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# The epoch-making importance of Ervin Bauer's theoretical biology

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A R T I C L E I N F O

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A B S T R A C T

Ervin Bauer was the only biologist who recognized that the best way to develop theoretical biology on an equal footing with theoretical physics was to follow the method that has ensured the great successes of modern theoretical physics: the general method of science. Following this method, he succeeded to find the universal principle of biology. From this principle he managed to derive all the basic equations of biology, that of metabolism, reproduction, growth, responsiveness and successfully explained all the fundamental phenomena of life. In this paper, I introduce Bauer's theoretical biology and discuss whether he understood it within the framework of the modern physical worldview, or in a broader framework. I point out that the theoretical biology of Ervin Bauer is the first to go beyond the physical worldview, to establish a deeper, biological worldview, and thus to represent a major advance in our understanding of the nature of life, with a significance even greater than that of the Copernican turn. Clarifying the difference between the living and the non-living, it is important to consider the difference between machines and living organisms. It is well known that machines are the manifestations of a dual control; globally, their behavior is controlled by their given structure, while locally, their behavior is governed by the physical laws. Based on Bauer's theoretical biology, it is pointed out that living organisms manifest a three-level causality; the 'additional', biological level corresponds to the autonomous, time-dependent control of their structures.

## 1. Introduction: The Copernican turn changed the basic ranking of our three types of experience

I report here on an epoch-making work, Ervin Bauer's magnum opus, Theoretical Biology (Bauer, 1935/1967; Grandpierre et al., 2022), which paves the way for an unexpectedly profound reinterpretation of life, science, the scientific worldview, and the way in which we think and make decisions. Only one work in the history of science has proved so epoch-making: Copernicus' magnum opus. Whereas in the medieval worldview of Copernicus' time the human-inhabited earth was at the center of the universe, and beyond the sphere of the stars stood the immortal souls and the Creator of supreme value, the Copernican turn has placed inanimate matter at the top of the new value system, in which the soul is assumed to be insignificant and God non-existent. It is difficult to imagine a greater reversal. On the one hand, the Copernican turn paved the way for prosperity and material well-being. On the other hand, it led to a never properly founded, one-sided, only partially true worldview resulting a radical change in a long-standing and previously unquestioned medieval mindset that not only modified the ultimate interpretative foundations of our understanding of reality, but also radically altered it, to the extent that the basic attitude of the post-Copernican age is still the most fundamental determinant of social consciousness. This new mindset entails a fundamentally different perception of reality, a different prioritization of the fundamental types of experience. In the post-Copernican perception of reality, *the experience of the 'external', physically measurable world appears as the only reality, the authoritative kind of experience. In contrast, the 'inner' experience of thoughts, even when following logical laws, and of feelings, even when following moral laws and conscience, appear as unsignificant side-effects of the fundamentally physical world. Despite the fact that the laws of logic - and conscience - are given by Nature, and as such are objective, post-Copernican thinking has relegated them to the purely subjective, arbitrary elements of reality.* This new mental framework in turn has radically altered our understanding of Nature, as well as of ourselves, generating alienation. Although Cartesian dualism preserved the divine aspect of reality, it separated this aspect from the scientifically intelligible world. Over the centuries, the enormous successes of physics have increasingly modified the concept of reality in a way that it lost its aspects and values associated with the world of life and reason. Thus, we arrived first at Newton's clockwork created by God, then at Laplace's machine without God, and in the 20th century, at Bertrand Russell's icy, terrifying scientific worldview, in which the universe is ultimately lifeless, meaningless and

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worthless, and utterly indifferent to life. Since this fundamental change of the way of scientific thinking is based on a one-sided, physicalistic perception of reality, in this physicalistic picture life, apparently, lost its causal power and significance.

*In the last centuries, we have learned a new, one-sided conception of reality that only recognizes the physical kind of experience. Accordingly, we no longer know even what life is - even though every small child does.*

This is why Ervin Bauer's theoretical biology giving a thorough, exact and scientific definition of life represents a groundbreaking, second Copernican turn in the history of science. Bauer established a radically new biology that formulated the universal principle of life by the general, basic backbone of scientific method (Bauer, 1935/1967, 51). His biology has the power of the most elegant and complete version of modern theoretical physics. It led to a new scientific worldview that provides a deeper and more complete explanation of the nature of the Universe, unifying the science of the inanimate and the animate world. *This new worldview redefines the concept of nature, complementing the material world with the equally universal world of life and reason.* The concept of nature becomes reinterpreted from inanimate nature to living Nature. This turn opens fundamentally new perspectives for the development of science.

The social importance of the scientific worldview is much greater than that of science itself. While science only transforms our material means, the scientific worldview transforms *our way of thinking. The worldview that becomes dominant in society has a civilization-shaping significance*. The almost incomprehensibly huge social changes that have taken place since the Middle Ages are rooted in the physical worldview, without which they could not have happened. *It is the worldview that is the intellectual tool for interpreting and governing our life.* If this worldview is fundamentally incomplete, our perception of reality becomes distorted. Since we need to interpret and evaluate the world correctly in order to make well-founded decisions, the change in worldview at the end of the Middle Ages meant a fundamentally new system of perceiving reality and a radically new set of values for society as a whole – including the scientists' mindset.

## 2. Laws are what make science powerful

Without theoretical laws, we cannot talk about theoretical science. Theoretical science is what makes science powerful. As Ervin Bauer writes, "*science can explain the phenomena it studies only insofar as it reveals their laws*" (Bauer, 1935, 43). While the description of phenomena is limited to a mere account of data, *the laws of Nature capture the common and determinative features of phenomena and give an account of these characteristics in a way that is useful for predicting behavior.*

*Even more important than laws are the most powerful elements of science, the fundamental principles. Fundamental principles are defined here as the ones that unify the universal laws of Nature and define their most fundamental orientation.* They orientate the laws of Nature in the same way as the laws of Nature determine the directivity of the behavior of observable phenomena. Each fundamental principle defines an unbounded world, because universal principles are always and everywhere valid and thus cannot be limited in space and time. *Fundamental principles are the foundations of reality. They are the basis, driving and directive powers of Nature as a whole.* The most fundamental principle among them unifies and guides all the fundamental principles of Nature. This is the ultimate principle of how Nature works.

This ultimate principle is the most effective and profound tool of our thinking. It is the tool by which we can understand the nature of the Universe. From the point of view of the human mind, the fundamental principles are explanatory principles; from the point of view of Nature, they are causal principles unifying and governing the gigantic network of causes and consequences; they link the causes within us to Nature's causal network. The fundamental principles are of worldview significance defining a way of understanding the nature of life, matter and man. They are the most essential components of Nature. They are the most important things to know to understand ourselves and the world. The fundamental principle of physics - the principle of least action – defines and explains the working of the whole physical world. The fundamental principle of biology defines and explains the working of the whole biological world, including the nature of life and the nature of the Universe. *It is the discovery of the fundamental principle of biology that demands a fundamentally new, broader and deeper system of interpretation and evaluation of the world, a qualitatively new understanding of life, a life-centered worldview that includes not only the physical but also the emotional and intellectual aspects of life.* It is crucial to recognize that life, as we shall see, is much more than its interpretations through the lens of the physicalist worldview.

As it was emphasized by the outstanding geneticist Theodosius Dobzhansky: "Purposefulness, or teleology, does not exist in nonliving nature. It is universal in the living world … The origin of organic adaptedness, or internal teleology, is a fundamental, if not the most fundamental problem of biology" (Dobzhansky et al., 1977, 95). Arguably, teleology cannot be present in physics, since physical objects cannot choose the endpoint of their processes. Because the prevailing view today is that physics is the only fundamental science, it seems for many that the concept of internal teleology should be banished from science. But a serious objection can be raised: the existence of teleology cannot be denied in biology, and biology is a science. Nevertheless, accepting the dominant physicalistic assumption most biologists is inclined to reinterpret teleology in physical terms. It may seem that the basic premise of physicalism is a simple and plausible premise. It is excellently applicable within physics. But when this premise becomes an extended view of the world as a whole, including biology, it becomes like a straitjacket too narrowly tailored.

Physicalism seems to be underpinned by the widespread notions that neo-Darwinism is the general science of life, and so teleology can be only apparent; this understanding was the reason to introduce a physicalism-tolerating term for teleology, 'teleonomy'. Nobel-laureate biologist Jacques Monod in his book representing "a philosophy for a universe without causality" - as it is written on the book's front cover -, admits that "Objectivity nevertheless obliges us to recognize the teleonomic character of living organisms, to admit that in their structure and performance they act projectively [purposively – A. G.] … In fact the central problem of biology lies with this very contradiction [between 'apparent' and real purposiveness – A. G.], which, if it is only apparent, must be resolved; or else proven to be utterly insoluble, if that should turn out indeed to be the case" (Monod 1972, 21–22). We will return to the questions of teleology and teleonomy later on in this article.

What follows shows that it is precisely the two most important aspects of life are ignored in the currently dominant physicalist view of life: (i) the fundamental principle of biology and (ii) decision-making of the living organism.

Bauer's first publication on a universal principle of biology has been published in the leading scientific journal of the time, in the Naturwissenschaften (Bauer 1920a), and in a monograph in the series edited by Wilhelm Roux, a leading biologist of that time (Bauer 1920b). Ervin Bauer's major work, *Theoretical Biology* was published in Russian in 1935, and in Hungarian in 1967; a partial English translation has been published in Hungary in 1982 (Bauer 1982). The fate of this extraordinary book is also extraordinary: its study and understanding have been hindered by an extraordinary set of historical, political, scientific and ideological obstacles. Written together with my two co-authors, biologists Miklós Müller and Gábor Elek, in 2022 I edited and published the until now most comprehensive book about Ervin Bauer's life and scientific works (Grandpierre et al., 2022).

When we attempt to explore the nature of life, we must rise above our deep-rooted beliefs. It is crucial to realize that the task of science is to explain Nature as she is, instead of raising our preconceptions above reality. We need a fresh eye to notice the essential novelty of life beyond its physical aspects. The historically dominant ways of conceiving life, namely, anthropocentrism and physicalism are based on ill-founded preconceptions. Freeing ourselves from such preconceptions, exploring and finding a new, deeper and more solid ground is not an easy task. This is why evaluating Bauer's work properly has been an extraordinary challenge for even his greatest admirers. Over the past four hundred years, a physicalistic approach has become deeply ingrained within us, and has become the basis of our understanding of reality. Replacing the physical worldview, which has reigned for centuries and is considered unquestionably solid interpretation of reality, and building a worldview to a deeper, biological basis, has been a largely unnoticed and unexpected challenge.

There are many reasons why Bauer's work has not been properly appreciated. Apparently, for those who knew Bauer's major work, there was simply no adequate system of interpretation and evaluation available to recognize that Bauer's theoretical biology goes beyond the physical framework; among the few who recognized the need for a biological worldview that went beyond physics, there did not seem to be any who were familiar with Bauer's major work. And even if there had been those who met both conditions, there was no other branches of science that could be helpful for this task.

But, quite unexpectedly, since Bauer's time, the scientific background has changed radically.

### *2.1. The epochal significance of Ervin Bauer's theoretical biology is made almost inescapable by dozens of new disciplines and the requirement for sustainability*

At the time when Copernicus's work was finally accepted, this was the result of a convergence of new scientific discoveries that had reached a critical mass: the more precise measurements of Tycho Brahe, the arguments of Giordano Bruno, Galileo's experiments, the decisive achievements of Francis Bacon and René Descartes in the methods of science, Kepler's laws and then Newton's laws, all reinforcing each other. Their congruence has had a huge impact on the way scientists think; scientific research has become reoriented towards a new, physicalist basis.

In our times, the situation is akin to a Copernican turn: the convergence of new disciplines proving the existence of a universal biological law has reached critical mass. Independently of each other, a whole range of new disciplines investigating the relationship between life and the Universe have emerged on the scene, all reinforcing each other in a way outlining a fundamentally new picture of the Universe. These new disciplines are the following:

(1) the biocentric cosmology of the eminent biochemist Joseph Lawrence Henderson has shown that most of the physical and chemical properties of atoms and molecules in the Universe are in the favorable, frequently in the most favorable range for life, despite the fact the life is utterly improbable on a physical basis (Henderson 1913, 1917; Barrow et al., 2008; more recent results are summarized in Grandpierre 2021b, 239–253).

(2) Anthropic [human-centered – A. G.] cosmology, which is a somewhat misleading name, as this discipline could be more properly termed as life-centered, since it actually investigates the cosmic role of *life,* using cosmological models. It has shown that the fundamental physical constants, the form of physical laws and quantum fluctuations that caused the big bang and shape cosmic evolution are in a favorable range for life (Barrow and Tipler 1986; Grandpierre 2021b, 289–301).

