
On the technological and theological roots of the notion of “law of nature”

Mauro Dorato
Department of Philosophy
Università degli studi “Roma Tre”
dorato@uniroma3.it

The main purpose of this paper is to shed some light on two important historical processes which, in my view, have essentially contributed to the establishment of the modern, purely descriptive, non-normative concept of “law of nature” in the scientific domain: the influence of the technological development on our ways of representing nature, and the belief in an omnipotent creator imposing his immutable will to nature.¹

Allow me to note, first of all, that in the following I will be distinguishing between *laws of science* and *laws of nature*. The former refers to the linguistic and conceptual instruments that are used in science to *represent* regularities in nature; the latter, *if* real, should be regarded as whatever is represented or denoted by the former, and therefore as something that exists independently of us. In a word, the distinction in question is that between a *truth-bearer* – namely a law of science, which in physics usually corresponds to a differential equation – and *the truth-maker* – the law of nature itself, which, if anything, is whatever there is in nature that makes our equations either true, or at least approximately true. Unless otherwise specified, in trying to highlight the origins of the notion of “law of nature”, by this expression I will be referring to the truth-maker and not to the truth-bearer.

¹ For a more thorough historical reconstruction of the transition from a normative to a purely descriptive notion of “law of nature”, I refer the reader to my *The Software of the Universe*, Ashgate, 2005, chapter 1.
I should also add at the outset that my overall purpose is not simply historical: by sketching the main philosophical positions on laws of nature defended in the 17th century, I hope to show in what sense the views debated today can be traced back to the discussions on the role of God in nature. For instance, we are sometimes told that the concept of “law of nature” has only an historical interest – “it is vestigial” (van Fraassen 1993, p. 432) – and, as such, should be superseded by the more entrenched notions of “symmetry” and “invariance”. One could then maintain that a realistic position about laws of nature could be justified only by a theological argument, so that once we abandon the theological view of the origin of laws, we should also abandon realism about natural laws, or the belief in the existence of some mind-independent truth maker. In order to assess the plausibility of this argument, I suggest to track our steps back into the past.

§1 The role of technology in the origin of a purely descriptive notion of law of nature

Interestingly enough, in Greek philosophy “law” (nomos) was used only in a prescriptive, normative sense, to refer to the laws of the cities (poleis), and was never referred, descriptively, to the regular motions of heavenly or earthly objects (see Dorato 2005, ch.1). The term “law” presupposed the existence of lawgivers, and therefore of intelligent beings – the citizens – that were capable to obey as well as to violate a particular rule. The fundamental question we should ask is therefore how and when did the concept of law lose its normative meaning to become also associated, in a purely descriptive sense, with the regular workings of nature.

In order to answer this question one must come to appreciate how the evolution of the concept of natural law has been profoundly affected by cultural, global changes in our ways of conceiving nature. Among these changes, those owing to technology are of particular
importance, given that as soon as the art of “machine-making” reached a sufficient level of complexity, the functioning of a few parts of nature, and sometimes of all of it, was compared to that of a technological artifact. To put it simply, it was the very possibility of reproducing the functioning of parts of the natural world through the construction of machines that significantly helped shape a notion of “law of nature” that eventually became completely descriptive, and therefore lacking in normative elements.

To briefly but concretely expand on this thesis, in the philosophies of nature tending towards animism or panpsychism – namely the anthropomorphic attribution of the typical powers of the mind also to the “inert” world – the universe is generally identified with a gigantic animal with a soul, whose organs are tightly and reciprocally connected by fluids and fluxes of “sympathies” (positive influences) and “antipathies” (negative influences) flowing through its parts instantaneously. In this way of conceiving of nature, which characterized a few aspects of Renaissance philosophy, but which can also be found in the ancient world and in other historical eras, any separation of what we today call a “physical system” from the rest of the universe (and from the observer) becomes illegitimate. If every part, in fact, comes to depend instantaneously on changes that occur in all the other parts at a distance, any modification of the original system would not be experimentally controllable in principle, except for in ways that we now judge to be completely illusory, like rituals or magic formulas. The fundamental point is that in such a universe, in which we might imagine that every entity has a relationship of some type with all the others, the formulation of simple scientific laws and the discovery of laws of nature would be impossible. This is true, at least, if by “natural laws” we mean functional relationships holding between two or more variables characterizing a physical system, in which interactions with the “rest of the universe” can in principle be screened off, or are at least controllable.
On the other hand, depicting nature as an enormous machine, as “mechanicism” did in modern times, obviously meant identifying natural laws with whatever was most important to the functioning of the machine itself, namely with the relationships between its parts. These could be considered “separate” or “separable,” precisely because they functioned in a way that was relatively independent from the rest of the machine. In particular, the laws of nature could be exemplified by the principal mechanisms which transmit movement (and therefore energy) from one part of the machine to the other, i.e., though levers, springs, gears, pistons, cylinders, etc.

