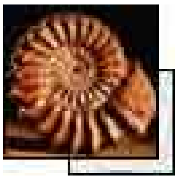
Laws of Nature



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I. The Notion of Natural Law and Its Use in the Sciences

1. The Notion of Law and Its Classical Reference to the Presence of a Lawmaker. The proper context for the notion of “law” is the social/civil context. It contains the idea of a rule or “dictate” (Lat. *lex*, deriving from the Gr. *léghein*, meaning “to say”), but it is also not far from the idea of a tie, or bond (Lat. *ligare*). Like its synonym “norm” (Gr. *nómos*), law signifies a positive prescription whose purpose is to “regulate” (that is, to “order with measure/order according to rule and measure”) the behavior of the members of a community. This immediately implies a reference to an “authority” who is responsible for the law as well as, and this is especially significant, the order and end which this authority intends to introduce or accomplish with the law. Because the concept of law implies that of an authority, world religions have placed the notion of God [2] at the basis of the idea of law in a natural and almost instinctive way. This is demonstrated by the fact that, up to the modern era, the concept of law, even in its strictly social and civil context, was never understood without reference to its theological connotations.

The religious experience of Israel has played a significant role in human culture. One of the most important events in the history of Israel is the giving of the "Law," that is, the Decalogue (cf. *Dt* 5:1-22). The Jewish law is distinguished from extra-Biblical traditions by its depth and transcendence, but it also shares with the laws of other peoples the purpose of regulating both the relationships between human beings and God and the relationships among the members of human society. In keeping with the Biblical message, Christian theology (which in a certain sense extended the notion of law from the positive, civil sphere to the cosmic level and eventually to the natural, moral sphere) would introduce, with the philosophy of Thomas Aquinas, the notions of "divine law" and "natural law." Divine law concerns the plan for the world "conceived from eternity by God" through which the Creator leads all things towards their ends with provident wisdom (*lex eterna est ratio divinae gubernationis*; cf. *Summa Theologiae*, I-II, q. 93). Natural law concerns the law inscribed by the Creator in human nature (cf. *Ps* 19:8-15; *Rom* 2:14-16). The human conscience, in recognizing this "natural law," is able to distinguish good from evil and command the will to perform acts that correspond to the good (cf. *Summa Theologiae*, I-II, q. 94). The human person cooperates in the divine law with human liberty, that is, according to his or her "natural reason." Natural reason is a characteristic of human nature as such, and it sets human beings apart from irrational creatures who follow the divine law according to an "inclination" (an inclination related to their specific essences) that is willed by the Creator. In the opinion of Aquinas, even in this last case of irrational creatures one speaks of "natural laws" as participating in the divine, eternal law, that is, as having an analogous relation to the rational and personal world in which laws are understood and obeyed freely. According to what is meant by analogy properly speaking (which involves proportionality as opposed to a simple metaphor), God the Creator is seen as the "legislator" who "orders and disposes all things according to measure" as the transcendent authority on whom all laws rest. Without identifying the Creator of the world with the law, or with laws, the universal, eternal, and stable character of laws is easily derived from some of God [3]'s philosophical attributes. The laws flow from God's truth and they manifest it, particularly in their regularity or "lawfulness," which in turn suggests their relationship to the notions of constancy and faithfulness. We will deal with the relationship between the Biblical image of God and the epistemology of natural law further on (see below, VI).

2. The Terminology Concerning Laws Used in the Natural Sciences. As heir to the philosophical terminology that has characterized —and, in part, still characterizes— scientific language, science widely uses the concept of "law." The most general definition of law is that of a constant and verifiable relationship, which can typically be described by logical-mathematical language, between the observable quantities at play in a specific phenomenon. If physical observables are involved, the mathematical formalism is generally expressed with an equation that makes it possible to calculate and predict the behavior of certain quantities as a function of space and time. The "mathematization" of a certain phenomenon is, therefore, the typical condition in which a certain law of nature is sought, discovered, and described. At the same time, reducing the phenomenon to mathematics always implies a certain simplification, if not a real loss, of the complexity or richness of the phenomenon in question: We are then dealing with a "scientific" representation (that is, a representation that can be scientifically studied) of nature. The "linear" form of a good number of equations associated with the main laws of nature allows for an efficacious treatment and prediction of the phenomenon under study. As with the 2nd law of mechanics, $F = ma$, or $F = m\, dv/dt$, all linear equations have the property that the sum of two solutions is also a solution. These include complete time-reversibility (the form of the equations do not depend on the sign of t, that is, on the direction of the arrow of time). However, nonlinear equations are equally common, as happens, for instance, with many laws of hydrodynamics in which the sum of two solutions is not a solution. In the nonlinear case, the possibility of a mathematical treatment is much more limited and, in certain situations, strongly conditioned by the accuracy with which one can set the "initial

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conditions." In other words, the set of numerical values of the equations chosen to "scientifically" represent a "natural" phenomenon cannot be solved to determine the "state" of the system in question. The fact that in the 2nd law of thermodynamics the arrow of time admits only increasing values (of time) implies that many laws which incorporate this law on some level (and not only in a strictly thermodynamic context, but also in the more interesting context of chemical reactions and biological processes) are irreversible with respect to time. This gives credence to a vision of the world that is no longer simply a vision of an ordered and balanced universe but also of a universe that has a "history" and which develops and evolves.

In the formulation of a law, two aspects are nearly always at play. The first is an inductive, *a posteriori* aspect related to observation. The second is a deductive, *a priori* aspect, related to a theory or a set of principles with which one attempts to interpret what is occurring. An example of this is the formulation of the "law of gravity" within a specific "theory of gravitation," or of "laws of light propagation" in an "electromagnetic theory," for instance, as described by Maxwell's equations. At times, it is difficult to distinguish between these two aspects. For example, one speaks of three laws, but also of three "principles" of dynamics, of thermodynamics, etc. Even as early as the period of the development of the scientific method, F. Bacon (1561-1626) and later R. Descartes (1596-1650) used the term "law" to signify both principles and functional relations. Nevertheless, the term "principle," just like the mathematical term "theorem," is more often used to describe a system with a hypothetical/conceptual character (think, for example, of D'Alembert's or Hamilton's principle in mechanics, or of the conservation theorems), whereas the term "law" always implies an attempt to order or describe an experimental observation.

Classical physics uses a great number of laws that have become a part of standard terminology. They range from Kepler's three laws of planetary orbits to the laws of Coulomb, Ohm, and Faraday for electrical phenomena, from statistical laws such as that of ideal gases and the law of increasing entropy, to laws of mathematical physics such as Gauss' and Poisson's law. In optics, one speaks of the laws of Fresnel and Huygens and, in fluid dynamics, of the laws of Navier-Stokes and Bernoulli. In cosmology, there is Hubble's law governing the expansion of the universe and the period-luminosity law for Cepheid stars (stars whose pulsating period strictly depends on their intrinsic luminosity). With the help of the latter, discovered by Miss H. Leavitt, astronomers succeeded for the first time in establishing a distance scale that extends beyond the confines of our galaxy. In quantum mechanics, the use of the word "law" has not been abandoned. Planck's law (which governs the radiation from a black body) is used, as are statistical laws such as the laws of Fermi and Dirac and of Bose and Einstein, which describe the energy distribution of a gas of different classes of particles, that is, fermions (of which electrons are best known) and bosons (such as photons).

The concept of law, however, is applied in disciplines other than physics and astronomy. In chemistry, one speaks of the laws of oxidation and reduction and the laws of electrolysis. Biology refers to Mendel's laws concerning the transmission of hereditary traits. There are even laws in disciplines such as economics, of which the law of supply and demand is the most famous. As to the social sciences, sociologists have studied the existence of specific laws in an attempt to describe and predict behavior, trends, and societal reactions to certain environmental and economic circumstances. These laws must necessarily be "statistical," since they attempt to describe "sociological" phenomena on a large scale and as a whole: They cannot describe the free behavior of an individual since the behavior of an individual cannot be predicted scientifically. It is precisely the existence of human free will that limits the applicability of laws in the field of human behavior and makes sociological and economic laws substantially different from the laws of the natural sciences. Any theory or discipline that claims to describe all human phenomena exhaustively and deterministically through the use of laws endorses a

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view in which psychological and social reactions are seen as the necessary consequences of the conditioning to which the individual is supposedly subject. This type of outlook contains an implicit reductionist vision, if not a wholesale denial of free will.

II. The Principle of Lawfulness as the Basis of Scientific Knowledge

1. Why Does Science Speak of Laws? The extensive recourse to the notion of law in the sciences seems to suggest that there must be an epistemological motivation at root. The reason the notion of law is used in the sciences is because the "regularity" and "stability" observed in many natural phenomena was, from the very beginning, the founding principle behind the organization and progress of scientific knowledge. Historically, this started from the spontaneous and increased use of "taxonomy" (the observation and classification of recurrent forms) and, especially, from the instinctive and eventually systematic observation of the sky. The regular rising and setting of the sun, the moon, stars, and the periodic motions of the internal planets (Mercury and Venus) represent, in fact, a grandiose example of "lawful" behavior. The sky [4], with its beckoning toward transcendence, provided the natural link between the lawfulness that was being observed and divine authority. It offered, among other things, a certain relative contrast to terrestrial phenomena whose regularity turned out to be difficult to discern and whose behavior was judged, at times, to be changing and erratic.

Throughout the centuries, scientific inquiry would preserve, nearly unaltered, this sensibility towards regularity, which enters into two phases of scientific research: the observation of the phenomenon, and the repeatability of the experiment. On the experimental side, the search for regularity is almost always associated with the search for a reciprocal relation, which appears to the scientist under the guise of a regular relationship between two or more quantities (which a graph can easily transform into a mathematical expression). In this way, a correlation can be transformed into an equation and thus suggest the existence of a law.

