is not the result of an adaptation to the environment or of natural selection (at least if a unique universe is assumed), because it regards instead "congenital" conditions. The only way to remove the significance of fine tuning is to postulate either a cosmological and omni-comprehensive general law by which those conditions or coincidences may be deduced, or the existence of infinite universes. Both postulates have already been recognized as *a priori* philosophical requests, which cannot be demonstrated on the basis of mere experimental observations (see above, III.2). Moreover, the teleological indications suggested by the Anthropic Principle are unique for another reason as well. They no longer regard a teleology confined to one or more parts of the natural world, as occurred, for instance, in the 18th century argumentation on the functioning of the human eye, in the later discussion about the delicate equilibrium of the terrestrial atmospheric conditions for the sustenance of life or, more recently, when emphasizing the surprising informational complexity of

molecular DNA. For the first time we are faced now with a global and all-encompassing teleological proposal, intended to show the functioning of a finalistic principle from the era of Planck (10-33 sec from the *Big Bang*) up until our days.

In my opinion, it is precisely this specific peculiarity of the Principle that makes it so interesting. The Anthropic Principle, in fact, is able to join together the three components of Design: coherence, teleologism, and reference to a mind. It could not be otherwise, when embarking on the undertaking —impossible for science, yet inevitable for the scientist— to make one concept of everything, from its origins until the present, using the ideal, comprehensive frame that contemporary cosmology is today able to provide. In the origins, "coherence" becomes "project". In so doing, we grasp (and perhaps recover) an important aspect of finality, often forgotten. It is that finality indicates not only the physical or temporal "end" towards which a process tends, but also the coherence of the entire process as a whole. As the ends for an athlete are not only to arrive at the finishing-line, but also to achieve this in the shortest time possible, and the ends for a musical composition are not only to arrive at the last note, but to grasp the whole symphony, so the possible functioning of an Anthropic Principle would remind us that the finality of the cosmos must lay, and be recognizable, within every moment of its existence (cf. Harris, 1991, p. 168).

When the three dimensions of finality are joined together, the whole argumentation moves from the scientific onto the philosophical terrain and the Design flows within the thesis of the SAP. It must be underlined that the argument for Design possibly associated with the SAP does not necessarily possess a theistic value; rather, it simply points to a "mind." We realize this also by reading the many reflections of scientists who take on themselves the onus of traveling along the path of the Anthropic Principle, while being as faithful as possible to the observational data. Freeman Dyson's comment is sufficiently eloquent: "I conclude from the existence of these accidents of physics and astronomy that the universe is an unexpectedly hospitable place for living creatures to make their home in. Being a scientist, trained in the habits of thought and language of the twentieth century rather than the eighteenth, I do not claim that the architecture of the universe proves the existence of God [13]. I claim only that the architecture of the universe is consistent with the hypothesis that mind plays an essential role in its functioning." (Dyson, 1979, p. 251). A further conceptual step would be to judge whether this philosophical position is truly coherent in itself. It is the assertion of those scientists who speak of a mind that is supposed to be the owner of the "project" of the universe, without being recognized as something distinct from the universe itself and, therefore, being immanent to it. Within a metaphysical perspective, as developed in the frame of the philosophy of Being, the affirmation of a necessary mind immanent into a contingent material cosmos would lead to open contradiction, indicating, rather, that a project for the whole of the material cosmos must lie outside, that is, must be transcendent to it. A cosmic mind does not necessarily point to God or to a Christian Logos [14]: however, when opportune clarification is made in order to avoid hidden pantheism [15], and more precise conditions are specified, scientists' reflections upon the reliability of a cosmic mind are consonant with a theistic perspective.

3. Anthropic Principle and the Christian Theology of Creation. For Judaeo-Christian Revelation the whole universe, with all the richness of its phenomenology and forms, expresses a unique project of God. The Christian universe is the intentional effect of a personal Word, intelligible and open to dialogue. It develops through time, not driven by blind chance, but according to a rationality which stems from an original simplicity, that has in God its first and its final causality. Life originated as fruit of His creative will, aimed at developing towards the appearance of intelligent life at its apex. The human person enjoys a special dignity, being created in the image and likeness of God, and having therefore the capacity to recognize the Creator through His works. The greatest dignity of the created world is shown by the Incarnation of the Son of God, because a human, created nature, is taken up by God, in the Word made

flesh.

