ROBERT BOYLE ON THE LAWS OF NATURE

by

BRUCE ALAN HODDING

B.A.(Honours), The University of Victoria, 1989

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIRMENT FOR THE DEGREE OF

MASTER OF ARTS

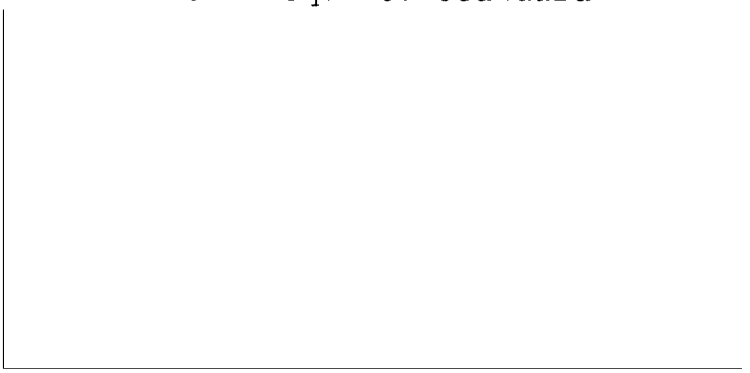
in

THE FACULTY OF GRADUATE STUDIES

(Department of History)

We accept this thesis as conforming

to the required standard



THE UNIVERSITY OF BRITISH COLUMBIA

April 1992

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

(Signature) _____

Department of History

The University of British Columbia
Vancouver, Canada

Date April 30, 1992

DE-6 (2/88)

ABSTRACT

This thesis is an extensive investigation of the use and the concept of the laws of nature in the works of Robert Boyle. Care has been taken to place Boyle's use in both the general linguistic context of his age and the context of each specific text. The thesis finds two uses of the laws of nature in Boyle's works, the prescriptive and descriptive, and traces these to two different historical origins. It also traces Boyle's concept of the laws of nature to two different medieval doctrines, voluntarism and concurrentism. This thesis both challenges the received view of the origins of the laws of nature in the seventeenth century and argues that there is more continuity between the discourse of the late middle ages and the early modern period than is sometimes thought. That is, in developing his concept of the laws of nature, Boyle translates the scholastic discourse of voluntarism and concurrentism into the mechanical philosophy.

TABLE OF CONTENTS

ACKNOWLEDGEMENT

I wish to thank my supervisor, Dr. Stephen M. Straker, for his support and comments during the formation of this thesis.

INTRODUCTION

Interest in the emergence of the concept of the laws of nature has recently been revived by Bas van Fraassen in his book *Laws and Symmetry* where he suggests that only in the seventeenth century did this concept come "to stand for the central object of scientific inquiry, and for a pre-eminent candidate for explanation of the charted phenomena."[1] Some years ago this question was addressed in three important papers. The first two works, by Edgar Zilsel and Joseph Needham, offer a sociological account for the rise of the concept of the laws of nature in the seventeenth century.[2] In the other work, Francis Oakley tries to account for the emergence of the idea by reference to the long natural law tradition upon which one could draw for an analogy.[3] More recently, Jane E. Ruby

---

[1]Bas van Fraassen, *Laws and Symmetry* (Oxford: Clarendon Press, 1989) 1.

[2]Edgar Zilsel, "The Genesis of the Concept of Physical Law," *Philosophical Review* 51 (1942): 245-279; Joseph Needham, "Human Laws and the Laws of Nature in China and the West," *Journal of the History of Ideas* 12 (1951): 3-30, 194-230. Although Needham claimed that he acted in ignorance of Zilsel's work (Needham 18, fn 46), the two are in almost complete agreement in arguing that sociological reasons account for the rise of the concept of the laws of nature. Needham goes beyond Zilsel, though, in arguing that the sociological reasons which gave rise to the concept in the west, although apparently present in China, were actually not fully there and that any possible development of the concept of the laws of nature was blocked by other sociological factors.

[3]Francis Oakley, "Christian Theology and The Newtonian Science: The Rise of the Concepts of the Laws of Nature," *Church History* 30 (1961): 433-457. As Oakley notes, the phrase "laws of nature" was used for both the moral and physical realms in the seventeenth century. For the purpose of this paper, though, in order to keep the distinction clear, the phrase "natural law" will be used to refer to the moral order and "laws of nature" to the natural order.

suggests that the origin of the modern descriptive sense of the laws of nature finds its roots in the scientific tradition reaching back to Roger Bacon in the thirteenth century.[4] However, what none of these works tries to do is to clarify what was meant by the laws of nature in the seventeenth century. Since a mere perusal of the voluminous writings of Robert Boyle (fl. 1651-1691) reveals a considerable discussion of the idea of the laws of nature, it seems that a more careful reading of his works would permit a closer examination of the emergence of this idea in the seventeenth century. If it could be discovered what Boyle meant by the phrase and its place in natural science, we could see whether the importance of the laws of nature arises for Boyle from what might be called internal grounds, that is, from the very nature of the science he is promoting, or whether there is a need, or to what degree there is a need for further explanation.

Both Zilsel and Needham cite Boyle as a prime example in their accounting for the rise of the concept of the laws of nature by sociological factors.[5] They note that in Boyle there is a view that the laws of nature were prescribed by God. Zilsel asserts that the modern concept of physical law finds its origin "in a juridical metaphor," and in "theological ideas." Later he says

---

[4]Jane E. Ruby, "The Origin of Scientific 'Law'," *Journal of the History of Ideas* 47 (1986): 341-359.