The machine is therefore to be regarded at the same time as a component of nature – because it is a physical system among others – but also as an abstract schema of formal relationships existing among its parts. These relationships express well-defined causal roles, where the word “causal role” is really equivalent to the functions that the parts of the machine are capable of carrying.

It should be clear why the “laws” governing” the functioning of a machine and expressing these set of formal relationships cannot be anything but purely descriptive: even if they respond to a plan or human design, the functions of the parts are realized and carried out by inanimate objects, which have neither plans nor conscious motives. Once it is believed that the entire universe can in principle be likened to a gigantic machine, it is also believed that such a universe can be “controlled” by laws that can be exemplified without the existence of any intelligent being.

This fact, which in the historical literature has been curiously neglected, has decisively contributed to the emergence of a purely descriptive sense of “law of nature”, as we use it today: in this sense, a natural law refers to a reliable, reproducible, predictable and regular behavior of a part of nature (the machine and whatever it stands for), where these three

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2 The idea of the universe as an organism having a soul, anima mundi, was originally described in Plato’s
attributes are the core of what is meant by a law of nature. Furthermore, let me also note that the machine itself provides the privileged environment in which the laws of nature can be tested, given that it constitutes in some sense a concrete though artificial model in which all possible preemptive and preventing effects can be screened off.

§2 The theological underpinnings of the notion of law of nature

Despite the fact that the concept of law in the greek world was reserved to what regulates the social conduct in a human group, already in pre-socratic thought we find a characteristic entanglement of descriptive elements, concerning the behavior of natural entities, with prescriptive elements, calling into play a conscious will that plans, orders, and governs. For instance, we read in Heraclitus that «Helios (the Sun) does not overstep its bounds: if it does, then the Erinyes, the ministers of Dike (justice), will find it» (H. Diels and W. Kranz (eds.) 1934-37, B 29).

The meaning of this passage is obvious: the orbit of the Sun in the sky is constant and regular as a consequence of a divine order attempting to establish some form of balanced justice. The projection of the human social organization on the behavior of natural objects is then bi-directional: exactly as each person in a well-ordered society has a definite social role and, in order to avoid injustice, cannot trespass the limit assigned to her by the social rules, also an anthropomorphized Sun must abide by the role and the “laws” that the goddess of justice assigned him. Conversely, the regular and reliable motion of the heavenly objects is a normative model for the human conduct in the social group.

It is well-known that the passage from a vision of nature in which descriptive and normative aspects are inextricably entangled, to a “disencharnted” vision, in which “natural

Timaeus, which also makes reference to an underlying mathematical structure.
laws” were considered to be fact-like and devoid of any teleological aspect, is one of the most important philosophical consequences of the scientific revolution of the modern age. Interestingly, it is only if we consider that the word “law” in Greek philosophy stood for a command issued by a conscious will (a lawgiver) that we can make sense of the view that, with the advent of the monotheistic religions’ creationism, one can conceive of God as imposing his will to the inanimate nature, which consequently must be obeying laws insofar as it has been created by him and obeys his commands. As we will see, universality and necessity, which we associate with the notion of a law of nature even today, find their historical roots in the idea that nature is the expression of the constancy of divine will and for Descartes, even the conservation of certain physical quantities (momentum) is due to the immutability of God.