(3) Laboratory experiments on the origin of life (Miller-Urey experiments, Bar-Nun et al., Steinman and Cole, Ponnamperuma, Sidney Fox and Klaus Dose, summarized by Davies 1998, 232–239, Grandpierre 2021b, 200–202) proved the existence of a natural law that helps to create molecules that play an important role in life processes.

(4) Empirical research has shown the sudden emergence of life on Earth over 4 billion years ago (Benner et al., 2019).

(5) Oparin's results have shown the existence of an autonomous law of life and the central role of teleology in biology (Oparin 1960, 5–12; Grandpierre 2021b, 253–283).

(6) New results have shown that we are living in a bio-friendly universe (Davies 1998, 232–241; Davies 2003, 2006).

(7) Astrobiology, the science that studies the relationship between life and the universe, has come to the view that "life is a cosmic imperative" and that, although it seems physically impossible, 20–30% of the mass of cosmic clouds is made up of highly complex biomolecules (Davies 1998, 232–241; The University of Hong Kong, 2011; Kwok 2013, Hoover 2014, Grandpierre 2021b, 284–289).

(8) The Gaia theory, according to which the Earth is a living system that regulates itself within a range favorable to life (Lovelock 1987; Grandpierre 2021b, 301–322).

(9) Recent advances in biology have shown that the organization and configuration of protein polypeptide chains follows biologically preferable pathways, and that there must be a pre-cellular factor that directs the interaction network of cellular components towards biologically preferred collective states (Tompa and Rose 2011; Grandpierre 2021b, 309).

(10) Ervin Bauer's theoretical biology has shown that life has its own universal principle (Bauer, 1935/1967).

(11) The generalization of the Bauer principle (Grandpierre 2007) led to the principle of greatest action, the exact formulation of teleology, of biological autonomy, and the quantitative theory of biological, autonomous decision-making (Grandpierre 2012a, 2013, 2021b, 169–237; Grandpierre and Kafatos 2012; Grandpierre and Kafatos, 2013, Grandpierre et al., 2014, Grandpierre 2021a, 2022a, 2023a, b), and

(12) to the generalization of the principle of greatest action to the principle of life, which includes also biological motivations, feelings and thoughts (Grandpierre 2021b).

All these new disciplines, independently from each other, provide a compelling argument for the fundamental role of life in the Universe and for the existence of a principle of life itself, showing that this principle shapes the conditions everywhere in the Universe in a direction favorable to life (Grandpierre 2021b, 243–322). *The convergence of these new disciplines provides irrefutably solid scientific evidence, from both theoretical, observational, and experimental perspectives, that there is a principle of nature that governs the development of the conditions toward becoming favorable to life* ("laws of nature rigged in favour of life", Davies, 1998, 232–239, Grandpierre 2021b, 243–322). It is the Bauer principle and its generalized version, the principle of greatest action that provides an explanatory basis for all these disciplines. This new set of scientific findings is a powerful demonstration of the need to build our scientific worldview on a deeper and broader, life-centered foundation, and gives Bauer's seminal work a significance akin to the Copernican turn.

What does it mean to interpret Bauer's work on a biological basis rather than within the framework of physicalism? It means the recognition that biology has its own universal principle, valid everywhere and at all times, which cannot be derived from physical laws, which determines the fundamental orientation of biological behavior, which transcends physical causality; that it is a principle to which physical laws are subordinate, and which therefore has profound cosmological significance.

The deductibility of the principle of physics from the principle of biology, as its limiting case, changes the frame of reference for our view of reality, changes the initial ground for the interpretation of Nature. For example, the physical world view is the basis for the idea that humans are essentially made of atoms. In contrast, the existence of the universal principle of life means that life is more fundamental than matter. This means that man, rather than being fundamentally composed of atoms, is fundamentally composed of the principle of life and the free will that goes with it. The atoms of our body and the physical laws, instead of determining our thinking and actions, are tools for the physical realization of life.

## 3. We need a theoretical biology that reveals the universal laws of life

Regarding the extraordinary difficulties of understanding Ervin Bauer's theoretical biology*, the best first step is to consider the place of biology in natural science, appreciating the extremely profound nature of the question "what is life?"*. As the eminent physicist and astrobiologist Paul Davies writes, the origin of life is "one of the great scientific challenges of our time" (Davies 1998, x), which *"*will not be solved without our first having a deep understanding of the nature of life*"* (ibid. xvii). In fact, the very existence of life is completely unexpected and inexplicable on a physical basis, and its 'peculiarities' are extraordinary; for example, purposive, teleological, goal-directed activity is completely absent from all of physics. Paul Davies warns us that understanding the nature of life is a notoriously difficult problem. "*It tests the very foundations of our science and our worldview. A discovery that promises to change the very principles on which our understanding of the physical world is built deserves to be treated as an urgent priority*" (ibid. xvi-xvii). *Davies concludes that the question "what is life?" will finally be answered by "a fundamentally new kind of organizing principle"* (Davies 2019).

Without knowing the very principles on which our understanding of the world is built, we do not know what kind of world do we live in. Until we do not know about the fundamental principle of the physical world, we do not know what inanimate matter is; and until we do not know the principle of life, we do not know what life is. And until we do not know what is inanimate matter and what is life, we are missing just the most important things to know.

Until we do not know what physics is, we will not know whether physics includes biology or not. In order to realize the importance of the question "what is life?", it is crucially important to answer the question "w*hat is physics?"*. In this fundamental question, too, confusion is general. For example, the Encyclopedia Britannica, on the one hand, claims that physics is "the systematic study of the inorganic world, as distinct from the study of the organic world, which is the province of biological science" (Osler et al. 2020). However, the same Encyclopedia, on the other hand, claims also that physics "is concerned with all aspects of nature on both the macroscopic and submicroscopic levels" (Weidner and Brown, 2024). The highly significant point whether physics is a complete science of Nature or not is not clarified.

Can we understand the nature of life if we interpret it in terms of the science of lifeless, inanimate matter? Albert Szent-Györgyi, the Nobel Prize-winning biologist, drew attention to the fact that the central problems of biology remain unsolved. Today's physicalist biology has huge 'white spots' that it is unable to make sense of. *We must therefore begin by exploring the unknown landscapes of our knowledge, and for this we need a broad horizon based on natural philosophy* (Szent-Györgyi 1983, 7). Unfortunately, this broad horizon has been left out of today's training of biologists.

"*[T]he difference between an inorganic and an organic system lies not in the greater complexity of the latter, but in the orderly directiveness of its activities towards the ends of living, developing and reproducing"* (Russell 1945, 183). If we treat living organisms "as differing merely in complexity, we leave out what is distinctive" of them. *"A purely material system cannot, ex hypothesi, perceive, strive or act purposively*" (ibid., 184). "A biochemist can give you the structural formula of most of these substances [biomolecules such as ATP, chlorophyll, hemoglobin etc.]. But the really interesting problem is not what these substances are, but what they do" (Szent-Györgyi 1983, 62). "It seems as if something very important is missing from our current thinking, a whole dimension without which these problems cannot be approached" (ibid., 64). *Remarkably, it is Bauer's theoretical biology that discovered this most fundamental dimension of biology, and determined the basic equation of biological work* (Bauer, 1935, 46–53).

### *3.1. The founders of quantum physics recognized that the teleology of life goes beyond physics*

Founder fathers of quantum physics, for example, Niels Bohr, Werner Heisenberg and Eugene Wigner recognized that the problem of life goes beyond the conceptual framework of physics, since, for example, it excludes teleology (e.g., Bohr 1933, 458a; see McKaughan 2005, 516; Heisenberg 1965, 242). As Bohr put it: "The asserted impossibility of a physical or chemical explanation of the function peculiar to life [teleology – A. G.] would in this sense be analogous to the insufficiency of the mechanical in atomic analysis for the understanding of the stability of atoms". In other words, the science that includes the teleology of life is related to quantum physics in the same way that quantum physics is related to classical physics. "Bohr clearly recognized the importance of teleological or finalist concepts going beyond physics and chemistry" (McKaughan 2005, 517).

Eugene Wigner also argued that biology is a more general science than physics, which includes physics as a special subdivision: "Since it is rather clear, in retrospect, that physics in the past always dealt with situations which turned out later to have been limited cases … It may well be suggested, therefore, that present-day physics represents also a limiting case — valid for inanimate objects." Wigner considered inanimate matter "as a limiting case in which the phenomena of life and consciousness play as little a role as the nongravitational forces play in planetary motion" (Wigner 1970). Niels Bohr and Eugene Wigner repeatedly argued that quantum physics needed to be complemented.

### *3.2. Quantum physics is fundamentally incomplete, its completion requires a general theory of the behavior of living organisms*

Quantum physics cannot, of course, describe the behavior of physicists who determine the experimental conditions and observe the experiments, for example, how they set up measuring equipment. John von Neumann, Werner Heisenberg and Henry Stapp emphasized that observations are central to quantum physics. This means that to complement quantum physics, we need a general theory of observers. The most general theory of observers is the general theory of living beings. There exists only one general biology that is suitable for this purpose: Ervin Bauer's theoretical biology (Grandpierre 2007; Grandpierre et al. 2014).

Robert Rosen, professor of biophysics at Dalhousie University, writes in his book on the nature of life: "In a letter to Leo Szilard, Einstein said, «One can best feel in dealing with living things how primitive physics still is» (Clark 1972; emphasis added). Schrödinger (and Einstein) were not just being modest; they were pointing to a conundrum about contemporary physics itself, and about its relation to life" (Rosen 1999, 7). In 1944, the Nobel-laureate quantum physicist, Erwin Schrödinger wrote a famous book entitled as "What is Life?" (Schrödinger, 1944/2012), to shed some light to the very question about which biology, according to him, was about. Life is something that distinguish living organisms and their behaviors from inert matter (Rosen 1999, 6). "Schrödinger's answer to this conundrum was simple, and explicit, and repeated over and over in his essay. Namely, Schrödinger concluded that organisms were repositories of what he called new physics" (ibid., 8). In his Chapter 7, entitled as "Is Life Based on the Laws of Physics?", in its first section, Schrödinger stated that "… *from all we have learnt about the structure of living matter, we must be prepared to find it working in a manner that cannot be reduced to the usual physical laws*" (Schrödinger, 1944/2012, 77). Nevertheless, Schrödinger assumed that life should be based some yet unknown, new type of physical laws. "What Is This «New Physics»? The new physics involves going from special to general, rather than the other way around" (Rosen 1999, 27). Bearing in mind that physics is the science of inanimate matter, it is clear that the more general "new physics" that defines life must belong not to physics but biology, so it is more proper to name it as new biology. Ervin Bauer's major work "Theoretical Biology" (Bauer, 1935; 1967) provides just such a new, general biology.

All these issues are now far beyond the intellectual horizons of today's biology education. What is more, today's training in biology is actually discouraging biologists from examining the fundamental questions of life. The philosopher of science Mario Bunge writes:

> "Students of life become interested in a definition of the concept of life during their freshman year and at the end of their career. In between they are discouraged from trying to elucidate that concept and, in general, from getting involved in philosophical questions. They are encouraged instead «to get on with their business», which supposedly is anything but trying to understand life" (Bunge 1985, 4).

Moreover, they usually are trained according to the false belief that the problem of the existence of life has been essentially solved by molecular biology and neo-Darwinism, and that the problem of life does not exist. For example, Günter Vogel and Harmut Angermann's Springer Atlas of Biology states that: "Historically, real-world systems have been considered either "living" or "non-living" and have been classified as belonging to the disciplines of physics or biology. This distinction is not theoretical but practical, since the only difference between the two types of system is the degree of complexity" (Vogel and Angermann, 1992, 1). As we have seen above, the essential difference between an inanimate system and a living organism lies not in the greater complexity of the latter, but "*in the orderly directionality of its activities towards the ends of living, developing and reproducing*" (Russell 1945, 183). Within the framework of the physical worldview, biological directionality remains overlooked.

It is certainly due to the dominance of the prevailing physical approach that the central questions of biology remained unrecognized and unappreciated. This situation is described by Robert Rosen as follows: "I daresay that, expressed in such terms, the Schrödinger question [what is life?] would be dismissed out of hand by today's dogmatists as, at best, meaningless; at worst, simply fatuous" (Rosen 1999, 6). As award-winning biologist, Nick Lane wrote: "*Few biologists are more than dimly aware of the black hole at the heart of their subject. The biggest questions in biology are yet to be solved*" (Lane 2015, 2–3). As widespread as it is today, the belief that life is or at least can be understood in terms of physical theories is ill-founded. This can be illustrated also by the following quote from a book by Paul Davies, the eminent physicist, astrobiologist and author.

