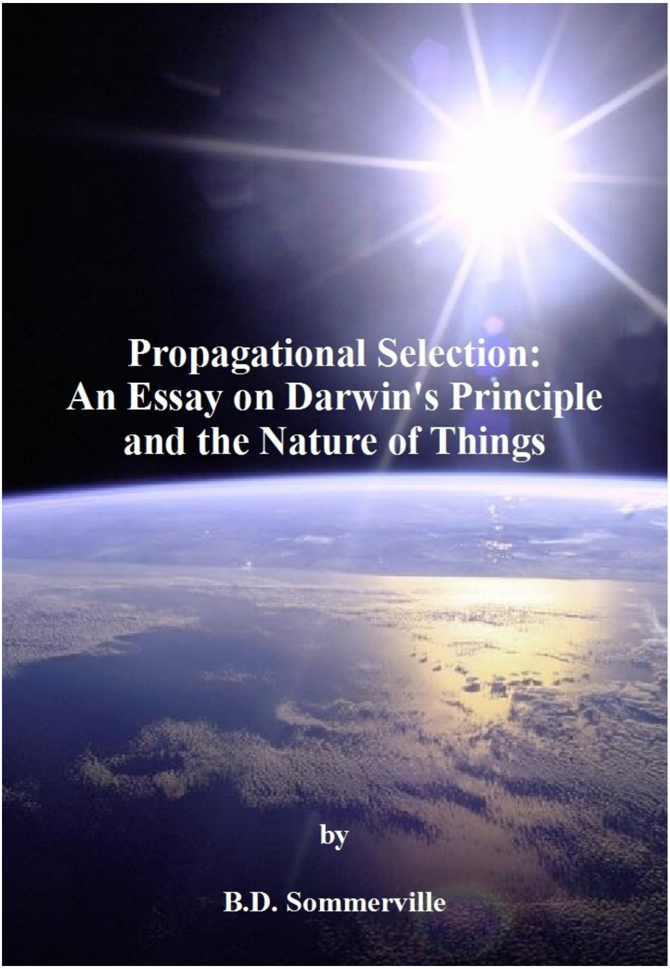

Propagational Selection: An Essay on Darwin's Principle and the Nature of Things

by

B.D. Sommerville

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PROPAGATIONAL SELECTION

THE discovery of the true essence and form of Nature continues to elude scientific enquiry. The fact that present theories of physics and cosmology do not explain the order of nature is conceded by Stephen Hawking in his popular work *A Brief History of Time* (1988), where he states that the mathematical models constructed by cosmologists cannot answer the question of why the universe exists. Of this fundamental question, he writes that “most scientists have been too occupied with the development of new theories that describe *what* the universe is to ask the question *why*.” The ‘why’ question Professor Hawking leaves to the philosophers, albeit in his view they “have not been able to keep up with the advance of scientific theories.” So before addressing the ‘why’ question, philosophers, along with the rest of us, must await the “complete theory” that can be understood by everyone, a theory which he believes to be imminent.[*]

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[*] Stephen Hawking, *A Brief History of Time from the Big Bang to Black Holes* (Bantam Books: London, [1988] 1996), pp. 184-85.

Yet the world has long been waiting for that condition of quiet repose implied by the term “complete theory”. Over the last two thousand five hundred years, cosmologists have fabricated quite a few theories, including those of Aristotle, Ptolemy, Copernicus, Kepler, Brahe, Newton, Einstein and their lesser satellites. Each consecutive theory has been overlaid by a new, sometimes radically different, successor, and there seems to be no reason why the current relativistic and quantum theories should be exceptions. The paradigm changes that accompany scientific activity, analysed by Thomas Kuhn in *The Structure of Scientific Revolutions* (1962), do not enthrone unassailable theories founded on simple mathematical truths. If history is a guide, a complete theory is a distant prospect, and the claim that one is imminent must be taken *cum grano salis*.

In the meantime, who will address the question of why the universe exists, in language that everyone can understand? If the cosmologist is too busy describing, and if the philosopher is unable to keep up with the ‘advance’ of these descriptions, who remains?

Clearly, this is a job for an amateur, for someone who passes his days in idle speculation, someone unrestrained by facts, and without a reputation to lose. And indeed I tremble at my own temerity as I offer a view that owes more to Darwin than to Newton or Einstein. It appears that the deeply satisfying explanation of life's evolution given by Charles Darwin's principle of natural selection far surpasses in explanatory power any corresponding theory of cosmological evolution. Let us, then, consider the proposition that in order to answer the enduring 'why' questions, cosmologists and philosophers should take a leaf from Darwin's book, and further consider the general form that such a theory might take.