The relationship between humankind and the created world is summarized in a passage from *Gaudium et spes*: “Through his bodily composition man gathers to himself the elements of the material world; thus they reach their crown through him, and through him raise their voice in free praise of the Creator.” (n. 14). It is easy to note that this theological perspective is certainly in agreement not only with the scientific data that points out the existence of a certain number of biotic conditions, but also with those philosophical formulations that offer a possible finalistic reading of the Anthropic Principle. However, two clarifications are here needed. Theology warns that such a finalism must be able to refer to a source of rationality, to a *Logos*, that does not identify itself with the same universe, but transcends it. That humankind realizes itself to be the voice of all creatures, and these find in the human being the crowning and the awareness of their long evolutionary history, is a sign of human freedom, not the result of blind necessity. At the same time, the agreement between these two perspectives, theological and scientific, does not constitute a “scientific demonstration” of the existence of a personal Creator. We can speak only of a simple *consonance*: the biotic conditions expressed by the Anthropic Principle are *consistent* with what the theology of creation says, but the knowledge brought about by the Principle is not asked to provide any logical-demonstrative proof for the contents of theology. Let us look at the reasons for that.

If the universe has a first transcendental Cause, that determines all the cosmic fundamental characteristics and features, and drives the physical-chemical evolution as a final Cause does, then the analysis of science would reveal just what it observes: a cosmos with steady and intelligible properties; the capability the universe has to be unified by a certain rationality and thus be recognized as the effect of a unique cause; the presence of conditions necessary to host life; times of physical and biological development long enough to allow cosmic evolution, and thus life. Nevertheless, the reverse inference does not stand: that is, the observation of all these delicate conditions, *necessary but not sufficient* for the development of life, does not reveal on its own, and with scientific methods only, the existence of a Creator. What on the philosophical and metaphysical level has the character of an intentional finality, and on the theological level reveals itself as source of meaning and having the character of a gift, on the level of mere empirical analysis can be only seen as physical and mathematical coherence.

Such a necessary distinction does not mean that a scientist cannot use the evidence of this coherence as support for the credibility of his or her faith in God the Creator. It only means that to judge things in this way requires a further philosophical abstraction, above the empirical data, and likely implies the decision to put the presumed evidence for Design in relation with other motives to believe in God, already possessed by the subject. This is why, starting from the same data, there are scientists who arrive only at inferring the existence of a “cosmic mind,” an immanent intelligence with which only mathematics, not the human person, can actually dialogue. Philosophy and theology indicate this total identity between God and the world by the name of pantheism [15].

Thanks to the above-stated distinction between the scientific and philosophical levels, the objections that deny any scientific significance to the data associated with the Anthropic Principle (see above, III.2), do not constitute, on their own, any “scientific” refutation of the existence of a Creator. As I have remarked before, such objections are philosophical, not empirical, and they are not exempt from *a priori* assumptions, more or less declared. In particular, the recourse to a multiplicity of universes, invoked to justify the existence of anthropic conditions for our universe, does not imply that the appearance of humankind must be considered a casual epiphenomenon devoid of any purposive value. This last conclusion cannot be strictly supported by science, since all these universes belong to “unconnected” space-time regions that would not be the object of physics, nor of a consistent statistics grounded upon the experimental method. Neither would the role of a Creator be denied from a philosophical point of

view, since nothing forbids multiple universes, in one of which life has flourished, from all belonging to the same creative project. To support a *many-worlds* model as a unique, possible justification for the biological suitability of our universe, rather manifests the defense of a philosophy that maintains, at any cost, a casual interpretation of life, that is, its non-purposeful appearance. On the other hand, to consider the appearance of life and then humankind as the inevitable result, within a unique universe, of an immanent evolution that denies a transcendent, divine project, is also an *a priori* philosophical conclusion, since there is no scientific evidence that the necessary conditions to host life in the universe are also sufficient conditions for the appearance of intelligent life.