"Fifty years ago, many scientists were convinced the mystery of life was about to be solved. (…) Today, however, the picture of the cell as nothing but a very complicated mechanism seems rather naïve. (…) Mechanistic explanation is an important part of understanding life, not the whole story.

Let me give a striking example of where the problem lies. Imagine throwing a dead bird and a live bird into the air. The dead bird will land with a thud, predictably, a few meters away. The live bird may well end up perched improbably on a television aerial across town, on the branch of a tree, on a rooftop, in a hedgerow, or in a nest. It would be hard to guess in advance exactly where.

As a physicist, I am used to thinking of matter as passive, inert and clodlike, responding only when coerced by external forces - as when the dead bird plunges to the ground under the tug of gravity. But living creatures literally have a life of their own. It is as if they contain some inner spark that gives them autonomy, so that they can (within limits) do as they please. Even bacteria do their own thing in a restricted way. *Does this inner freedom, this spontaneity, imply that life defies the laws of physics, or do organisms merely harness those laws for their own ends*? If so, how? And where do such 'ends' come from in a world apparently ruled by blind and purposeless forces?

This property of autonomy, or self-determination, seems to touch on the most enigmatic aspect that distinguishes living from nonliving things, but it is hard to know where it comes from. What physical properties of living organisms confer autonomy upon them? Nobody knows" (Davies 1998, 8–9; emphasis added).

Let us add: all human beings have a well-working explanation for the reason of our actions: we act because we want to achieve our goals. Although the "how?" has remained unexplained, the theory of biological autonomy has shown that *it is our volitional energy that is capable to do biological work by generating bio-currents in our brain conforming to our decisions* (Grandpierre 2012b, 2023b; Grandpierre and Kafatos 2012, 2013). In case of organisms behaving instinctively, their attachment to their living nature is what nourishes the 'spark' of their autonomy by turning their unconscious vital energies towards the direction given by the principle of life. Life is not, in fact, primarily a physical state, but an unceasing *activity* to achieve the goals that are the motive force of life. *Life is essentially a vital activity, a ceaseless action for fulfilling life's norms given by the principle of life*. These norms serve as the source of primary causes of biological behavior; the physical state of the living organism is only a consequence of these biological activities.

When it comes to such basic questions, common sense is better equipped than biologists who unconsciously adopt the approach of today's biologist training. Our actions and purposes are an integral part of our everyday life, involving countless and consistent experiences of countless people. It is the most basic fact of our lives that we can think, feel and act, either instinctively or consciously, autonomously and purposefully. In other words, it is the practice of biological causality that makes our lives. Yet today, by the preconception ingrained into most biologists' mindset, however, *there can be only one cause: the physical cause. This theorem is known as 'the causal closure of the physical domain'* (Kim 1993, xv, 215, 287; Kim 1996, 131–132, 147–148). Physicalism entails that physical theory can in principle provide "a complete and comprehensive theory of the world" as a whole (Kim 1993, 96), not simply of the "physical domain" understood as a limited part of the world (ibid., 220). On the basis of a consistent physicalist view, it is almost inevitable that scientists will ignore the problem of biological teleology, since the causal closure of the whole world rules out biological causes. The most fundamental fact of our everyday life, mental causality, the ability to act of our own volition and to direct our thinking and acting purposefully, is forced to be denied by the consistent physical view. In this respect, physicalism is "patent absurdity" (Griffin 2014, 273–274; Griffin 1998, 218–227). If there were only physical causes, then our thoughts and actions would be completely independent of our wills and desires, because they too would be governed by physical causes. Consequently, these words your read now would have no meaning, no sense and no significance, our life would have no value, because everything would continue to be governed by physical causes, completely independently of them. If only physical causes would exist in the world, it would mean that all our actions in reality are sheer happenings independent of our will and desires (Moya 1990, 2–3). This is a completely absurd view since it denies the causal power of all our thinking and feeling, denies the most fundamental fact of our everyday individual and social reality, that is, our capacity to think and act according to our goals. This absurd view is based on an unfounded but sweeping assumption about the nature of reality, which is falsified by Bauer's theoretical biology and its extensions, the theory of biological autonomy (Grandpierre 2012b; Grandpierre and Kafatos 2012, 2013) and the comprehensive theory of life (Grandpierre 2021a, 2021b, 2023a, 2021b, b) having shown that the elementary particles in our brains are governed, most fundamentally, by the principle of life, the principle of reason and our autonomous, non-physical decision-making. *In order to have a correct theoretical biology, it is inevitable that biological autonomy, that is, the capacity to generate biological causes, that is, to act in a purposeful way, either consciously or unconsciously, must be recognized and explained.* In view of all this, it becomes understandable why most scientists were unable to approach Ervin Bauer's theoretical biology with a sufficiently broad and profound perspective. If biological causes also exist, they must exist beyond the world of physical causes, and so their only way to become physically manifest is that they can cause physical causes.

## 4. The relation between biological behavior and the fundamental principle of biology

First, let us compare the directivity of physical and biological behavior. Physical changes are brought about by physical forces. The arising spatial direction of physical behavior can be anything; at the same time, physical changes have a kind of *deeper directionality* corresponding to the path of least resistance, according to the principle of least action. *This deeper orientation gives the behavior of all physical things a common characteristic: passivity, in other words, environmental determination.* In other words, physical things are incapable of acting and producing new changes; they themselves have no causal power to elicit new physical causes beyond the one corresponding to that of the physical laws.

*In biology, the role of physical forces is played by biological motivations*. Biological changes have also a deeper directionality, different from that of physical changes. This deeper orientation gives the behavior of all living organisms a common characteristic: activity. Biological activity is directed towards the mobilization of internal energies and abilities, the maintenance of life, growth and wellbeing. Living organisms have the capacity to mobilize and redirect their internal free energies in response to internal and external changes in order to bring about new changes. Living organisms have causal power; they are able to initiate the physical causes necessary for the realization of biological needs. In this way, living organisms continuously develop new, biologically needed and organized physical conditions which would not occur in a world having merely a physical nature.

*It is this biological directionality and causal power that makes the nature of living organisms qualitatively different from the nature of physical things.* This difference has become scientifically explained by, on the one hand, the principle of least action and, on the other hand, the Bauer principle and its generalized versions, the principle of greatest action and the principle of life. While the Bauer principle is the principle of biological energies, the principle of greatest action involves the principle of time-management, too, and the principle of life involves in itself also the principle of biological motivations. Biological motivations generate deviations from physical behavior.

*It is essential to recognize that it is just the deviations from the passive course of events that constitutes the active behavior of living organisms*. These deviations add up in biological processes, becoming increasingly different from what is physically expected. For example, a bird that regarding its physical properties is fully equivalent to a dead bird but alive, will behave very differently. When dropped from the same height, it does not remain inactive but opens its wings, and its path gradually deviate more and more from the physical one. "*The living creature has a will of its own or a mind of its own; it works persistently along lines which are not those of least resistance, towards a result which is not immediately attained*" (Thomson 1920). Physical, passive, clodlike events are happenings; biological, active, purposeful behavior are actions. It is this difference that makes living organisms different from complex machines. Life can be easily and certainly distinguished from non-life in everyday life as well as in science, with the help of the physical and the biological principle.

This means that the physicalist approach, which assumes that biological activity can be derived from passivity, that the animate can arise from the inanimate, and the living from mere clod-like matter, is mistaken.

## 5. Biology must discover its own universal law

Already in 1935, the year of the publication of Bauer's major work, Nobel Prize-winning biologist Alexis Carrel pointed out that *although biologists had acquired a huge amount of data, they could not interpret them scientifically due to the lack of equations defining biological changes.*

"There is a strange disparity between the sciences of inert matter and those of life. Astronomy, mechanics, and physics are based of concepts which can be expressed, tersely and elegantly, in mathematical language. They have built up a universe as harmonious as the monuments of ancient Greece. They weave about it a magnificent texture of calculations and hypotheses. They search for reality beyond the realm of common thought up to unutterable abstractions consisting only of equations of symbols. Such is not the position of biological sciences. Those who investigate the phenomena of life are as if lost in an inextricable jungle […] They are crushed under a mass of facts, which they can describe but are incapable of defining in algebraic equations. From the things encountered in the material world, whether atoms or stars, rocks or clouds, steel or water, certain qualities, such as weight and spatial dimensions, have been abstracted. These abstractions, and not the concrete facts, are the matter of scientific reasoning. The observation of objects constitutes only a lower form of science, the descriptive form. Descriptive science classifies phenomena. But the unchanging relations between variable quantities— that is, the natural laws—only appear when science becomes more abstract. It is because physics and chemistry are abstract and quantitative that they had such great and rapid success. In learning the secret of the constitution and of the properties of matter, we have gained the mastery of almost everything which exists on the surface of the earth, excepting ourselves. The science of living beings in general, and especially of the human individual, has not made such great progress. It still remains in the descriptive state" (Carrel 1939, 1–2).

It is shocking that this irrational situation has not changed to date. In their article in the prestigious journal Nature, biologists Roger Brent and Jehoshua Bruck put it this way:

"Today, by contrast with descriptions of the physical world, the understanding of biological systems is most often represented by natural-language stories codified in natural-language papers and textbooks. This level of understanding is adequate for many purposes (including medicine and agriculture) and is being extended by contemporary biologists with great panache. But insofar as biologists wish to attain deeper understanding (for example, to predict the quantitative behavior of biological systems), they will need to produce biological knowledge and operate on it in ways that natural language does not allow" (Brent and Bruck, 2006, 416).

It is important to see that the equations of physics are laws of change, determining the character of physical behavior. *Since the great and rapid success of physics is due to the discovery of universal laws of physics, to surmount the "strange disparity between the sciences of inert matter and those of life" we need to discover the universal laws of biology*.

It is very unfavorable for the development of science that the central questions of biology have been off the agenda. As astrobiologist Carol E. Cleland has put it, to give a scientifically convincing answer to the question "what is life?" *we need a sufficiently general theory of life*. In other words, we need a general biology, with its most general, fundamental principle that apply to all aspects of biology, just as the principle of least action applies to physics. Cleland writes about this:

"In order to provide a scientifically compelling answer to the question 'what is life?' we need a theoretical identity analogous to 'water is $H_2O$'. But as the discussion above indicates, this presupposes a theory of living systems. The requisite theory must be general. Just as modern chemical theory encompasses all forms of water (on Earth and elsewhere in the universe), we want our theory of life to encompass all forms of life, wherever it may be found in the universe. *The question is do we currently have such a theory?*

*Many biologists believe that neo-Darwinian evolution provides us with such a theory.* This explains the popularity of Darwinian definitions of 'life' … (T)he popularity of Darwinian definitions suggests that neo-Darwinian evolution might provide us with a sufficiently general theory of living systems.

*Unfortunately, however, this is not the case.* Neo-Darwinian evolution (also known as the "modern synthesis") provides a molecular and biochemical framework for understanding evolutionary processes, and the history and geographical distribution of life on Earth. It is, however, based exclusively upon our experience with familiar Earth life. And there are compelling biochemical reasons for believing that familiar Earth life does not provide us with an adequately general sample of the possibilities for life. (…) Neo-Darwinian evolution explains the astounding morphological diversity of terrestrial life in terms of a common biochemical framework. But molecular analysis of extant organisms coupled with knowledge of the mechanisms of evolution also reveals that much of this diversity is an historical accident" (Cleland 2006, 596–598; emphasis added).

> "*The contemporary quest for answers to foundational biological questions is deeply rooted in Aristotelian assumptions … the Aristotelian character of biological thought may in part explain why we lack a truly general theory for even familiar life (let alone life considered generally). (T)he rapid development and greatest empirical successes of the other natural sciences (most notably, chemistry and physics) occurred after the abandonment of Aristotelian concepts and principles. It strikes me as a bit scandalous that biology is the only natural science whose foundations are still dominated (albeit often tacitly) by neo-Aristotelian ideas*" (Cleland 2019, 32).