As an introduction, it is necessary to contrast the Darwinian method of explanation to the methods used in the physical sciences. Then the application of Darwin's principle to the origin of life is discussed, followed by an extension of that principle to the origin and evolution of the cosmos.

We naturally seek to explain physical phenomena in terms of the faculties of emotion, thought, and will that characterise our own mental life. Thus primitive humans endow inanimate objects with souls or spirits, thereby explaining creation and change in anthropomorphic terms. By applying this method of explanation to the visible universe, the cosmic process has been endowed with a purpose and will embodied in one or more great spirits or gods, who guide and direct their creation towards an end result.

This teleological or goal-directed method of explanation, in a weaker form, still underpins modern physics and cosmology. The very concept that cosmological order is expressible in terms of the ‘laws of physics’, representing absolute and timeless criteria by which events unfold in a deterministic manner, is teleological. This is so because the system of order that the laws of physics describe is assumed to inhere in the nature of things, and to imbue all matter with deterministic and predictable behaviour. This implies that the outcome of any event is determined in advance, its end inhering in its origin.

Yet we should not suppose that the mere existence of something requires that it behave in an orderly or predictable manner. This false association between matter and order, which presupposes guidance and direction, derives from the (rightly) teleological view that our own actions are the subject of guidance and direction by the mind. This mode of theorising in physics, however, merely projects onto the inanimate universe the human capacity for acting according to our will, and hence is both anthropomorphic and teleological. For example, here is an explanation by the 20th century physicist Max Planck of the emission of light from stars:

> Out of all the possible paths leading from the star to the eye of the observer, light will always follow the one which it can cover in the shortest time, allowance being made for the differences in its velocity in different atmospheric layers. Thus, the photons which constitute a ray of light behave like intelligent beings: out of all the possible curves they always select the one which will take them most quickly to their goal.[*]

While this is an extreme example, the more common statements by physicists that an entity behaves in a certain way ‘in order to’ achieve some result suggests a purposive action. Such language, and the attitude of mind it reflects, is unsuited to explain a universe in which intelligence and will seem to be by-products, rather than controlling agents.

Moreover, the physical sciences are hard pressed to explain how those absolute and timeless criteria, expressed as laws, arose in the first place, and their adoption as an assumption is just as much an act of faith as that of any theist. Some descend the teleological ladder even further, explaining order as a reflection of ‘the mind of god’, a belief no better than a superstition. When embracing faith and superstition, the scientist shuns reason.

However, there is a system of scientific explanation

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[*] Max Planck, [1949] 1968. *Scientific Autobiography and Other Papers*. Greenwood Press: New York, p. 178.

that avoids these philosophical problems. Purely descriptive and teleological methods were abandoned by Charles Darwin in favour of the system of explanation embodied in his principle of natural selection, which has an explanatory dimension that the physical sciences lack.

Prior to the publication of *The Origin of Species* in 1859, natural history was a practice in which plants and animals were described and accorded a place in the Linnæan system of classification. Deep explanations of creation were largely the province of religion. Indeed, the theology of the late eighteenth and early nineteenth centuries incorporated this descriptive natural history into many of its soundest arguments for the creation of the world by a benevolent God.

As the nineteenth century progressed, however, geological and palæontological evidence showed that species had existed, and had changed, over vast periods of time, and that large scale destruction of species had occurred in the distant past. Darwin, and his contemporary Alfred Russel Wallace, sought and found an explanation for this, and for the beauteous order of nature, in the process of natural selection.

The science of life then ceased to mere description and became a true system of explanation. The principle of natural selection tells us *why* every form of life is well adapted to its environment. It explains the highly ordered relationship between a species and its changing conditions of existence in space and time. The only forms that reproduce successfully and proliferate are those that have an orderly and conformable relationship to their conditions of existence, while those that do not, fail to endure. Thus the beautiful adaptations we see in the natural world do not reflect the purpose of an omnipotent creator, but are the necessary outcome of natural processes. Nature is impelled to operate in this way, and it is inconceivable that some form of selection would not operate in the natural world. This is what is meant by the term ‘necessity’ when used as a synonym for evolution. The English philosopher James Sully well conveys this aspect of natural selection in an essay published in 1881. “The wondrous correlations and interdependencies of life,” writes Sully, “its curious and beautiful adaptations, are now viewed as arising by a process that is as much a matter of mechanical necessity as the falling of an unsupported body to the ground.”[*]

