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Extending Whiteheadean Organic Cosmology to a Comprehensive Science of Nature

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The modern scientific worldview is based on one science only: physics. Correspondingly, modern cosmology is a physical cosmology. Alfred North Whitehead was not satisfied with this and developed successfully a fundamentally different, organic cosmology on new philosophical ground.[1] Considering that Whitehead was one of the most influential, yet least understood of the 20th century's philosophers,[2] it is timely to indicate some arguments as to why was Whitehead was not satisfied with physical cosmology.

Whitehead summarized his argument about the insufficiency of the modern scientific worldview in his late work *Modes of Thought* (1938).[3] As he wrote, according to the general common-sense notion of the universe developed in the "scientific" revolution, which is actually only a "physics" revolution, it became usual to conceive Nature as composed of permanent things, namely bits of matter, moving about in space which otherwise is empty. There can be no doubt that this general notion expresses large, all-pervading truths about the world around us. The only question is as to how *fundamental* these truths may be.[4] As Whitehead's philosophy argues, this modern idea is fundamentally faulty. It is the development of natural science that has gradually discarded every single feature of this

[1] A. N. Whitehead, *Process and Reality* (New York: The Free Press, 1978 [1928]), 103.
[2] H. J. Spencer, H. J. Alfred North Whitehead: The Man And His Work. Book Review, 2017; accessed at https://www.academia.edu/34612509/ALFRED_NORTH_WHITEHEAD_-_THE_MAN_AND_HIS_WORK
[3] A. N. Whitehead, *Modes of Thought* (New York: The Free Press, 1938).
[4] Ibid., 130.

original materialistic notion. Why is it then that in philosophy the worldview of classical physics is still dominant? It is because, as Whitehead points out, the state of modern thought is that after the formation of the doctrine, every single item in this general doctrine was then denied by recent developments of modern science itself, but "the general conclusions from the old doctrine as a whole are tenaciously retained."[5] The modern scientific worldview not only suffered from such profound inconsistencies, but also "omits those aspects of the universe as experienced, and of our modes of experiencing, which jointly lead to the more penetrating ways of understanding."[6] Namely, the scientific worldview tends to ignore other similarly important worldviews which together form culture: the worldviews of religion, ethics, and art.[7]

Nature Fundamentally Consist of Activities

What Whitehead called "process" in his main oeuvre *Process and Reality* had, in some important respects, become reformulated later as "activity."[8] Instead of conceiving Nature as consisting fundamentally of matter and space, for Whitehead's organic cosmology, *Nature fundamentally consist of activities*.[9] In other words, all changes are due to activities of underlying causes, and all activities of Nature arise from a subtle life—the life of Nature. As he formulated it, physical science had reduced Nature to activity, and had discovered abstract mathematical formulae which are illustrated in these activities of Nature. This interpretation of modern physics might seem straightforward. These abstract mathematical formulae are the fundamental equations of physics formulated as differential equations. These differential equations describe differences in the state of matter arising over the course of time. They describe changes of matter in space and time. These changes arise, at the quantum level, by

[5] Ibid., 132.
[6] Ibid., 135.
[7] Whitehead, *Process and Reality*, xii.
[8] Whitehead, *Modes of Thought*, 140, 146-8, 151, 166, 169.
[9] Ibid., 166.

the *activities* of virtual particle pairs generated spontaneously from the quantum vacuum, as quantum electrodynamics teaches us. But the origin of the physical laws generating these virtual particles has remained unexplained. In this way, the explanatory system of modern physics is fundamentally incomplete. This means that the explanatory system of modern science is defective. When searching for the explanations of natural phenomena, it is irrational to stop the exploration at a certain, awkward step. Indeed, nobody will ever be satisfied by the irrational answer "just because," especially in science and philosophy. As Whitehead expressed it, the fundamental question remains: *How do we add content to the notion of bare activity?* This question can only be answered "by fusing life with Nature."[10] (MT 166). "It is the status of life in Nature that is the modern problem of philosophy and of science."[11]

The Problem of Activity

Now let us take into account this argument from another angle. What should we mean by the notion of "activity?" The problem of activity in philosophy is a very profound one. It is the topic of a significant branch of philosophy called "action theory" (Moya 1990).[12] Usually we think that when we act by moving our hands, or by some other bodily movement, we are responsible for what we did. This is not the case according to physicalism, the view dominant in modern philosophy of science. Physicalism tells that there are things about which most people refer to as "actions," that are really nothing but "occurrences"—causal consequences of previous or simultaneous physical conditions. In this sense, all physical changes, including that of quantum electrodynamics, are merely occurrences, as far as they are consequences of previous or simultaneous physical conditions. Now we arrived to the point. As quantum electrodynamics teaches us, all physical interactions, governed by physical laws, arise due to

[10] Ibid.
[11] Ibid., 148.
[12] C. J. Moya, *The Philosophy of Action: An Introduction* (Polity Press: Cambridge: 1990)

virtual particles created from the quantum vacuum and absorbed by material objects. Within the conceptual framework of physics, the creation of such a flux of virtual particles occurs *spontaneously*. The term "spontaneous" carries the meaning "without outer cause." In quantum physics this means: *acausally*. So the production of virtual particles violates the universal Principle of Causality. Moreover, the production of virtual particle pairs violates also the law of energy conservation. This twofold failure of quantum theory may be considered as important indications. There can be no exceptions from a law of Nature that are, according to their concrete formulations, exceptionless.[13] Similarly, there can be no exceptions from a universal principle like the Principle of Causality. This means that, in a strict sense, the generation of virtual particles cannot be regarded as mere physical occurrence as defined above. Something should be present there that physics cannot grasp. This something is more significant because it acts beyond the physical aspect of the quantum vacuum, and the quantum vacuum, that is, the "sea" of virtual particles holds the key to a full understanding of Nature.[14] Moreover, let us take into account that spontaneity is one of the determining characteristics of living organisms.[15] Whitehead's philosophy suggests that even apparently physical phenomena are more fundamentally genuinely organic or biological activities. This problem leads to consider the possibility of a biological origin of physical laws governing the production of virtual particles.

As Whitehead concluded in *Modes of Thought*, the main object of his work is to indicate the need for a systematic cosmology based on the idea of life as the fundamental factor

[13] J. Earman and J. Roberts, J., "Ceteris Paribus, There is No Problem of Provisos," *Synthese* 118 (1999): 439-478.
[14] P. Davies, *Superforce: The Search for a Grand Unified Theory of Nature* (Touchstone, New York, 1984), 104; P. W. Milonni, *The Quantum Vacuum: An Introduction to Quantum Electrodynamics* (Academic Press London, 1994), xiii.
[15] E. Bauer, *Elméleti biológia* (Theoretical Biology) (Akadémiai Kiadó, Budapest: 1967) (in Hungarian; translated by dr. Miklós Müller from Russian: "Theoreticheskaya Biologiya" and from German: "Die Grundprinzipen der rein naturwissenschaftlichen Biologie"; with excerpts in English, main text in Russian, 1982; in Russian, 1935, 1993, 2002).

responsible for all activities in Nature.[16] In the following pages, I aim to present such a systematic cosmology based on the best traditions of physics. Here we show how to extend these traditions to biology and to the science of consciousness.

The Origin of Physical Laws

After almost a century, physics seems to preserve its hegemonic status as allegedly the only science that can be fundamental. This view is based on the implicit assumption that the world consists fundamentally of matter (or matter-like physical entities), which is not a scientific but a *metaphysical* claim that may or may not be true. Let us start from the present situation in which physicists consider the fundamental equations of physics governing all physical activities as brute, inexplicable and irreducible facts. Indeed, as one of the most outstanding physicists, Paul Davies has stated,

> It seems that almost all physicists who work on fundamental problems accept that the laws of physics have some kind of independent reality. With that view, it is possible to argue that the laws of physics are logically prior to the universe they describe. That is, the laws of physics stand at the base of a rational explanatory chain, in the same way that the axioms of Euclid stand at the base of the logical scheme we call geometry."[17] (Davies 2004).