## 6. The main path of science is defined by the general scientific method searching for the fundamental principles of nature

The scientific method is a search beyond empirical laws for the fundamental, most general, and encompassing laws that are generated by logical generalization. Since Antiquity, "*The basic idea of inquiry identified here is that there are two «directions» to proceed in our methods of inquiry: one away from what is observed, to the more fundamental, general, and encompassing principles;* the other leads from the fundamental and general to other possible specific instantiations of those principles. *The basic aim and method of inquiry identified here can be seen as a theme running throughout the next two millennia of reflection on the correct way to seek after knowledge: carefully observe nature and then seek rules or principles which explain or predict its operation*" (Andersen and Hepburn 2021; emphasis added). Note that the second direction of inquiry, "from the fundamental and general to other possible specific instantiations of those principles" can be followed only after the inquiry has reached its aim in the first direction, identifying the "fundamental, general, and encompassing principles". Despite more than two millennia of research, it seems that this result has not been achieved. As Francis Bacon, the founder of the modern scientific method, wrote: the true way of investigating and discovering truth starts "*from the senses and particulars, by ascending continually and gradually, till it finally arrives at the most general axioms, which is the true but unattempted way*" (Novum Organum, §XIX, Spedding et al., 1870, 50). Bacon noted that "the way in use" of discovering truth, instead of thoroughly searching for 'the most general axioms', works with 'intermediate axioms' (ibid.).

In biology, this main aim of scientific research has been forgotten. "The aim [of science] is to formulate broad principles that summarize various phenomena in the most general way possible, and that are typically expressed economically and precisely in the language of mathematics. The ultimate aim is to formulate some general principles that summarize and explain all these disparate phenomena" - says the Encyclopedia Britannica in its "physics" entry. *In short, the main goal of science is to formulate a minimal set of overarching fundamental principles which summarize and explain the empirical world in the most transparent way possible.* The nature of scientific explanation should not depend on changes in society. It belongs to the nature of explanation to explain the many with the few; the best explanation is which explains the most with the least. Independently of civilizations and history, at the heart of the scientific method is the simplest explanation of how Nature works. *The main path of science, naturally, has been determined by the main aim of science, searching for the well-founded fundamental principles of Nature.*

Now it is time to face the fact that, without any scientific reason, recently the main purpose of science has been abandoned. Scientific explanation has stopped at the level of natural laws, simply ignoring or rejecting the primary role of fundamental principles in scientific explanation. As the well-known cosmologist Paul Davies writes: "Almost all physicists who do basic research seem to accept that … *the rational chain of explanation is based on physical laws*, in the same way that Euclid's axioms are the basis of Euclid's logical construction of what we call geometry" (Davies 2004, emphasis added). Regarding the importance of the scientific method for a realistic theoretical biology, it is important to notice here that *there is a significant, even crucial, difference between laws and axioms, in terms of the depth of explanation.* The main aim of science can only be achieved through the *most general axioms*, discovering all the fundamental principles. This is because it's not just the phenomena but the laws of nature also need explaining. Only the most general principles can provide an integral, deeper and more insightful explanation than laws. A law of nature explains a whole class of phenomena at one struck; a fundamental principle explains a whole class of laws of nature. *The main purpose of science, to explain how Nature as a whole works, is not achieved by laws, but by the fundamental principles, which are one level of explanation deeper than laws*. In Baconian terms, today's scientists, due to the superficial nature of the present scientific worldview, stop the scientific method at the '*intermediate axioms*' instead of attempting 'the true way' to arrive at the most general axioms of Nature. It was the recognition of the crucial importance of the 'most general axioms' that set "a theme running throughout the next two millennia of reflection on the correct way to seek after knowledge" (Andersen and Hepburn 2021). Even Thales (626/623 – c. 548/545 BCE) was searching for the 'arche', the first principle of all existing things, and not for "intermediate axioms" practical in a certain field of study. The extraordinary importance of fundamental principles was certainly already part of the culture already in Thales' time.

It seems that the main aim of scientific research has been surviving until the 1930's, and Ervin Bauer was one of its last representatives. As Gerald Holton wrote, "The German literature of the late nineteenth and early twentieth centuries contained a seemingly obsessive flood of books and essays on the oneness of the world picture. They included writings by both Ernst Mach and Max Planck, and, for good measure, a 1912 general manifesto appealing to scholars in all fields of knowledge to combine their efforts in order to "bring forth a comprehensive Weltanschauung." The thirty-four signatories included Ernst Mach, Sigmund Freud, Ferdinand Tönnies, David Hilbert, Jacques Loeb– and the then still little-known Albert Einstein" (Holton 2003). It is an irrational development that, since the 1930's, a position that ignores the nature of explanation has prevailed in science.

### 6.1. Ervin Bauer and the Hilbert-program searching for Nature's axioms

Ervin Bauer's ideas were formed early on. His knowing about the program of David Hilbert, one of his Göttingen teachers and one of the most prominent mathematicians of the early 20th century, probably played an important role in this. Hilbert pointed out that "*anything at all that can be the object of scientific thought becomes dependent on the axiomatic method, and thereby indirectly on mathematics, as soon as it is ripe for the formation of a theory. By pushing ahead to ever deeper layers of axioms in the sense explained above we also win ever-deeper insights into the essence of scientific thought itself, and we become ever more conscious of the unity of our knowledge*" (Hilbert 1918, in Ewald 1996, 1115).

Ervin Bauer (1890–1938) began founding his theoretical biology by clarifying the method of science (Bauer 1920a,b; Bauer, 1935, 15–29). It is possible that Hilbert's argument could play a role in turning the young Bauer's attention toward the 'deepest axioms' of Nature. According to Bauer's summary given in the first chapter of his major work, the general method of science begins by collecting data on observable phenomena and experimental results, classifying them according to their common characteristics, and recognize their empirical regularities that hold among these common characteristics. This corresponds to the development of descriptive science. The next step is the systematical generalization of the empirical laws of a given science into universal theoretical laws. *Formulating universal theoretical laws is the first step in the development of theoretical science*. Whereas empirical laws can capture a relatively narrow range of phenomena, theoretical laws capture a much broader range, integrating these empirical laws into simpler, more general and deeper laws.

It was this general scientific method that made possible the extraordinary successes of theoretical physics. It has defined the main path of scientific development. The decisive insight recognized by Ervin Bauer is that *it is this general scientific method that has also set the course for the development of theoretical biology* (Bauer, 1935, 20).

Bauer gives useful examples. In physics, Galileo's experiments on free fall led to an empirical law. Galileo found that free-falling objects fall slowly at first, then faster and faster, accelerating downwards, and that the rate of acceleration is directly proportional to the square of the time elapsed. The law of free fall is an empirical law. In comparison, Newton's law of gravitational attraction is a theoretical law, from which, as a special case, can be derived not only the law of free fall, but also Kepler's empirically found laws of planetary motion.

Bauer recognized that to establish theoretical biology he has to explore the universal characteristics of life common in all living organisms and arrive at their deepest explanation, to formulate the universal principle of general biology. The decisive step on the path to the most efficient method of science is the formulation of a universal principle which governs all the fundamental theoretical laws. *Only in the case of science with a fundamental principle can we speak of a mature theoretical science*.

### 6.2. Modern biology has not developed its own basic concepts

In addition to the primary importance of the universal principle of biology, the other main component of theoretical biology, which deals with the deepest questions of biology, must be the development of its own basic concepts. Carl Hempel, one of the greatest philosophers of science of the 20th century, drew attention to the inextricable link between the concepts and fundamental laws of science. "*The concepts of science are knots in a network of systematic interrelationships, in which laws and theoretical principles form the threads*" (Hempel 1966, 94). Unfortunately, the situation of contemporary biology in this respect is so rudimentary that in their article entitled as "The Tragicomedy of Modern Theoretical Biology" it was characterized as a kind of tragicomedy (Seel and Ladik 2020). János Ladik and Maximilian Seel argue that "*the concepts of contemporary physics are not general enough to describe biology … [they] are also misunderstood or not adequately defined in today's biology. They therefore lead to misunderstandings, confusion, disagreements and possible failures - and these are the ingredients of tragicomedy*" (ibid.). They point out that the explanation of life in terms of physics is unlikely. Rather, they argue, "*new concepts arise in the description and explanation of biological systems, and therefore a more comprehensive theory is needed, encompassing both biology and physics*" (ibid.). And they add: "*the main obstacle to the development of an acceptable theory of life is not computational complexity but conceptual ambiguity*" (ibid.).

There is something tragic about the fact that modern theoretical biology has ignored the central problems of biology, has not followed the general method of science, and has not developed its own basic concepts. As we will see, Bauer exactly defined the own concepts of biology: that of life, responsiveness etc.

## 7. Ervin Bauer's systematic search to find the universal laws of biology

According to the arguments of Ervin Bauer, we can only speak of a theoretical science if we succeed in finding the general laws summarizing and explaining empirical laws (Bauer, 1935, 23). "*Our task is therefore to summarize and express in one or a few laws the characteristics of which are peculiar to all living systems*" (ibid., 32). *There is only one correct approach to proving that biology has its own general laws: to follow the methodology of science, because this is the path that leads to the discovery of general laws* (ibid.).

In order to create a theoretical biology that can be the biological counterpart of modern theoretical physics, Ervin Bauer undertook a systematic exploration of the universal principle of biology. While the laws of nature can be formulated in terms of differential equations, i.e., equations that define instantaneous, step-by-step changes, giving the close-up view, *the fundamental principle must be an integral principle determining the trajectory connecting the initial and the final states at one stroke, giving the panoramic view.*. Instead of 'axioms' which must be postulated, the 'fundamental principles' are observationally grounded. They are obtained, with the help of the general scientific method, from empirical observations.

### 7.1. Ervin Bauer on the mechanistic and vitalistic traditions of biology

In stark contrast to the impartiality demanded by the scientific method, *the two approaches that have dominated Western civilization in recent centuries, the mechanistic – better called as the physicalist - and the vitalist are based on an arbitrary assumption and an unconditional commitment to that assumption*. The physicalist view is based on that arbitrary assumption that life is nothing more than a physical phenomenon caused and controlled by physical changes. The vitalist view, on the other hand, assumes that the only essential element of life in a non-physical, unknowable factor that is present only in living things. Ervin Bauer sheds light on the arbitrary, biased and non-scientific nature of these traditional approaches as follows.

Ervin Bauer considered it unworthy of science that such biased views define the framework of scientific research (ibid., 202–203; Bauer 1920b). He argued that accepting such hypothetical starting points and uncritically adhering to them is far from the way science works. *If we want to do science, the methodology of science must be the guiding principle. Accordingly, once the aim is to provide a scientific explanation of biological phenomena, we must use the methodology of science to identify the most general laws of biology itself and the distinctively biological concepts*.

"Both tendencies [physicalism and vitalism – A. G.] stop before the decisive moment and try to cover up their stagnation with false philosophy. Scientific investigation, however, does not stop, and, in spite of the restraining influence of these tendencies, penetrates ever deeper into the special and general laws of the motion of living matter" (Bauer, 1935, 18). The various properties of the 'life force', its conditions of operation, should be empirically discovered or postulated, rather than merely assumed. *Distinctively biological principles and concepts should be obtained from experience and their generalization so that the facts can then be traced back to them, and thus explained*; just as chemistry has created the concepts of chemical value, isomerism, etc. In this way, too, we must arrive at special biological concepts, principles or results" (ibid., 203; Bauer 1920b). Bauer determined the concept of life by following the general scientific method and formulated it in an exact mathematical form. His theory was able to determine exactly what material changes are inextricably linked to the operation of the universal principle of biology.

### 7.2. Bauer's way of discovering the universal principle of biology through the three requirements

Ervin Bauer developed a qualitatively new approach to establishing the existence of the deepest and most general law of nature, which governs the truly universal aspects of life. Modern physics had progressed from Galileo's law of free-fall and Newton's laws, which summarized Kepler's laws of planetary motion, to the fundamental laws of classical and quantum physics. Since modern biology had not even reached the point of establishing sufficiently general descriptive equations, Ervin Bauer could not strictly follow this path of the development of physics. In his quest to discover the universal natural law of life, he did follow the main path of science in another way. *The task was to explore, summarize and express in one or a few laws the features characteristic to all systems considered living, but only to those* (Bauer, 1935, 32). The Aristotelian concepts about life - metabolism, reproduction, etc. -, do not satisfy this requirement. While Aristotle tried to grasp the nature of life through its observable manifestations, Bauer was searching for that laws which exactly define the nature of life fulfilling the necessary and sufficient conditions of a good definition with a mathematical precision.

Among the most fundamental and universal characteristics of life, he found the principle governing the universal laws of change in biology, which is manifested in the control of behavior (Bauer, 1935, 43–59). Bauer arrived at the universal principle of biology in three crucial steps, which he formulated as the three fundamental requirements for life. For a system to be called living, some basic requirements must be met which are characteristic to all living systems, and only to them (ibid. 32).