§3 The three positions on laws of nature in the 17th century and their contemporary counterparts

Very schematically, in the 17th century we find at least three main views on the nature of laws, the last of which is quite independent of theological worries or considerations. The first view I will sketch, which I call the theologico-metaphysical view, is definitely accompanied by a robust form of realism about laws of nature. Defenders of this position are, among others, Kepler, Galilei and Descartes, who believed that the study of nature is a way of studying the will and the mind of God, since nature obeys in an infallible way his precepts. The contemporary, secularized heirs to this view are Armstrong, Dretske and Tooley who, however, defend a metaphysical realism about universals and about natural necessity that is devoid of any theological underpinning.

The opposite, rival position is what I will refer to as the “analogical view”, historically defended by Boyle, Spinoza, Locke, holding that we can talk about “laws of nature” only in a
metaphorical way, since the term “law” only applies, strictly speaking, to people capable of rational deliberation. This position is close to various contemporary forms of conventionalism, empiricism, regularism or neoregularism, according to which there are no laws of nature, but just regularities, which are only partially described by our simplified and abstract scientific laws.

The third position is what I will call **essentialism**, represented by Francis Bacon, and holding that discovering laws is tantamount to discovering the *forms* or the essential, microscopic properties of the macroscopic bodies around us. This position is close to the contemporary forms of essentialism and dispositionalism, variously defended, among others, by Harré and by Bigelow, Ellis, and Lierse. Historically, this position is independent of any theological derivation, because Francis Bacon is decidedly realistic about laws while denying at the same time any role for a theological derivation or justification or their existence.

3.1 The theologico-metaphysical view of laws in the 17th century

For the *Holy Scripture and nature both equally derive from the divine Word*, the former as the dictation of the Holy Spirit, the latter as the most obedient executrix of God’s commands; moreover, in order to adapt itself to the understanding of all people, it was appropriate for the Scripture to say many things which are different from absolute truth, in appearance and in regard to the meaning of the words; on the other hand, *nature is inexorable and immutable*, as she does not care at all whether or not her recondite reasons and modes of operations are revealed to human understanding, and so she never transgresses the terms of the laws imposed on her; therefore, whatever *sensory experience* places before our eyes or *necessary demonstrations* prove to us concerning natural effects should not in any way be called into question on account of scriptural passages whose words appear to have a different meaning, since *not every statement of the Scripture is bound to obligations as severely as each effect of nature*. (Galilei 1968, V vol., pp. 282-283, my emphasis)

In the above-cited letter to Benedetto Castelli, dated 1613, Galilei stresses that since the scriptures and nature are both creations of God, what has been dictated by the Holy Spirit (the Scriptures) cannot contradict the Book of Nature, even though the letter of the Biblical text can sometimes lead us to believe the opposite. In case of conflict, however, one must follow our sensory experience and necessary demonstrations: while the Scriptures have been written
by men for ignorant men, the Book of Nature has been *directly* written by the hands of God, in such a way that nature is “*the most obedient executrix of his commands*”.

Apart from any controversial consideration concerning his personal faith, the possibility that the main reason for attributing the origin of laws directly to God was an attempt to escape from the censorship of the Catholic Church and get support in his new experimental studies would of course undermine the statement that Galilei was a realist about the laws of nature because he believed that they were a direct creation of God.\(^3\)

However, another famous passage from *The Assayer*, originally published in 1623 – in which Galilei affirms that, unlike many books made of paper, the great Book of Nature “which is continually open before our eyes (I say the universe) […] is written in mathematical language, and the letters are triangles, circles, and other geometrical figures” (Galilei, 1968, vol. VI, p. 232) – makes us propend for the view that he really believed in a God that, like a geometer, had created the world according to rules coded in a mathematical language. Galilei’s realism about laws is therefore supported by a theological faith, since he is even convinced that the human knowledge of mathematical truths is *intensively* (from the point of view of certainty) equal to the divine one: the difference between us and God lies only in the fact that *extensively*, or by number, he knows *all* of such truths immediately (Galilei 1968, vol. VII, pp. 128-129).