[5]Zilsel 247, 273-274; Needham 27, 29, 30.

that "the law-metaphor originates in the Bible...".[6] Zilsel notes that the idea of God as the divine lawgiver is central to Judaism and had ramifications in both the physical and moral realms. He gives the following examples of the idea in the physical realm.[7] In Job 28:26, God is described as making a law for the rain. The Hebrew word is *chok* from the verb *chokak* meaning to engrave. It was translated into Latin in the Vulgate as *ponebat legem*. Zilsel states that in the Vulgate the term "law" (*lex*) appeared one other time, in Proverbs 8:29, but that there are several times when God gives commands or prohibitions to nature. Among the ancient Greeks, the idea of a divine lawgiver for the physical world was also known. Most prominent of all the examples Zilsel gives are those from the Stoics. Zeno's disciple Cleanthes, in a hymn to Zeus, speaks three times about the "law according to which the prince of nature steers the universe."[8] There are also other examples from Chrysippus, Ovid, and Seneca.

Zilsel accounts for the rise of the idea of God as the divine lawgiver by reference to the presence of strong central monarchies which led to the idea of human legislation being projected onto God. He also explains the Stoic use of the "law-metaphor" by

---

[6]Zilsel 246, 247, 263. Needham places the origin of the concept of a divine lawgiver for non-human natural phenomena in ancient Babylon, but otherwise is in agreement with Zilsel; Needham 18, 18-30. Oakley merely notes that the concept found its roots "deep in classical and Semitic antiquity"; Oakley, "Laws of Nature," 433.

[7]Zilsel 247-248.

[8]Zilsel 251.

reference to the rising monarchies of the time, the empire established by Alexander the Great.[9] The idea that nature is subject to God's commands lay dormant till the seventeenth century, till the return of the rise of absolute monarchies and strong central governments.[10] The concept of the laws of nature with God as lawgiver arose only from a comparison of nature and state. That is, inanimate objects were likened to the citizens of a state: under obligation to obey the central ruler. Zilsel says that it is not surprising that the Cartesian idea of God as the divine legislator arose only forty years after Jean Bodin's theory of sovereignty.[11]

Shortly after their work, a noted medievalist, Francis Oakley, challenged their account. While agreeing that the concept of the laws of nature found its ultimate origin from the idea of a divine lawgiver, he rejects Zilsel and Needham's sociological explanation for the emergence of the idea in the seventeenth century. He also rejects their formulation of the question. Instead of asking why the concept of the laws of nature came into prominence in the seventeenth century, Oakley asks why the view of the laws of nature as imposed emerged when it did after being suppressed for so long by the view of the laws of nature as immanent. Like the others, though, Oakley notes that the origin of the laws of nature is not

---

[9]Zilsel 249-251.

[10]Zilsel 276-279.

[11]Zilsel 278. Zilsel claims that Descartes was the first natural philosopher to use the "law-metaphor" in the strictly scientific sense.

exactly the same as the origin of modern science and that the question is why mechanical regularities became interpreted as divine laws.[12]

Oakley suggests that the weakness of the sociological explanation is exposed by its inability to account for the different metaphysics of the Stoic and Semitic ideas of the laws of nature.[13] In order to do this, Oakley draws on a distinction made by Alfred North Whitehead in *Adventures of Ideas* between three different concepts of the laws of nature: immanent, imposed, and descriptive.[14]

Whitehead characterizes the immanent view of the laws of nature as the concept that the order of nature is reflected in the essences or forms of things such that to know the essence of something is to know its relation to other things.[15] The idea of immanent law is constructed on the notion of "the essential interdependence of things," the metaphysics of "Internal Relations." On the other hand, the imposed view of the laws of nature has a metaphysics of "External Relations," where independent particulars are forced into relation with one another. There is no connection between the laws of these relations and the inner

---

[12]Oakley, "Laws of Nature," 434.

[13]Oakley, "Laws of Nature," 434-435.

[14]Oakley, "Laws of Nature," 436, fn. 23.

[15]A.N. Whitehead, *Adventures of Ideas*, New York: Mentor Books, 1955) 116-120. Note that among those who fall under this rubric, only the Stoics use the term "law."

natures of the particulars; the order of nature is not reflected in their essences. This view of the laws of nature involves the idea of a transcendent divine lawgiver. It is sometimes referred to as the prescriptive view. Finally, the descriptive view of the laws of nature is a positivist idea that laws merely describe observed regularity without any attempt to give metaphysical explanation. In this case, laws carry no causal implications.[16]

Oakley shows that the Stoics had an immanent view of the laws of nature and that the seventeenth-century natural philosophers held the imposed law position. By making this distinction, Oakley is able to question the sociological method of accounting for both the Stoic and the seventeenth-century concepts of the laws of nature by recourse to the same factor: the rise of political absolutism. He suggests that because the Stoics had a view of immanent law, no idea of divine command could play a part in their concept of the laws of nature.[17] He also claims that Descartes, rather than taking the analogy for the laws of nature from the political sphere, took it from the ideas current about the moral order which reflected a long voluntarist tradition of a God who

---

[16]D.M. Armstrong says if laws of nature are seen as nothing but the regularity of the behaviour of things then they can not be used as an explanation, and to extrapolate from this they can not be causal. He writes: "to say that all F's are G's because of the law that all F's are G's is a good explanation unless law is a mere regularity, for it says that all F's are G's because all F's are G's." See his *What is a Law of Nature?* (Cambridge: Cambridge University Press, 1983) 40.