Let me make an important distinction here in order to use an unambiguous terminology. Let me distinguish between *physical equations* that are the ingredients of physics and the *physical laws* that are their referents in Nature. With this terminology, the physical equations are at a deeper level in the chain of physical explanation than the results of calculations which they determine. Correspondingly, the physical laws themselves stand at a deeper level in the causal chain of Nature than physical phenomena. This means that, besides the explanatory chain of physics, I am also speaking about the causal chain of Nature. In these terms, my question here is: what is the origin of physical laws in the causal order of Nature? Should we consider

[16] Whitehead, *Modes of Thought*, 168.
[17] P. Davies, "When Time Began," *New Scientist*, October 9, 2004.

them as brute, irrational, irreducible facts, as it is usual, or is it possible to obtain still deeper insights into the workings of Nature? Is it possible to make a step ahead in exploring the causal chain of Nature and answer this question with the help of modern theoretical physics? According to some opinions, it is possible, and the only factor that may achieve that feat, yielding all the fundamental equations of physics, is *the Principle of Least Action*.

The Principle of Least Action (PLA) and the Origin of Physical Laws

The Principle of Least Action determines the path of a particle, or the way in which a physical process becomes realized, between a given initial point (or state) and its endpoint (or final state). It indicates that the path to be realized will be the one for which a certain mathematically defined quantity called "action" is the least. I can illustrate the meaning of the Principle of Least Action by considering a free-falling stone dropped from a height, or an apple falling from a tree. The stone falls down in a straight line to the ground. If it would behave differently in the same situation, it would use more energy and more time. The end result is equilibrium—the stone on the ground. The principle of least action tells that the path taken by the stone is the one that is characterized by the minimum of action.

I had pointed out that all the fundamental laws of physics can be derived from the PLA, including the Euler-Lagrange equations of mechanics, the Maxwell equations of electrodynamics, the Einstein equations of gravitation, or the Schrödinger equation of quantum physics.[18] *I argue that one can regard the Principle of Least Action as physics in a nutshell.* It

[18] A. Grandpierre, "The Biological Principle of Natural Sciences and the Logos of Life of Natural Philosophy: A Comparison and the Perspectives of Unifying the Science and Philosophy of Life*," Analecta Husserliana*, Vol. 110, Part. II, 2011, 711-727; A Grandpierre, "On the First Principle of Biology and the Foundation of the Universal Science, in *Astronomy and Civilization in the New Enlightenment*, eds. Tymieniecka, A.-T. and Grandpierre, A, Analecta Husserliana, vol 107 (Springer, 2011), 19-36. At present, the only fundamental equation of physics what is not yet derived from the PLA is the fundamental equations of thermodynamics. Yet the Second Law expresses the same equilibration tendency as the PLA itself. It seems that thermodynamical irreversibility only complicates the details of calculations (Sieniutycz 2005). Moreover, „there is no a priori reason" against unifying thermodynamics into the rest of physics on the basis of PLA. There is hope for [coping with some mathematical difficulties and achieving that] the PLA will embrace ALL of physics (Coopersmith 2019). "It [the PLA] underlies ALL physics" (Coopersmith 2019). We note here that Coopersmith interprets the PLA in the approach of physics, while we work here in a wider approach including genuine biological laws, principles, feelings and thoughts. In our approach, it becomes clear that the 'Universe' is not merely the physical universe but also the emotional and

is the fundamental principle of physics, its most powerful tool and its highest achievement. It is the defining principle of physics and physical matter. It is the most important thing to know in physics. Physical matter is what is behaving according to the PLA. This means physics is the science of inanimate, inert matter. Consequently, it does not describe the behavior of 'animate', living organism. Regarding the key importance of the PLA in physics, the question arises: does Nature have other, similarly fundamental principle corresponding to the realm of life?

The Universal Principle of Biology: Bauer's Principle

Carol Cleland,[19] a philosopher of science at Colorado University, has pointed out that the solution to the problem of how to define life requires an adequately general scientific theory of life. Unfortunately, until now most scientists and philosophers have not known about Ervin Bauer's powerful theoretical biology[20] because Stalinism put Bauer's works on index for decades; it is still only available in Russian and Hungarian. To my best knowledge, this is the most promising theory that can serve as the basis for an exact and adequately general scientific theory of life.[21] His work was compared to Einstein's highest aspirations. Today Bauer is often presented in Russian and Hungarian literature as a scientist who was much ahead of his time; he is now regarded as the founder of the general theoretical biology which aims to achieve something like Einstein's great goal, to unify all of physics in one grand equation[22]. Bauer has been the only scientist who has pointed out that the only possibility of giving a scientific answer to the question "does biology have its own laws?" is to search systematically for these laws. He did search these laws systematically and found the universal law of biology, which is named after him: Bauer's Principle.

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intellectual dimensions and their corresponding principles, the Principle of Life and the Principle of Reason. In this wider approach, the Universe is fully active, driven by the Principle of Life, acting below the quantum level.

[19] C. E. Cleland, "Understanding the Nature of Life," in Seckbach, J. (ed) *Life as We Know It* (Springer, Dordrecht, 2006), 597.

[20] Bauer, *Elméleti biológia*.

[21] Grandpierre, A., Chopra, D. and Kafatos, M. 2014, The Universal Principle of Biology: Determinism, Quantum Physics and Spontaneity. NeuroQuantology 12: 364-373.

[22] M. Muller, Ervin Bauer (1890-1938), a Martyr of Science. The Hungarian Quarterly 178, 123-131, 2005.

It is important to recognize that life has two fundamental aspects, the lawful and the autonomous. The lawful aspect of life is given by Ervin Bauer's theoretical biology in the form of Bauer's Principle, which is the universal law of life. According to this principle, "the living and only the living systems are never in equilibrium; they unceasingly invest work on the debit of all their free energy budget against that equilibration which should occur for the given initial conditions of the system on the basis of the physico-chemical laws."[23] The initial state the living organism is characterized by its potential differences and free energies (differences in pressure, concentration, electric fields, etc.). If the living organism would be isothermally isolated, it would lose all these potential differences and free energies due to the equilibration that would inevitably occur as the second law of thermodynamics shows. In contrast to a similar but dead organism, the living organism will act against equilibration and mobilize all its potentials and energies against the deadly equilibrium. *This internally initiated work against equilibration is the characteristic and universal property of living organisms and a crucial feature that distinguishes them from inanimate bodies.*

Remarkably, Bauer was able to derive all the fundamental phenomena of life—metabolism, growth, reproduction, and irritability—and their fundamental equations from his principle. He derived from his principle also the law of increasing potential of living matter as the law of evolution.[24] On that basis, it seems one can regard Bauer's Principle to be *the first principle of biology,* because the term "first principle" means, in our context, the deepest and most comprehensive principles of Nature, mathematically formulated as a variational principle in an integral form, from which all the fundamental laws and phenomena of physics, or biology, or psychology can be derived. Causally, only three first principles are possible, corresponding to the three ultimate causal powers, namely: matter, life and consciousness or reason.

[23] Bauer, *Elméleti biológia*, 51.
[24] Ibid., 184-195.

Built on Bauer's theory, I found that the adequately general scientific theory of life requires taking into account the other basic property of all living organisms, namely, their autonomy. Inspired by a week-long discussion at Chapman University with Henry Stapp, I developed such a theory, and I worked out the scientific theory of biological autonomy.[25]

We can observe that the biological principle must be independent, since physics is conceived as governed by the Principle of Least Action, and Bauer's Principle acts in the opposite direction by urging living organisms to mobilize their energy resources and to initiate actions creating systematic deviations from the Principle of Least Action. I found it important to bring Bauer's Principle into the context of modern physics. Realizing the all-comprehensive significance of the Principle of Least Action in physics I attempted to generalize the PLA in such a way that it can be harnessed by living organisms.