Summing up, I would suggest that the major relevance of the Anthropic Principle in the terrain of dialogue between science and religion resides in the fact that it furnishes the researcher with elements of reflection on the ultimate whys of reality, and on the "mystery of being". Taking the cue from scientific observations, the researcher wonders again about the role of humankind in the cosmos, with a questioning capable of involving him or her at the existential and even religious level. Science is not new to the possibility of provoking "ultimate" questions from inside, that is, from within its research activity, although it perceives its inadequacy to answer these questions exhaustively by means of empirical tools only. The elements of reflection offered by the Anthropic Principle appear, from this point of view, among the most stimulating for the comprehensiveness of the context in which they emerge, which is no longer the context of one or another discipline, but that of physical cosmology, strained by desire to make the whole universe a unique object of intelligibility.

V. Anthropic Principle and Theological Christocentrism

1. Unity and Coherence of the Cosmos under a Christocentric Perspective. A central aspect of the Christian theology of creation is to indicate the Incarnation of the Son of God, more precisely the design of God-Father to recapitulate and reconcile all things in Christ, as the most important principle of coherence and unity of all that is created. Such a headship of the Incarnate Word does not operate because of the Incarnation alone, but as a result of the whole paschal mystery of Jesus Christ, dead and risen. The glory of Christ's resurrection [16] is thus presented by the Sacred Scripture as the completion of the expectation of the whole created world, as the beginning of a new creation. Based on the Christological Pauline hymns (cf. *Eph* 1:3-10; *Col* 1:15-20) and the Johannine doctrine of the mediation of the Word in creation (cf. *Jn* 1:1-4; cf. also *Heb* 1:2-3), theology has expressed in various ways the headship of the risen Christ, re-reading in a new Christological context that anthropological headship which the human being enjoys in the account of creation made by the book of *Genesis*. In that account, the human being stands as the apex of an ascending path, that starting from simpler living forms rises up to the appearance of *Homo sapiens*. The position of Christ in creation reveals and redeems the position of the first Adam within the plan of God. This theological perspective can be found in authors belonging to different historical epochs, from the Fathers of Church up until our time, and is usually indicated by the name of "Christocentrism." We could then ask whether the centrality of life and the special role of intelligent observers, as they are stated by the Anthropic Principle, might contain some points of connection with a theological anthropology finding its completion in Christology. Note that the reverse question, that is, whether a Christocentric theological perspective may shed light on the coherence, rationality, and significance of a created universe, object of study of the natural sciences, is also meaningful. The reader can find suggestions about that in the article of this Encyclopedia Jesus Christ, Incarnation and Doctrine of Logos [14], in Section III.

That Scripture affirms, when speaking of Jesus Christ, that "all things were created through him and for him," and moreover that "He is before all things, and in him all things hold together" (*Col* 1:16-17) had

already brought Duns Scotus (1265 ca.-1308) to suggest that Christ, the Incarnate Word, was the first of the predestined, He was the true end God had in mind while creating the universe (cf. *Reportatio Parisiensis*, Book III, d. 7, q. 4). This medieval Master does not consider that the Incarnation, as the crowning of creation (elevating purpose) and as redemption of humanity (healing purpose), would answer two scopes of the creative will of God. Scotus tried to overcome the *impasse*, proper to its epoch, of having to choose or confront between these "two aims of the Incarnation." He affirms, instead, that the Incarnation of the Word is rather the grounding reason for creation itself, including all its consequences: God would not have wanted Christ for the universe, but rather *the universe for Christ*. The Christocentric perspective of Scotus undoubtedly has the merit of placing the accent back on the relationship between Christ and creation. However, it seems to place the Incarnation "as such" at the center of the divine design, more than the Paschal mystery of the risen Christ, as would have been suggested, for instance, by considering the *Book of Revelation*, which presents the immolated Lamb having the characters of the Alpha and the Omega (cf *Rv* 1:8; 21,6; 22:13), the eternal mediator who works both in the beginning and in the end.