The idea that the order of nature is the manifestation of a pre-ordained plan, or has any purposive element, is cast off by the principle of natural selection. Biological evolution

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[*] James Sully, “Scientific Optimism”, *Nineteenth Century*, 10 (1881):575.

requires no pre-existing plan, no end goal towards which things tend, no God to initiate or direct the development of life. More importantly for scientific explanation, however, is the fact that natural selection requires no pre-existing form of order, force, or physical law to operate; evolution makes its own order as it goes along. In contrast to the theories of the physical sciences, Darwin's principle is a *dysteleological* explanation, and the elimination of the mystical idea of an absolute eternal plan or order underlying nature is Darwin's great intellectual legacy. This fact is not fully appreciated in the physical sciences, which remain in a descriptive pre-Darwinian stage of development, declining to address the 'why' question.

It might be objected that the theory of natural selection deals only with the macroscopic aspects of life, which are the result of microscopic phenomena that *do* obey the laws of physics: the chemical forces, for example, that determine the structure of the DNA molecule, the chemical basis of life. The process of natural selection, so it is said, is simply the large-scale effect of molecular and atomic forces, and can be reduced to a physical description.

To adopt this reductive view, however, is to relapse into a descriptive and teleological way of thinking. While a purely physical theory might adequately describe natural selection as a mechanical and material process, any attempt to reduce it to a wholly physical theory is to miss the essence of the principle. Its great merit is that it disposes of the need for law, plan, or purpose in nature *on any level*. "Being abstract and outside of time," writes the philosopher Daniel Dennett, the process of natural selection "is nothing with an *initiation* or *origin* in need of an explanation." The blind process of trial and error gives rise to a "timeless Platonic possibility of order."[*] Thus Darwin's principle tells us why order is a constant accompaniment to nature. This quality of *necessity* makes natural selection, as an explanatory first principle, superior to descriptive physical theories, which must always appeal to some lower level theory, or some system of 'law', for support.

Having seen how well the Darwinian theory answers the biological 'why' question, let us consider how an analogous principle might be applied to the inorganic cosmos. As biological order is so well explained by natural selection, can it also explain the measure and harmony of the wider universe?[**]

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[*] Daniel C. Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (Simon & Schuster: New York, 1995), p. 184.

[**] In *The Life of the Cosmos* (Weidenfeld & Nicolson: London, 1997), Lee Smolin advances a theory of "cosmological natural selection", which adopts a multiple universe hypothesis. The aim of the present essay, however, is to consider the evolution of time, space, matter, and energy in our own universe.

The problem is best approached by examining the principle of natural selection in greater detail to see how it has already been extended to explain the origin of life. This is the first step in extending it to the inorganic realm.

In *The Origin of Species*, Darwin states that natural selection involves variation, a struggle for existence, and inheritance, which are pre-requisites for biological evolution. Variation provides the differing materials which are subject to selection, the selective agent being the changing conditions of existence of organisms, including the struggle for existence with each other. Inheritance perpetuates the successful variations:

> Any variation, however, slight, and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection, in order to mark its relation to man's power of selection.[*]

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[*] Charles Darwin, *The Origin of Species by Means of Natural Selection: Or the Preservation of Favoured Races in the Struggle for Life*, J. W. Burrow ed. (Penguin Books: London, [1859] 1985), p. 115.

The role of variation, inheritance, and environment are again emphasised when the essential elements of natural selection are restated: “But if variations useful to any organic being do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance they will tend to produce offspring similarly characterised.”[*]

The phrase “will tend to produce offspring similarly characterised” can be stated more economically as ‘reproduce’. An organism with the useful variation will reproduce more than the one without it, and thus the useful variation proliferates. The differential reproduction of the useful variation constitutes natural selection, which results in adaptation, and the development of biological order.

As originally formulated, the principle of natural selection requires that the organism already have the capacity for reproduction. *The Origin of Species* is concerned primarily with life as it exists today in the living species around us, and in the fossilised remains of past life. The origin of life is not discussed, but only species that have evolved to a high enough level of organisation to be observed easily or to fossilise

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[*] Darwin, *The Origin of Species*, pp. 169-70.

readily. Such species have a well-developed capacity for reproduction.