The Fundamental Principle of Biology: The Principle of Greatest Action (PGA)

In biological organisms the final state is determined by the living organisms themselves.[26] Ludwig von Bertalanffy, the Hungarian-born founder of theoretical biology, has suggested "to extend principles like that of least action [into biology]"[27] and to formulate a generalized Principle of Least Action.[28] Action is an ideal tool of choice to describe biological phenomena since it can act between a given initial state and a biologically wanted end state. Living organisms must be able to select the endpoint of the action principle according to the requirements of life, according to their biological aims, and to realize the selected end state—

[25] A. Grandpierre, "Genuine Biological Autonomy: How can the Spooky Finger of Mind Play on the Physical Keyboard of the Brain?" Athens: ATINER'S Conference Paper Series, 2012), No: PHI2012-0197; A. Grandpierre and M. Kafatos, M. "Biological Autonomy," *Philosophy Study* 2/9 (2012): 631-649; A. Grandpierre and M. Kafatos, 2013. "Genuine Biological Autonomy: How can the Spooky Finger of Mind Play on the Physical Keyboard of the Brain?" in *An Anthology of Philosophical Studies*,Vol. 7, P. Hanna (ed.) (Athens Institute for Education and Research, 2013), ch. 9, 83-98.
[26] L. von Bertalanffy, "An Outline of General System Theory," *The British Journal for the Philosophy of Science* (1950): 134-165.
[27] L. von Bertalanffy, *Problems of Life: An Evaluation of Modern Biological Thought* (New York: John Wiley and Sons. Inc., 1952, 201.
[28] L. von Bertalanffy, *General System Theory: Foundations, Development, Applications* (New York: George Braziller Inc., 1969), 101-102.

that is, to act. I found that the only option to take into account the fundamental fact of biology, teleology, in the context of the Principle of Least Action is to generalize it by allowing its endpoint to be variable and selected by the living organism according to biological aims.[29] Such final causation is fully compatible with the mechanistic explanation, and it is the only means to explain biological behavior at the global level of the living organism.[30] Actually, final causation can be realized in the physical realm only with the tool of physical causation. Biological causation consists in mobilizing and organizing the free energies of the living organism in a special way suitable to realize the given biological cause. This means biological causation and physical causation occur simultaneously. It is plausible to assume that normally all the activities of the living organisms are selected in harmony with fundamental biological aims, to live, to live well and to live better[31], throughout their lifespan. In biology, we must admit as basic explanatory tools a special, non-human type of teleology as well as the existence of biologically available energies corresponding to biological aims.

Being alive involves a fundamental urge to maintain life as high as possible, and as long as possible, far above the physically expectable end state. We can define "vitality" as the free energy mobilizable by living organisms for their biologically initiated actions. For living organisms, both vitality and time are crucially important. I generalized the mathematical form of the Principle of Least Action by allowing the endpoint of the integral of action to be variable and selected by the living organism according to its living nature, maximizing both vitality and lifespan.[32] Allowing the endpoint of the action principle to be variable endows living organisms with the ability to initiate their actions autonomously. Such a generalization would provide a

[29] A. Grandpierre, "Biological Extension of the Action Principle: Endpoint Determination beyond the Quantum Level and the Ultimate Physical Roots of Consciousness," *Neuroquantology*, 5 (2007): 346-362.
[30] Grandpierre, A., Chopra, D. and Kafatos, M. 2014, The Universal Principle of Biology: Determinism, Quantum Physics and Spontaneity. NeuroQuantology 12: 364-373.
[31] A. N. Whitehead, 1929/1971, The Function of Reason. Boston: Beacon Press, 8.
[32] Grandpierre, A. "Biological Extension of the Action Principle: Endpoint Determination beyond the Quantum Level and the Ultimate Physical Roots of Consciousness, NeuroQuantology, 5: 346-362, 2007.

way to build biology upon the complete theoretical framework worked out by theoretical physics. The least action principle only needs to be generalized by one step that allows for biologically determined endpoints: *biological teleology*. Selecting biological endpoints is the prerequisite of biological action. This is why biological autonomy is the other fundamental aspect of biology besides the lawful aspect. This generalized principle can be used maximally for biological aims when biological actions are maximizing the capability of living organisms to act as long as possible. The fundamental biological activity is directed towards biological aims realizing maximal vitality on the longest possible timescale. Surprisingly, when the biological cost is free energy and time, the tool measuring biological cost is the same "action" that is minimized in physics by the Principle of Least Action. This means that living organisms' biological activities contribute maximally to regenerate their free energy content and their ability to do work as well as live their life as long as possible. Based on such considerations I obtained *the Principle of Greatest Action* in a mathematical form.[33]

With the term "vitality" Bauer's Principle tells that living organisms continuously work to maintain and regenerate their vitality. Bauer's Principle can be called as the Principle of Maximal Vitality. The difference between the Principle of Greatest Action (PGA) and Bauer's Principle is that in the latter, the amount of mobilizable energy is maximized, while in the PGA, the length of the time intervals in which the mobilizable energy is maximized is also maximized. It is vitally important for living organisms to find the best decisions in all situations and act properly in order to make the largest number of best decisions and actions possible during their finite lifetime. Somewhat simplifying, while Bauer's Principle can be regarded as the Principle of Greatest Vitality, the PGA involves another principle, which acts to find and realize the best decisions corresponding to maximal vitality on the longest timescale and minimize the time necessary to find it. Because making the better decision and making the same decision faster in

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[33] Ibid.

the same situation requires a smarter mind, this second principle involved in the PGA will be named the Principle of Greatest Reason (PGR). The PGA is the decision maker, and the PLA is the executive agent. The Principle of Greatest Vitality is the normative principle supplying the vital energetic direction for decisions. The Principle of Greatest Reason is the normative moral principle corresponding to decisions about what is really important life.

One can regard evolution with its upward trend[34] as corresponding to the evolution of reason or the capability of smart decisions that are the central elements of biological autonomy (Grandpierre 2012a).[35] This biocentric idea of reason fits with Whitehead's argument that the function of Reason is to promote the art of life.[36] Because the PGA involves the optimal combination of Bauer's Principle and the Principle of Greatest Reason, I consider it as being the most general, fundamental or first principle of biology expressible in terms of physics.

I emphasize that the same "action" is maximized in biology – at the biological level of selecting biological aims according to the biological principle - that is minimized in physics, at the physical level in the given spatial and temporal framework. Moreover, this interpretation fits nicely with Maupertuis's interpretation of "action" as being the "unity of the vital force in the Universe."[37] This argument indicates that the "action" in the physical Principle of Least Action is indeed of biological origin.

The Principle of Least Action characterizing the behavior of inanimate objects can be regarded as the special case of the PGA in cases when the capability to act decreases to unmeasurably small values. Remarkably, once the living organism determines its endpoint, its action will be determined most economically, that is, on the basis of the Principle of Least Action. The living organism must decide only as to the most important aspects at the global

[34] A. N. Whitehead, *The Function of Reason* (City: Publisher, 1929/2018), 7; E. Bauer, 181-182.
[35] Grandpierre, "Genuine Biological Autonomy."
[36] Whitehead, *The Function of Reason*, 4.
[37] P. E. B. Jourdain, "Maupertuis and the Principle of Least Action". The Monist, 22: 414-459, 1912.

level of its organism, namely, the end to be realized, and the details will be executed by the physical principle. The causal order of Nature makes biology primary and physics secondary.