Yet, in an equally original way, the scientist also perceives the "problem of induction." The essence of this problem resides in the question of whether the regularity one observes in a finite and limited number of trials is normative of the phenomenon or whether it can be invalidated from a certain moment on, thereby giving a provisory, and in a certain measure, unfounded character to scientific knowledge. The cognitive value of induction, which is a central theme of the philosophy of science, has been called into question by D. Hume (1711-1776) and by neopositivism. In more recent times, it has been defended by A.N. Whitehead (1861-1947) and J. Stuart Mill (1806-1873) but vigorously contested by K. Popper (1902-1994). It must, however, be noted that the belief in the universal (and, in a certain sense, absolute) character of laws (which is needed to scientifically motivate the problem), as well as the willingness to revise them (accepting their partially conventional character), are attitudes which coexist in harmony in any scientific experience. This is nothing but the effect of the two-fold theoretical/deductive and empirical/inductive (but also idealistic, and at the same time, realistic) aspects present in every scientific investigation.

Recognizing the existence of a "principle of law and uniformity" as the indispensable basis for the process of scientific knowledge—a principle which, due to its importance, not a few authors have referred to as "scientific faith" in the orderliness of nature—is not equivalent to assuming a rigid "principle of determinism [5]." According to the latter, once the state of a system and the laws that describe the behavior of physical-mathematical quantities in space and time are known, it is always possible to *deterministically* know the system's configuration in each past and future moment. The "principle of lawfulness" must also be distinguished from the "principle of causality," which states that every finite or

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contingent entity in the order of being, and every change in the order of becoming, always has a cause. The principle of causality has a metaphysical significance and is therefore much more general: It does not depend on whether the laws of nature are stable or uniform, or on whether it is possible to accurately predict all effects from the knowledge of their causes. In particular, the mechanistic worldview made an unwarranted identification between the principle of causality and the principle of determinism.

2. Law and Regularity in Several Specific Fields. The search for “regularity” also guides the formulation of “statistical” and “probabilistic” laws and therefore, in this case as well, the notion of law is employed. With statistical laws, which originally arose in the context of social phenomena, one attempts to understand the regularity exhibited by a system considered in its globality. This is because this type of law is used when there is no capacity or possibility to observe the behavior of single individuals as they had been previously observed, due to different reasons: the role played by human liberty (as happens, for example, in sociology); the large number of individuals (for example, the use of statistics in biology); the inability to count the mathematical-physical entities involved (as happens, for example, in thermodynamics). The probabilistic laws describing a single individual or entity, and not necessarily an entire “statistical” system, simply give the probability that a certain event (among many other possible events) will occur. They are considered to be *laws* because they are capable of rigorously describing, through what are called “distribution laws” (Gauss, Poisson, Bayes, etc.), what the expected outcome of a certain phenomenon will be. A probabilistic law cannot be directly utilized to predict the behavior of a single event. However, it is capable of predicting behavior for a sufficiently large and practically infinite number of actual cases (as in the law of “large numbers”). Employing statistical laws doesn’t signify a weakening of the principle of causality. This is due to both the broader, metaphysical meaning of the principle of causality, as well as reasons intrinsic to the nature of statistical and probabilistic laws. Statistical laws do not propose to follow the “causal” phenomenon of every single element in the system, while the incapacity of probabilistic laws to precisely predict the outcome of a single event is due to a lack of knowledge of all the determining causes, and not to a defect in causation.

Quantum mechanics [6], due to its robust theoretical apparatus, often refers to “principles,” even though many of them (not the least of which is the principle of indetermination) reveal the existence of a kind of laws of nature, laws that describe “mathematical determinacy,” or the existence of intrinsic limits with regard to certain phenomena. Schrödinger’s equation, which governs the evolution of a wave function of a certain quantum state, is, in the end, a correlation law relating different quantities. A correct epistemology can demonstrate that, in this area of physics, the principle of causality is not invalidated, and that the properties of the quantum world can continue to rest, in the last analysis, on the “specific properties” of particles or of their interactions (see below, V).

3. Natural Laws, Elementary Properties, and Physical Constants. In the context of studying natural laws, scientific observation reveals the presence of “physical constants.” Each of these (such as the universal gravitational constant, denoted *G*) is intrinsically tied to differential equations that describe a certain physical law and can be extracted from ordinary constants of integration, when the equation representing this law is solved in its integral form. From Coulomb’s law to Planck’s law, from Boltzmann’s law to Kirchoff’s law, all of the main equations of physics contain important like-named constants: They are fixed values that are not imposed by the physical-mathematical formalism but are in a certain sense “found” by the scientist who “discovers” the law. Selecting aptly from the units of measure in which equations are expressed, many of these constants are “dimensionless”; that is, they can be transformed into pure numbers independently of the units chosen (e.g., sec, cm, gr, etc.). There are also constants that correspond to stable properties of matter such as the electric charge *e* or the electron mass *me*. The constant *c*, which denotes the velocity of the propagation of light in a vacuum, as well as the four “interaction constants” (which can also be expressed as dimensionless numbers) of the four fundamental

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forces of nature (gravitational, electromagnetic, weak nuclear, and strong nuclear) (see Barrow, 2003).

Interest in the constants of nature arises for the most part from the fact that they seem to offer access to a sort of "substratum of lawfulness" present in matter [7], which is independent from our particular formulations and therefore free from any kind of anthropomorphism. Similarly, if the mathematical form of certain equations may contain a certain amount of arbitrariness, this is not so for the physical constants involved. Taken together as a whole, the constants of nature give a working description of "our" world: They are interrelated and interdependent in such a way that changing only one of them would mean changing practically all of them, thereby changing the characteristics of the entire physical world. The delicate balance existing between the ranges of the four fundamental forces, regulated by numerical values of the corresponding constants of nature, constitutes one of the principle reasons for the interest in and influence of the Anthropic Principle [8] (see Davies, 2007). It is not surprising that the constants of nature have attracted the attention of the greatest scientists. Max Planck (1858-1947), who discovered the constant *h* (named after him) that regulates the scale of interaction between all phenomena of the quantum world, stated that its validity was independent, not only of space and time, but also of other epochs and cultures, and could be extended beyond our civilization on earth.

As I will discuss below in section V, natural laws can be viewed as the effect of "specific properties" existing in the material elements of the physical world that, in turn, are the effect of a metaphysical *form* at the philosophical level, which Aristotle would have called a "formal causality." The law of gravity, for instance, in all of its formulations (Newtonian, relativistic, etc.), indicates the property that every mass has of attracting another mass, or, if one prefers, of curving the space-time in which it is placed. Analogously, electromagnetic interaction "reveals" the property of an electron to possess the same electric charge always and everywhere (whether on earth, or in the Andromeda galaxy, today or 5 billion years ago...). The phenomena of the physical world (one could say something analogous for the chemical and biological world as well, albeit with a certain dependence on what happens on the physical level) therefore exhibit a "formal specificity." That is to say, they exhibit a certain number of qualities, some more or less independent and fundamental than others, capable of referring to an ever more fundamental specificity, eventually leading to individuating irreducible formalities. Science has no need to *define*, or to explicitly *reflect upon* such qualities, dealing as it does mainly with quantities, but it nevertheless finds them in its work and receives them as something *given* from the physical world under study. It is true that in certain areas of contemporary physics one prefers to describe specific properties of elementary particles in terms of reciprocal interactions (the "gauge principle") according to a vision in which significant information belongs to fields, interactions, or relations, instead of to the single particles as such (which are also subject to change in their properties according to the "physical environment" in which they are placed, as happens, for example, between electrons and photons in the presence of a "Higgs field"). However, such perspectives do not contradict the necessity of reality resting on stable and definite properties, but simply imply that such a foundation must lie on a more general and deeper level that takes into account the coordinated behavior of the properties belonging to many individual entities.

In sum, one could say that the "principle of lawfulness and regularity," viewed under the perspective of the laws of nature, of the physical-chemical constants, or of specific natural properties (of particles, fields, or their interactions), suggests the existence of "forms" in nature. Within a more general perspective, one must say that the universe is made not only of matter, energy, or space-time, but also of information *[9]*. In philosophical terms, the interactions and transformations possible in the real world imply not only an "efficient causality" but also and necessarily a "formal causality." The fact that scientific activity mainly deals with the first, and takes the second for granted, should not lead us to disregard the immense significance the existence of forms has in the structuring of the material universe.

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III. The Debate Surrounding the Status of Natural Laws: Comparisons among Scientific, Philosophical, and Theological Thought

The common consensus over the importance of natural laws in the sciences seems to break down when one begins to ask questions regarding their origin and meaning. Several questions arise: whether laws have their basis in the "nature of things" or whether they are determined by the cognitive categories of the subject; whether the regularities we observe in nature correspond to real relations or are instead simple functional propositions; finally, the question arises of whether the laws of nature embody some finalism [10] present in the world or are instead the product of the conjunction of a mere sequence of events.

1. A Few Historical Clarifications. The philosophy of the *Logos* found in classical antiquity admits the existence of universal and stable laws that are responsible for the form and becoming of the cosmos (of which human beings and their destiny are a part). Such a philosophy of the *Logos* has two main forms, Platonism and Stoicism, which embrace two different views of one's relation to nature. Stoicism posits immanent laws whereas Platonism posits transcendent laws. However, in classical antiquity, in both cases, whether immanent or transcendent, laws were placed within a sacred, divine context, which viewed the *ratio* of the law (or of laws) as a reflection of a finalism, or better yet, of a *fatum*. According to Aristotle, the "reason" for the order and regularity of nature does not lie in abstract ideas, but rather in the principles inherent in things, according to a finalism capable of ascending, through the chain of causes, to the First Cause. (According to Aristotle, although chance and indetermination are present in nature, they do not have the same dignity as a true cause.) The only classical philosophy at odds with this scheme was the ancient materialism [11] as it was developed in the atomism of Democritus and Leucippus. They claimed that fortune was the ultimate explanation of everything, and they consequently negated all forms of finalism: They believed in the gods but rejected the notion of the gods as lawmakers, because even the gods are made of atoms and are therefore subject to the whims of fortune.