[17]Oakley, "Laws of Nature," 437, fn. 28.

imposes moral law according to his free choice.[18] He then notes that Boyle, as well as Descartes and Newton, held the view of the laws of nature as imposed by God. Oakley concludes that the metaphysical change necessary for the emergence of classical science was the Semitic idea of God as the transcendent lawgiver replacing the Greek idea of an immanent or even pantheistic God.[19]

A more recent article by Jane E. Ruby challenges not only the sociological accounting of the emergence of the concept of the laws of nature in the seventeenth century but also the received notion that modern scientific law has "its origins in the metaphor of divine legislation, with the prescriptive connotations subsequently disappearing."[20] Ruby notes that Boyle is often used to support this view. She does not dispute that Boyle held the imposed law position but tries to show that a merely descriptive view of law in connection with nature was held before Boyle and the seventeenth century, namely in the thirteenth century by Roger Bacon. She also notes that this connection between "laws" and nature was done in absence of those sociological factors that Zilsel and Needham use to support their claim and several centuries before the conditions they describe arose.[21]

In Boyle's works there are many references to the word "law."

---

[18]Oakley, "Laws of Nature," 438, 441.

[19]Oakley, "Laws of Nature," 451-452.

[20]Ruby 341.

[21]Inexplicably, as there are so few works on the rise of the concept of the laws of nature, Ruby does not deal with Oakley's article.

He speaks of law relating to rational creatures such as moral and civil law, and law referring to abstract ideas to mean something similar to the common use of the word "rule." For example, in talking about his own writing style, Boyle says "I have knowingly and purposely transgressed the laws of oratory..." (I:305). In this case, "law" denotes some good internal to the thing in question. Boyle also refers to laws in connection with non-rational, non-sentient bodies. These instances are noted as physical laws and are the object of this investigation. This paper will try to show that there are two sources for Boyle's conception of the laws of nature and that the problem is far more complex than has heretofore been suggested. Following this, an attempt will be made to place Boyle's concept of the laws of nature in some sort of context. Finally, this paper will conclude by considering whether this project has assisted in furthering the discourse over the emergence of the concept of the laws of nature to its position of prominence in the seventeenth century.

CHAPTER I

BOYLE'S USE OF "THE LAWS OF NATURE": IMPOSED LAW VERSES DESCRIPTIVE LAW

The earliest use by Boyle of the word "law" in connection with the physical world appears in *Some Considerations touching the Usefulness of Experimental Natural Philosophy*. This work was published in 1663, but internal evidence points to it being written much earlier. In the "Author's Advertisement," Boyle says that it was written ten or twelve years before when he was about 21 or 22 years old (II:4).[22] That would put the date at either 1651 - 1653 or 1648 - 1649.[23] The book was written ostensibly to a friend, whom Boyle called "Pyrophilus" (II:4), but it seems that its real intent was a Baconian attempt to promote the advancement of knowledge through observation and experimentation and to justify this through the practical applications of the findings. This was the first volume and it contains two parts, each with five essays on various subjects relating to natural philosophy. A second volume with the same title was published eight years later.

In the first essay of the first part, entitled "Of the Usefulness of Experimental Philosophy, principally as it relates to the Mind of Man," Boyle twice refers to physical laws. He argues

---

[22]All parenthetical references in the text are to the six volume collection: Robert Boyle, *The Works*, ed. Thomas Birch, 2nd ed. (1772; Hildesheim: Georg Olms Verlagsbuchhandlung, 1965). The Roman numeral refers to the volume number and the Arabic numeral refers to the page number.

[23]For various reasons, R.S. Westfall puts the date at 1653. See his "Unpublished Boyle Papers relating to Scientific Method," *Annals of Science* 12 (1956): 65, fn 6.

that man, being such a noble creature, should not live "ignorant or unstudious of the laws and constitutions of that great commonwealth (as divers of the antients have not improperly styled the world)..." (II:9). Early in the same paragraph he was speaking of "nature's mysteries" and undoubtedly would interchange "nature" with "commonwealth" or "world" here, so when he speaks of the laws of the commonwealth or world he means the same thing as when he speaks of the laws of nature. It is evident, however, that he feels no need to explain here what he means by laws, probably because the use of the term was common enough.[24]

Later, Boyle avers his notion both of the place of the laws of nature, as the proper study of natural philosophy, and of the innumerability of them: "But the objects of natural philosophy being as many as the laws and works of nature, are so various and so numberless..." (II:10). In these first references to the laws of nature it appears that Boyle is using the phrase to mean the rules governing the behaviour of bodies. That is, it is used in a collective fashion to refer to all the specific laws that govern nature which, as we will see later, are in some sense descriptive laws.