The Anthropic Principle and the Principle of Greatest Action

It is one of the greatest unsolved puzzles of cosmology as to how the fundamental physical parameters of the cosmological conditions are fitted in such an extremely special manner that the result is an otherwise extremely improbable universe favorable to life.[38] The anthropic principle is, in cosmology, any consideration of the (1) structure of the material universe, (2) the values of the constants of Nature, or (3) the form of laws of Nature that bears upon the existence of life.[39] The anthropic principle tells that (1) the quantum fluctuations giving rise to the Big Bang and its further evolution have such special properties that they are necessary to accommodate life. Similarly, (2) the laws of Nature have such special forms that they make life possible. Again, (3) the fundamental physical constants take on such special values that they are necessary to life. "The properties of matter and the course of cosmic evolution are now seen to be intimately related to the structure of the living being and to its activities; they become, therefore, far more important in biology than has been previously suspected. For the whole evolutionary process, both cosmic and organic, is one, and the biologist may now rightly regard the universe in its very essence as biocentric."[40] This are the statements of Lawrence Joseph Henderson, one of the leading biochemists of the early 20th century. The quantum fluctuations, the laws of Nature, as well as the fundamental constants and the properties of atoms and molecules, are preferential for life.[41]

Recently, Henderson's prediction has been confirmed.[42] Updated, more detailed, but

[38] P. Davies, *The Goldilocks Enigma: Why Is the Universe Just Right for Life?* (Allen Lane, Penguin Books, 2006), 300.
[39] Refer to the "anthropic principle" entry in Encyclopedia Britannica, 2012.
[40] L. J. Henderson, *The Fitness of the Environment* (New York, Macmillan: 1913), 312.
[41] J. D. Barrow and F. Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford University Press, 1986), 132.
[42] J. Barrow, et al (eds), *Fitness of the Cosmos for Life: Biochemistry and Fine-Tuning* (Cambridge: Cambridge University Press, 2008).

essentially similar conclusions were reached by Wald and Needham.[43] It is claimed that not only is carbon important, but across the periodic table each element seems to be uniquely suited for life's evolution and emergence. For example, Wald[44] presented detailed arguments showing that phosphorus and sulfur have surprisingly many properties making them ideally suited for life's purposes. Recently Morris has shown that phosphorus and zinc bring indispensable properties at each cellular stage.[45] An increasingly large number of material properties have become known which seem to be fine-tuned for life. About 99% of the living parts of living organisms are made of the four elements: H, O, N, and C. The striking parallels between the relative cosmic abundances of reactive elements (especially H, C, O, and N) and the elemental composition of living matter have been pointed out by many authors.[46] "It is clear that the universe appears remarkably "fine-tuned" for life as we know it."[47]

Moreover, an increasingly large number of material properties are fine-tuned for life, too. For example, water has 66 (!) known anomalies, most of which are inevitable for life.[48] The unique properties of water, carbonic acid, compounds of carbon, hydrogen, and oxygen are fine-tuned for life.[49] Such a context fits well with the extremely special organization of plants, animals, humans and the almost perfect construction and working of living organisms. Considering that the laws of Nature are the machinery by which Nature works, while the quantum fluctuations, the fundamental constants and the atomic properties are the inputs to the

[43] G. Wald, G. 1962, "Life in the second and third periods; Or why phosphorus and sulfur for high-energy bonds?" in *Horizons in Biochemistry*, M. Kasha,M., and B. Pullman, B., eds. (New York: Academic Press, New York, 1962), 127; A. E. Needham, *The uniqueness of Biological Materials*, Oxford: Pergamon Press, 1965).
[44] Wald, "Life in the second and third periods."
[45] S.C. Morris, S. C. 2010, "What is Written into Creation?" in D. Burrell, et al., eds. *Creation and the God of Abraham* (Cambridge: Cambridge University Press, 2010), 176-191.
[46] See for example S. Fox and K. Dose (eds.), *Molecular Evolution and the Origin of Life* (New York: Marcel Dekker, 1977).
[47] C. F. Chyba, and K. P. Hand "Astobiology: The Study of the Living Universe," *Annual Review of Astronomy and Astrophysics*, vol. 43 (2005): 31-74.
[48] K. Tuttle, "SLAC Researchers Reveal the Dance of Water," 2009, available at http://home.slac.stanford.edu/pressreleases/2009/20090811.htm; C. Huang, et al., "The Inhomogeneous Structure of Water at Ambient Conditions," *PNAS* September 8, 106/36 (2009): 15214-15218; M. Chaplin, "Water Structure and Science: Anomalous properties of water," 2015, available at http://www1.lsbu.ac.uk/water/water_anomalies.html.
[49] Henderson, *The Fitness of the Environment*, 312.

laws of Nature, we can regard the fundamental constants, the properties of cosmic quantum fluctuations and that of atoms as the buttons upon it. These buttons can be put into a very large set of possible positions, but only relatively small ranges of the possible values are consistent with the existence of life. The fundamental meaning of the "anthropic" cosmological principle is that the buttons on the machinery of Nature are all set to the position "LIFE."

The anthropic cosmological principle raised the possibility that the whole physical universe may be the product of biology, and we are living in a biofriendly Universe. Paul Davies summarizes the key points arguing for a biofriendly Universe in the following form:[50]

> -The existence of life as we know it depends delicately on many seemingly fortuitous features of the laws of physics and the structure of the universe.
>
> - A famous early example of how the laws of physics seem to be fine-tuned for life is the production of carbon in stars, which requires a numerical "coincidence" to produce a nuclear resonance at just the right energy.
>
> - All four forces of nature are implicated in the life story. Changing the strength of any one of them, even by a small amount, could render the universe sterile.
>
> - The masses of some fundamental particles could not be very different without compromising the habitability of the universe.
>
> - The measured value of dark energy is 120 powers of ten less than its natural value, for reasons that remain completely mysterious. If it were 119 rather than 120 powers of ten less, the consequences would be lethal.

Davies notes that one of the possible explanations of the biofriendly nature of the Universe is offered by the overarching "life principle" that steers the evolution of the universe towards life and mind.[51] As he writes, this solution has the advantage of "taking life seriously" and it offers a better explanation than its alternatives. Its only apparent "disadvantage" would

[50] Davies, *The Goldilocks Enigma*, 171.
[51] Ibid., 300.

be that "teleology represents a decisive break with traditional scientific thinking" and "certainly make scientists nervous."[52] As I pointed out, bringing in teleology in a way I proposed is scientifically not only completely acceptable but makes science much more powerful: restoring the logical consistency of quantum physics, and offering unexpectedly deeper and broader explanations for such notoriously unsolvable problems like the mind-body problem, the origin of physical laws and the relation between physical, biological and mental causation.

On Gaia Theory

This is all-the-more interesting since Lovelock developed a very fruitful and far-reaching theory of the Earth as a self-regulating system.[53] The self-regulation includes such processes that keep the temperature and chemical composition of the atmosphere, the acidity, sulfur and salt content of the oceans, and, apparently, even volcanic activity, continent drift and continent albedo in a biologically favorable range. Lovelock has found that a whole series of parameters—like the 21% value of the oxygen content of the atmosphere, the average temperature of the atmosphere between 10 and 20° C for over three billion years, the salinity of the oceans, the carbon dioxide content of the atmosphere and the sea water, or plate tectonics—are regulated by Gaia.[54] For example, if the concentration of oxygen was just a few points higher, devastating forest fires would engulf the planet. But if the oxygen level was a few points lower, animal life would perish.[55] The self-regulation of Gaia occurs in a special manner setting up parameter values favorable for life. Loosely I can say that all parameters for life on the Earth are more or less finely and effectively tuned into the parameter range favorable for life.