An analogous case can be made for Descartes:

In the beginning, [in his omnipotence] he created matter, along with its motion and rest; and now, merely by his regular concurrence, he preserves the same amount of motion and rest in the material universe as he put there in the beginning […] For we understand that God’s perfection involves not only his being immutable in himself, but also his operating in a manner that is always utterly constant and immutable. […] Thus, God imparted various motions to the parts of matter when he first created them, and he now preserves all this matter in the same way, and by the same process by which he originally created it; and it follows from what we have said that this fact alone makes it most reasonable to think that God likewise always preserves the same quantity of motion in matter (Descartes, 1985, Part II, article 36).

\(^3\) Galilei must have believed that it was possible to conquer the Church’s approval and have its immense power on his side (see Geymonat 1957).
Here the emphasis of the passage is on the conservation of the quantity of motion (linear momentum) throughout the history of the universe, which is guaranteed by the immutability and perfection of God’s will. From this passage and similar ones in the *Principle of Philosophy*, we can infer that also Descartes, like Galilei, founded his belief in the existence of *laws of nature* on his religious faith. The *necessity* and the spatio-temporal *universality* of laws of nature (the most general conservation principles) were based on attributes of God that had been transferred to nature via the process of creation, a process that for Descartes can be regarded as continuous.

If, in the contemporary scenario, we try to identify the *secularized* “closest continuant” version of this early-modern metaphysical view – where “secularized” means that the presence of God is excluded from the natural scene – we stumble in the so-called Dretske (1977), Tooley (1977), Armstrong (1983)’s *realistic* view on laws. By eliminating the idea that God literally *rules* over the world through his laws we are left with the view that laws are necessary relationships between properties, regarded as *universals*. “Universal” is the jargon term for entities that, against nominalism, are regarded as existing independently of our minds and constituting “the repeatable characteristics of the spatio-temporal world” (Armstrong 1983, p. 82). According to the Dretske-Tooley-Armstrong camp, empirical regularities like “all crows are black” become explainable and derivable from the fact that the property of crow-ness \( C \) necessitates that of blackness \( B \): \( N(C,B) \rightarrow (\forall x(C(x) \rightarrow B(x))) \).

Clearly, in this realist, secularized version of the Galileian-Cartesian view, we cannot claim that laws of nature literally *govern* or *control* a physical system, since by making God non-necessary for the presence and origin of natural laws, the latter must be explainable as the by-product of spontaneous self-organization. It is only in a metaphorical sense that we

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4 Believing in the existence of a monadic universal like “is red,” or “has a positive charge” means believing that the same property is exemplified, respectively, by every red object and by every positively charged entity. The same applies to polyadic universals or *n-ary relations*, like the binary relation “has more mass than”.
can claim that laws *constrain* a physical system in the sense that they *obligate* it or *force* it to do something. Laws as such can have *no causal influence* on concrete bodies, but at most *describe* such influence between bodies: only conscious beings can perform those actions that we metaphorically attribute the laws as a reminiscence of a theological worldview. However, within the theological outlook, it makes perfect sense to claim that laws of nature *rule* and *govern* over the natural world, because the latter is the product and creature of God.

Apart from the common realism about laws, tracing this contemporary view to the metaphysical theology of Descartes and Galilei may seem partially arbitrary. However, there is a sense in which the" top-down" mechanism of explanation of the properties of concrete bodies in contemporary necessitarianism – from the laws regarded as fundamental to the properties of the bodies – resembles, in my view at least, an incomprehensible *deus ex machina*, which may remind one of a typical theological explanation of the origin of the laws.

§3.2 The analogical, conventionalist view

«Only by analogy is the term ‘law’ applied to natural things», claims Spinoza in chapter 4 of his *Tractatus Theologico-Politicus* and a few years before Robert Boyle had voiced the same skepticism about the existence of laws of nature: I do not hesitate sometimes to talk about the laws of motion … as imposed by God upon bodily things, often defining them (for the sake of brevity or out of habit), “laws of nature.”[…] However, I cannot understand how a body lacking intellect and senses […] can control and determine its own movements in a way that makes them conforming with laws. (Boyle 1686, pp. 170)

It is of extreme interest to recall that Robert Boyle’s refusal to attribute the term “law” to nature, as highlighted in this quotation, was motivated by a voluntaristic vision of God: a conception of nature as ruled by rigid and immutable laws was deemed incompatible with God’s freedom to change the nomic or causal link between events. If he had wanted to, God could have imposed different laws upon the world, and could change them at any moment of time, a fact that renders the laws themselves not
necessary, but only contingent, and unlike the conception defended by Descartes, not even immutable.