The second essay of the first part, simply titled "Of the Same," carries on the discussion of the first essay. Here, while asserting that the universe was made for man, and using the Bible and ancient authors to build his case, Boyle reveals his knowledge

---

[24]As will be shown later, many people in seventeenth-century England used the phrase "laws of nature."

of, and perhaps his debt to, the ancient Stoics. He states that, although Lactantius said the Stoics did believe that the world was made for man, Seneca dissented, using these words which Boyle quotes:

> *Non causa mundo sumus hyemen aestatemque referendi; suas ista leges habent, quibus divina exercentur. Nimis nos suspicimus, si digni nobis videmur, propter quos tanta moveantur:* 'We are not the cause of the seasons and returns of summer and winter to the world: these have their own laws, accommodated to the exercise of divine beings. We arrogate too much honour to our selves, if we esteem our selves worthy, that such vast bodies should fulfil such motions for our sakes' (II:18).[25]

Clearly Boyle knew of the Stoic use of the word "law" in connection with nature and knew so early on in his career. However, the role that the Stoic notion played in Boyle's thought is difficult to determine. Undoubtedly, he also knew of the Biblical use. It would appear in the passage just cited that Seneca's use of law in reference to non-sentient bodies is metaphorical although this might be presumptuous as the ancients did believe that divine beings moved the planets and stars. In his sketch of the rise of the concept of the laws of nature, Zilsel calls the Stoic use metaphorical.[26]

Further on in the same work, in an essay entitled "Containing a requisite Digression concerning those, that would exclude the Deity from intermeddling with Matter," Boyle first connects the laws of nature with God. He claims that many who wish to deny God only inquire as to the immediate cause of the phenomena and stop

---

[25]Boyle's translation. The marginal note is "Secundo De Ira, cap. 27."

[26]Zilsel 251.

there. If they were to go further, Boyle avers, they would find that the primary cause of things is either certain "fixt laws of nature," or the size, shape, motion, primary affections, and arrangements of matter, and that all of these point to an "intelligent author of things," that is, God (II:37). It seems that Boyle is using the term "fixt" here as an intransitive verb to mean rigid, just as he later uses the term "settled" in connection with the laws of nature. That is, he is not saying in this instance that the laws of nature were established by God; he does this later.

Boyle defines what he means by the laws of nature in an explanatory bracket where he calls them the "rules of action and passion among the parcels of the universal matter" (II:37). This seems to include the notion of cause and effect since he was just discussing the search for the causes of phenomena. If such is the case, then Boyle is talking about causal law which means they are not merely descriptive. Note that on the one hand, by calling the laws of nature the "rules of action and passion," Boyle is reducing the laws of nature to the laws of motion. All in Boyle's mechanical philosophy is to be ultimately accounted for by matter in motion. On the other hand, Boyle interchanges "rules" for "laws." The significance of this could possibly mean for Boyle what Ruby has shown it meant for Roger Bacon.[27]

Bacon interchanged "rule" (*regula*) for "law" (*lex*). Ruby shows that for Bacon *lex* used interchangeably with *regula* merely

---

[27]Ruby 347-348.

stood for a description of the behaviour of entities. In this case, Bacon was speaking of optics so the entity was rays of light. Ruby says that early on in its Roman use *regula* took on the meaning of "rule" in the sense of "guideline or standard." She says that *lex* was also used to mean standards or customs developed for the practice of various disciplines. By Bacon's time, both *lex* and *regula* were used in this non-prescriptive manner to indicate not what was set down by authorities but what was inherent in the nature of the thing. Ruby notes, though, that in the thirteenth century, *lex* shifted between a vaguely prescriptive-descriptive meaning and a clearly descriptive meaning.

However, by connecting in the passage the laws of nature with God, Boyle is showing that he views the laws of nature as evidence of purposeful design. This is implied by his use of the phrase "the intelligent author of things" although, as mentioned earlier, Boyle does not say here that God established the laws. It seems that in this case Boyle is restraining from speaking about laws in a prescriptive fashion.

Boyle goes on to make the link between God and the laws of nature even more explicit when he says that God made, arranged, and set in motion matter so that the phenomena God intended to result do in fact result and "must as orderly follow, and be exhibited by the bodies necessarily acting according to those impressions or laws" (11:39). Note that Boyle does not say that God established the laws. His use is still descriptive. He connects the idea of the laws of nature with the order found in nature; they are

responsible for the order so that the laws of nature are more than just descriptive, they are necessary, they are something deeper. The reference here to "impressions," it seems, relates to the idea of motion rather than to the idea of order. It is not used interchangeably with laws.

It appears though that Boyle is well aware of the prescriptive idea of the laws of nature, which he will refer to later, since he rejects as metaphorical or figurative the ascription of laws to matter. He first questions how those who adhere to the idea of *anima mundi* can claim that brute matter "can act according to laws, and for determinate ends, without any knowledge either of one or of the other" (II:38).[aa] So when Boyle goes on to say that phenomena result from God setting matter in motion, he claims that bodies act according to the laws of nature "though they understand them not at all" (II:39). He uses the clock analogy of the parts of the clock working without knowledge or intent yet acting in an orderly and seemingly purposeful fashion and achieving what appears to be determinate ends. Note, though, that these laws hold a criterion of necessity; they are not merely descriptive.