The first requirement of life captures the spontaneous nature of the behavior of organisms, which is triggered by internal causes. "*It is characteristic of all living beings, first of all, that spontaneous changes occur in their state, changes of state which are not brought about by external causes outside the living being*" (ibid.). "No one calls a body or material system living if he does not observe changes in it or if he merely observes passive changes in it occurring without the 'active' participation of the system" (ibid.). In other words, if all its changes are only the direct result of external physico-chemical laws, then the system is inanimate. "According to our first requirement, living systems in an unchanging environment necessarily have differences in potentials that can be balanced even without external influence, i.e., they have a working capacity" (ibid. 43).

Bauer went on to formulate the second requirement. If responsiveness is understood as the property of living organisms that after the discharge and the equalization of the potential differences, the system is recharged, the potential differences are restored – "then this characteristic already covers our first requirement, since for recharging, for the restoration of the potential differences, work, energy is needed, which the system can only provide if "spontaneous" processes are taking place in it, without external assistance" (ibid., 40–41). There can undoubtedly be internal causes in physical systems, too. In the case of life-specific behavior, however, the internal causes are continuous throughout the life of the organism, occur on a timescale which is tens of thousands of times longer than the duration of the physical processes in the environment, occurs independently of the physical environment, and fulfill the second and the third requirement, too.

*The second requirement of life is that the equilibration of the potential differences induced in the living organism does not take place as expected from the initial conditions and reaction rates, but is altered by the energizing process taking place in the organism* (Bauer, 1935, 41). In the case of living organisms, the system itself exerts certain internal forces, in addition to the external constraints and forces that are imposed to it, altering the action of external forces, in a way which is not solely the result of changes in the state of the external environment and the initial conditions under which the forces act. The response of the organism does not correspond to the strength of the external action - insignificant effects trigger intense processes; very often there is also a lack of topographical correspondence; a process triggered by a 'stimulus' acting in one place takes place in a completely different place in the organism. The course of the process triggered by an external stimulus cannot therefore be deduced from the magnitude of the influence and the initial conditions prevailing in the parts of the system receiving the influence, since it is precisely these conditions that are changed by the organism through the processes of work (ibid.). It is usual to regard responsiveness as the disproportionality of the external effect and the resulting change of state, in which the individual reaction chains are unknown, while it is assumed that this only applies to the individual discharges, the one-off equalization of potentials, which are determined only by the initial conditions (ibid. 42). With a detailed argument giving illustrative examples as well, in Bauer's theoretical biology gives a biologically defined concept of responsiveness: it is defined as the ability of organisms to respond to the processes of equilibration elicited by external influences by internal processes that require energy and lead to a re-increase in the otherwise equilibrating potential differences (p. 42). While the physical concept of responsiveness is based on a physical process, discharge, i.e., an equilibration process, the biological concept of responsiveness corresponds to a biological process, recharging, a process initiated by inner causes towards regenerating the disequilibrium state. "*Our second requirement is that, in response to an environmental state change, the system necessarily performs work that modifies the state changes induced by the external forcing*" (ibid. 43). Living organisms must exhibit changes that are different from the changes that are manifested in inanimate systems within the same conditions. This requirement is what constitutes biological *responsiveness, or response to stimuli.*

### *7.3. The third requirement: replenishment with biologically directed energies*

According to our first requirement, writes Bauer, living systems in an unchanging environment necessarily have a working capacity. According to our second requirement, in response to an environmental effect or a change of state, the system necessarily performs work that modifies the changes of state induced by the external effect. *The third requirement defines the direction of biological work,* and incorporates the first two requirements. "*The work of the living system, whatever the environmental conditions, is directed against the occurrence of the equilibrium which, in the given environment and the given initial state of the system should occur*" [on the basis of physical laws - GA] (Bauer, 1935, 44). It also connects biological work with structural changes. The living organism's reaction to any external or internal change is to *restructure itself* in a biologically beneficial way recharging its structures by biologically mobilizable energies. In other words, biological work is a kind of re-engineering the organism's structures. "*In a system in which the work done on parts of the system is a fundamental characteristic and general law of the system, as in living systems, we are confronted with other, new laws*" (ibid., 48). "*The indispensable condition for the fulfilment of our third requirement is that the system should use its work to change the conditions prevailing in it, i.e., its structures, to create internal potential differences"* (ibid. 49). *It "expresses those properties of the organism that are usually called adaptation, purposefulness [teleology – A. G.], regulation, unity, and which are considered to be characteristic of organisms*" (ibid., 50).

In this way Bauer arrives, for the first time in the history of modern science, to the suitable scientific definition of life: "Thus, we obtain the universal law of biology, which states: *The living and only the living systems are never in equilibrium, and, through their free energy, they are continuously working against that equilibrium which, within the given initial conditions, would be required by the physico-chemical laws"* (Bauer, 1935, 51). This universal biological principle introduced by Bauer was later called the Bauer principle. He adds: such a general law, if true, leads to correct conclusions in each case. If it does not contradict the facts, explains biological behavior, and thus forms the basis of all investigations, it is called a biological principle. "Our principle must be supplemented in order to obtain a quantitative expression. We assert that the living system always converts its *entire* free energy content into work against the realization of the expected equilibrium. This is already a quantitative statement, and can be experimentally verified by measurements" (ibid., 51; emphasis GA). Accordingly, he formulated his principle in precise mathematical terms (ibid. 52–53). The living organism uses *"practically all its free energy for the work necessary to change the properties of its structure", i.e., to change the physical conditions within it* (ibid. 54). The energy from an external source is used by the organism to create its own mobilizable free energy content, to build, renew and maintain biological structures (ibid. 62). I think that it must be astonishing to realize, after centuries attempting to explain everything by physical mechanisms and conditions, that *all* living organisms, independently of their internal and external conditions, are *able* to behave independently of physical mechanisms and conditions, and manifesting their own fundamental nature, based on their own fundamental principle, deviating maximally from the expectations of the physicists.

The Bauer principle means, first of all, that *the way life works within the given conditions is not in the direction of the least action principle, but in the direction of the greatest possible deviation from it.* This means that the Bauer principle is not derivable from physical laws, it is not a new *physical* law as Schrödinger believed, and it cannot be derived from the principle of least action. The Bauer principle is the own law of biology; it is biology's first universal principle.

Secondly, an important lesson of the Bauer principle is that *life is not directed towards mere survival just at the threshold of sheer survival, but towards improving and uplifting life, towards maximal potential for life, towards well-being in all fields of life*; in terms of mobilizable or vital energy, towards the greatest possible height above death. This means that the desirable life for a living being is, contrary to popular understanding, not an easy, idle, fully comforted life running along the pathways of least resistance, but the mobilization of all energy to achieve the best potential for life. When a process in our organism proceeds towards physical equilibrium, or when an organism's behavior follows the pathways of least resistance, this is the path to decay, to disperse the energy, to fall towards death. In contrast, the main path of life proceeds towards a high level of life which is the farthest from the minimal level of sheer survival. It means if you want to live well, you must do your best for mobilizing all your energies and uplift all your inner states towards their highest possible states. It corresponds to living beings living life fully, living with their full life energy, rather than wasting it. *On the basis of the Bauer principle, we can realize that we are living beings in the literal sense of the word only when and to the extent that we recognize and realize our best possibilities, mobilize our life energy to develop our capacities to cope with difficulties and use it to improve life.*

We can add that the Bauer principle is not limited to the life of the individual. The individual, according to Ervin Bauer's theoretical biology, is a psychogenic concept, not derived from observation of nature, but from self-observation (ibid. 211). Self-observation gives only a partial view of Nature. The view that the individual, conceived within the limits of his skin, is the only unit of life is a partially true and partially false view. The Bauer principle is a universal principle prevailing everywhere and everywhen. It applies to all forms of life, including individual, communal and universal.

### *7.4. What is the fundamental difference between machines and living things?*

Bauer showed by detailed arguments and examples that living organisms are not in dynamic equilibrium (Bauer, 1935, 55–57), are not working on the basis of the Le Chatelier-principle, and are not machines (ibid., 54–59, 64–65). One of the most striking and important differences between living beings and machines is highlighted by the next definition of Bauer's principle: "In the case of machines, the source of work is never a change in the condition or structure of the machine's parts. The forces of the machine parts operate only when the parts are moved by external sources of energy relative to those parts. Meanwhile, the internal state of all the parts of the machine remains virtually unchanged (except for stress, wear, etc.) The function of the machine parts is simply to convert some energy (chemical, thermal, electrical, etc.) into the work of the machine. In living systems, however, the energy of the internal structures of living matter is converted into the working of the machine. The energy input of the machine comes from the outside world and used for relative motions of the components of the machines. In contrast, in living organism the energy of the nutrients is converted into internal work *on the structure of living matter*, changing the physical conditions *within* the 'components' of the organism in a directed way, to renew and transform the internal structure of the components themselves in a way increasing their capability to do work. Living organisms are not machines in the ordinary sense of the word. Living systems are neither thermodynamic nor chemodynamic machines. *They obey their own special laws, which distinguish them from machines and inanimate systems*" (Bauer, 1935, 64–65; emphasis added).

This internal work recharging the gradients within the biological structures regenerating their biological functions is termed as biological work. Biological work is essentially invested at the microscopic, more precisely, at the quantum level (Grandpierre et al., 2014). All molecules are incessantly acted upon by the biological principle, which makes their behavior deviating from that which is physically expected. The energy required for biological work is not provided directly by external sources; the living organisms transform the physico-chemical energies of the nutrients into a biologically directed form of energy, and only after then becomes the biologically transformed energy utilizable for the biological work. As we will see below in a bit more detail, it is impossible to build a machine that works by physical forces in a way that the changes of its molecular states constantly deviate from the changes required by the laws of physics within the given physical conditions.

## 8. The Bauer principle requires a biological interpretation

*Bauer's principle cannot be placed in any branch of physics, including non-equilibrium thermodynamics*, since its very essence is the lawful and maximal deviations from physical pathways. In living organisms, the Bauer principle governs the physico-chemical conditions, including chemical dynamics, reaction kinetics (Bauer, 1935, 47–48; Pross 2003) as well as the conditions within which the laws of thermodynamics are actualized. Bauer was well aware that the theoretical biology he had established required not a physical but a *biological* interpretation; interpreted on a physical basis, it is precisely its essence that is lost. "*In the living organism, the laws of physics and chemistry are valid, but they are subordinated to the higher laws of the biological unit, and therefore manifest themselves in a particular form*" (Bauer 1930, 101). This means that, in living organisms, thermodynamical laws are subordinated to biological governance.

Just as the Copernican turn radically transformed our worldview towards discovering the importance of the physical world, so theoretical biology, which is more profound than theoretical physics, radically transforms our worldview towards discovering the importance of cosmic life. This implies a more complete view about science. For the last four centuries, the words 'physics' and 'science' have meant the same thing, because physics alone has had a theoretical science with universal laws. The emergence of Ervin Bauer's theoretical biology radically changed this situation. Bauer scientifically proved that life also had its own laws. This scientific achievement disproved the fundamental assumption of physicalism. It is necessary to broaden and deepen the concept of science as well as changing our notions about the nature of scientific laws from being merely coercive into laws that prevail only indirectly, becoming more coercive only on a long-term, and can realized only through the mediation of living organisms.

### *8.1. The next step developing further Bauer's theoretical biology: the principle of greatest action*

This is all the more significant because Bauer's theory has been developed further (Grandpierre 2007, 2012a, 2015, 2021a, 2023a, 2023b, 2023c). In order to bring Bauer's theory into the context of theoretical physics, *the principle of least action has been generalized by* *taking into account biological autonomy as well as the Bauer principle*. The "inner freedom" that Paul Davies sees as the core of biological autonomy (Davies 1998, 9) is nothing other than the capacity for, at least within certain limits, freely choose and physically realize an end, in other words, the capacity to act for realizing biological aims.

It is important to see that the Bauer principle is a principle determining the *biological* usage of free energy. In order to clarify the relation of the Bauer principle to the laws of physics, it is advisable to compare it to the principle of least action, because the principle of least action plays a similar role in physics as the Bauer principle in biology. Remarkably, the principle of least action can be regarded as a cost function (Rosen 1967, 4, 155). Cost functions has meanings in biology, engineering and economics. Life can be regarded as a task to use our free energy and our lifetime in the most economical way to realize the ultimate aim of life determined by the directionality of the Bauer principle. Energy and time are the two physical quantities having a primary biological relevance as a biological cost. The 'action' in the principle of least action can be regarded as a cost function that measures, in infinitesimally small intervals, the product of energy investment and time investment and sums them up. *Remarkably, these two quantities are of vital importance for all living organisms; these are the two most important factors in realizing the action in the most economical way.* Let me mention here that, of course, physical systems do not decide about their behavior; it is the working principle of the physical world that determines their behavior.