The Judeo-Christian tradition provided a climate favorable to the development of the notion of law and natural laws (see above, I.1). It contributed significantly to the birth of the scientific method, whose philosophical premises were set forth in the patristic and medieval periods. But, one might ask, "Is recognizing a theological root to laws, and therefore appealing to a Legislator (as Christianity does) equivalent to adopting a *deterministic* vision of nature? To answer this question, it is necessary to keep in mind that in the Christian theology of creation [12] the world does not have the same attributes as the Creator. The "necessity" of that which happens in nature is not absolute but relative with respect to God, who is the only necessary being. Philosophical reflection on the presence of laws, and therefore of a Legislator, deduced from the regularity and lawfulness of natural phenomena, did not coincide, historically, with the affirmation of an absolute philosophical determinism [5]. In general terms, this was because it was a common belief that that which occurred within the material sphere (which in classical antiquity was called the "sublunar" world) was subject to change and corruption and, consequently, to occasional failure. Several clarifications, however, have to be made regarding the heavenly bodies. According to Aristotle, the latter belong to the sphere of the divine. Their eternal motions and their nature are incorruptible. Therefore, they are in no way comparable to that which happens in the sublunar world. In the philosophy of Thomas Aquinas (1224-1274), the conviction remains that the heavenly bodies belong to a higher sphere not subject to corruption. However, he does not attribute divine attributes to the heavenly bodies, since heavenly bodies are completely distinct from God. Aquinas' references to the "necessary" nature of created things (which concern beings on various levels) intend, in the first place, to establish their autonomy [13] and their own creaturely consistency rather than to posit the determinism of their motions. But in a more specific and certainly more radical way, Christian theology considers absolute determinism untenable for at least two reasons. These reasons have to do with both the existence

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of human liberty (which belongs to the world of nature and interacts with it) and, above all, to the existence of the liberty of God on whose will the laws of the world, in the last analysis, depend. It was the late scholastic period, beginning with Francisco Suarez (1548-1617), that increasingly favored erroneously equating the affirmation of God with the affirmation of absolute determinism. This was largely due to the philosophical vision that arose out of interpreting the successful application of mathematical formalism to physical phenomena as indicating a strict link between God [3]'s rationality and the rationality of nature

2. The Vision of the Laws of Nature in the Modern Age. From the modern era onward, the epistemological significance of the laws of nature began to be denied, although without denying —at least in its premises though not in many of its conclusions— a theist vision of nature. This was due in large part to the line of thought initiated by the empiricism of Locke (1632-1704) and Berkeley (1685-1753), which would then overflow into the theoretical formulation of the Scottish philosopher, David Hume. The latter maintained that the regularity of connections that seem to exist between different phenomena, including the cause-effect relation, does not correspond to real relationships existing in nature. Rather, this seeming regularity of connections derives from our repeated experience of seeing events in their sequential combinations, combinations that lead one to think of a law or principle of causality, which, according to Hume, are merely ideas that we project onto the things observed (cf. *An Enquiry Concerning Human Understanding*, 1748). What we erroneously judge to be laws are, according to Hume, nothing but empirical invariants, confined within the unstable horizon of induction, and therefore epistemologically conditioned by the limits of sensible knowledge, a knowledge which operates through subjective habits of the mind. In the critical philosophy of Kant (1724-1804), judgments of empirical knowledge are "synthetic a posteriori" and cannot attain universal knowledge, which is reserved to "synthetic a priori" knowledge, i.e., conditions of knowledge dictated by the categories of the subject (cf. *Critique of Pure Reason*, 1781). According to Kant, natural laws are therefore purely empirical and not universal. They are limited to the "phenomenal" world and are incapable of saying anything about the reality of things "in themselves" ("noumenon").

The heritages of Hume and Kant converge in the neo-empiricism and phenominalism of Ernst Mach (1838-1916). According to Mach, concepts, theories, and scientific laws are none other than pragmatic tools whose study is motivated by a criterion of pragmatic economy and efficacy without any possible implication on the objective plane, or on the ontological one (cf. *The Analysis of Sensations*, 1886; *Knowledge and Error*, 1905). Mach considers the regularity of nature an unverifiable hypothesis (referred to as "the problem of induction"), and laws are only a reconstruction of multiple facts without an intrinsic relation to things. But in Mach's thought we also find an unexpected conception of the world as a whole and the suggestion of a connection between local phenomena and those which occur on the cosmic scale, with a partial revival of the idea of universality as the necessary condition for any research activity.

The critique of the objectivity of the laws of nature delineated by phenomenal empiricism, and later adopted by transcendental rationalism, precludes any reference whatsoever to a "Legislator." Any such reference, if it exists, must be sought along other paths. As interpretations that espouse epistemological skepticism toward a real knowledge of nature (and of the Absolute, as deduced from nature), empiricism and critical transcendental philosophy lead to a radical agnosticism [14]. The classical and medieval philosophical tradition (though making it clear that analogical knowledge of a Legislator, derived from observation of the natural order, had to be developed along metaphysical and not physical lines, e.g., consider the fifth way of Thomas Aquinas), had certainly favored a cultural climate in which the presence of laws, order, and regularity were considered a reflection of the action of an intelligent Creator. The subsequent loss of the original (Biblical and philosophical) conceptual coherence where such a correspondence had been forged favored a certain "absorption" of the notion of "law of nature" into a

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deterministic and mechanistic vision, in contrast with that authentic view of the relationship between God and creation already posited by the finest Christian theology. Descartes became its main adherent: His rationalism maintained and defended the notion of law but exalted its geometrical dimension, its mathematical flexibility, and the ease with which such a notion could be controlled and manipulated. In harmony with the epistemological optimism of Leibniz (1646-1716), and in opposition to the pessimism of Locke and the skepticism of Hume, the greatest supporters of the laws of nature —whether in science with Galileo (1564-1641) and later, in an even more pronounced way, Newton (1642-1727) and Laplace (1749-1827), or in philosophy with Comte (1798-1857)— would not favor the revival of the previous conception of law. The increasingly weakened reference to a Legislator, which was barely traceable in the Anglican apologetics of the 17th and 18th centuries, and was present in an even more ambiguous way in the deism of the Enlightenment, would disappear entirely in the 19th century. The debate over the possibility of arriving at the existence of a Creator starting from creation would become completely absorbed in, and reduced to, debates for and against determinism

3. More Recent Views. Between the 19th and 20th centuries, the situation seemed completely overturned: The French "spiritualists" such as Bergson (1859-1941) and Blondel (1861-1949) —mainly in an anthropological context, but also with implications for cosmology— combated determinism in the name of human liberty, and in the name of the irreducibility of life and the richness of the spirit [15] to a world made only of matter [7]. With E. Boutroux (1845-1921), a critique of determinism was launched from the point of view of the epistemology of natural laws (cf. *The Contingency of the Laws of Nature*, 1874). The notion of law was thus attacked on numerous fronts. It was attacked by Neopositivism (heir to the empirical-phenomenic school of thought), which reduced law to pure convention, to a prioriprojections of the subject, or to propositional functions with a pragmatic value. It was also attacked by those who asserted the inadequacy of scientific induction, which was held to be a kind of aporia if considered against the inference of universal knowledge. Lastly, it was attacked by an anti-determinist vitalism, which does not question laws as such, but opposes a flat and rigid vision of nature and things that it maintains the idea of laws would imply and foster.

Even after the decline of determinism in the second half of the 20th century, philosophers of science would maintain a certain ambiguity regarding their manner of dissecting the theme of the laws of nature, although they would again turn their attention to the epistemological status of laws. With Thomas Kuhn (1922-1996), attention shifted to the great scientific-cultural paradigms that, in their revolutionary changes, sweep along with them every previous conceptual framework and its normative vision (cf. *The Structure of Scientific Revolutions* [Chicago: University of Chicago Press, 1962]). Karl Popper would distance himself from both the conventional/instrumental vision of science and the possibility of arriving at universally valid explanations. According to him, only relations in the mathematical sense, and not essences, can explain stability and universality. Laws of nature are assertions about the structural and relational properties of the world. They cannot, however, penetrate the truths existing at the root of those relations. In a science that progresses by hypotheses and refutations (and which can therefore always be discredited), and in a science that Popper intentionally ceases to attempt to place within a broader theory of knowledge (cf. *The Logic of Scientific Discovery* [London: Hutchinson, 1959]; *Conjectures and Refutations* [London: Routledge, 1963]), the question of truth and of the limit to which all the cognitive processes must tend cannot be fully treated. However, he doesn't completely ignore the topic, either, as it emerges in several of his ethical-social writings (cf. *Unended Quest* [London: Fontana - Collins, 1976]; *The Open Society and Its Enemies* [London: Routledge and Kegan Paul, 1952]). In the 20th century, there was no lack of philosophers who were favorable to a more realist vision of the laws of nature. Among them were J. Maritain (cf. *Philosophy of Nature* [New York: Philosophical Library, 1951]) and R. Bhaskar (cf. *A Realist Theory of Science* [Leeds: Alma Book Co., 1975]).