The relation between the mystery of Christ, center and fulfillment of creation, and an Omega point towards which the history of the cosmos would tend, was firstly proposed in the 20th century by Pierre Teilhard de Chardin (1881-1955). The French author reads the biological and cosmological evolution —of matter to life, of life to man, and of man to Christ— as a grandiose ascending process that realizes the definitive headship of Christ over all things: "in place of the undefined point of convergence required as term for this evolution it is the clearly defined personal reality of the incarnate Word that is made manifest to us and established for us as our objective, that Word 'in whom all things subsist.' Life for Man: Man for Christ: Christ for God." (*Hymn to the Universe* [London: Collins, 1965], p. 87). It is not surprising, therefore, that the work of Teilhard is implicitly (and sometimes explicitly) present in numerous presentations of the Anthropic Principle, especially those made by scientists who are believers (cf. Coyne et al., 1987). Probably it has also inspired the reflections of Barrow and Tipler (1986) on the final destiny of the universe (cf. ch. 10), so giving origin to the formulation of a Final Anthropic Principle (FAP). This final formulation of the Principle, however, is hardly convincing, and seems to endorse quite a reductionistic vision of life and humanity: only "information [17]," in their view, will be eternally present in the cosmos. In the following years, Barrow has ceased to proceed along this line of thought, while Tipler has developed it in a way that is even less convincing, philosophically fantastical, and clumsy (cf. Tipler, *The Physics of Immortality*, 1994). In reality, as far as I know, the original thought of Teilhard de Chardin did not contain a reductionist vision of life. Nor does it share the idea of a determinist finalism that would lead the whole cosmos towards the Incarnation, with absolute necessity, up to a point in which the universe assumes divine characteristics in a somewhat pantheistic way: "To confirm the presence, at the summit of the world of what we have called the Omega point, do we not find here the very cross-check we were waiting for?", wrote the French thinker; soon specifying: "to be more exact, 'to confirm the presence, at the summit of the world of something in line with, but still more elevated than the Omega point.' This is in deference to the theological concept of the 'supernatural', according to which the binding contact between God and the world, *hic et nunc* inchoate, attains to a super-intimacy (which is thus outside all logic) of which man can have no inkling and to which he can lay no claim by virtue of his 'nature' alone." (*The Phenomenon of Man* [London: Collins, 1959], p. 298).

The suggestion and grandiosity of the Teilhardian vision of a finalism [10] aimed at reaching Christo-Omega explains the attraction the French thinker has exercised upon many writers, who took from him inspirations later developed also in non-Christian scientific and literary contexts. On the other hand, I think Teilhard seems to have underestimated the mediation that Christ exercised "in the beginning," and he did not offer, also for the not-strictly theological character of his writings, a complete understanding of the relationship of continuity/discontinuity between the first and the new creation. To be

adequately appraised, the consideration of such a relationship would have required, at some level, also the pondering of the mystery of human sin (for an evaluation of Teilhard's thought, cf H. de Lubac, *The Religion of Teilhard de Chardin* [London: Collins, 1967] and *Teilhard Explained* [New York: Paulist Press, 1968]).

2. The Paradox of the Cosmos and the Mystery of the Risen Christ. Beyond the attempts of Duns Scotus and Teilhard de Chardin, what could a Christocentric theological perspective add to the dialogue between science and theology within the terrain of the Anthropic Principle? A theology of creation that would recognize the existence of a "harmony" or a "consonance" between the suggestions brought about by the Anthropic Principle and the dynamic vision of a created world that tends towards the emergence of the human being (see above, IV.3), could read the "meaning" of creation according to a Christocentric, and not merely anthropocentric, perspective. On the other hand, just as the Anthropic Principle could not demonstrate, on the scientific level, that the appearance of the human being fulfils an immanent and unavoidable cosmic law, so it could not demonstrate any necessity for the Incarnation of the Word-Logos. If it is true that God wants the world for Christ, it is no lesser true that this will belongs to the *mystery of the God-Father*; it belongs to a personal intentionality that remains non-accessible to scientific data, or to any philosophical (aprioristic) use of a strong Anthropic Principle. In spite of that, when a Christocentric and not merely anthropocentric perspective is assumed, the "consonance" between theology and science could reveal unsuspected dimensions, hidden in the biblical data. The New Testament affirmation that "all things exist in Christ" and that creation was made "in view of Christ" would show once more the coherence and unity of all material reality, now summarized in the true human nature of the Incarnate Word. Suggestions for Christology might be derived too. They should be prudently evaluated, but had certainly something to gain from the widening of horizons brought about by contemporary cosmology, as pope John Paul II once affirmed: "Does an evolutionary perspective bring any light to bear upon theological anthropology, the meaning of the human person as *imago Dei*, the problem of Christology —and even upon the development of doctrine itself? What, if any, are the eschatological implications of contemporary cosmology, especially in light of the vast future of our universe?" (*Letter to the Director of the Vatican Observatory* [18], June, 1, 1988, OR, October, 26, 1988, p. 7).