The action principle is an ideal tool for describing biological teleology or end-directedness precisely because it directly connects the initial state to the final state. Utilizing this important observation, we can give account about living organisms' ability to select the end-state of the processes they initiate. *Biological teleology becomes mathematically describable if we allow the endpoint of the action integral to be a free variable*. In this way, for the first time in the history of science, teleology, which has been banished from science for the last four hundred years, can be defined with mathematical rigor (Grandpierre 2007, 2014, 2021b, c, 2022, 2023a, b; Grandpierre et al., 2014).

In order to account for the living nature of living organisms, this free variable must be fitted to the Bauer principle. The Bauer principle is a maximum principle. The principle thus obtained in these two steps is the *principle of greatest action* (Grandpierre 2007). Thus, the life principle, which has been exiled from science for the last two-and-a-half thousand years, can be defined with mathematical rigor (Grandpierre 2007, 2014, 2021b, c, 2022, 2023a, b; Grandpierre et al., 2014). Remarkably, the principle of greatest action defines the biological directionality of teleology. It offers a guiding principle for our goals in case if we are willing to live our life more fully.

It is important to notice that the principle of least action corresponds to that limit case of the principle of greatest action in which the capacity to act is restricted to the microscopic range, in a rate limited by the uncertainty principle of quantum physics. Instead of life being "*a widespread and inevitable outcome of physical laws which are intrinsically slanted in favour of biology*" (Davies 2006, 252), we can see that, actually, the principle of least action is a limiting case – and an inevitable consequence - of the principle of greatest action.

It is not an easy task to consider the relation of biological purposes to end-states conceived within the framework of the 3+1-dimensional physical world. Biological purposes have their own context *beyond* the 3 + 1 dimensions of physical space and time. It is essential to keep in mind that living organisms must be able themselves to decide on the specific details of their actions. The number of these details is innumerable, since "actually, there are an innumerably large number of properties pertaining to each object" (Ashby 1961, 39–40). Moreover, the same biological purpose can be achieved in many different ways. So, the living organism must, inevitably, decide at least the smaller details of its activities. This means that the 'free variable' in the principle of greatest action corresponds to a biological, at least minimally free 'will', which we might call 'biological autonomy' (Davies 1998, 9–13; Grandpierre 2012b; Grandpierre and Kafatos 2012, 2013).

*By such developments of the Bauer principle, it became possible to account for biological actions, both about the universal, lawful aspect of biological behavior and biological autonomy.* And since plants and animals have a much lower degree of decision-making capacity and have a much higher degree of instinctiveness than humans, the lawfulness of the universal aspect of biological actions prevails in the vast majority of the living world.

Let us illustrate the necessity of decision-making of all living organism by the following example. When a fish is thrown back into the river, life's command is short: live the best possible life! This command does not inform the fish in terms of physical details and spatial coordinates what to do and when. There is an immense number of possibilities to "convert" the ultimate aim of life into a concrete aim what to do now and how. The fish may answer to life's command: OK, but what to do now, turn to left or right? The answer is not told by the life principle. This question must be answered by the fish itself. Organisms commonly have alternative means of performing the same function, therefore, they must decide between biologically equivalent alternatives (Grandpierre and Kafatos 2012). Similar is the case with the aim of behaving well. It is impossible to enumerate or enlist the number of possibilities of behaving well.

The ultimate orientation of biological goals is defined by biological directionality, i.e., by the directionality of the biological principle. *While the principle of greatest action is the source, driver and guiding principle for all biological, life-enhancing goals, the principle of least action is the principle of the most economical realization of biological goals*. While the Bauer principle is the principle of energy management, the principle of greatest action combines energy management with time management.

This brings us to a point that opens up radically new horizons in our understanding of Nature. It becomes apparent that the principle of least action is, similarly to Bauer's theoretical biology, "subordinated" by Nature's causal order to the principle of greatest action. The primary biological cause of biological behavior is given by the ultimate biological aim determined by the principle of greatest action, and can be perceived instinctively. The secondary, at least slightly intellectual cause is determined by a decision about how to realize this aim in the given 3+1-dimensional situation. The arising decision is transmitted through the nervous system to the muscles, where the tertiary, executive, physical causes act and carry out the primary, biological purpose.

Let us illustrate the relation of the principle of greatest action to the principle of least action with an example! A bridge construction company wants to build as many bridges as possible every year. This goal is in line with the principle of greatest action – as it happens, the ultimate goal of the company is to maximize production. But if the company has already translated this ultimate goal into a given spatial and temporal framework, that is, if the company's management has decided where and what kind of bridges it wants to build, then the company should build each bridge in the most economical way, so as not to waste time and energy. *The management of the company should apply the principle of least cost to each bridge; only in this way can the company succeed in building as many bridges as possible and achieve its goal of maximum production*. In other words, the principle of greatest action implies in it a requirement that biological aims should be achieved as economically as possible, that is, based on the principle of least action. It becomes clear that the principle of least action is the best possible tool of the principle of greatest action. The fundamental principle of the physical world is the best possible means for the principle of greatest action to work. It belongs to the logic of the causal order of Nature that the fundamental principle that defines physics is subordinated to the principle that defines biology.

This makes clear the relationship between the two fundamental branches of science, the science of inanimate matter and the science of life, physics and biology. The relationship between biological and physical principles, the principle of greatest action and the principle of least action, can be compared to the relationship between a driver and a car – the biological principle plays the role of the driver, who steers the car to its destination, while the physical principle, at a lower level, determines the behavior of the car and drives it to its destination; with the difference that, in contrast to the driver, the biological principle acts on all parts of the organism simultaneously.

On strict scientific grounds, we found that biology is more fundamental than physics; biological causes precede and determine physical causes in the causal order of Nature. *Biological causes generate such physical causes that would not be present in their absence; they generate all the physical conditions necessary to realize biological teleology.* All these are strong arguments for valuing the importance of Bauer's theoretical biology in respect that he took the first and decisive step towards discovering a deeper level of reality than quantum physics.

The concept of the physical universe is based on an extremely simplified model. Not even a teapot emerges from the equations of physical cosmology (Ellis 2005). The reason is simple: the teapot is created by causes representing teleology arising from life. Life is inseparable from creativity. The inexhaustible richness of details in the Universe, the continuous creation of information in the evolution of the biosphere are completely absent from physical cosmology. The information content of the Universe is 'flowing' into the fabric of the Universe from 'below', from biological causes that exist beyond the quantum level, elicited the Big Bang, enriched and continuously enrich the biological information content of the Universe (Grandpierre 2018).

In this light, it is important to revise our present fundamental system of values, which was established only relatively recently, by the scientific revolution, as I indicated it above in the first paragraphs. As Albert Szent-Györgyi put it, *life itself is more important to us than the details of how matter works*. Accordingly, the realistic, comprehensive science of life is much more important for humankind than the science of inanimate matter. "Life is our single and supreme treasure, the center and essence of everything. It must be the starting point and the end point of any unified approach to understanding human existence with all its phenomena" (Szent-Györgyi 1970, 109). Ludwig Wittgenstein, one of the most influential thinkers of the 20th century, wrote in an often-quoted passage of his major work: "We feel that even when all possible scientific questions have been answered, the problems of life remain completely untouched" (Wittgenstein 1963, §6.52). Realizing that, due to Ervin Bauer, the science of life has born, this famous statement also needs to be revised. Bauer's theoretical biology and its further development are unexpectedly fruitful also for such disciplines like a comprehensive philosophy of life (Grandpierre 2021b), or a comprehensively life-oriented economics (Grandpierre 2022b, 2023c). This may not be a real surprise for those who thinks that the fundamental principle of life,[1] when scientifically grounded, is the best guiding principle in all fields of life.

### 8.2. Even Boris P. Tokin could not agree that the Bauer principle is a general principle of biology

All of these considerations indicate how extraordinarily challenging is to find the proper evaluation of Bauer's theoretical biology. It was Boris P. Tokin who was among the firsts to recognize the significance of Bauer's work and who did the most to make it known. He worked for more than five decades to ensure that Ervin Bauer received the recognition he deserved. In 1931, Tokin, as director of the K.A. Timiryazev Institute of Biology in Moscow, invited Bauer to organize a general biological laboratory and to continue his research on theoretical biology. Tokin took the first step to revive Bauer's memory after the rehabilitation of Ervin Bauer in 1956. He wrote articles and books about Bauer and initiated the publication of Bauer's major work in Hungarian. Moreover, Tokin seems to be the only one who commented on the main point of Bauer's theory, the question of whether there can be an overarching principle of biology from which all its fundamental equations can be derived. But no matter how much respect he had for Bauer's work, even Tokin could not agree with Bauer's boldest thesis, that the universal principle of biology discovered by Bauer can serve as a principle from which the laws of all life phenomena can be deduced. And why, you will see below.

### 8.3. Tokin did not know that there was a fundamental principle of physics

Tokin raises a remarkable question at the end of his book (Tokin 1965) which is crucial for understanding Bauer's entire oeuvre. "In evaluating Bauer's whole work, among many other methodological issues, a central problem arises. Is it possible to formulate a single principle of biology from which the laws of all life phenomena can be 'deduced'? It is true that there is theoretical physics, which is a set of specific concepts and laws of physics … It is also true that there is a need for theoretical biology. However, there is no science which can formulate all the laws obtained empirically in a single principle which covers all the phenomena and from which principle one can derive all the manifestations of the motion of matter which is the subject of the science in question. Newton's laws, or the modern theory of the relativity of space, time and the attraction of mass, are undoubtedly fundamental principles. The principle of the conservation of matter and energy is also a general principle. No natural phenomenon contradicts these principles. But can all the laws of optics, for example, be deduced from these principles? The modern physical interpretation of the atom is equally valid for all matter, but is it conceivable that on this basis one could try to deduce from the laws of quantum mechanics the laws of motion of celestial bodies, for example?" (Tokin 1965, 116).

### 8.4. The biological interpretation of the Bauer principle requires knowledge of the fundamental principles

There are physicists, not a few of them, who hold that the principle of the least action is the sole and exclusive principle of the Universe, which explains all physical processes. For example, Anthony Zee, a Chinese-American physicist, writer, and a professor at the Kavli Institute for Theoretical Physics and the physics department of the University of California, Santa Barbara, wrote: "*The [least] action principle turns out to be universally applicable in physics. All physical theories established since Newton may be formulated in terms of an action. The action formulation is also elegantly concise. The reader should understand that the entire physical world is described by one single action*" (Zee 1986, 109; see also Jennifer Coopersmith' full book, Coopersmith 2017). We have to add that the principle of least action has many different forms, depending also on the types of interactions considered. In contrast to today's so-called Theory of Everything, which attempts to unify the four fundamental interactions, the principle of least action works at a deeper level beyond the concrete form of the interactions. It determines the fundamental directivity of physical behavior. Here it is advisable to think in the most general version of the least action principle which includes all the fundamental interactions in it, and so it can be considered, in a most general sense, as the unified theory of the physical world. In this sense, Tokin's question of deducibility can be answered positively even in the physical framework. And since Bauer mathematically derived the fundamental laws of metabolism, reproduction, growth and responsivity as well, it can be regarded as a universal principle of biology. At the same time, it has more general versions, as I indicated above.

It is just the unusually profound nature of the Bauer principle that means a difficulty for a habitual thinking stopping at the explanatory level of the laws of nature. Even the outstanding theoretical biologist Ludwig von Bertalanffy did not recognize the extraordinary profundity of the Bauer principle, despite the fact that he indicated his hope that, for establishing theoretical biology, "*the attempt will be made to extend*

[1] The principle of life, also in the form life principle, is obtained as a minimal extension of the principle of greatest action including biological motivation, the two basic types of which are emotional and intellectual causes leading to decision-making (Grandpierre 2021b).

*principles like that of least action*" (Bertalanffy 1952, 201), into biology.

Due to the hegemony of the physical interpretation, life is frequently interpreted within the framework of non-equilibrium thermodynamics. In the physical approach, life is treated frequently as if it would be a kind of phenomena of dissipative systems (e.g. Volkenstein 1994). It is typical that without any reasoning, justification or support, scholars classify living beings as dissipative systems, ignoring their most essential aspect, their livingness. As the title of Volkenstein's 1994 book in English says, he considers biology in a physical approach: "Physical Approaches to Biological Evolution". The question of whether the physical approach is suitable or not for understanding the central problems of life escapes due attention by accepting this approach.