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4. God, the Universe, and Laws: A Unique Topological Cosmology. John Barrow (1990) suggested a way of summarizing, in topological terms, the possible relations between "Laws," " Universe [16]," and " God [2]." According to the English scientist, the relationship between the universe and its laws can be represented in five different ways. In the first way, the "set" of the universe *U* is a subset of the "set of laws," *L*, that is, *U* ? *L*. This would correspond to the Platonic conception in which laws (that is, their *ideas*) have a certain autonomy and consistency independently from the real cosmos. This view is close to several contemporary conceptions of cosmology, which mathematically treat an ideal multiplicity of possible universes as something that is conceptually (when it is not chronologically) prior to the physical universe as such. In the opposite case, *L* ? *U*, the laws of nature appear to be "islands of rationality" of perhaps local, but not universal, validity. They are changing islands originating from conventional boundaries inside the universe, which maintains its own identity even without its islands. In the third case, *U ? L*, the universe coincides with its laws and therefore is reinforced in its identity and uniqueness, because it would not make sense to speak of time, physics, or models without reference to its existence or in a way independent from it. The fourth alternative is *L* = ? that is, only *U* exists and not *L*. There are no laws of nature because the universe does not admit either regularity or law. In the case that laws do exist, they are pure mental constructs without any real foundation. This is a conception that is very much in keeping with the radical philosophy of randomness, in this instance elevated to the status of definitively explaining the real world. The last alternative is one in which there is no universe *U* = ?. It is equivalent to a kind of physical nihilism in which laws can exist without any need of a universe. It is a vision that radicalizes the first case described above, and is not far from those conceptions of contemporary cosmology that describe the origin of the universe as a random fluctuation of a quantum wave function, whose preexistence, with respect to every possible physical reality, is posited.

If one extends this peculiar topology to the relationship between "God" (*G*) and "Laws" (*L*), other interesting situations arise. A situation in which *L* ? G (the reality of laws is a subset of the reality of God) is, in essence, one of the most intuitive (but not the only) form of a Christian theology of creation: God is the sovereign Creator of the laws of nature who can modify or suspend them according to His will. The other alternative, *G* ? *L*, corresponds to a reductive, if not completely contradictory, image of God in keeping with several "process theologies" in which the nature of God [3] depends on the history of the world. It also practically represents classical dualism, where the divine primordial principles of Good and Evil are subservient to the cosmic law of conflict, which completely conditions their ability to create. Polytheism also falls into this category because, according to polytheism, everything that belongs to the world of the divine follows the same law (*fatum*) of the human and material world. The identification *G ? L* between God and Laws describes the situation of pantheism [17] in its differing versions, ancient and contemporary, including the assumption of a universal cosmic law that replaces a personal God. This is what happens in Buddhism and, more recently, in the New Age *[18]* movement. But the identification between *G* and *L* also indicates identity between the attributes of the philosophical image of God and the laws of nature, which are held to be eternal, absolute, rational, and changeless. For the reasons mentioned above (see numbers 1 and 2) concerning determinism, such a conception of the laws does not correspond to the Judeo-Christian God, even though certain thinkers have maintained they do. Moreover, the Judeo-Christian theology of creation [12] maintains a "real" distinction between God and the world. In order to state, as most theologians do, that "God works through the laws of nature," there is no need to identify the two terms with each other. Finally, the two remaining possibilities, God without Laws and Laws without God, can be associated with two views that are not uncommon today: The view of an *unlawful* God (that is, a God who is not a source of intelligibility and providence), and the atheistic view which holds that the ultimate explanation of natural laws does not refer to any other reality beyond them.

IV. Reflections in Contemporary Science on the Meaning of Natural Laws

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In the past few decades, the debate over the status of natural laws has been sustained mainly by thinkers directly involved in scientific research. Scientists observe, and are surprised by, the stability and mutual connection of laws. They ask why they are intelligible and why the mathematical formalism is so successful in describing them, and they seek a deeper meaning to the fundamental constants of nature. One of the reasons for this type of inquiry is our contemporary, and rather satisfactory, formulation of a consistent, global, evolutionary picture of the universe, which has the capacity to link the physics of the *microcosm* with that of the *macrocosm*. “The concept of law,” Paul Davies says, “is so well established in science that until recently few scientists stopped to think about the nature and origin of these laws; they were happy to simply accept them as ‘given.’ Now that physicists and cosmologists have made rapid progress toward finding what they regard as the ‘ultimate’ laws of the universe, many old questions have resurfaced. Why do the laws have the form they do? Might they have been otherwise? Where do these laws come from? Do they exist independently of the physical universe?” (Davies, 1992, p. 73).

1. What is the Nature of the Laws of Nature? A certain irreducibility of the laws of nature to the category of principles (and thereby claiming an epistemological status for them of their own) was proposed by Henri Poincaré (1854-1912), albeit in a somewhat conventional perspective. J. Clerk Maxwell (1831-1879), Max Planck, and Albert Einstein (1879-1955) offered a decisively realist vision of the laws of nature, insisting on a fundamental faith in the “lawfulness of reality” as a presupposition to scientific knowledge. “In the faith that the real world is governed by laws,” the founding father of quantum theory noted, “the physicist forms a system of concepts and principles, a physical view of the world, which he develops as best he can, so that such a view, which lies on the level of the real world, gives him the same messages as the real world would” (M. Planck, “Positivismus und reale Aussenwelt,” in *Wege zur physikalischen Erkenntnis* [Leipzig: S. Hirzel, 1933]). A correct understanding of this “world view” requires, according to Einstein, that the inductive and deductive approach be inseparable, “The supreme task of the physicist is to arrive at those universal elementary laws from which the cosmos can be built up by pure deduction. There is no logical path to these laws; only intuition, founded upon experience, can reach them” (*The World as I See It* [London: J. Lane, 1955], p. 125). From the logical point of view, laws are “free creations of the human intellect that cannot be justified a priori,” but from the point of view of experience, our intuitions turn out to follow certain norms. Our free creativity is limited by the “liberty” of nature.

Several contemporary physicists such as Carl von Weizsäcker, Richard Feynman, Paul Davies, and John Barrow seem to pursue this line of reasoning. They have all emphasized, albeit with varying perspectives, the “given,” objective, and in a certain sense, founding character of the laws of nature. One can understand the action of the laws of nature only by conceiving of them on the cosmic scale, that is, only by assuming that laws are universally valid. In the introduction to his university course on quantum electrodynamics, Richard Feynman alerted his students, “the reason that you might think you do not understand what I am telling you is, while I am describing to you *how* Nature works, you won’t understand *why* Nature works that way. But you see, nobody understands that. I can’t explain why nature behaves in this peculiar way” (*QED*: *The Strange Theory of Light and Matter* [Princeton: Princeton University Press, 1985], p. 10). The fact that the laws they use are imprecise and can be revised have led a good number of scientists, such as Feynman, to emphasize that laws are descriptions and not explanations, therefore preferring the category of “relation” for them, instead of “essence,” as if the “principle of lawfulness or regularity” seemed to belong more to nature than to its laws. Nature exhibits continually new and unpredictable behavior, however, this is always in a way that does not lead to chaos or indeterminism, but rather to new and more general levels of understanding and lawfulness

In his defense of the objective, epistemological status of natural laws, Paul Davies states, “it is important to understand that the regularities of nature are real. Sometimes it is argued that laws of nature, which are

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attempts to capture these regularities systematically, are imposed on the world by our minds in order to make sense of it. It is certainly true that the human mind does have a tendency to spot patterns, and even to imagine them where none exist. Our ancestors saw animals and gods amid the stars, and invented the constellations. And we have all looked for faces in clouds and rocks and flames. Nevertheless, I believe any suggestion that the laws of nature are similar projections of the human mind is absurd. The existence of regularities in nature is an objective mathematical fact. On the other hand, the statements called laws that are found in textbooks clearly *are* human inventions, but inventions designed to reflect, albeit imperfectly, actually existing properties of nature. Without this assumption that the regularities are real, science is reduced to a meaningless charade" (Davies, 1992, p. 81). One of the reasons used to support this point of view is the fact that laws can predict and explain new events that go beyond the originally studied phenomenon, often allowing for a successful interpretation of other, new phenomena. Starting from proposed laws, one can deduce verifiable consequences in new contexts, which lead in turn to new and unexpected discoveries, often unrelated to the original subject of study.

As has been noted, the problem of the realist view of the laws of nature (that is, other than determinism) has been revisited in quantum mechanics [6]. It must, however, be kept in mind that along with what are by nature idealist interpretations (e.g., Copenhagen's interpretation of Bohr and Heisenberg), there have also been more realist ones, developed by such physicists as David Bohm, John Bell, Richard Feynman, and more recently, John Cramer (see Realism [19]; for a general overview, cf. J. Gribbin, *Schrodinger's Kittens and the Search for Reality* [Boston: Little, Brown & Co., 1995]). As Polkinghorne (1988) has concisely put it, in quantum physics, "we are presented with a picture of the physical world that is neither mechanical nor chaotic, but at once both open and orderly in its character" (p. 341).

2. The Intelligibility of the Laws of Nature and the Search for Their Unification. The debate within the scientific realm over the laws of nature is often associated with the question of their "intelligibility": One wonders how it is they can be described by a mathematical formalism that is relatively simple, and not uncommonly, elegant and a thing of beauty [20]. One also wonders why there is a necessary correspondence between our mind and logic, on the one hand, and the way nature seems to behave, on the other. Such harmony is both a type of faith (we have to "accept" induction) and a realization (the predictability of deduction). From a philosophical perspective, the rules of the debate reproduce those found between a realist and an idealist view of natural laws, as pointed out above. In the religious-theological perspective, the possible Legislator is sometimes dressed in the robes of an Architect. In popular science books, one finds concepts such as the "cosmic code" or "cosmic blueprint." In a sense, the issue of intelligibility is related to the fact that the *substance* of the universe, as already noted, is not only mass-energy, but also information. A certain amount of intelligible information must be coded within the structure of nature, and science deals with its decoding. As a consequence, the old debate about the role of a Legislator, whom the laws of nature seemed implicitly to refer to, has today shifted to debate about the *source* of information and the diverse answers we could posit. One such answer is that information that is intelligible to us is nothing but an immanent and self-consistent cosmic code. Another answer is that information comes from a selection effect ruled by the very presence of human beings, so that our universe is intelligible only because it is capable of hosting life, and is one universe among many possible others, none of which are inherently intelligible. Finally, a last possible answer is that the source of information and intelligibility resides in the creative action of a transcendent Logos.