Precisely regarding this "future," I believe that theological Christocentrism brings its specific contribution to the new vision of the cosmos produced by the Anthropic Principle. This Principle, in fact, ends up in a paradox: that of a universe that is recognized as "finely tuned" with respect to the parameters necessary for life (WAP), or even declared purposefully oriented to the appearance of intelligent observers (SAP), but a universe in which the "window of opportunity" for the sustenance for life and of human beings remains extraordinarily small. The thermodynamic evolution of the Sun will not permit the terrestrial biosphere to perennially maintain the favorable parameters of temperature, humidity, pressure, etc. that today make survival possible, but will end up by altering, in an irreversible way, the conditions necessary for life, impeding its prolongation. Although it will happen on a time-scale that is rather long when compared to the interval of time corresponding to the origin of the human species (though comparable with that corresponding to the appearance of life on the planet), it is a very short time-span when compared to the whole history of the cosmos, which is still very young, as shown by its overall chemistry. Such a situation provokes the radical question of why, from its very genesis, does the universe contain the keys for an opportunity that would be destined to terminate quite soon? Would something serve this "evolutionary effort," this delicate action of fragile equilibriums, if then life is destined to be extinguished on a time-scale much shorter than that of the future existence of inanimate matter? The possibility that extraterrestrial life [19] has grown on planets around stars different from the Sun would leave the paradox unresolved. The general conditions for the stability of galaxies (stellar evolution at their interior) and of the cosmos in its entirety (cosmological expansion) limits in some way the favorable conditions for life within narrow, well-circumscribed intervals of time.

It is from the mystery of the Risen Christ, and that of his relationship with the whole creation, that such a paradox might receive some light. A universe created through Christ and in view of Christ would imply, by analogy, the same logic of death and resurrection revealed by the Incarnate Word. In a Christocentric universe, life and matter are destined to be transfigured like the body of the risen Christ. Once it is assumed that our created universe has to reproduce the same logic of the paschal mystery, then the existence of a narrow window of opportunity for life, as the adequate conditions for its development last for a very limited time, no longer appears contradictory, even though the whole cosmos is so well-regulated to favor the emergence of life. This is a response that faith, not science, can offer to the paradox, but one that maintains a deep coherence with what theology affirms concerning a creation understood within a Christocentric perspective, enlightening science on what it could not say on its own. At the same time, the existence of this paradox can demonstrate the inconsistency, both on scientific and philosophic levels, of the idea that the strong Anthropic Principle is an expression of an all-encompassing and deterministic super-law, governed by a mind immanent within the same cosmos. In fact, it is precisely in this case that the enormous evolutionary effort made by the cosmos would remain truly contradictory.

The extraordinary import of such questions manifest that the major existential question regarding human life can also be extended to a cosmological level: why is there death [20]? Such a question seems to now assume a new physiognomy, able to engage the universe in its wholeness. Scientific analysis can explain the manner in which death will occur, both on the personal and cosmic level, but is not able to free humankind from the idea that in the event of death and in the apparently unavoidable destiny of life in the cosmos, there is contained a contradiction that can be healed. Perhaps, because of the intimate perception of such uneasiness, the world of science could focus more attention on hearing the words of the Psalmist: “When I see your heavens, the work of your fingers, the moon and the stars that you set in place, what are humans that you are mindful of them, mere mortals that you care for them?” (*Ps* 8:4-5).

Read also: Cosmology [3]
Finalism [10]
Laws of Nature [5]
Universe [8]

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