In the same work, Boyle asserts that bodies act according to the laws of nature,

> as if there were diffused through the universe an intelligent being, watchful over the publick good of it, and careful to administer all things wisely for the good of the particular

---

[aa]The idea of *anima mundi* was an extreme version of the Neoplatonic idea of a Spirit of Nature, which was used by such seventeenth-century Platonists as Thomas Vaughan. See Robert A. Greene, "Henry More and Robert Boyle on the Spirit of Nature," *Journal of the History of Ideas* 23 (1962): 451.

> parts of it, but so far as is consistent with the good of the whole, and the preservation of the primitive and catholick laws established by the supreme cause (II:39).

Boyle denies that God is physically diffused throughout the universe, personally guiding matter in a law-like fashion; he only states that it appears so. However, this seems to be a concession to Henry More's idea of the Spirit of Nature. It is interesting, though, that it should come in a work where Boyle is countering the idea of *anima mundi*. E.A. Burtt says that in this case Boyle had forgotten "his antagonism to this doctrine of the Cambridge divine [Henry More],"[29] but this can not be so. It could be that Boyle uses "as if" to stress the similarity of his and More's accounting for the phenomena. More, in the *Immortality of the Soul*, says that the Spirit of Nature works in a manner like the laws of nature, that is, consistently and inevitably.[30] However, later Boyle will talk about God's action in the universe in such a fashion that leads one to believe that he may have more in common with More's idea of the extended Deity than he admits.

In the passage just quoted it is the first time that Boyle says in any way that God established the laws of nature and it is the first instance of any clearly prescriptive view of the laws of nature. It is also the first time that Boyle speaks about the preservation of the laws of nature but it seems in this case that

---

[29]E.A. Burtt, *The Metaphysical Foundations of Modern Physical Science*, 2nd ed. (1932; London: Routledge and Kegan Paul Limited, 1972) 193.

[30]Greene 461; More's work was published in 1659, at least seven or eight years after this work by Boyle.

he does not suggest that there is a providential care of a reified set of laws, but rather that the law-like action of bodies is not violated in any way. It should be mentioned that nowhere does Boyle ever talk about the immanent view of the laws of nature. His use is always either the imposed view or the descriptive view, or something in between. That is, Boyle views nature as a collection of unconnected particulars that either are forced into a relationship with one another by an external force, God, or are merely described in such a fashion that they appear connected.

Also in this essay, Boyle for the first time refers to specific physical laws. In the first instance, the context is a discussion, by way of example, of why gold will sink in mercury while other bodies will float on it. Boyle feels that the mechanical philosophy can better account for the phenomena than can the notion of occult sympathies. He asserts that "gold being the only body heavier than quicksilver of the same bulk, the known laws of the Hydrostaticks make it necessary, that gold should sink in it, and all lighter bodies swim on it" (II:36). Boyle goes on to say that the cause for this is gravity, but then states that what gravity is may be considered as mysterious as the notion of occult sympathies. Whatever gravity is then, in such an accounting, the laws of hydrostatics merely describe the behaviour of the liquid mercury. That is, it is merely a descriptive or a phenomenological law. However, it is only in Boyle's accounting of the phenomena that such a law could even be described. To see the phenomena as a body sinking in liquid because of gravity means that this

behaviour can be described according to hydrostatical laws. In contrast, to see the phenomena as the result of occult sympathies means that the behaviour is not subsumed under this pattern of laws. In other words, if one was to assert the notion of occult sympathies, the order of the phenomena would be different as a different cause would be assigned.

The other instance of a reference to a physical law occurs in the next essay, which returns to the original discussion of the usefulness of mechanical philosophy. Here Boyle is speaking of how the eyeball is evidence of God's design and creation of the world. He says that an optical lens, in this case the eyeball of a white rabbit, will cause an image to be inverted, "according to the optical laws" (II:53). Again, the law is descriptive, but this time not of the motion of matter, but of the behaviour of the rays of light in refraction.

The next work of Boyle's to mention physical laws is *Hydrostatical Paradoxes, made out by New Experiments* which was published in 1666 but was obviously written in some form earlier as it was presented to the Royal Society in May, 1664 (II:745). In it, Boyle sketches several paradoxes and in looking for the cause of one paradox, notes that a certain object must sink in water "according to the known laws of hydrostaticks" (II:756). This use is similar to the other use of the physical law just given. The discourse, though, was written ostensibly as a response to a book by Pascal which contained two treatises: one on the equilibrium of liquors, and the other on the weight of the mass of the air. In

talking about the book, Boyle says that the conclusions are "consonant to the principles and laws of the Hydrostaticks" (II:745). Boyle interchanges the terms "principles" and "laws" here. This seems to recall Ruby's note of the interchange of "rule" and "law." That is, both "rule" and "principle" mean a guideline that is inherent to the thing in question and not imposed. Furthermore, "principle" also has the association with mathematics that "rule" has.

The significance of these usages comes out in the preface to this work, which was probably written later than the work, probably in 1666, the year the work was published, since Boyle notes that works presented to the Royal Society are not allowed to have a preface (II:745). In the preface, Boyle twice refers to the "laws of the Hydrostatick" (II:743, 744), but more often he refers to the "principles" of hydrostatics (II:739). In fact he twice refers to the "principles and theorems of Hydrostaticks" (II:741, 742), and once to "hydrostatical theorems" (II:741). Boyle is also explicit about the connection between hydrostatics and mathematics, although he does not reduce one to the other for he says that hydrostatics is not "purely mathematical" (II:740). He states, though, that most of the work on hydrostatics has been done by mathematicians since Archimedes set out his propositions but that he will not use mathematics to explain his position since not all men are well enough versed in mathematics to understand or follow the theorems. It is important to notice that the root of the idea of laws connected to hydrostatics is more likely to have come from the

notion of rules or principles associated with mathematics and geometry than from the idea of divine or human legislation.