The consonance that the intelligibility of the physical world could have with the theology of the Christian Logos is mentioned in other entries of this Encyclopedia such as Mystery [21] and Incarnation and Doctrine of Logos [22]. Here I will summarize a number of reasons that suggest why the issue of the intelligibility of nature seems to remain significant for contemporary science as well. First of all, the

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question concerning the meaning of intelligibility cannot be addressed to the laws themselves, because they are precisely what make the behavior of reality understandable and predictable. It must be directed, instead, both to mathematics and to the human mind. Many mathematical properties observed in nature are less obvious than they seem. Not a few laws could have been other than simple, symmetric, and equipped with convergent integrals. It is for this reason that they can be easily approximated with ideal models. Many phenomena with radial or spherical symmetry are described by equations whose variables have "simple" natural numbers as exponents, centralizing all that is "problematic" in the mathematical computation to the transcendental (that is, transfinite) value of p. What would happen if these exponents were complicated rational or even irrational numbers?

If mathematics is to a large degree a projection of the human mind onto the real physical world, the physical world must also have the property of allowing such a "work" of projection, showing itself apt to host a web of logical-mathematical relations that let us interpret and predict many phenomena. The link between mathematics and nature seems to be pushed much further than what the simple construction of real numbers from natural numbers might suggest. "One might (indeed one should) expect that the world evidences itself as lawful only so far as we grasp it in an orderly fashion. This would be a sort of order like the alphabetical order of words. On the other hand, the kind of order created, for example, by Newton's gravitational theory is of a very different character. Even if the axioms of the theory are posited by man, the success of such a procedure supposes in the objective world a high degree of order, which we are in no way entitled to expect a priori" (A. Einstein, "Letter to M. Solovine," March, 30, 1952, Eng. transl. quoted by S. Jaki, *The Road of Science and the Ways to God* [Chicago: University of Chicago Press, 1978], p. 193). One of the ways to drastically reduce the problem is to make the following objection: The laws that govern the cosmos and allow intelligent life to evolve necessarily have to be the same as those that govern the behavior of the human mind. The agreement between the human intellect and natural laws would then depend only on the fact that the brain operates according to physical laws, and that these laws turn out to be completely compatible with the brain. In reality, such an objection is not very convincing. The biochemical and physical functioning of the brain, on the one hand (whose laws are certainly in agreement with those of the cosmos to which it belongs) and, on the other hand, the mind's rational activity of abstraction (with its ability to find mathematical form in physics) operate on two distinct and irreducible levels, as the mind-body relationship [23] seems to indicate. Justifying the fact that we live in a "mathematical" universe only because our universe is "anthropically selected" from infinite possible "non-mathematical" universes is a philosophical a priori hypothesis and not a scientific solution in the strict sense. Finally, the intelligibility of the laws of nature cannot be considered a consequence of natural selection in our biological evolution, because it is difficult to maintain that the ability to solve differential equations has been a historically relevant factor in the survival of the human species. The biological evolution of humans has virtually stopped when human beings have begun to adapt the outer environment to their own life and survival, fundamentally thanks to the birth of culture. Now, the intelligible representation of the world achieved by mathematics is part of that historical and intellectual path, which started precisely when biological evolution ceased.

Without solving the riddle of intelligibility, whose complete explanation does not seem feasible within the scientific method alone, we can conclude nonetheless that both the structure and the intelligibility of the universe are two aspects closely tied to each other. If the scientist accepts as "given" the former, that is, the ultimate reason for why the universe is as it is, he or she is also obliged to accept as given the latter, that is, the profound reason for why we can know it. In principle, it would have been only biologically possible for humans to adapt and organize our place in the world, that is, without any intellectual understanding of it. However, this has not been the case.

The most ambitious field in which both the intelligibility of natural laws and the ability to describe them

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mathematically are evident is without a doubt the project of the unification of the four fundamental forces. Scientists, who have already been able to describe within the same formalism both electric and magnetic fields, have been able, in more recent times, to unify the electromagnetic and the weak nuclear forces, and to experimentally confirm this with the discovery of the corresponding particle/carriers of the unified field. Today, there are several satisfactory theories, usually called the "standard model" or also GUT (Grand Unified Theories) capable of including in the same unified picture a third force, the strong nuclear one. However, unifying the fourth remaining force (the gravitational force) has lead to much greater difficulties. The mathematical formalism used is not univocal, as evidenced by the fact that the equations involved have many free parameters; however, the physical view of the cosmos that emerges from it is highly suggestive. A mathematical unification of the forces is reasonable, and it may progress because the universe is "susceptible to being unified." The formulation of increasingly general "symmetry groups" is undoubtedly the work of the creative mind of the researcher, but nature must contain, in its foundations, on some level, a closely-knit structural reality on which such unifying rationality can rest.

Another offshoot of the search for a unified theory is the exciting, and in a sense seductive, idea of propounding a Theory of Everything (TOE). Although it is not supported by the majority of cosmologists, there have been several animated adherents such as S. Hawking (*A Brief History of Time* [New York: Bantam Books, 1988]) and S. Weinberg (*Dreams of a Final Theory* [New York: Pantheon Books, 1992]). According to this *dream*, the definitive discovery of mathematical-physical laws that, in the first moments of the universe, regulated the progressive separation of the four fundamental forces through "symmetry breaking" occurring as the global temperature decreased, revealing the secret window to the ultimate reason for the existence of these forces, or of the single "superforce" from which they emerged, and would thereby give the ultimate explanation for everything. But the attempt to use a similar unified formalism as an exhaustive description of all of physical reality leads to obvious contradictions, not only on the philosophical level, due to the incapacity of the scientific method to treat the "problem of the whole," but also on the strictly physical level (cf. Ellis, 1991; Barrow, 1990 and 1998). This leads to the classic "problems of incompleteness," either on the logical or ontological level, and it ends by again proposing the canons of an untenable reductionism [24].

3. An Evolutionary View of the Laws of Nature: From Being to Becoming? The increasing importance attributed to the concept of evolution [25] and the greater attention paid to the arrow of time [26], especially from the thermodynamic consideration of irreversible processes, has introduced, in the last decades, important new discoveries in our way of looking at the natural laws, placing them in a highly philosophical framework. Such new discoveries have been described by some authors in terms of a transition from the ideal, ordered, and changeless cosmos governed by natural laws to a real, disordered universe of evolutionary processes. If the scientific interpretation loses its "paradise of laws" (cf. Cini, 1994), it would also lose that philosophical vision that has traditionally been built on the notion of law and, consequently, on its Legislator. Strictly speaking, this philosophical view does not stem from the discovery of the mathematical unpredictability of complex phenomena (I have already alluded to how mathematical predictability is different from both the principle of causality and the principle of lawfulness, which are always at work), but from the fact that, in the origin of the order, structuring, and diversification of reality, there would no longer be the idea of "natural law," but that of "process." This latter notion is supposed to represent higher phenomena such as self-organization, functional development, the emergence of complex structures, and adaptation to and interaction with the environment, which are supposedly those things truly responsible for all the properties and morphologies observed in nature. The new vision would involve physics (giving a greater emphasis to the relational-global elementary properties of matter) as well as, and above all, chemistry and biology, which are fundamentally open to the categories of "transformation," "development," and "emergence."

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The Belgian chemist and epistemologist of Russian origin, Ilya Prigogine (1917-2003), has contributed a great deal to the development of the new vision described above. The study of the evolution of thermodynamic systems *far from equilibrium solutions* allows one to describe the emergence of organized structures that are morphologically more interesting and complex than the initial system (mainly Prigogine and Stengers, *La Nouvelle Alliance*, 1979; see Prigogine, 1980 and Prigogine and Stengers, 1984). The "non-equilibrium solutions," which are possible near "bifurcation points" of a system, are those that are the most "indeterminable." They can, therefore, only be treated probabilistically (in orographic terms, they could be compared to the behavior of a ball on the peaks of contours) and describe the "evolutionary dimension" or the "creative development" of the system. The equilibrium solutions, instead, located far away from the bifurcations (represented by the behavior of balls in the valleys), reduce the system to a predictable and deterministic phenomenon with well-known laws. Such behavior exists in nature where one observes a progressive diversification of chemical, biochemical, and biological laws. And it also holds when we consider the formation of rather structured physical systems (for example, the thermodynamics of a star) out of chaotic systems (the cloud of hydrogen gas from which it is formed). We are dealing with the emergence of "order from chaos" (*Order Out of Chaos* is actually the title of the English translation of *La Nouvelle Alliance*). Non-equilibrium thermodynamics succeeds in describing "islands of decreasing entropy," which contain the novelty of a world in evolution, standing against the background of a global law of "increasing entropy," which instead concerns the universe as a whole, as it moves very probably towards a state of progressive thermal and energetic degradation.

Due to the explicit philosophical slant given to the above mentioned scientific picture by Prigogine himself, such a picture has been used to pose the question of whether the main factor of organization (and interpretation) of the physical universe could be represented by the laws of nature, since the "emergence of the unpredictable" does play a key role. Since natural laws are more easily associated with the description of systems in equilibrium, having stable solutions, and with predictable evolution, they lead to the notions of bond and eternal recurrence; the idea of emergence and complexity, on the contrary, would lead to the notion of creativity and even to that of liberty. In keeping with this change of perspective—and using the terms of what has by now become a classical antithesis—Prigogine holds the primacy of becoming over being, of process over substance, bringing into such an antithesis the great ideas and heritages of philosophy and religion (cf. Prigogine, 1986). He cites the work of M. Heidegger, *Being and Time* (1927), and the philosophy of the process developed by Whitehead, as a more fitting philosophical framework. But there is more. A science whose importance and interpretative power are shifted from time-reversible equations (typical of the natural laws traditionally—and reductively!—understood) to the thermodynamics of irreversible phenomena (which are responsible for the true novelty and richness of the universe and are typically closer to biology) would finally permit "a new alliance" between the material world of physics and the world of humans and life. A less deterministic science, freed from any physicalistic legalism, could dialogue more easily with the humanities, disciplines that are open to liberty and to creativity.