When considering the origin of life, however, the capacity for reproduction cannot be adopted as a pre-requisite for natural selection for the clear reason that prior to the beginning of life, reproduction, in the strictly biological sense, did not exist. Nevertheless, there is an elementary selective principle which accommodates the processes that have given rise to reproduction.

It is well known that reproduction is an outcome of an elementary form of selection which operated in the distant past among the large organic molecules that were the building blocks of life. The DNA molecule has the capacity to replicate, to make copies of itself, and it is probable that other organic macromolecules (RNA, for example) developed this capacity even earlier. The replication of DNA is the basis of inheritance, and is the process by which useful variations endure.

The most useful variation in a complex organic molecule at the primordial stage is the capacity for replication itself. In the earliest stages of organic evolution, an elementary form of selection would favour any molecule capable of replication, because such a molecule would proliferate more than any other organic molecule that lacked this variation. The former is the fittest by virtue of its capacity for replication, and so dominates, in terms of sheer numbers, all other organic molecules. Thus reproduction, while a pre-requisite for natural selection, is at the beginning of life an *outcome* of an elementary process of selection operating at the first term in the evolutionary series. Reproduction or replication need not be pre-requisites for such a process to occur in the inorganic world; these forms of propagation are the *result* of selection.

This elementary principle of selection has the potential to bridge the physical and biological sciences. As John Olmstead writes:

> In the parlance of biological evolution, self-replication confers a selective advantage to the form that is endowed with that capability, and it is in this context we can view the emergence of life as closely similar to the emergence of a species. . . . Is this concatenation of a physical principle (random sampling in the absence of a clearly directing force) with a biological principle (persistence of a form with a replicative advantage) sufficient from both the scientific and metaphysical perspectives? Occam's Razor favors this rather simple explanation for life's emergence, but reductionism shouts against elevating natural selection to a primary cause.[*]

Strictly speaking, this elementary form of selection is

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[*] John Olmstead III, "Observations on Evolution," in *Entropy, Information, and Evolution: New Perspectives on Physical and Biological Evolution*, Bruce H. Weber, David J. Depew, and James D. Smith eds. (Massachusetts Institute of Technology: Cambridge, Mass., 1988), p. 256.

only quasi-Darwinian, since it applies to inorganic matter, and does not require reproduction as a pre-requisite. Nevertheless, it does employ the elements of variation, selection, and inheritance in the theory, and captures its dysteleological aspect.

The following concept, also framed in this way, constitutes the next step in understanding how a selective principle may be applied to the evolution of the cosmos.

The idea of *propagation*, I suggest, is the key to understanding physical phenomena in terms of a selective principle. By propagation, I mean the capacity for a physical entity or phenomenon to 'make more of itself', or otherwise to transmit its characteristics to like entities or phenomena. For example, the universe seems to have an abundance of space, time, matter, and energy, and these phenomena must have been generated and multiplied in some way. Moreover, the phenomenon of motion is passed, or propagated, from one particle to another. Linking this broader view of propagation to a selective principle, it follows that any entity or phenomenon which through random variation acquires the capacity for propagation will be selected or preserved, and will proliferate.

It follows that the phenomena or entities that are likely to proliferate most, and become the most commonplace, are those with the greatest capacity for propagation. But more than this, *phenomena having a propagative nature are the only kind that seem to have become sufficiently abundant to constitute our universe.* Space, time, motion, and electromagnetic energy all seem to be of this kind.

The property of motion is perhaps the clearest example of a propagative phenomenon that is preserved by selection. The existence of matter, and its constant motion on all scales, from the vibration of atoms in a crystal to the swirling of a galaxy around its centre, is one of the most remarkable and universal phenomena. Motion is transferred from one particle of matter to another through close interaction (or collision) involving one or more of the so-called forces of nature. Motion thus has a propagative quality, spreading throughout any system of interacting particles. Similarly, the product of velocity and mass, momentum, is a compound condition of matter that is propagated among interacting particles. The existence and transfer of motion and momentum, and the thermodynamic processes so arising, may thus be understood as the outcome of selection favouring a propagative phenomenon.

The propagative nature of space consists in its capacity to make more of itself. The observation of distant galaxies has revealed that on the whole they are receding from each other, and that the material universe is expanding. This recession has led cosmologists to conclude that space itself is expanding, either at its outer limit (in whatever dimensions that limit exists), or perhaps throughout its whole extent, in which case space is said to be stretching. The expansion of space might be considered the result of the preservation of a type of space that not only has extension, but which continually multiplies that extension; that is, which propagates.