Actually, the Gaia Theory did not present an exact definition of life; yet this point can be treated by Bauer's theoretical biology and the Principle of Greatest Action. Although self-

[52] Ibid.
[53] J. E. Lovelock, *Gaia. A New Look at Life on Earth* (Oxford University Press, Oxford, 1987).
[54] Lovelock, *Gaia*; B. Klyce, "Gaia," 2014, available at http://www.panspermia.org/gaia.htm
[55] D. Fideler, *Restoring the Soul of the World: Our Living Bond with Nature's Intelligence* (Rochester: Inner Traditions, 2014), 218.

regulation exists in engineering, I call due attention to the fact that in the case of Gaia, the regulation must have a biological nature, because it regulates the parameters according to *life's* requirements. Similarly, according to the anthropic principle, the processes of the quantum vacuum seem to be finely and effectively tuned into the parameter range favorable for the development of galaxies, stars and planets suitable to harbor life, as well as to the origin of cellular life on Earth.[56] The similarity between the bio-friendly aspects of the Gaia Theory and the cosmological anthropic principle should be noted here.[57] Both assume an activity towards realizing favorable conditions for life. I suggest considering that these similarities are closely related. If so, this may be mutually beneficial for both the Gaia Theory and the anthropic cosmology. Such a connection seems to indicate that the Universe is, similar to Gaia, a living superorganism. If the anthropic cosmological principle and Gaia Theory are related, as I suggest here, then we can obtain a new and profound explanatory context for studying their relations. The Gaia Theory may suggest that the bio-friendly Universe regulates itself in the closely optimal range for life and evolution, and vice versa, the self-regulation of Gaia in the range closely optimal for life is due to the same cosmic factor that explains the cosmological anthropic principle. I propose here that this common cosmic factor explaining both the Gaia Theory and the bio-friendly Universe theory is the Principle of Greatest Action.

The Gaia Theory posits that the organic and inorganic components of Planet Earth have evolved together as a single living, self-regulating system. It suggests that this living system has automatically controlled global temperature, atmospheric content, ocean salinity, and other factors, that maintain its own habitability. In a phrase, Gaian life maintains conditions suitable for its own survival by keeping conditions on our planet just right for life to persist. Lovelock's Gaia hypothesis opened unexpectedly profound and new vistas for the development of science.

[56] A. Grandpierre, A. 2018a, "The Fundamental Biological Activity of the Universe," in *Eco-Phenomenology: Life, Human Life, Post-Human Life in the Harmony of the Cosmos*, S.William S. Jadwiga, D. Verducci (eds.), vol. 121 (Analecta Husserliana, 2018).
[57] Barrow and Tipler, *The Anthropic Cosmological Principle*.

It is so radical that its road towards becoming an acknowledged part of established knowledge could cannot occur without controversies and misinterpretations. Indeed, the idea of Gaia involves a heretic idea: the idea of life.

A Few Words about the Helios Theory

Searching for the origin of solar activity, I developed a comprehensive theory suitable to explain the fundamental physical and conceptual problems of solar activity.[58] My theory of solar activity has two aspects. The first is the physical aspects. Some predictions of this theory have already been confirmed. The second corresponds to the conceptual problems that the Sun is capable of creating an extremely complex dynamo machine within it that generates magnetic fields from scratch, from mass motions. I became aware that complex machines present a fundamental conceptual problem because the working principle of machines incorporates teleology in it.

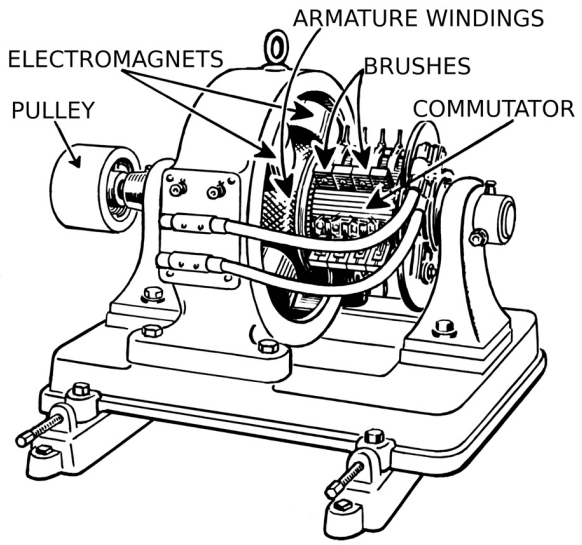

Figure 1. The dynamo is a highly complex machine with a design. It works by suitably arranged and rigidly prepared components like rotating electromagnets, armature windings,

[58] A. Grandpierre, "The Helios Theory: The Sun as a Self-Regulating System and as a Cosmic Living Organism," *Process Studies*, 46/2 (2018), 206-228.

pulleys, brushes and commutators. How could a dynamo be present in the Sun? Source for the diagram: Archives of Pearson Scott Foresman, https://commons.wikimedia.org/wiki/File:Dynamo_(PSF).png Archived at October 10, 2020

Another conceptual problem of solar activity is that is it a mere physical occurrence or is it a true, genuine *activity* of the Sun. My research led to reveal the latter option that suggests the living nature of the Sun. I named this theory as the Helios Theory.[59]

Considering the Helios Theory in the context of the anthropic principle, the biofriendly Universe and the Gaia Theory can be mutually beneficial. Indeed, if the whole Universe is intimately related to life, then we find the Sun as existing in a biofriendly Universe. If so, it is almost inevitable that our Sun also has biological aspects. My findings pointing toward biological aspects of solar activity fit into this timely, already threefold biological framework: the anthropic, life-centered cosmology, the Gaia theory and astrobiology (see below). The Helios Theory states that the Sun continuously initiates actions from its global level and these changes, together called solar activity, are directed in such a way as to generate conditions favorable to maintain its own activity.[60]

I propose that the bio-friendly regulation of fundamental physical constants, physical laws and quantum fluctuations arise from a fundamental, biological principle of Nature. If so, then not only the Earth and the Universe, but also the Sun must have a fundamentally biological aspect. This means that ultimately, the anthropic cosmological principle, the bio-friendly nature of the Universe, the biological regulation of Gaia and the self-regenerating nature of solar activity—can all be related. Now let us have a closer look to another closely related field, namely, astrobiology and origin of life research.

Scientific Breakthroughs Toward Life: The Origin of Life

In the second half of the 20th century a whole series of highly significant breakthroughs have occurred in the research of life and the Universe. Among these achievements, studies on

[59] Grandpierre, "The Helios Theory."
[60] Ibid.

the origin of life have played a pioneering role and opened unexpected perspectives towards a new science: astrobiology. In the famous Miller-Urey experiment in 1952, Stanley Miller demonstrated that relatively simple processes can produce complex organic molecules necessary for life from inorganic substances. In 1955, Miller experimentally confirmed that more than 20 percent of the mass of a gas consisting of simple carbon, hydrogen and oxygen molecules can be converted into amino acids if the gas, which also contains methane, is submitted to electric discharges. Bar-Nun and his co-workers in 1970 found that up to 36% of ammonia (a molecule consisting of a nitrogen and three hydrogen atoms) present in the reaction mixture was incorporated into the amino acids (amino acids are molecules consisting from more than eight atoms!) when put in a hot test tube and subjected to the effects of shock waves. Such high yields will require a highly selective set of sequential reactions in the gas phase (Bar-Nun et al., 1970– Bar-Nun 1970).[61] In such experiments, the four most abundant amino acids of living matter, glycine, alanine, aspartic acid, and glutamic acid, are consistently formed in appreciable yields.[62] In spite of the non-biological compounds detected in these experiments *a trend toward the living state long before the first life appeared is clearly indicated*. The tantalizing conclusion suggested by the above survey of experimental data is that *in every phase of cosmic evolution, from the origin of the elements, to the appearance of protocells*, there is a discernible preferential movement toward carbon-based living states.[63]

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As it was shown by the biogenetic experiments of Gary Steinman and Marian Cole, amino acids might form peptide chains in a manner that was "anything but random." Their experiments seemed to confirm that *molecules significant for life are made preferentially*. They found that "*preferential interaction has been observed at higher levels of organization as well,*"