The scientific merit and the epistemological novelty of non-equilibrium thermodynamics are incontestable. However, the majority of the "philosophical" consequences brought about by Prigogine's suggestion are questionable. As alluded to above, these consequences stem from an unconsciously reductive view, not only of natural laws (which he identifies with determinism) and of the principle of lawfulness (identified with the notion of a static order that precludes any novelty), but also of science itself as a whole. The possibility of dialogue among the natural sciences, the humanities, and philosophy has certainly increased due to the abandonment of mechanism, though to overcome mechanism we do not need to reject the notion of laws. The development of such a dialogue depends, in my opinion, on more

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grounded philosophical factors, which would make a new unity of knowledge [27] possible, by providing a better scientific explanation for the "creative" and open behavior of nature.

Non-equilibrium thermodynamics does not constitute a negation of the value of the laws of nature for at least two reasons. In the first place, any thermodynamic system, in whatever way it is represented, does not constitute the "formal cause" of the emergence of an ordered and complex structure, but simply constitutes its material and chronological context. The emergence of novelty is due to an "act of nature": If the act of nature does not have the form of a reproducible law (which is, in fact, the law describing a ball which falls from the top of a hill), this is so due to the non-reproducibility of the same boundary conditions (or initial conditions) of the system, not because of the absence of any principle of lawfulness or regularity (which in this case is the very law of gravity, which causes the ball to fall, even if we do not know where). In the second place, the behavior of fluctuations and instabilities from which the system will later evolve in an unpredictable way can be described by mathematical-physical laws, as happens, for example, in the instabilities that occur in fluid dynamics. As a proof of this, Prigogine would *inevitably* continue to use the notion of law, describing the behavior of nature as a delicate balance between fortune and necessity, between fluctuations and deterministic laws, between symmetry breaking and the laws that cause such breaking.

4. Special Aspects in the Field of Biology. For biology, as opposed to physics, thinking of the laws of nature in terms of "processes" rather than simple regularities does not represent a change of viewpoint. "Laws" are not often spoken of in biology, but their existence is nevertheless evident. The genetic code contained in the DNA of cellular nuclei gives rise to particular developments in a certain individual and not to others. Hereditary traits are transmitted following certain rules of combinatorics. To the same interactions with the environment, living beings react in the same way, that is, according to a "principle of lawfulness," etc. From the historical point of view, the debate over the presence of a possible "Legislator" arose along two classical lines of thought, whose opposition to each other gave, and continues to give, rise to misunderstandings. They are, on the one hand, the use of the marked organization, complexity, and finalism [10] evidenced by living beings for apologetic ends, and on the other hand, the attempt to explain all these features as chance outcomes, by simply appealing to the ideas of accidental genetic variations, natural selection, adaptation to the environment, or other factors. I will confine myself here to mentioning only some recent developments which could aid an understanding of what the term "law" might mean within a biological context (for an overview of the main interdisciplinary aspects, cf. Russell, Stoeger, and Ayala, 1998).

A special case of "biological law" is that of the Darwinian theory of evolution, based on the law of natural selection, which is thought of as a process determined by two factors: random genetic mutation, with the passing of hereditary traits, and the survival of the species whose mutations cause morphologies that are fitter to the environment. Although evolution, as well as adaptation, is certainly at work, Darwinian and neo-Darwinian views are debated today, because the passing on of hereditary traits of mutations is not a fixed rule, and because the origin of mutations is no longer seen as fully "random," but also due to the action of factors other than those once imagined (cf. Jablonka and Lamb, 2005).

The "lawful behavior" of living beings can be outlined on at least two levels. The first level is to consider that there are processes of "steering" or "confluence," through which structural or thermodynamic principles intrinsic to molecular or cellular organization are manifested during the evolution of living organisms, when circumstances make those processes possible (cf. Webster and Goodwin, 1996). It is as if biological evolution did not have to "make a path for itself," but rather simply "follow the contours of the landscape" that had already indicated the path to be taken. One author, Stuart Kauffmann (1995), has underlined the existence of a natural tendency living beings have to develop specific complex structures,

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following paths that are determined by inner processes and outer environmental conditions. Other authors, such as St. George Mivart in the past, and Simon Conway Morris in the present, have explicitly spoken of “evolutionary convergence,” in order to point out that different species in far-distant but similar environments evolve toward the appearance of the same morphologies (cf. Conway Morris, 2003). The second level is the reevaluation of the “specific individual formality” of the living organism, be it a cell or a complex organism, as a unity and a subject of functions that cannot be reductively interpreted as a simple sum or combination of the properties of the component parts. Such behavior indicates, in essence, the ability of the organism to maintain and develop, in a consistent way, invariant characteristics such as, for example, homeostasis, functional symmetries, immunity to external agents, etc. According to the “Gaia hypothesis,” a similar behavior is in a certain way applicable, on a planetary scale, to the entire biosphere, seen as a sort of *living* organism that tries to maintain and develop its own life (cf. J.E. Lovelock, *A New Look at Life on Earth* [Oxford: Oxford University Press, 1979]; *The Ages of Gaia: A Biography of Our Living Earth* [London: W.W. Norton & Co., 1988]). It is interesting to note that in the middle of the 20th century, Teilhard de Chardin had already theorized about both areas of inquiry (cf. L. Galleni, “HowDoes the Teilhardian Vision of Evolution Compare with Contemporary Theories?” *Zygon* 30 [1995], pp. 23-43).

From a more traditional point of view, recourse to the idea of law and regularity has always accompanied the description of the phenomenon of life. There is a well-recognized “functional regularity of living organisms,” in virtue of which every part serves the good of the whole, and the whole defends its parts, according to a logic that transcends the individual and works towards the good of the species. There is a certain “constancy in existence” manifested by the replication of the same structures, which provides a certain morphological, functional, and also reproductive, regularity. Analogous to what happens in the variational principles of mathematical physics, in biology a kind of “law of simplicity” also seems to operate, a fundamental law that leads the living organisms to act with minimal work (i.e., with a simple and sure way of proceeding that avoids useless complications).

V. Towards an Ontological Analysis of the Laws of Nature: Scientific Laws, Natural Laws, and the Metaphysical Notion of “Nature”

Resuming the questions put forth by Paul Davies, “where do natural laws come from,” and, also “could they have been different than they are?” implies shifting one’s attention from their epistemological to their ontological status. The need to consider this level, sooner or later, was addressed from a historical viewpoint by Pierre Duhem: “Theoretical physics can never give us the explanation of experimental laws; it does not reveal to us the reality that is hidden beneath sensible appearance. But the more it is perfected, the more we sense that the logical order in which it places the experimental laws is a reflection of an ontological order; the more we doubt that the relations it establishes between observational data correspond to relationships between things, the more we discover that it tends to be a natural classification [...]. Nevertheless, if the physicist is incapable of motivating such a belief, he is no less incapable of taking away its reason of being” (*La théorie physique*, 1914, pp. 35-36). Another epistemologist and scientist, Henri Poincaré, though recognizing that scientific laws are conventional, wondered if, as a whole, laws could be independent from their conventions, if they could be considered “invariant.” He later concluded, however, that the existence of invariants is fundamentally required by the “translating” role of science: The relations between scientific facts—inevitably expressed through conventions—exist because invariant laws exist. Such laws are the relations among facts in and of themselves, of which scientific laws are, precisely, a translation (cf. *The Value of Science*, 1911, ch. X, § 4).

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We are therefore led to a necessary distinction between “scientific laws” and “natural laws,” or, if you prefer, the “lawful behavior” of nature.” The two are not identical (cf. Artigas and Sanguineti, 1984). We can only work with the former, not with the latter. Scientific laws have a limited cognitive scope and are always subject to experimental revision. Their intelligibility and ability to be known rest on an “invariant” substrate of a thoroughly metaphysical character, which, in the first approximation, would be representative of the “laws of nature.” Later we will see that they rest on the “metaphysical nature of each entity,” that is, on that operative principle describing the formal properties and the possibilities of active and passive interaction of a physical being, and manifesting its essence.

Richard Feynman loved to associate the image of musical rhythm with experimental laws that relate different phenomena to each other. In a sense, the lawful behavior of nature is what makes the regularity and cadence of “rhythm” possible, and which permits scientific laws to be discovered and described with mathematical formulas. Scientific laws have a necessarily conventional character and allow for a multiplicity of approaches and formulations whose freedom is, however, limited by the responses received “from nature” through an experimental method open to reality. Once understood in this way, laws of nature are a kind of “asymptote” which the scientific laws approach. We are dealing here with a “philosophical,” rather than a “mathematical,” asymptote. Science, in fact, cannot “supply the reason” for the laws of nature, or for the principle of lawfulness inherent to all natural entities. The lawful behavior of nature has a character of “givenness,” of something received. Although the ultimate “why” embodied by the laws of nature escapes the scrutiny of science, it is precisely in virtue of them that science is possible. Scientific laws describe the world without being able to “explain” it, whereas the laws of nature supply the reason as to how the world is the way it is, without being able to describe it directly.

A realist epistemology of natural laws does not imply that the mathematical expressions that describe physical processes “are there, inside things,” or that the regularity and symmetry, in virtue of which we can arrive at a formulation of a law, constitute the “real and concrete” structure of that phenomenon. A realist vision of natural laws states only that the “principle of lawfulness,” the point of departure for the structuring of scientific knowledge, is a principle that responds to the nature of things. Its cognitive validity does not turn out to be genetically compromised by the problem of induction. Its existence is the consequence of natural, stable, and intelligible properties, whose ultimate explanation science receives from reality, as something “given.”