At the same time, thermodynamics can be a suitable tool in the study of life and Ervin Bauer's theoretical biology. For example, Erwin Schrödinger (Schrödinger, 1944/2012) has obtained important insights about the nature of life with the help of thermodynamical considerations. The thermodynamic concept of extropy has been shown to be particularly suitable for characterizing the energetic aspect of biological behavior by the distance from physical equilibrium (Grandpierre 2012c). Recently, Gábor Elek and Miklós Müller (Elek and Müller, 2024) discussed the relation of thermodynamics to Bauer's work in more details (ibid.). As they also pointed out, the Bauer principle requires not a thermodynamical, but biological interpretation. Of course, every biological process has a physical aspect that is suitable for scientific study. Yet through a physical study we will not obtain the answer to the question that is at the heart of biology, "what is life?".

## 9. Interpreting the theoretical biology of Ervin Bauer – was he a dialectical materialist or a more deeply thinking scientist?

Ervin Bauer's theoretical biology could be interpreted in one of two basic ways, as a dialectical materialist theory or as a more profound biological worldview transcending the framework of physicalism. Whatever one may think of dialectical materialism, this question cannot be avoided, because Bauer wrote his major work in the Soviet Union, where dialectical materialism became an instrument of the ideology obligatory for scientists as well. Now we must be able to distinguish dialectical materialism as a philosophy of science, which guided scientific research of the time, from its connotations of ideological coercion.

It is noteworthy that in Bauer's time, and indeed to this day, there is only one elaborate philosophical system which claims that biology must have its own fundamental law(s), independent of physical laws. That philosophical system is, remarkably, just dialectical materialism. Dialectical materialism, primarily through the work of Engels (1883), provided a conceptual framework for biological laws in which the fundamental laws of nature form a three-levelled structure: (1) the basic laws are the physical laws, (3) the highest-level laws are the laws of society, and (2) the biological laws are in the middle. Since the basic laws of physics are known, and those of society, allegedly, are also given by Marx and Engels, the only unknown factor in this picture was the fundamental law(s) of biology. Thus, the discovery of the fundamental principle of biology was also of epoch-making importance in the context of dialectical materialism. With the discovery of the universal principle of life, due to Ervin Bauer, the scientific foundation of dialectical materialism could be considered complete. Bauer's work could be easily regarded as one of the 'crown jewels' of dialectical materialism.

At the same time, dialectical materialism demanded that the laws of life be subordinated to physical conditions. Bauer's life and the fate of his entire theory depended to a considerable extent on his ability to meet these ideological demands and to defend himself against possible ideological attacks. Actually, Bauer's life's work perfectly fulfils the requirement of dialectical materialism regarding physical laws as fundamental and that biological and social laws only come into being at a later, higher level of the organization of matter, when the material conditions for life and consciousness have already been established (as it was claimed later on by Oparin; Oparin, 1960). According to this dialectical materialist interpretation, the Bauer principle is strictly limited to the organization of living beings, i.e., it is a local law. Outside the living beings, presumably in the vast majority of the world, physical laws determine the fundamental direction of processes.

In the Introduction to his major work, written in 1935, Bauer writes that the conditions for the laws of motion of living organisms are the state, organization and structure of the matter of living organisms. In this way, he is formally in full conformity with dialectical materialism, in a certain sense subordinating biological laws to physical conditions, classifying the biological laws as depending on physical conditions. At the same time, in presenting his results, Bauer defined his principle as a universal law.

Indeed, Bauer's major work can be read in several ways. If viewed through the lens of dialectical materialism, it fits perfectly into the system of dialectical materialism even on a second reading. However, there are circumstances which indicate that this impression must be received with reservations. These circumstances are such that to observe them we must step outside the context and mindset of dialectical materialism and return to the most general methodology of science, as Bauer did. It is in this broader, biological context that it becomes apparent that Bauer's work goes beyond the framework of dialectical materialism, pointing towards the establishment of a unified, comprehensive natural science.

According to the thinking of those who consider physics to be fundamental, life is not more than the working of physical laws within the given, extremely complex physical conditions. For them, these physical conditions represent the essence of life. There is an underlying truth in this view, namely that highly organized life is sensitively dependent on physical conditions.

However, it is important to see that the physical conditions necessary for life cannot arise from physical laws. Indeed, to create the conditions for the first cellular life on Earth, as Oparin has shown (Oparin 1960, 9–13, 29–31), purposeful organization is required, in a degree that is vastly superior to even that of the most complex machines. Physicists knows no purposefulness; it is usually not necessary within the framework of physics. As Paul Davies writes: "teleology represents a decisive break with traditional scientific thinking, in which goal-oriented or directional evolution is eschewed as antiscientific … these may not be fatal flaws, but they certainly make scientists nervous" (Davies 2006, 300). The real point for us here is not don't "make scientists nervous" but to recall that the main aim of science is to understand how Nature as a whole works, regardless of today's scientific preconceptions and ideological expectations.

Actually, there are cases where physicists cannot ignore the existence of teleology. One such case is the operation of machines. No machine can come into existence until it has a purposeful organization that is suitable for the performance of its functions. The motions of the parts of machines act as input conditions for the physical laws securing the working of machines. The structure of the machines contains purposefulness. As parts of the machines move, the input conditions of the physical equations change in such a way that, under these changing conditions, their solutions, the "outputs" of their physical equations lead to results corresponding to the operating principle of the machine. As the eminent physical chemist, economist and philosopher Michael Polanyi put it: *the operating principle of a machine is the principle of control at a higher level of organization, which utilizes physical laws for human ends*. The behavior of machines is, at the same time, governed by physical laws and physical conditions. The purposeful organization determining the relative motion of the parts of machines is determined by man; at the same time, the spatio-temporal motion of the machine's parts is governed, within the actual conditions, by physical laws. Yet the way a machine works is fixed. The working of the machine lies in the *fixed order* of the *purposefully organized* input conditions of physical laws, in a way suited to human purposes (Polanyi 1968). *Machines are manifestations of a two-level causality: at the higher level of their operating principle, they represent teleological, purposeful causation; at their lower level, they* *represent physical causation.*

*Living organisms, unlike machines, are manifestations of three levels of causality.* Their first, highest-level teleological organization corresponds to the directionality of the principle of greatest action – or, in a more general context, to the directionality of the life principle. Their second causal level corresponds to their momentary biological aims determining the momentary states of the biological structures of the organism. Their third causal level is given by physical causes executing the momentary biological aims. Since their momentary biological aims are constantly changing, demanded by the continuously varying external and internal conditions, living organisms constantly and flexibly modify the way of their second-level teleological organization. In a living organism the purposeful organization of the organism itself continuously changes; the 'parts' as well as the momentary 'design' of a living organism constantly change. *Accordingly, in the case of living organisms the 'order' of the purposefully organized input conditions of physical laws is also constantly changing, at variance with the case of machines.*

As Bauer writes, physical laws are independent of whether "the movements in question actually occur in nature" (Bauer, 1935, 24). The most general biological laws, precisely because they are always and everywhere valid, are necessarily independent of any particular physical conditions. The universal principle of biology is therefore independent of whether the material conditions for the emergence of life are present or not. It prevails in cosmic space before the big bang occurred in the quantum vacuum as well as prevail on Earth before the birth of the first living Earth cell. Bauer himself implies this (ibid., 24–25). This also explains why the physical processes in the formation and development of the Earth could have led, under biological control, to the creation of the physical and biological conditions necessary for the birth of the first cell (Grandpierre 2013). All this means that *physical laws and conditions that arise on a physical basis are not sufficient for the conditions necessary for life.*

Bauer has shown that the universal principle of biology governs the changes in the energetic state of molecules and in all their structures. We can conclude that this principle must operate at a level deeper than the molecular one. Since the energetic states of molecules at the level of physics are governed by the laws of quantum physics, the biological principle must act deeper than the quantum level. *The biological principle is the principle governing – and purposefully organizing - the input conditions of quantum physical laws.* The biological principle, together with its inseparable biological autonomy, may be interpreted as providing the continuous 'observation' that continuously 'jumps' quantum wave functions in a way serving biological purposes. Due to the extreme complexity of living organisms the energetic states of molecules, supramolecules and higher organizational units form continuum bands offering favorable conditions for biological governance with infinitesimally small energies. As Bauer has shown, the energetic state of each molecule in the organism of a living being must constantly change in ways different from each other, also in ways different from what is expected on the basis of physical law, and, at the same time, in ways that are in accordance with the biological purpose(s). This is why living organisms are not machines; instead, they can be seen as attached to the ultimate goal of life, and to that end they are constantly producing new machines from their structures that best serve that ultimate goal under the physico-chemical circumstances. The physicist has no way of setting up for each molecule a 'traffic light', a microscopic policeman or 'Maxwell's demon' capable of forcing each molecule individually to change at each moment in a way different from the local physical conditions and the laws of quantum physics, all different from the others. In each infinitesimal time step of extremely short duration, the biological principle can only act within the limits of the Heisenberg indeterminacy relation. But many small changes can do a lot if they are lawfully and purposefully organized.

The principle of greatest action provides exact scientific basis for interpreting all the new disciplines mentioned above in the paragraph about the new disciplines of anthropic cosmology, astrobiology and others. In this light, it becomes clear that *physical cosmology is only a part of biological cosmology, that life is a deeper and more fundamental reality than matter, and that matter is the means of the manifestation of life on the cosmic stage.*

## 10. Teleonomy and teleology: the two fundamental types of biological directiveness

It is highly useful to distinguish between two fundamentally different types of biological directionality: (1) the first corresponds to non-conscious, instinctive end-directedness manifested in the structure, function and behavior of living organisms, and the other (2) to characteristically conscious goal-directed activities. At variety with widespread beliefs, I consider that living organisms have only one instinct, the life instinct, that governs all their activities in all fields of life.[2] Accordingly, instinctive behavior is to be distinguished from species-specific activities.

While deterministic physical laws have a coercive nature, the realization of the life instinct depends on the decisions of the living organism. The ability of decision-making is rooted in the fact that the end-state of the greatest action principle is a free variable (Grandpierre 2007). This means that the principle of greatest action involves a two-level causation. The fundamental or ultimate biological aim, the aspiration towards the greatest height above the physical equilibrium (measured in entropic, more precisely, in extropic units, ibid.) in the longest timescale of life, is given by Nature. At the same time, the living organism has to decide itself about (i) whether it identifies itself fully with life's ultimate aim or, instead, it has a different aim, and about that (ii) within the concrete situation, what kind of longer- or shorter-term goals are necessary to realize the aim with which it identified itself. Naturally, living organisms can act in full agreement with the directivity of the life instinct; in that case, they can preserve or regenerate their full biological integrity. They can also deviate from it; but if they deviate too frequently from it, their biological integrity will be sooner or later seriously damaged.

It is a fact that all species behaves fundamentally instinctively, except human beings. It belongs to human nature that, while we are inclined to preserve and develop the integrity of our living nature, we also tend to preserve and develop our full intellectual integrity. The unique, extraordinary character of human intellect, its universal range and its corresponding universal responsibility, opens wide perspectives also before deviations of the intellect from following the life instinct. When the intellect uses its life-given freedom to ignore or deny the instinct of life, a fundamentally new situation arises which is characterized by the exclusive dominance of conscious goals and alienation from the fundamental directionality of life. It is this circumstance that gives primary importance to the distinction between the two basic types of behavioral orientation. The first corresponds to behavior that is characteristically instinctive; the second is that in which conscious goals play the dominant role. *The first type gives rise to teleonomic, the second to teleological behavior.* The ideal case preserving the full integrity of human nature is the one in which their relationship is not antagonistic but harmonious, in which reason promotes the main purpose of life as best as possible in the given life situation. The life-given freedom of the human intellect can be helpful regenerating human integrity when realizing that the life instinct recently became intellectually clarified due to the Bauer principle and its generalization, the life principle.

[2] The instinct theory of biological motivations tells that biological motivations arise from the life instinct. Today, the concept of the universal life instinct is replaced by fixed, species-specific, biologically inherited reflexes and reflex-like patterns of behavior. Realizing that the life instinct is much more fundamental, flexible, and is fully consistent with human free will, it is possible to show that all the main objections against the instinct theory of motivations (Nevid 2017, 280–281) become invalid.

In this way, teleonomy is found as corresponding to instinctive behavior, guided unconsciously by the life instinct; teleology is found as corresponding to conscious purposefulness. This interpretation gives back both the goal-directedness, 'nomic' lawfulness and internality of teleonomy.