In *Occasional Reflections upon Several Subjects*, published in 1665, Boyle speaks of how the contemplation of nature leads one to praise God's greatness and bounty. He says of animals that "the laws of their nature" makes them examples of God's glory and wisdom (II:350). Presumably he is talking about the patterns of order in their behaviour. If so then, this too is a descriptive law.

In a letter to Henry Oldenburg, dated March 24, 1665, Boyle gives a short account of the "statical baroscope," what is known today as a barometer.[31] In this letter he makes one reference to a specific law:

> That according to a hydrostatical law (which you know I have lately had occasion to make out) if two bodies of equal gravity, but unequal bulk, come to be weighed in another medium, they will be no longer equiponderant; but if the new medium, be heavier, the greater body, as being lighter in specie, will lose more of its weight, then the lesser and more compact; but if the new medium be lighter than the first, then the bigger body will outweigh the lesser: and this disparity arising from the change of mediums, will be so much the greater, by how much the greater inequality of bulk there is between the bodies formerly equiponderant (V:649).

By "make out" here Boyle means discover. It is probable that he discovered the law by experiment and that this is recorded in his work *Hydrostatical Paradoxes, made out by New Experiments* which, as noted, was presented to the Royal Society in 1664. It is probable that it is recorded in this work because if so it meets the

---

[31]The same letter is recorded a second time in the collection of Boyle's writings. This time the reference to "hydrostatical law" appears on III:140. This other recording was from the *Philosophical Transactions* dated July 2, 1666.

criteria of being both recent and undoubtedly known by Henry Oldenburg who was the secretary of the Royal Society at this time. However, it was not referred to there as a law -- if recorded there -- or any where else. This, as far as I know, is the only law of which Boyle claims discovery.[3e] It shows us what Boyle, in fact, thought a specific law to be. Again, it is merely descriptive of the regular behaviour of bodies.

According to internal evidence, Boyle's next work, *The Excellency of Theology, Compared with Natural Philosophy*, was also written in 1665, although it was not published until 1674. In the publisher's advertisement, it is noted that the author wrote the work in 1665 when he left London to avoid the plague (IV:1). The book was also published anonymously although the publisher indicates that the author feared recognition since he referred to his known works in the texts. The work is clearly Boyle's. As the title indicates, he was trying to raise the standing of the study of theology from what he thought was a loss of prestige in the face of the advancing natural studies. Appended to the work is a treatise entitled "About the Excellency and Grounds of the Mechanical Philosophy." It was probably written about the same

---

[3e]Boyle did not refer to what we now call Boyle's Law, that the pressure of gas is inversely proportional to its volume, as a law. For his account of the law, see his *A Defense of the Doctrine touching the Spring and Weight of the Air*, I:156f. It was first called a law by Mariotte, of the Académie des Sciences, in *Discours de la nature de l'air*, which was published in 1672. See Marie Boas, "The Establishment of the Mechanical Philosophy," *Osiris* 10 (1952): 422.

time.[33]

In keeping with the theme of the work, Boyle declares that the contemplation of God is far more noble an enterprise than the contemplation of "the laws, according to which the parts of matter hit against, and justle one another, and the effects or results of such motion" (IV:20). In the same place, Boyle says that although man has a will of his own, "all material things move only as they are moved, and have no self-determining power, on whose account they can resist the will of God" (IV:20).

The majority of references to the laws of nature in this work occur in the discourse on the "Mechanical Hypothesis." Here we find an important account by Boyle of the laws of nature. The context is the discussion of how the mechanical philosophy is better than Aristotelianism in accounting for the phenomenon of an image of a man cast into the air by a "concave spherical looking-glass." Boyle says that one skilled in "catoptricks" will be satisfied that "the phaenomenon is produced by the beams of light reflected, and thereby made convergent according to optical, and consequently mathematical laws" (IV:69). Nowhere else in his collected works does Boyle link physical laws with mathematics or even mention mathematical laws in relation to physical laws. In one other place, though, he does mention mathematicians in relation to physical laws but only in that they have worked hard to discover them.[34] In this instance, it is not exactly clear what Boyle means

---

[33]Westfall 64, fn 4.

[34]See *Languid and Unheeded Motion* V:2

by linking mathematical laws to optical laws. Presumably Boyle means by mathematical laws the mathematical expression of physical laws since clearly the laws of mathematics, meaning the rules of mathematics, are not the same as physical laws. Optical laws, as mentioned, are the rules governing the behaviour of rays of light through a lens. Undoubtedly Boyle was aware that the behaviour of light through a lens could easily be expressed mathematically. Perhaps, though, for Boyle, what counted for a law had to be expressible mathematically. In Ruby's discussion of the long history of connecting "law" and optics, she notes that A.C. Crombie suggests that Roger Bacon's use of "law" reflects his "program for mathematizing physics."[35] So mathematical law here for Boyle means nothing more than the mathematical expression of a descriptive law.