According to Aristotelian metaphysics, one easily shared by any realist perspective of the physical world, every material being has its own “nature.” In his *Commentary on Book II of the Physics of Aristotle*, Thomas Aquinas defines “nature” as an operative principle in virtue of which every being, because it has a specific “essence,” acts according to what it is. Nature is nothing but the “natural inclination” that regulates the ways in which a certain being can interact with what surrounds it. Nature is a principle of motion but also of rest; that is, it refers not only to the regularity of interactions but also to the stability of intrinsic properties (cf. *In II Physicorum*, lec. 1, nn. 145-146; lec. 14, n. 267; cf. also *Summa Theologiae*, I-II, q. 6, a. 5, ad 2um). Once understood in this way, “nature” turns out to be related to “formal causality.” One of the four classical causes of a being (together with material, efficient, and final causalities), formal causality indicates the existence of a form, of specific given properties that *cause* that entity to be as it is. To the contemporary scientific mind, this concept is not far from that of information, patterns, or imprinting. Is must be noted that formal causality has a privileged relation to “final causality.” This does not mean that a kind of external Agent operates through these forms (differing from the Platonist view, the Aristotelian view of causality is inherent to things) but only that a Final cause, insofar as it is responsible for the being and plan of all that exists, is also the ultimate explanation for the “why” of the specific nature of every being. In the cosmos of Thomas Aquinas, who added to the Aristotelian vision the theological perspective of creation, the Final and the First Cause coincide with

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God the Creator. A created cosmos obviously possesses a global and rational design; however, finalism and design—as well as a Legislator's will and action—are not imposed on the physical world from the outside but are rather the result of the harmonious behavior of all created beings according to their own natures. The global design of the universe is then caused by the formal causality each creature has which, in turn, is associated with a final causality, that of an Intelligent Creator.

It seems to me that the perspective briefly depicted here about the distinction between scientific laws and the laws of nature, and the implied relationship of the latter to the metaphysical notion of nature, and therefore to a formal causality, has a couple of interesting advantages. First, it gives a reason for the intelligibility of scientific laws, which need to be anchored to an ontological level deeper than the epistemology of scientific formulations themselves. Second, it helps in understanding, in a non-conflicting way, the relationship between divine action (or a divine plan for the world) and natural phenomena. God's plan for the universe and His efficient action in the physical world, i.e., His final causality, need no additional activity or influence other than the formal causality associated with all material entities (cf. Tanzella-Nitti, 1997). Although there is a certain finalism [10] that has a regulative role in many scientific formulations (think for instance of Hamilton's principle, or of the laws of thermodynamics), the scientific method generally views the idea of a final cause with suspicion, whereas it is much more open to acknowledging the existence of formal causes, as they constitute the familiar stuff of researchers' ordinary work.

There is no lack of authors who have suggested a certain convergence between the metaphysical notion of nature and the basic and founding properties of physical reality, demonstrating that the latter must, on a certain level, rest on the former (cf. R.J. Connell, *Matter and Becoming* [Chicago: Priory Press, 1966]; P. Durbin, *Philosophy of Science: An Introduction* [New York: McGraw Hill, 1968]; cf. also W.A. Wallace, *Modeling Nature* [Washington D.C.: The Catholic University of America Press 1996). However, it must be kept in mind that the notion of nature is a *metaphysical* one, whereas basic properties such as mass and the charge of elementary particles, or some other more fundamental property of physical reality, are only physical formulations. Nevertheless, it seems clear that the ultimate cause of any lawful physical behavior must rest on a kind of metaphysical substratum. This should hold when we consider the quantum world as well, a world in which physical properties are understood more in terms of relations, connections, and interactions, than as intrinsic characteristics of material beings as such. In fact, the metaphysical notion of nature is a notion "open to relation" in that it denotes not only an active principle of operation, but also a passive principle, the specific ability of receiving new forms, of giving rise to specific interactions (cf. *Summa Theologiae*, I-II, q. 6, q. 5, ad 2um; *De spiritualibus creaturis*, a. 2, ad 8um). It does not contradict the notion of relation, emergence, and process, but simply regulates their operative modes along paths of behavior that cannot be totally chaotic.

The concept of the metaphysical nature of a being is a notion open to the multiplicity and richness of the phenomenal world because it is capable of inducing (or receiving) a practically infinite number of connections with other beings and with the environment as a whole. It is a relative (as opposed to absolute) notion, a principle of operative formality in a world of subjects where one is ordered to the other: *in natura est alterum propter alterum, sicut et in arte* (in nature, one thing exists for another, as it is in art) (*In II Physicorum*, lec. 13, n. 257). In the ordered "cosmos," which emerges from the metaphysical vision of Thomas Aquinas, the causal role of the whole is not weakened, nor is the relational value of the properties of the various components, which spring from their mutual dependence, undervalued. Finally, in a cosmos like this there is a place not only for the substance, but also for the process: The only requirements is that all processes, and the many levels on which a process operates, must have as their ultimate subject something which is not itself a process.

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VI. Towards a Theology of Natural Laws

1. The Cosmos: Where the Covenant between God and Human Beings Takes Place. There is no doubt that Biblical Revelation presents the natural world as a cosmos governed by laws. These laws are willed by the providence of a unique Creator, and the entire inanimate and animate world obeys them. Laws' action is described in a language that is, primarily, neither philosophical nor speculative. The effects of laws are rather described in a narrative, wisdom style, which is at times highly aesthetic, even though the sacred Author wants to communicate specific philosophical or metaphysical distinctions concerning the relationship between God and nature. A "created" world manifests itself with the characteristics of law, order, and regularity because it is an effect of the Divine Word. It is a personal, intentional, intelligent, and also a good, provident, and faithful word: The wise word of God created all things and maintains them in existence, leading the entire universe towards its final end (cf. *Wis* 8:1, 11:24-26; *Ps* 33:4-9, 104:24-29). With the help of divine wisdom, human beings can acknowledge the existence of laws in nature and understand the truth contained in them (cf. *Wis* 7:17-21). The main contexts that call for the action of natural laws are those of celestial phenomena, the behavior of living beings, including in relation to their habitat, and finally, the human person and his or her moral life. Biblical passages regarding this are numerous. The most celebrated ones are the first pages of Genesis, Psalms 19 and 104, chapters 36-29 of the Book of Job, and chapter 43 of Sirach. References to the "rationality" of God's creative project and to the "lawful" behavior of nature can be found almost everywhere in the Wisdom books (cf. *Prv* 3:19-20, 8:22-31; *Sir* 16:24-26, and from 42:15 to 43:33; *Ps* 119:89-91), and a few times in the prophetic books (cf. *Jer* 31:35-37).

The main idea that emerges from a reading of these passages is that the stability of the natural laws is the image and expression of God's faithfulness and the truth of His covenant, in which creation participates as its first primordial step. It is the faithfulness of God to Himself, to the truth and goodness of His project, but it is also His faithfulness to men and women, because the laws will never be revoked and are constantly in action as a sign of God's favor and love. The stability of the heavens is the image of God's faithful love for the people He has chosen: "Thus says the Lord, He who gives the sun to light the day, moon and stars to light the night; Who stirs up the sea till its waves roar, whose name is Lord of hosts: 'If ever these natural laws give way in spite of me, says the Lord, then shall the race of Israel cease as a nation before me forever'"(*Jer* 31:35-36).

In the context of natural laws, it seems difficult to separate what is inscribed in nature from what is inscribed in the heart of man: The "law" by antonomasia is the moral law inscribed by God in the human conscience. To live according to this law is a sign of wisdom and a source of happiness. The laws of nature play the role of "accompanying" and "favoring" human understanding of the moral law. They also offer a certain "assurance" of truthfulness and goodness, linking the provident truth of the moral law to the truth of the laws of the cosmos, a cosmos that is under the gaze of everyone. A good example in this regard is Psalm 19.

Natural laws have, finally, the function of inspiring human beings to give glory to God, to help them recognize the existence of the Creator through the order and regularity with which creation is governed. "The moon, too, that marks the changing times, governing the seasons, their lasting sign[...]. The beauty, the glory, of the heavens are the stars that adorn with their sparkling the heights of God, at whose command they keep their place and never relax in their vigils. A weapon against the flood waters stored on high, lighting up the firmament by its brilliance: behold the rainbow! Then bless its Maker, for majestic indeed is its splendor [...]. Lift up your voices to glorify the Lord, though he is still beyond your power to praise. Extol him with renewed strength, and weary not, though you cannot reach the end" (*Sir* 43:6, 9-11, 31-32).

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Theology and Christian tradition have received this Biblical heritage, often associating natural laws with the idea of a "world order." In a discourse given in 1992 at the Pontifical Academy of Sciences, John Paul II affirmed: "Those who engage in scientific and technological research admit, as the premise of its progress, that the world is not a chaos but a cosmos; that is to say, that there exist order and natural laws which can be grasped and examined, and which, for this reason, have a certain affinity with the spirit" (John Paul II, *Discourse to the Pontifical Academy of Sciences*, October 31, 1992 [28], in *Papal Addresses*, p. 343). A page of the encyclical *Fides et Ratio* (1998) offers a similar view, introducing the idea of an existing "natural order of things" that makes the activity of science possible: "It is the one and the same God who establishes and guarantees the intelligibility and reasonableness of the natural order of things upon which scientists confidently depend, and who reveals himself as the Father of our Lord Jesus Christ" (n. 34). Other discourses or messages of the Catholic Magisterium allude elsewhere to a link between the reality of laws in nature and the role of a Provident creator, especially those addressed to scientists. The title of a speech, "The Laws That Govern the World," given by Pius XII to the Pontifical Academy of Sciences in 1943, is self-explanatory and its language certainly betrays a past historical context: "You contemplate, measure, study such a universal order: it is not, nor can it be, the fruit of absolute blind necessity, and neither can it be even of chance or luck: chance is a part of fantasy, and luck, the dream of human ignorance. In order, you seek a reason which intrinsically governs it, an arrangement of reason in a world which, even without life, moves itself as if it lived, and works by design as if it intended. In a word, you seek the law, which is precisely an arrangement of reason of One Who governs the universe and has fixed it in nature and the movements of its unconscious instinct" (Pius XII, *The Laws That Govern the World: Address to the Plenary Session of the Academy*, February 21, 1943 [29], in *Papal Addresses*, pp. 100-101).