[61] A. Bar-Nun, et al., "Shock synthesis of amino acids in simulated primitive environments," *Science* 168 (1970): 470-473; 1970, A. Bar-Nun, "Schock Synthesis of Amino Acids II," in *Cosmochemical Evolution and the Origins of Life*, John Oró (ed.) (Springer Science & Business Media, 1974), 109-116.
[62] D. H. Kenyon, "Prefigured Ordering And Protoselection In The Origin Of Life," in *The Origin of Life and Evolutionary Biochemistry*, K. Dose, S. W. Fox, G. A. Deborin, T. E. Pavlovskaya (eds.) (Springer: 1974), 210.
[63] Kenyon, "Prefigured Ordering And Protoselection In The Origin Of Life," 211-212.

going so far as to allege that "*a type of built-in 'predestination' can be identified at several levels of biological order*."[64] (emphasis is mine – A. G.) Sidney Fox was one of the early pioneers in biogenesis research. He believed that "*there are inherent properties in the atoms and molecules which seem to direct the synthesis towards life*"[65] (emphasis is mine – A. G.). Apparently, Fox implied that these atomic and molecular properties are the ones which determine the biologically important information and pave the way towards life. Cyril Ponnamperuma, who was another early pioneer in biogenesis research, also believed that "there are inherent properties in the atoms and molecules which seem to direct the synthesis towards life."[66] Sidney Fox and Klaus Dose[67] claimed evidence that *the basic laws of physics and chemistry were biased in favor of generating biologically significant molecules* (emphasis is mine – A. G.).[68] Sidney Fox also concludes that "amino acids determine their own order in condensation," and that this non-random "self-instruction" infuses macromolecules with crucial biological information, paving the way for life.[69] In astrobiology, a new discipline became popular, *biological determinism, claiming that given the right conditions, life will inevitably form after a sufficiently long time, and once life gets started, it will very probably progress toward intelligence*. Nowadays biological determinism is the prevailing philosophy at NASA.[70]

Such experimental results had the unexpected consequence that somehow there must be a law of Nature that is responsible for the life-favoring effects observed. It seems that most scientists believe that this unknown law must be a yet unknown law of physics or chemistry. I

[64] G. Steinman and M. Cole, "Synthesis of Biologically Pertinent Peptides Under Possible Primordial Conditions," *PNAS* 58 (1967): 735-742.
[65] Cited in P. Davies, *The Fifth Miracle: The Search for the Origin of Life* (London: Penguin, 1998), 235-236.
[66] R. Shapiro, *Origins: A Skeptic Guide to the Creation of Life on Earth* (City: Summit Books, 1986), 186-187.
[67] S. Fox, S. and K. Dose, (eds.) *Molecular Evolution and the Origin of Life* (New York: Marcel Dekker, 1977).
[68] Cited in Davies 2003. P. Davies, "How Bio-friendly is the Universe?" International Journal of Astrobiology 2, 115– 120, 2003. http://arxiv.org/pdf/astro-ph/0403050.pdf.
[69] S. Fox, "Prebiotic toots of informed protein synthesis" in *The Roots of Modern Biochemistry*, H. Kleinkauf, H. von Dohren, and L. Jaenicke, L. (eds.) (Berlin: de Gruyter, Berlin: 1988), 897.
[70] P. Davies, "Biological Determinism, Information Theory, and the Origin of Life," in *Many Worlds: The New Universe, Extraterrestiral Life and the Theological Implications*, Steven Dick (ed.) (Philadelphia: Templeton Foundation Press, 2000).

have to disagree here because we already saw that physical laws must be derivable from the Principle of Least Action and that life is based on the Principle of Greatest Action that is not derivable from the PLA. In the absence of biological laws, the behavior of atoms and molecules would be governed towards physical equilibrium. As Paul Davies demonstrated it, "bricks alone don't make a house."[71] If atoms and molecules are governed "upwards" from physical equilibrium, manifesting a behavior just the contrary to the one expected on a physical basis and given initial conditions, something beyond physics is needed.

It is important to emphasize here that these laws of Nature into which life is written cannot be the laws of physics. Indeed, as Paul Davies argues,[72] no simple law can generate, alone, a random information-rich macromolecule to order. A law of Nature of the sort that are generally known – physical laws - will not create biological information or any information at all. Ordinary laws only transform input data into output data. They can shuffle information about but they cannot create it. The laws of physics, which determine which atoms react together and how, are algorithmically very simple; they themselves contain relatively little information. Consequently, they cannot be responsible for creating informational macromolecules on their own. Contrary to the oft-repeated claim, then, life cannot be "written into" the laws of *physics*.[73] I argue that these laws, into which life is written, must be *biological laws* and, ultimately, the Principle of Greatest Action.

For a long time, it was considered that, taking into account the extreme complexity of cells, billions of years and extremely lucky conditions were required for the appearance of life. Indeed, the popular theories require an immense number of "big bangs" so that one "universe" could develop in which life actually forms. Now that recent findings show the almost instantaneous appearance of life on Earth around four billion years ago, this fact is in sharp

[71] Davies, *The Fifth Miracle*, 236.
[72] Ibid., 232-239.
[73] Ibid., 236-237.

contrast with abiotic hypothesis. The new developments prove that the occurrence of life is much easier than believed. The only thing that may make the appearance of life on Earth almost instantaneous is a biotic factor preceding the first cell on Earth. The fact that most astrobiologists accept the thesis that life is written into the laws of Nature is related, as I had shown[74] to the presence of a biotic factor that facilitates the origin of the first living cells on Earth.

On the Origin of the First Cell on Earth

How did the first living cell arise on the Earth? Recently, I published a detailed paper in the scientific journal *Biosemiotics* in which I show that the first living cells on Earth could not arise merely on the basis of chance and physical laws from inanimate matter.[75] Nowadays it is widely held that life on Earth had originated abiotically from inanimate matter (this hypothesis is known as "abiogenesis"). This view assumes that although the extreme complexity of cells makes it extremely improbable, the necessary atoms and molecules were put into the right order and into the necessary spatial structure by "abiotic evolution" and chance. Falsifying this belief, I showed that in living cells a variety of biomolecules have a global-level function serving to maintain the life of the cell as a whole. A cell cannot be alive if its proteins do not have their global, biological functions, like cell signaling orchestrating cellular activities (Berridge 2012). As the entry "biology" in the Encyclopaedia Britannica (Green 2012) states, living organisms cannot exist without biological functions: "Living things are defined in terms of the activities or functions that are missing in nonliving things." I discovered that such global-level biological functions could not arise from the physico-chemical structure of biomolecules and their local-level functions.[76]

[74] A. Grandpierre, "The Origin of Cellular Life and Biosemiotics," Biosemiotics 6/3 (2013), 421-435.
[75] Ibid.
[76] Ibid.

Actually, the arrangement of atoms and molecules in a protein must be suitable, but this is not sufficient. The physico-chemical properties are necessary since they are the conditions of the function. Nevertheless, these physico-chemical properties do not involve the actual practice of the potential function. An example helps: a pebble having a sharp edge could serve as a knife. But are all sharp-edged pebbles knives? As long as men did not discover its potential function, the pebble could not serve as a knife. A "knife" is not only a physical object, but a tool having a function; and it can be only endowed with such a function by a human. Similarly, a protein formed before the first viable cell cannot have its global-level biological functions merely by physico-chemical properties. An average protein in our cells decays on a timescale of 20 minutes. Only a viable cell can make a tool having a useful function for that cell. A protein, even if its physico-chemical properties make it suitable for serving a certain function, could not act in the absence of a living cell. How could the protein "know" that its task is to defend the to-be-born cell from all possible pathogens? A protein, even if it has the most suitable physical and chemical properties, is only a tool, but it cannot act by itself. Only a biotic factor can assign a biological function to matter. Therefore, even in the scenario of abiogenesis, assuming the extremely improbable coincidence in which all the necessary atoms and molecules are put together by physico-chemical forces into the same structure that is identical to that of a living cell, its proteins would not have global-level biological functions securing the maintenance of life at the cellular level. The protein in the zombie-cell could not have the function to defend the cell effectively against all possible pathogens. Physico-chemical properties are necessary, but not sufficient to establish such global-level biological functions.