Through the glasses of physicalism assuming that only physical causes may exist, both teleology and teleonomy seems to be not more than mere appearance, a result of physical causes, arising from, e.g., complexity and physical laws. Ernst Mayr in 2004 considered that the dual control of living organisms is due completely to the genes: "In contrast to purely physical processes, these biological ones are controlled not only by natural laws [Mayr means here physical laws – A. G.] but also by genetic programs. This duality fully provides a clear demarcation between inanimate and living processes" (Mayr 2004, 29). The corresponding metaphysical hypothesis is that the causal relationships within organisms and cells can, in principle, be explained exhaustively by physical mechanisms (Koutroufinis 2023a, 217). Spyridon Koutroufinis pointed out that "the absolute majority of contemporary biologists and Anglo-Saxon philosophers of biology regard that «goal-directedness is an unproblematic causal consequence of the architecture of an adaptive system» (Walsh, 2015, 195f). This line of reasoning considers teleology as explicable merely by a mode of speaking" (Koutroufinis 2023a, 214, 216).

Koutroufinis had shown why teleonomy, or end-directedness, is the most essential property of living organisms, and why it represents a causal level beyond physical causation. As Koutroufinis pointed out: "There is a rapidly increasing number of publications in the fields of genetics, epigenetics, and plasticity that demonstrate the ability of organisms not only to reorganize their own phenotype (West-Eberhard, 2003) but also their genomes (Shapiro, 2011; Sultan, 2015; Jablonka, 2017). The geneticist, James A. Shapiro, speaks about the «natural genetic engineering» of organisms, which means nothing less than that «living cells can engineer their DNA» (Shapiro, 2011, 2). *Those insights have undermined the understanding of organisms as physical translations of genetic programs into phenotypes*. Due to this development, the metaphor of the genetic program is increasingly giving way to systems-theoretical considerations of the organism as proposed by systems biology, a newly emerged discipline based on the assumption that the nature of organisms and cells can be captured by the theory of dynamical systems and physical self-organization" (Koutroufinis 2023a, 210–211; references therein). Koutroufinis has shown by detailed arguments that the systems-theoretical approach, due to its methodology, cannot capture the most essential aspect of living organisms, the end-directedness of biological processes. *"In stark contrast to artificial and natural inorganic systems, organismic and cellular processes not only reach their characteristic end-states, but rather autonomously create the necessary conditions for the production of these states by profoundly influencing their own material constitution" (*ibid. 204). "In sharp contrast to systems biological mechanisms, real organisms are able to change the value of most quantities that in mechanistic models are represented by static parameters" (ibid., 222). All genuinely organismic processes produce most of the conditions of their becoming. The organism "permanently and profoundly restructures its own material structure" (ibid., 225). Koutroufinis has succeeded to show that the ability of organisms to autonomously and profoundly transform their material structure escapes the explanatory power of systems biology's mechanistic thinking.

Koutroufinis' remarkable achievement fits nicely with Bauer's, pointing out that the living organism uses "practically all its free energy for the work necessary to change the properties of its structure" (Bauer, 1935, 54), to build, renew and maintain biological structures (ibid. 62). Bauer had shown that *the nature of life is determined by the universal law of biology expressing the biological directionality, or teleology, of biological behavior* (ibid. 50–51). On this basis, it is clear that *physical laws and conditions that arise on a physical basis are not sufficient for the conditions necessary for life*. The conditions necessary for life are generated by biological processes initiated by the biological principle and living organisms. I note here that Koutroufinis also pointed out that *the vitality of living beings rests on their ability to continually reorient their teleological activity to suit the ever-changing circumstances* (Koutroufinis 2023a, 234; emphasis added).

It is this aspect of Ervin Bauer's work that corresponds to the "third transition in science" as argued for by Stuart A. Kaufman and Andrea Roli (Kauffman and Roli, 2023). They called attention to the unquestionable fact that due to the evolution of life on Earth, continuously new, unforeseeable physical conditions are produced which cannot be treated in the Newtonian – or physicalistic – paradigm. They pointed out that the set of possibilities that constitute the phase space or state space defining the set of all possible values of the variables is continuously changing. It is this state space which is fixed in the Newtonian paradigm and which is varying in biology. Koutroufinis had shown that this is the weak point in systems biology which requires a certain set of fixed parameters in order to solve its equations, but in biology the values of these "parameters" are changing significantly (Koutroufinis 2023b, 24–27). Koutroufinis wrote: "as Stuart Kauffman noted two decades ago, we do not have a mathematical framework that can describe a process that modifies its own state space, from which he concluded that «the way Newton, Einstein, Bohr, and Boltzmann taught us to do science is limited»" (Koutroufinis 2023a, 226).

It is easy to see now that the popular concept of autopoiesis is a highly misleading concept for explaining anything definitively biological. As Bauer's and Koutroufinis' quoted works show, a physicochemical model is unable to explain life's biological teleology. As it had been shown, "organismic teleology goes decidedly beyond mechanistic explanations" (Koutroufinis 2023a, 231). As the fathers of the term 'autopoiesis' themselves explicitly stated, *autopoiesis is a physicalistic and mechanistic concept*. In their approach, living organisms are conceived as nothing but machines (Varela 1979; Maturana and Varela 1980). Varela's opinion on autonomy is explicitly mechanistic: "Our approach will be mechanistic: no forces or principles will be adduced which are not found in the physical universe" (Varela 1979, 6). "Autonomous systems are mechanistic (dynamical) systems defined as a unity by their organization" (Varela 1979, 55). "An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components …" (Maturana and Varela 1980, 78). "By adopting this philosophy" (Varela, 1979, 7), autopoiesis is "nothing more and nothing less than the essence of a modern mechanicism" (ibid.). Koutroufinis, however, proved that modern mechanicism cannot grasp biological teleology (Koutroufinis 2023a, 2023b).

## 11. The importance of Bauer's theoretical biology

One of the reasons why Bauer's work is not recognized on its own merits is because it is not known. Three years after his major work (1935) was published, in 1938, his works were banned in the Soviet Union, where it was considered taboo for decades; and it was not published in English. Recently, new editions of Bauer's work have been appearing in Russian and his influence is growing. Many of those who know his work write of it with the highest praise. He has solved a problem in biology similar to the main ambition of the greatest physicists, Einstein, Hawking and others, who wanted to develop a theory that can unify all the fundamental equations of physics in a single equation. As Gerald Holton wrote: "Throughout Einstein's writings, one can watch him searching for that world picture, for a comprehensive Weltanschauung, one yielding a total conception that, as he put it, would include every empirical fact (Gesamtheit der Erfahrungstatsachen) – *not only of physical science, but also of life*" (Holton 2003, 27; emphasis added).

Today, due to the almost exclusive dominance of physicalism, the science of life lost its worldview significance. Physicists call the theory unifying the four physical interactions as the Theory of Everything, yet they have not yet achieved that goal. Ervin Bauer, however, managed to solve an even bigger problem, namely the formulation and unification of all the fundamental biological laws into a single equation. This is the reason why Bauer is often presented in Russian and Hungarian literature as a scientist who was far ahead of his time. *He was able, in biology, to achieve and even surpass Einstein's great goal of unifying all of physics in a single equation* (Müller 2005). Alexei A. Uhtomsky, a world-renowned researcher of neuroscience, founding director of the Institute of Physiology at Leningrad State University, dedicated a reprint of one of his papers to Ervin Bauer: "*To the Einstein of biology*" (Bauer, M. 2003). It should be added that, due to the habitual exclusivity of the dominant scientific worldview, it usually goes unnoticed that ideological constraints are not uncommon in science today. As biologist Robin W. Bruce wrote recently about the biological thinking of today, "the nature of true scholarship in our age [is] dominated by pervasive ideology and universal technicism" (Bruce 2013), and that the metaphysics of "evolutionary materialism was allowed to gain a monopoly of the mind" (ibid.).

To all this, we must add that it was perhaps also Bauer's fault - or the ideological constraints of the time - that he was frequently misunderstood, namely, by calling his principle the principle of non-equilibrium. In his main work it is written: "Let us call our principle the «principle of permanent disequilibrium of living systems»" (Bauer, 1935, 51). This naming can easily be misunderstood, since it seems to suggest that the *state* of permanent disequilibrium is the essence of the principle of biology. However, throughout his work, Bauer makes it clear that the essence of life lies not in the *state* of living beings, but in their *behavior*, in the biological work against physical equilibrium. This misinterpretation that places the biological state at the center can be easily dispelled.

It was Ervin Bauer who "*generalized the vast empirical material of biology and, by means of a high degree of abstraction, was the first in the history of biology to attempt to formulate a principle of biology which does not contradict any specific biological phenomenon. It is this principle that makes possible the accurate characterization of life as opposed to the phenomena of the inanimate world*" (Tokin 1963, 325). *Bauer's derivation of all the fundamental equations of biology, including the equations of metabolism, reproduction, growth, responsiveness and all the fundamental phenomena of life from his universal principle* (Bauer, 1935), *indicates its extraordinary importance.* For the first time in the history of science, biology achieved "the ultimate goal of science", discovering the universal principle governing the changes in living organisms. For "one of the main aims of science" is "to give a uniform account of empirical phenomena in the simplest possible systematic way" (Hempel 1966, 94); "it is the organization and classification of knowledge on the basis of explanatory principles that is the distinctive goal of the science" (Nagel 1974, 4).

From the universal principle of biology, Bauer deduced also the relation between assimilation and dissimilation, the impossibility of limitless growth, the existence of limits to assimilation, the limitation of the potential of living matter and the necessity of ageing. He deduced in the language of higher mathematics a series of special laws. He proved, for example, that the total amount of calories which the organism can convert during its entire life depends exclusively on, and is proportional to, the free energy of the ovum. *Bauer developed in a mathematical form a much more comprehensive biology than Darwin's theory of evolution.*

### *11.1. The importance of the Bauer principle for sustainability*

Since Copernicus, the greatest turns in science have all brought paradigm shifts *within the physical worldview*. The work of Ervin Bauer is the first to go beyond this physical worldview, to step outside the existing physical framework of paradigm shifts and create a radically new, biological class of paradigms, *leading to a radically new, deeper and more complete scientific worldview* that could have a decisive impact on the scientific worldview and our whole way of thinking. In this way, it represents an even greater and deeper advance than the Copernican turn in our understanding of the structure and nature of the Universe.

The principle of greatest action is a universal law of nature that binds all living beings together. It binds us in our deepest identity with each other and with Nature. The full appreciation of our deepest, Nature-given identity, that is, of our living nature implies a full appreciation of all forms of life. The principle of life has a cosmic scope. It offers a cosmic principle to guide human behavior. It allows a new, exact scientific understanding of the life instinct. By virtue of our deepest identity, we, as all living beings, tend to act in accordance with the life instinct; however, there can be and there are exceptions, especially in the world of man alienated from himself and from Nature. This alienation is closely linked to the greatest problem of our time, long-term unsustainability (Grandpierre 2022b). In this respect, the cosmic life instinct can be seen as the source of our natural inclination to live up to our deepest selves and act for the well-being of our individual, communal and social life.

As I see Bauer's theoretical biology, the root cause of unsustainability is the fundamental unsoundness of our way of thinking about the nature of life, and its consequences, the superficial, fragmented way of thinking, the ungrounded way of our life conduct. A healthy, fulfilling and well-grounded way of life requires a deep understanding of the life principle, its cosmic context and depth, shifting our worldview from a matter-centered to a life-centered approach. Regenerating and preserving the health, well-being and integrity of the natural environment requires acting in accordance with its working principle: the life principle.

The most decisive step of sustainability lies in the ranking of our fundamental values according to the primary value of life meant in its individual, communal, social and ecological context. What we really want is not extremely high material wealth but a life rich in fulfilling emotional, intellectual and physical activities. Our deepest identity is rooted in the life principle and our decision-making realizing it.

A prerequisite for sustainability is to learn to respect life in its individual, communal, social and cosmic context in a balanced manner. Cosmic life is one; planetary, social, communal, family, individual and cellular life should be harmonious. The universal nature of the Bauer principle makes it scientifically understandable that the Universe as a whole is living. The Bauer principle identifies the use of all of our life energy for the benefit of universal life as the natural course of life. And because the Bauer principle has more general forms, the principle of greatest action and the principle of life, which is the ultimate source, fundamental drive and compass of biological aims, it is suitable to show us the necessity of setting our goals for the benefit of universal life at the center of our worldview.

There is no doubt that there is a physical side to life, and the physical sciences have made significant strides in understanding these physical aspects. But life, and it is Ervin Bauer who has done most to understand it, is not limited to its physical aspects. The fundamental components of biology, the principle of life and teleology, cannot be understood through physics. Physics is the science of inanimate matter. Biology must become the science of life.

## Credit authorship contribution statement

**Attila Grandpierre:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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