Further on in the same discourse, Boyle claims that the "laws of motion" hold not only for large bodies but also for small particles and so tries to extend such mechanics into the physical structure of matter (IV:71). In fact, he extends the reach of the laws of nature to all objects: big and small bodies fall according to the same "laws of acceleration"; cannon balls and small shot observe the same "rules of motion"; the town clock and the pocket watch operate according to the same "laws of mechanism"; and the earth and a loadstone exhibit the same "magnetical laws" (IV:71-72). For Boyle, laws are universal in their application; bodies everywhere and of every size behave the same way. Furthermore, it

---

[35]A.C. Crombie, "The Significance of Medieval Discussion of Scientific Method for the Scientific Revolution," *Critical Problems in the History of Science* (Madison, 1959) 89; cited in Ruby 343.

can be seen that Boyle freely interchanges the words "laws" and "rules." Perhaps again this signifies the mathematical connection.

Elsewhere, Boyle says that the accepted criterion of hypotheses is that they "solve the phaenomena, for which they were devised, without crossing any known observation or law of nature" (IV:77). This is interesting because it shows that for Boyle there is a distinction between laws and hypotheses. Laws are certain whereas hypotheses are not. It is similar to Newton's distinction between laws and hypotheses. For Newton, the former are deductions from phenomena, which as such are able to be proven, whereas the latter are speculative.

This discourse, *The Excellency of Theology*, also contains the most succinct description of Boyle's mechanical philosophy found in any of his works. It also shows how his mechanical philosophy differs from both the mechanical philosophy of the ancient atomists and, although he does not mention them by name, the more recent Cartesians:

> But when I speak of the corpuscular or mechanical philosophy, I am far from meaning with the Epicureans, that atoms, meeting together by chance in an infinite vacuum, are able of themselves to produce the world, and all its phaenomena; nor with some modern philosophers, that, supposing God to have put into the whole mass of matter such an invariable quantity of motion he needed do no more to make the world, the material parts being able by their own unguided motions, to cast themselves into such a system (as we call by that name:) but I plead only for such a philosophy, as reaches but to things purely corporeal, and distinguishing between the first original of things, and the subsequent course of nature, teaches concerning the former, not only that God gave motion to matter, but that in the beginning he so guided the various motions of the parts of it, as to contrive them into the world he designed they should compose... and established those rules of motion, and that order among things corporeal, which we are wont to call the laws of nature. And having told this as to

> the former, it may be allowed as to the latter to teach, that the universe being once framed by God, and the laws of motion being settled and all upheld by his incessant concourse and general providence, the phaenomena of the world thus constituted are physically produced by the mechanical affections of the parts of matter, and what they operate upon one another according to mechanical laws (IV:68-69).

Besides being the first time Boyle refers to "mechanical laws," the significance of which will be discussed later, several things are apparent from this text. First, Boyle differs from the Epicureans in the fact that he ascribes to the idea of imposed laws of nature. For Boyle, the order and regularity of nature are not the result of chance or the mere motion of matter but are given by God and upheld by his providence.[36] That is, although we describe the laws of motion as they exist, they were prescribed by God in the first place. Second, the system of nature that now appears originally needed God's direct intervention to guide matter into those formations which could then proceed according to the laws of nature. Third, that once these formations and the laws of nature were established, all phenomena are produced mechanically. In other words, what appears in the world is a result not only of the rules of motion but also of the original design of nature just as a clock is not only a result of the motion of its parts but also of its original design. R.G. Collingwood says that the early modern natural philosophers had an idea of nature as structure and

---

[36]Both Plato and Aristotle rejected ancient atomism because they could not conceive how it could account for the order and regularity found in nature. See Gary B. Deason, "Reformation Theology and the Mechanistic Conception of Nature," in *God and Nature*, eds. David C. Lindberg and Ronald L. Numbers (Berkeley" University of California Press, 1986) 178.

function.[37] This characterization certainly fits Boyle's work.

Fourth, Boyle makes it clear that by the laws of nature he means both the "rules of motion" and the "order among things corporeal." That is, both the regularity and the order of nature are included in his definition of the laws of nature. It seems that Boyle's admission here might help to explain why there is already in this paper a conflict between what has been said about Boyle's concept of the laws of nature and the received idea about Boyle's concept of the laws of nature. That is, Boyle means two things by the "laws of nature". In the first place, he means the rules of motion which connects his discussion to what has been outlined as the descriptive view of the laws of nature. These are specific descriptive laws of the behaviour of bodies which can be given in mathematical terms. In the second place, Boyle means the order of things. Later in this paper it will be shown that he also calls this the "common course of nature" or the "ordinary course of nature." This use corresponds to the historical tradition of the notion of prescriptive laws of nature.[38]

A discussion similar to the one in the passage just quoted occurs in *The Origin of Forms and Qualities, According to the Corpuscular Philosophy*, published in 1666, but with explicit reference to Descartes. It is in this discourse that Boyle gives

---

[37]R.G. Collingwood, *The Idea of Nature* (1945; Oxford: Oxford University Press, 1981) 16.