It is well known that the biological function of biomolecules is not directly related to their physico-chemical properties. For example, the same adrenalin molecule could have the function of lowering blood pressure instead of increasing it. Another example may be the male sex hormone, the testosterone molecule, which does not have a really complex structure. It

increases libido and the tendency to commit aggressive actions. It plays a role in regulating energy economy as well as self-confidence and concentration. Nevertheless, its chemical properties are not in any clear relation with these functions. Jacob and Monod[77] discovered that there is no chemical necessity about which inducers regulate which genes.[78] "The result — and this is the essential point — is that so far as regulation through allosteric interaction is concerned, everything is possible. An allosteric protein should be seen as a specialized product of molecular 'engineering' enabling an interaction, positive or negative, to take place between compounds without chemical affinity, and thereby eventually subordinating any reaction to the intervention of compounds that are chemically foreign and indifferent to this reaction. The way hence in which allosteric interactions work permits a complete freedom in the "choice" of controls."[79] On such a basis, it becomes possible for us to grasp how in a very real sense the organism effectively transcends physical laws—even while obeying them—thus achieving at once the pursuit and fulfillment of its own purpose."[80] This means that the functional properties of proteins are determined by non-physical, i.e. physically arbitrary processes. It is this arbitrary nature of molecular biology that Monod calls "gratuity."

The biological importance of physically arbitrary processes is frequently acknowledged.[81] Maynard Smith[82] emphasizes the profundity of Monod's idea. For example, he calls attention to the fact that there is no chemical reason why CAC (cytosine, adenine, cytosine) should not code for glycine instead of histidine. This means that the biological functions are not physically determined. They arise by biological factors which are to be

[77] F. Jacob and J Monod, J. "On the regulation of gene activity," *Cold Spring Harbor Symposium Quantitative Biology* 26 (1961): 193-211.
[78] F. Jacob, *Chance and Necessity* (London: Fontana Books, 1974), 78.
[79] Ibid., 78-79.
[80] Ibid., 81.
[81] See for example, G. K. Hunter, "Is Biology Reducible to Chemistry?" *Perspectives in Biology and Medicine* 40 (1996): 130-138; M. Barbieri, "Organic codes: Metaphors or realities?" *Sign System Studies* 30 (2002): 743-754; H. P. Yockey, *Information Theory, Evolution, and the Origin of Life* (Cambridge: Cambrige University Press, 2006), 6.
[82] M. J. Smith, "The Concept of Information in Biology," *Philosophy of Science* 67 (2000): 177-194.

explored. Without biological functions, the first living cell could not be produced. Even the assumed zombie cell devoid of all pre-existing biological factors could not maintain its state in the absence of such biological functions that could preserve its structure and maintain it within variable conditions including an unforeseeably rich zoo of pathogens. My conclusion is that the first living cells on Earth must be generated by some *pre-existing biological factors*. But what kind of biological factors could pre-exist on Earth before the first living cells on Earth?

Now let us consider the conditions prevailing in the early of Earth. As solar rays arrive to the Earth and became absorbed by a stone, it becomes sooner or later weathered, its surface slowly disintegrates and decays. This means that the physical state of the stone proceeds towards equilibrium. This is just the contrary to the process realized when the same solar rays are absorbed by a living plant in the breath-taking process known as photosynthesis. By the remarkable organization of special appliances, molecular equipment and motors, the plant's cells become able to utilize the energy of solar rays for thermodynamically uphill biological aims. This does not happen in the case of a weathering stone. In order that solar rays could exert life-building effects, a biotic factor is required, the presence of a life building activity that is responsible for the utilization of solar effects for life's purposes.

In this way I found that the only solution to this problem is to hold that non-cellular life forms exist before the appearance of the first living cells on Earth.[83] We know that non-protein based life forms could also exist like the quantum vacuum or our Sun[84] and the Living Universe.[85] I propose that this biotic factor could be the Principle of Greatest Action, together with the input of biologically active information of solar radiation.

Astrobiology and the Origin of Life's Complex Ingredients in Cosmic Space

[83] Grandpierre, "The Origin of Cellular Life and Biosemiotics."
[84] Grandpierre, "The Helios Theory."
[85] A. Grandpierre, "Cosmic Life Forms," in *From Fossils to Astrobiology. Records of Life on Earth and the Search for Extraterrestrial Biosignatures*, J. Seckbach and M. Walsh (eds.) (New York: Springer, 2008), 369-385.

Astrobiology is the study of the origin of life, its evolution, distribution and future, encompassing not just life on Earth but also life beyond Earth. Its task is to investigate the presence of life in the Universe and explore the relations between life and the Universe. Astrobiology has been a recognized science by NASA since 1996, and today it is one of the most flourishing branches of astronomy. It is now well known that the Universe is widely populated by surprisingly complex organic molecules. The achievements of astrobiology offer new contexts and new perspectives for studying the relations between life and the universe. In this way, the results of astrobiology can be helpful in exploring the most universal aspects of life, laying the foundations for the biology of the future.

With the developments of deep drilling techniques, the signs of a deep hot biosphere having a total mass comparable to that of the biosphere at the surface are found in a depth of 10 km in the outer crust of Earth.[86] Life is present within much wider conditions than it is conceived previously. The extremophile bacteria (organisms able to survive in extreme environments) have proved to remain not only viable in conditions of extreme temperature, pressure, and radioactivity but also frequently even more proliferating than within terrestrial conditions. The limits of life expanded in an unprecedented and unimagined rate, including conditions present in deep space around -270 degrees Celsius.

The progress of space science made it possible to investigate organic molecules, the building blocks of life and their conditions, by direct measurements in the materials of meteorites, comets, planets and their moons. Soon it was discovered that comets and meteorites are rich in organic materials. The rapid progress of spectroscopy opened the way to detect organic molecules within planetary and extragalactic clouds as well.

[86] T. Gold, "The deep, hot biosphere," *PNAS* 89 (1992): 6045-6049.

With the advent of the means to explore space, the prospect of developing a truly universal science of biology now seemed possible for the first time.[87] Astrobiology has become one of the most flourishing branches of astronomy. It is now well known that the Universe is widely populated by surprisingly complex organic molecules, and comets, meteorites and even distant cosmic clouds are rich in organic compounds.

Organic compounds of high degrees of complexity are now known to be widespread in the Universe in regions of "impossible" space where, according to general perception, the density is too low for the synthesis of complex molecules.[88] Within regions of cosmic clouds, the density is so low that the collision of two atoms or molecules would require immense amount of time. Nevertheless, as observations show us, the atoms and molecules do meet with each other in these extremely rare cosmic clouds. What is more, they meet within conditions favorable for the formation of more complex molecules. Observations report on the widespread presence of surprisingly complex molecules. Furthermore, the formation of such extremely complex molecules occurs so frequently that *more than 20 percent of the carbon in the universe is tied up in polycyclic aromatic hydrocarbon*[89] *similar to coal and kerogen*. Such molecules form on the Earth only from living bodies, and only when high pressure is present for millions of years. Therefore, the universal presence and abundance of such highly complex molecules is more than surprising.