In short, the skeptical position on the objective existence of laws of nature that Boyle assumes was plausibly aimed also against the realistic and *a priori* metaphysics of the Scholastic tradition, and therefore had a deliberate anti-cartesian function. As the Italian scholar Paolo Casini writes, «according to Boyle, the laws of nature that may be discovered through experience are pure and simple “descriptions of phenomena”» (Casini 1976, p. 177): this radically empiricist position will be explicitly defended by Hume in the 18th century and later elaborated upon by J.S. Mill in the 19th century, and by F. Ramsey and D. Lewis last century.

In an empiricist philosophy, scientific laws attempt at describing the regular patterns of phenomena, and laws of nature are relationships between types of events that are exemplified by concrete events constantly associated in spacetime. It is interesting to note that in the modern age also this empiricist outlook on laws had a theological motivation, even though with the progress of modern logic, the attempt to distinguish genuine natural laws from accidental regularities depends on subtleties that were not available to the natural philosophers of the 17th century. According to Ramsey, who put forward a view later developed by Lewis «laws are consequences of those propositions we should take as axioms if we knew everything and organized it as simply as possible in a deductive system» (Ramsey 1928/1978, p.138, my emphasis). In this empiricist conception, laws of nature are those regularities denoted by the propositions that best help us to organize in a deductive way our knowledge of nature.
§3.3 Francis Bacon as the tertium quid between the metaphysico-theological view and the empiricist view

«in nature nothing exists besides individual bodies, which perform purely individual actions according to a law. In philosophy, however, this law [. . . ] is the foundation of knowledge as well as action. And it is to this law with its clauses that I intend to refer to when I talk about forms, a term that I adopt because it has become common use (Bacon 1620, II, 2, emphasis added).

As in current philosophy of modern science a natural kind is part of a real classification of nature and is identified by its microscopic structure, also in Francis Bacon «the form is such that if it were removed, the nature of which it is a form would also disappear». As such, the form or the law of a body is its essence. Interestingly, the form/law in Francis Bacon has to do with the latent causes or actions of a phenomenon, or with the actions of the particles that are hidden to the senses because they exist at a microscopic level (Bacon 1920, II, 1, 5, 6, 17). In short, then, what Francis Bacon calls “the laws of motion” or “the laws of action” refer to the “nature” or “structure” of phenomena as understood in a way that is essentially causal and microscopic, in contrast to what appears to our senses.

Following the essentialist theses on natural kinds developed by Saul Kripke (1980) and Hilary Putnam (1984, vol. II, pp. 215-271), a modern interpreter of Bacon’s doctrine on forms and laws of phenomena could anachronistically say that the form of water, for example, is simply the law that gives its chemical formula, $H_2O$. As Putnam affirms, anything having an internal (microscopic) structure made up of two hydrogen atoms and one oxygen atom, is water in any possible world, that is, it is necessarily or essentially water. This means that any substance which hypothetically had macroscopic properties identical to water (being odourless, tasteless, etc.) but with a different chemical formula, would simply not be water.

From a physical point of view, it would in any case be appropriate to emphasize that Francis Bacon’s interpretation of his laws is decidedly realistic, given that forms/laws are eternal and reflect the latent and microscopic structure of bodies. This also justifies his conviction that knowledge and human power are one and the same: the famous aphorism

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“natura parendo vincitur” (“nature can be defeated by obeying it”) presupposes, in fact, that the legality to which nature is subjected is not merely a convention constructed by us for the purpose of dominating and predicting phenomena. Rather, such a legality mirrors an order that is completely independent from our mind and language, as it is constituted by “a chain of causes which no force can dominate or break” (quoted in Rossi (1974, p. 75). Otherwise, what would the term “obey” mean? At the same time, however, Bacon refuses a theological underpinning of the notion of form/law. Even endorsing what we would now call “a realistic view of laws,” the Lord Chancellor did not in fact defend their existence on a theological basis, but on a purely methodological one. As Paolo Rossi claims: “the thesis of the sharp separation between science and theology remains one of the central themes of Bacon’s philosophy.” (Rossi 1974, p. xix).