Since time and space have some similarities, and are often treated together in the form of space-time, a corresponding view of time might be posited. The extension of time may be considered as the propagation of a certain dimension, which we call the temporal dimension. As both space and time are propagated, the space-time continuum expands. We will return to the question of time in a moment.

The propagation of electromagnetic radiation, or light, is another case in point. Once established, an electromagnetic wave will persist and continue to travel in space until it encounters a barrier. The propagative quality of light consists in the generation and continuous recreation of the wave cycle, as it radiates away from its source. The mutual relationship of the electric and magnetic fields, in which one gives rise to the other, is the kind of generative relationship that a process of selection would preserve. Considered as a stream of particles, or photons, the propagative aspect of light may be seen in the transference of energy to other particles with which the photons interact.

Indeed, the universe seems to be constituted largely of propagative phenomena; motion, space, time, and light all are propagative in their own way, by interaction, extension, duration, and radiation, respectively. Although the kind of propagation is different in each case, a general capacity for propagation is something these phenomena all have in common, and this points to a process of propagational selection underlying cosmological evolution.

A fundamental assumption of our discussion is that there is no pre-existing form of order or ‘law’, so the evolution of these universal phenomena must have begun from some primordial chaos, or random variations, occurring very early in the history of the universe. Such a random or chaotic state is likely to be one in which almost any simple phenomenon might arise by chance, since no order or system of causality would yet exist. Any phenomenon randomly gaining the capacity for propagation would necessarily be preserved, while all others would come into existence only to pass out of existence again, or otherwise remain limited and insignificant.

Returning to the difficult question of time, we have seen how moments have a tendency to multiply. Time, however, most clearly manifests itself in the persistence of the material bodies of the universe, or particles of matter. As H. G. Wells's Time Traveller so aptly puts it, "any real body must have extension in *four* directions: it must have Length, Breadth, Thickness, and—Duration."*

Physicists have identified a large number of fundamental particles with differing lifespans, and it is commonly observed that those with short lifespans are very rare in the universe. If we assume that the extension of matter in time is a form of propagation in a temporal dimension, and that in the past a variety of different particles with varying lifespans came into being, then the differential existence of particles with a long lifespan, or whose lifespan is increased through combination with other particles, is a process of selection. Any type of particle having a positive variation in the capacity for propagation in time would be selected, while any variation decreasing the capacity for propagation in time would not be selected. The material universe persists in time because

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*H. G. Wells, *The Time Machine: An Invention* (William Heinemann: London, 1895), pp. 2-3.

particles having the quality of transience are not selected, leaving a residuum of particles with the greatest capacity for propagation in time.

This suggests a novel definition of time in regard to the persistence of matter: The flow of time is constituted by instances of selection in favour of particles which have, through natural variation, the greatest capacity for propagating their initial interval of duration. It is not so much that these instances of selection require time, but that time is constituted by them.

A possible problem with the above statement, the reader may have noted, is that the term “variation” implies change, which requires that time already exist. If propagational selection requires time as a pre-requisite, how can time result from it? A similar objection could be raised against the principle of natural selection: if natural selection requires reproduction (or inheritance) as a pre-requisite, how could the reproductive capacity of organisms be the result of natural selection? The answer to this question has already been given above: we know that inheritance depends on the replication of the DNA molecule, and this capacity for replication is the outcome of an elementary form of selection operating at the first term in the evolutionary series. By the same token, we may expect that when the origins of space and time are better understood, their manner of propagation will be known, and the elemental form of necessity from which they arose identified.

Propagational selection implies that the physical characteristics of matter and energy have evolved as a result of their efficacy in promoting or maximising propagation. Any chance variation in a propagative phenomenon that improves its capacity for propagation would be selected. Such variations might include the advent of, or changes in, such properties as mass, charge, or the forces particles carry. The process by which such favourable characteristics are passed on in the inorganic world to become the norm, and how they effect propagation in any particular case, are questions for the physicist. The answers, however, are likely to be found in existing theories of physics which describe the propagative interactions known to occur between particles of matter, and between matter and energy. Here, the guiding question of the physicist should be: "How does this particular characteristic of a particle or a form of energy further the survival and propagation of the particle or energy?"

Moreover, the descriptive cause and effect explanations so widely employed by physicists can readily be accommodated within the concept of propagational selection, for what is an effect, if not the propagation of a cause? On this view, our cause and effect universe can be seen not as a whim of Nature, nor a deterministic outcome of a set of initial conditions, but as a kind of necessity attendant upon a form of Darwinian selection.