Instead of considering life to be sporadic, or a single event in the history of the Cosmos,

[87] S. J. Dick and J. E. Strick, *The Living Universe: NASA and the Development of Astrobiology* (New Brunswick, New Jersey, and London: Rutgers University Press, 2004), 2.
[88] S. Kwok, "Organic matter in space: from star dust to the Solar System," *Astrophys Space Science*, 319 (2009): 5–21; S. Kwok, S. and Y. Zhang, "Mixed aromatic-aliphatic organic nanoparticles as carriers of unidentified infrared emission features," *Nature* 479 (2011): 80-83; N. Neal-Jones and W. Steigerwald, "Building Blocks of Life Created in 'Impossible' Space," 2011; avaliable at https://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=2350.
[89] R. Hoover, "Need to Track Organic Nano-Particles Across the Universe? NASA's Got an App for That," 2014; available at https://www.nasa.gov/ames/need-to-track-organic-nano-partic-les-across-the-universe-nasas-got-an-app-for-that/ NASA.

as seen on the Earth, it is now almost universally accepted among astrobiologists that life has appeared at all places in the universe where the conditions allow, and that these conditions are much more permissible than was thought before. Life is a cosmic imperative; it is written into the laws of Nature—as it is formulated by the Nobel laureate biologist Christian de Duve.[90] *Even in places where life is not present, the conditions in the whole universe are continuously changing towards becoming more favorable for complex life.*

On the basis of astrobiological observations I arrived to the proposition that life might be a far more general phenomenon than the life forms familiar to us on the Earth. On the basis of Bauer's Principle, I had shown that even the cosmic vacuum can be regarded as a cosmic life form.[91] If so, the so-called "fluctuations" of the quantum vacuum may have not only physical but also biological character as well. More concretely, the spontaneous processes of the quantum vacuum may have not only a random, physical aspect, but also a non-random, organized, biological or bio-friendly aspect as well. This means that the quantum vacuum may have a fundamentally biological nature, as I predicted on the basis of Bauer's theoretical biology and the fundamentally cosmic nature of the principle of greatest action. Indeed, on the basis of the above results we may expect the PGA acts by creating organized fluxes of virtual particle pairs at every time and at every place throughout the Universe in a bio-friendly manner. This biological aspect of the spontaneous processes of the quantum vacuum may play a role in facilitating bio-friendly processes throughout the Universe, including cosmic space, cosmic clouds, stars and planets as well.

On Scientific Confirmations of Whitehead's Organic Cosmology

I found a remarkable agreement between Whitehead's organic cosmology, an essential agreement with the spirit of his philosophy of life, and a large number of agreements in details.

[90] C. Duve, *Vital Dust: Life as a Cosmic Imperative* (New York: Basic Books, 1996).
[91] Grandpierre, *Cosmic Life Forms*; *The Origin of Cellular Life and Biosemiotics*; A. Grandpierre, "Biologically Organized Quantum Vacuum and the Cosmic Origin of Cellular Life,"*Analecta Husserliana*, 116, (2014), 107-133.

As he stated, "The doctrine that I am maintaining is that neither physical nature nor life can be understood unless we fuse them together as essential factors in the composition of 'really real' things whose interconnections and individual characters constitute the universe."[92] Nature and life fused together is what I found in the theoretical biology of Ervin Bauer, in the Principle of Greatest Action as the fundamental extension of the Principle of Least Action into biology, in the Gaia Theory, in the Helios Theory, in anthropic cosmology and in astrobiology.

Whitehead required a wider scientific scheme in a way which is useful for science itself.[93] This requirement can be satisfied by my theory of the Principle of Greatest Action as being the generalization of the Principle of Least Action. My theory about biological autonomy as realized by decisions outside of the range of validity of physical laws is remarkably fitting with Whitehead's idea that "Such envisagement might reach to the attainment of the poising of alternative values with exercise of choice lying outside the physical laws, and expressible only in terms of purpose."[94]

Whitehead stated that "The lowest stages of effective mentality, controlled by the inheritance of physical pattern, involves the faint direction of emphasis by unconscious ideal aim."[95] Similarly, in his *Science and the Modern World*, he wrote: "The prompt self-preservative actions of living bodies, and our experience of the physical actions of our bodies following the determinations of will, suggest the modification of molecules in the body as the result of the total pattern."[96] Similarly, he assumed, "without any evidence, that electrons and hydrogen nuclei are such basic organisms… So far are they (the characteristic laws of inorganic matter – A. G.) from throwing light on the ultimate nature of things, that they blur and obliterate the individual characters of the individual organisms (like molecules – A. G.)."[97] I found

[92] Whitehead, *Modes of Thought*, 150.
[93] A. N. Whitehead, *Science and the Modern World* (New York: The Free Press, 70).
[94] Ibid., 108-109.
[95] Whitehead, *Modes of Thought*, 168.
[96] Whitehead, *Science and the Modern World*, 150.
[97] Ibid., 112-113.

astrobiological evidence underpinning Whitehead's prediction, namely, that bio-friendly activity is found to be present even in cosmic clouds.

Perhaps one of Whitehead's most profound recognitions is found at the end of lecture VIII, titled "Nature Alive," in *Modes of Thought*: "In these lectures I have not entered upon systematic metaphysical cosmology. The object of the lectures is to indicate those elements in our experience in terms of which such a cosmology should be constructed. *The key notion from which such construction should start is that the energetic activity considered in physics is the emotional intensity entertained in life*."[98] I think this remarkable idea finds scientific confirmation by the fact that the Principle of Least Action of physics, from which all the fundamental physical laws can be derived, itself can be derived from the fundamental principle of biology, which is the Principle of Greatest Action in the limit of unmeasurably small capacity to act. The only thing we have to take into account is that all living beings are sensitive beings and their decision making involves biologically governable emotional energies. This means that the fundamental overarching principle of biology corresponds to emotional energies. Therefore, the quantum world, where the expression of life is present, can be regarded as a world governed by physical laws which correspond ultimately to *cosmic emotional energies*, underpinning the Whitehead's idea that the energetic activity considered in physics is the emotional intensity entertained in life.[99]

It is important to note here that the Principle of Greatest Action involves within it the Principle of Least Action, the Principle of Greatest Vitality and the Principle of Greatest Reason. In the PGA all these three principles are unified, and so it may be suitable to serve as the basis of an all-comprehensive scientific world picture. The three fundamental principles can be regarded as the Principle of Matter (PLA), the Principle of Life (Bauer's Principle, the Principle of Greatest Vitality) and the Principle of Reason (PGR). These three fundamental

[98] Whitehead, *Modes of Thought*, 169, empahsis mine.
[99] Ibid.

principles could powerfully serve a comprehensive science just as the principle of least action did for physics. Their apex, the Principle of Greatest Action, should be extended towards characteristically biological concepts like feeling and thinking, because all living organisms have a first-person perspective due to their biological autonomy. Keeping in mind that it belongs to the nature of life to maintain life as high as possible and as long as possible, as the PGA tells, we may realize that the extended PGA offers a scientific perspective to the existence of values and meaning in Nature. Acknowledging the fact that life is by its very nature creative, the cosmic presence of the PGA introduces creativity as the most fundamental aspect of the Universe[100]. This is in strong agreement with Whitehead's innovative "philosophy of organism."[101] Remarkably, it was also intuited long before by ancient Chinese philosophy: ch'i or "Qi" is "the ultimate foundation for the existence of the universe," the "ontological source of the universe."[102]

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[100] A. Grandpierre, The Fundamental Biological Activity of the Universe. In: Eco-Phenomenology: Life, Human Life, Post-Human Life in the Harmony of the Cosmos. Smith, W. S., Smith, J. S., Verducci, D. (eds.) Analecta Husserliana Vol. 121, 115-140, 2018.

[101] „In all philosophic theory there is an ultimate which is actual in virtue of its accidents. It is only then capable of characterization through its accidental embodiments, and apart from these accidents is devoid of actuality. In the philosophy of organism this ultimate is termed 'creativity'; and God is its primordial, non-temporal accident" (Whitehead 1978, 7).

[102] Zhenyu Zengj, Semantic criticism: 'The westernization' of the concepts in ancient Chinese philosophy—A discussion of Yan Fu's theory of Qi," *Journal Article Frontiers of Philosophy in China* 6/1 (2011): 100-113.

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