The question arises whether theology might still use the notion of laws of nature, after the historical, and somewhat ambiguous, development that this notion underwent through the 17th and 18th centuries, and in light of their problematic epistemology, as highlighted by contemporary philosophy of science. In fact, it must be kept in mind that, from the beginning of the scientific method up to the middle of the 18th century, the discovery and fist mathematical formulation of laws was used precisely in order to demonstrate the existence of a Legislator. Then, from the end of that century onward, the autonomous action of those same laws was used to maintain there was no need of any Legislator or God-ruler at all, since the laws of nature worked well regardless. Moreover, it was the concept of nature [30] itself that experienced a radical change: At one time understood as a synonym for creation, in the 19th century the concepts of nature and naturalism began to be more in tune with the philosophical contents of materialism [11]. From the point of view of philosophy of science, as we have already seen, an ingenuous or inexperienced theological use of the laws of nature could turn out to be detrimental to theology itself, since the idea of a God-Legislator could be expected to follow the vicissitudes and fluctuations that occur in our understanding of what laws are and how they act.

Even taking all these difficulties into account, I endorse the judgment that the notion of laws of nature is still relevant for theology and its dialogue with science. It is theology's task to be aware of all these historical and epistemological vicissitudes, choosing an ever better and more consistent way to speak of laws. And a better way does exist: offering historical and philosophical clarifications aimed at distinguishing determinism from transcendental causality; relying upon the metaphysical concept of nature, including the notions of formal causality and information, thereby pointing out the lawful behavior of nature, no matter how problematic our epistemology of scientific laws might be; and, finally, stressing a theological understanding of the laws existing in nature as part of God's fidelity and His gracious covenant with human beings. I intend now to focus a bit more on this last idea.

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2. Stability of the Laws of Nature and God's Faithfulness. If we had to identify with which image of God the Biblical beckoning to a Legislator corresponds, we would have to respond that His most salient traits are not those of an architect, nor of a watchmaker or musician, but of a faithful Creator. In scripture, the notion of "natural law" is synonymous with "faithfulness" and "truth" (these two concepts derive from the same Hebrew word *'emet*). Only secondarily does natural law refer to the notions of rationality and order. Faithfulness does not mean determinism but rather the will and ability to fulfill what has been promised, a fulfillment which is brought about in ways that only God knows. If Christianity, with the guide of Biblical Revelation, has certainly favored a climate of "trust" in the existence of the laws of nature and in the rationality of the world, this cannot be translated, in epistemological terms, into a flat affirmation of determinism. Nature rests on stability, not on chaos or on eternal change, because God is "faithful," that is, "true." Lawfulness and faithfulness both reveal an order towards an end. God does not "take back" His gifts: The world He has placed in the hands of human beings does not completely escape their "grasp" because the world is true and real and, therefore, knowable. As Creator, God maintains His complete transcendence over the world and His complete separation from it (He is "holy," Heb. *qodes*, that is, "separated"), but even as Creator He founds, in an immanent way, the truth and autonomy of all things, and directs His provident gaze towards what He has always loved and willed as it is. The Biblical image of God is not that of a Legislator who from the outside imposes His laws on a nature that He forms in the manner of a demiurge. These laws are not "external" to the world, lying only in the mind of God (as Platonism would have it), but are "consigned to the truth of what was created," even though the plan of the world and the plan of its salvation certainly lie within God's wisdom.

The correct relationship between God and the laws of nature can be understood by considering God's transcendence over, and immanence in, the created world. God works through laws because He is the ultimate explanation of their specificity and existence, but He also exists over and beyond the laws, since the fact that they originated in the divine plan does not imply that the Creator identifies Himself with them. In this regard, a correct "theology of the laws of nature" must explicitly clarify that it is just as far from pantheism [17] as it is from deism. It must be kept in mind that the deism of the 17th and 18th centuries claimed to be a kind of rational religion and is therefore not open, by definition, to the notion of Revelation. Thus, the notion of God [2] (or of *Logos*) to which the scientist seems at times to refer when dealing with the question of the laws of nature can be utilized legitimately by the theologian only insofar as it remains "open" to a revealed image of God. Analogously, to avoid the stumbling block of pantheism, it is necessary that the divine *Logos* perceived in philosophy of nature be able to point "beyond the laws." If the laws are themselves "the Divine," and the scientist's wonder stops at the "cosmic code" without enquiring after its Author, Christian theology cannot but judge all that as one more example of pantheism.

Finally, the clarification made above about determinism can also help us understand the ambiguity of those speculations that hypothesize a world without laws and investigate both the relationship between God and an undetermined universe and, on the philosophical level, the relationship between God and chance. Whereas the negation of every law in nature is used by some to argue against the existence of God (e.g., Monod), others think that randomness and indetermination represent the space, or perhaps the "action," that would allow an original and creative intervention of God (e.g., Peacocke and Bartholomew). We maintain that at the origin of such interpretations there is always the difficulty of grasping the simultaneous transcendence and immanence of God, which becomes comprehensible within a metaphysics of creation based on the philosophical properties of the "act of being." When pondering the laws of nature, scientists rightly want to avoid the dangerous idea of a "controlling" God who programs nature or competes with its behavior. At the same time, they positively perceive the unconditioned and gratuitous character of the laws of nature, one that helps prevent the risk of self-reference: "Where do they come from?" (Davies), "Who gave these equations life, who breathed fire in them?" (Hawking). If a

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Creator exists, on the one hand, we posit the necessity of His transcendence over this world, and on the other hand, we are aware that He must sustain the world as an immanent cause, being the innermost life and the ultimate explanation of the universe. It seems to me that the possibility of a simultaneous affirmation of these two poles, the transcendence and immanence of God, as well as the assurance of being able to harmonize such a dialectic, gains insight only from the revealed image of God as we receive it by the Judeo-Christian tradition.

3. The Inexorability of Natural Laws and the Problem of Physical Evil. In the theological perspective, the theme of the laws of nature indirectly involves the problem of evil when their inexorability becomes a cause of harm, destruction, and death. This is the problem of "physical evil," thus called to distinguish it from the term "moral evil," which theology reserves for human sin. The possibility of a "suspension" of the laws of nature is usually invoked within the context of the theology of a miracle [31]. Here, one asks why God, ultimately the Author of the laws of nature, allows that some natural actions have effects that destroy the environment or damage the life of human beings. In other words, one wonders how such a situation can be still "in tune" with a Biblical vision that considers natural laws a manifestation of the faith and love of the Creator.

The fundamental premise to be put forth is that everything in the world that is involved in suffering, participates in the mystery of the humanity and death of Jesus Christ [22] and in his headship over the first and the new creation, and that, therefore, from a theological standpoint, suffering can only be completely understood in the context of such a mystery. And, this mystery offers some points for reflection that may render the problem of physical evil more comprehensible.

In the first place, it must be kept in mind that the actions of the laws of nature that can cause a physical evil (earthquakes, floods, cancer, viral pathologies, etc.) are the same actions that allow for the stability and the preservation of the world and for the growth and reproduction of living beings. Without these physical phenomena (for example, gravity, which might cause a physical disaster) or biological functionings (for example, chemical and biochemical processes that might let a cancer grow), the universe and life cannot subsist. The fact that such causes, forces, or processes are not set apart from a Legislator in whose Providence one trusts can lead to two conclusions. First, it allows one to understand the "radicalness" of the relation between God and His creation: Faithfulness to the created laws (which is, we recall, faithfulness to Himself) seems to have a greater value for the good of the world and its inhabitants than their suspension, transformation, and alteration. Second, we are led to believe that since the relationship between God and creation "involves" the humanity of the Incarnate Word, the mystery of His death and resurrection [32], then this same mystery is expected to contain and unfold the meaning of the transitory, limited, and fragile nature of created things, and of the suffering this vulnerability necessarily implies, suggesting it be considered in the light of a future transfiguration.

In the second place, it is the very firmness and magnificence of the natural laws, whose action can become at times a source of anguish and despair, that inspires in human beings feelings of confident surrender and trust in a Creator. The wisdom and faithfulness of those laws strengthens our hope in divine Providence, a hope capable of overcoming the suffering caused by those same laws, and fostering our faith in a final renewal, transfiguration, and restoration of justice. It is interesting to note that one of the Biblical accounts that presents human suffering with great drama and vividness, the Book of Job, ends by representing, in spite of everything, one of the most beautiful appeals to faithfulness in the goodness of the Creator. Job, who sorrowfully wonders why physical evil has put him to so bitter a test, and even at one point passes judgment on God for the horrible destiny inflicted on him, is asked by God to go out into the open, to look at the sky, and contemplate the beauty of creation, its laws, and its harmony (cf. collected speeches of *Job* 37:14 to 40:4). The human being cannot explain physical evil, but the

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contemplation of nature, governed by those same laws that can, at times, cause sorrow and calamity, may help in understanding that such an explanation *does* exist in the wisdom and power of God the Creator.

Read also: Autonomy [13]
Creation [12]
Determinism / Indeterminism [5]
Epistemology [33]
Finalism [10]
Nature [30]
Pantheism [17]
Realism [19]
Additional Related Documents: Adam Sedgwick, God and the Laws of Nature [34], 1833
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