As with biological variations, those being preserved in the inorganic world would satisfy two related criteria: they would enhance the degree of propagation while also having an orderly relation to the prevailing conditions of existence. That is, the new variation must maintain or improve the propagative fitness of the phenomenon with which it is associated, and this requires that it not cause susceptibility to moderation or obliteration by any existing phenomenon. The result must be the emergence of phenomena that can co-exist while propagating to their maximum extent.

The foregoing discussion seeks to articulate, in a very general way, the view that the enduring questions concerning the nature of things might be addressed using the Darwinian method, and to exemplify that method. To recapitulate: Any phenomenon arising randomly from the chaotic conditions prevailing at the inception of the universe, and having the capacity for propagation, must of necessity be preserved, and by virtue of that propagative capacity become abundant. Thus the intrinsic phenomena of which the universe consists, namely matter in motion, space, time, and light are all propagative in their own way, being characterised by interaction, extension, duration, and radiation. Such phenomena are the only kind that would constitute a universe. Moreover, any further variation arising by chance in the propagative phenomena or material entities of the universe, having the effect of enhancing propagation, and having an orderly relation to the prevailing conditions of existence, would also be selected. That is, selection favours the evolution of characteristics that promote co-existence and propagation, giving rise to a universe of order and plenitude.

Certain other metaphysical questions concerning the economy of nature might be similarly approached. The idea that nature does nothing in vain has been a metaphysical assumption of the sciences since antiquity, and finds support in physics, mathematics, and various principles of least action. In the biological world, efficiency is promoted by the competition for resources among the individuals of species. While there is no exact analogy in the inorganic world to the struggle for existence, there may be a similar process in cosmological evolution that determines which variations abound.

The variations in physical properties most likely to be favoured are those that maintain or improve propagation in the most efficient way. This fitness merely consists in the rapid proliferation of the phenomenon compared to those phenomena having less efficient forms of propagation. By efficient is meant forms of propagation that have the most parsimonious energy interactions, that achieve the greatest degree of propagation for a given amount of energy. Thus the most abundant phenomena of the universe, which form the subject of our scientific investigations, must of necessity be those that are most economical, or energy-efficient. The very pronounced effect of such a process may be seen in the inflation of space in the very early universe.

Alan Guth, in *The Inflationary Universe* (1997), gives a theoretical account of the history of the very early universe in which a rapid expansion, known as 'inflation', is described. Guth calculates the comparative expansion rates of two hypothetical types of space, which he labels type A and type B. If these two types of space were to arise together such that type B has a mere 0.001% faster exponential rate of expansion than type A, then the former will very quickly dominate the latter by becoming overwhelmingly larger. Within a second, the type B universe will render the type A universe insignificant, even if the latter has a head start by being initially 10^{1000} times larger. "For the numbers given," writes Guth, "the volume of type B inflation will overtake the volume of type A inflation in 3 x 10^{-29} seconds, and by the end of one second the volume of type B will be 10^3 x 10^{31} times larger than that of type A! . . . The unbelievably large difference in initial probabilities can be compensated in less than a second. *If multiple forms of inflation are possible (which is very likely), then the form that will dominate is the one with the fastest rate of exponential expansion*."[*] (Emphasis added.)

Although he does not characterise it as such, the theoretical possibility Guth describes is a form of Darwinian necessity. The inflationary universe having the greater rate of spatial propagation is preserved, while the other presumably plays little or no subsequent role in the evolution of the cosmos.

In summary, the capacity for propagation seems to be a feature common to space, time, matter, and energy. Their propagative qualities may have arisen randomly, being preserved by an elementary form of selection, the result of which is a universe expansive in space and time, and endowed with matter, motion, light—and life. This view implies that the universe has no purpose, meaning, or value, except that with which we imbue it, since the *raison d'être* of the universe—the

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[*] Alan H. Guth, *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Jonathan Cape: London, 1997), pp. 250-51.

‘why’ of its existence—is simply its own propagation.

Finally, we must abandon the notion that the evolution of the cosmos is sustained by some eternal and absolute quality of order, represented in the so-called laws of nature, and that the history of the universe is a causally deterministic series of events dancing to the tune of some cosmic score. Rather, the history of the cosmos should be considered synonymous with the chance advent of propagative phenomena, their selection, their efflorescence, and their further evolution. While this history has a beginning, it must necessarily have no *finis*—an eternal dawning of evolutionary possibilities, and worlds without end.

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