The role of F. Bacon is therefore of particular importance in order to highlight the historical fact that not all early-modern, realistic views on laws had a theological foundation. Analogously, the modern, purely descriptive notion of “law of nature” has also been influenced by technological developments. Therefore, today it is not possible to attack a philosophical realism on laws simply by claiming that by abandoning creationism such a realism must go too. Laws of nature, following Bacon’s view, may refer to hidden causal mechanisms which, in deterministic cases, “necessitate” their effect in some sense, and thereby “produce” it, by adding the appropriate causal circumstances or initial conditions. However, how can we obtain an analysis of nomic necessity that is different from that of Armstrong-Dretske-Tooley?

One solution to this problem has been suggested by Bigelow and Pargetter (1990), and by Bigelow, Ellis and Lierse (1992). Like Francis Bacon, these philosophers regard the necessity of a law as dependent on the essential nature of the properties that the law itself relates. The explicative direction of necessity in this case goes “bottom-up,” or from the
essential properties of the physical systems, which are seen as physically necessary, to the
necessity of the relationships between these properties, or the laws. On the contrary, with
Armstrong, Tooley and Dretske’s necessitarianism, we have seen that the explanation of the
necessity of laws goes “top-down,” since such a necessity, properly speaking, belongs only
to nomic relationships, and is then “inherited” by the single systems exemplifying these
relationships.

One more difficulty of the Dretske, Tooley, Armstrong’s type of necessitarianism is that their
view cannot take into account the idealized and abstract character of scientific laws. In fact,
for the purpose of salvaging their theory, necessitarists must choose between two options:
either (I) they assume that somewhere in the universe there are bodies that move inertially, or
pendulums that oscillate for eternity thanks to inextensible and weightless threads, or
incompressible fluids, etc., or (II) they hypothesize that the universals that are “exemplified
in degrees” correspond to entities like tendencies, dispositions, and causal powers, which are
susceptible to being measured and therefore to having a degree, and belonging to concrete
individuals. In any case, the first assumption is completely lacking in empirical meaning,
while the second, with its postulation of properties which, like dispositions and tendencies,
are present in degrees, would actually mean abandoning Dretske, Armstrong and Tooley’s
version of necessitarianism altogether, and accepting the view that laws of nature are
relationships between powers and dispositions, which characterize the individuals possessing
them in an essential way.

As the reader can imagine, the difficulty with the Bigelow-Ellis-Lierse solution lies in the
specification of essential properties: what are they, and how do we non-arbitrarily distinguish
them from accidental ones? In general, essential properties have to do with the microscopic
nature of entities or natural kinds that we consider: water is essentially H₂O; biological

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6 The role of the measurement of capacity in science has been especially vindicated in Cartwright (1989).
species are essentially identifiable through their distinct DNA sequence; gold is essentially the element whose atomic number is 79. Introducing essential properties means accepting the thesis that any substance whose chemical composition is not constituted by the molecule of H₂O would not be water, just like a substance whose atomic number is not 79 would not be gold. *An essential property is therefore a property which*, following Aristotle, *defines the identity of the entity that possesses it.*

§4 Conclusion

We have seen that the influence of technology on the formulation of a purely descriptive notion of law of nature weakens the claim that theology was the *only* force that drove the historical development toward the idea of an autonomous, descriptive, non-teleological, objectively existing *natural order*. This is not meant to deny, of course, that theology did play an important role. However, the “intermediate” position taken by Francis Bacon – refusing both a theological grounding of the notion of law of nature and a purely empirical understanding of it that was meant to leave room for the intervention of God in nature – a position playing an important role also in our days, likewise shows that the modern origin of the notion of law can be regarded as partially independent of theology. Consequently, the influence of the Aristotelian intellectual tradition in providing the framework for understanding the relation between properties of bodies – i.e., their dispositions – and laws governing their relations should not be underestimated.

§ 5 References