[38]Greene says that there is also a long tradition that the regular laws of nature represented God's general providence; Greene 466. More will be said on this later.

the most fully developed account of his corpuscular hypothesis.[39] While trying to account for forms in the essay "An Examen of the Origin and Doctrine of Substantial Forms, as it is wont to be taught by the Peripateticks, by reference to the mechanical philosophy," Boyle again feels the need to distinguish his corpuscular philosophy from those of Epicurus and Descartes:

> I differ both from Epicurus and Des Cartes, that whereas the former of them plainly denies that the world was made by any deity... and the latter of them... thought that God, having once put matter into motion, and established the laws of the motion, needed not more particularly interpose for the production of things corporeal, nor even of plants and animals, which, according to him, are but engines: I do not at all believe that either these Cartesian laws of motion, or the Epicurean casual concourse of atoms, could bring mere matter into so orderly and well contrived a fabrick as this world; and therefore I think, that the wise author of nature did not only put matter into motion, but, when he resolved to make the world, did so regulate and guide the motions of the small parts of the universal matter, as to reduce the greater systems of them into the order they were to continue in.... So that, according to my apprehension, it was at the beginning necessary that an intelligent and wise agent should contrive the universal matter... and settle the laws according to which the motions and actions of its parts upon one another should be regulated... (III:48).

Boyle goes on to talk about how he could envisage some combinations of bodies happening from the mere motion of matter but not such as "the bodies of perfect animals." These, in his opinion, resulted because of God's initial design and organization of matter and now occur through reproduction according to the "laws he had established in nature," so there is no need for God's special intervention with every case of reproduction of plants and animals.

Several things are noticeable here. First, Boyle feels, like

---

[39]Peter Alexander, *Ideas, Qualities and Corpuscles* (Cambridge: Cambridge University Press, 1985) 34.

Descartes, that both motion and the laws of nature come from God, from outside of nature. That is, nature is not self-sufficient.[40] Second, Boyle alludes to the fact that he disagrees with Descartes's notion of the laws of nature, but as Boyle deals with this in more depth in a latter discourse, discussion will be reserved until that time.[41] Third, Boyle's God is far more involved in the finer affairs of the first formation of things than Descartes's God.

Boyle's position on this point is also emphasized in another passage. He states that God, "who put matter in motion... and established the laws of motion among bodies... also, according to my opinion, guided it in divers cases at the beginning of things" (III:47). In an earlier section of the work, in "Considerations and Experiments touching the Origin of Forms and Qualities. The Theoretical Part," Boyle claims that mere matter in motion could not produce this "beautiful and orderly world," and that

> the wise Author of things did, by establishing the laws of motion among bodies, and by guiding the first motions of the small parts of matter, bring them to convene after the manner requisite to compose the world, and especially did contrive those curious and elaborate engines, the bodies of living creatures, endowing most of them with a power of propagating their species" (III:15).

As these excerpts show, Boyle consistently differentiates himself from both the Epicurean notion that the order of things happened by

---

[40]See Collingwood where he says that the early modern natural philosophers saw nature as dead and devoid of intelligence so that both motion and design had to originate from outside of nature in God; Collingwood 5.

[41]See *High Veneration* V:140.

chance, and from the Cartesian notion that God did not have to directly guide matter at the first formation of things. Boyle's assertion that God was directly involved in guiding matter at that time means that the original formation of things cannot be deduced by simply working backward from the present state of things according to the laws of motion. In a sense, Boyle is guarding against a kind of historical reductionism that seeks to find out the first formation of things from matter in motion alone. For Boyle, then, the original creation must remain a mystery despite the mechanical structure of the world.

In the essay "An Examen of Substantial Forms," Boyle uses the phrase "laws of nature" three times to denote the orderliness of nature while explicating the peripatetic position -- he differentiates it from Aristotle's stance -- on substantial forms. Speaking of what came to be known as secondary qualities, he states that

> these accidents being once introduced into the matter, we need not seek for a new substantial principle [form] to preserve them there, since by the general law or common course of nature the matter qualified by them must continue in the state such accidents have put it into, till by some agent or other it be forcibly put out of it, and so divested of those accidents (III:43).

Two things are to be noted here. First, Boyle equates the laws of nature with the "common course of nature." Second, what he has to say about qualities continuing in such as state as they are found unless changed by an outside force is what came to be known as the Law of Inertia, Newton's First Law of Motion. After this, Boyle says that bodies need no substantial forms to "preserve them in

that state as long as the law of nature requires," and that "the accidents of a body will by the law of nature remain such as they were" (III:43, 43). It seems that, for Boyle, in the discourse of mechanical philosophy, the laws of nature take over the role that substantial forms played in the scholastic discourse. In other words, what accounts for the preservation of certain qualities in an object in the scholastic discourse is substantial forms, while in the mechanical discourse it is the laws of nature. Hence, this is a case of a causal law.[42] The main significance, however, of this passage is that it is an instance by Boyle of a law of nature that refers to order of nature rather than to the rules of motion.

In a later essay, "Considerations and Experiments touching the Origin of Qualities and Forms. The Historical Part," Boyle again equates "laws" with the "course of nature" (III:75). He says that, among other things, those of the "Particularian philosophy" must know the "general laws and course of nature" in contradistinction to the followers of the "lazy Aristotelian way of philosophizing" (III:75). Boyle seems to be aware that the concept of the laws of nature is integral to the new developing science while it is not integral to an idea of nature centred on substantial forms.

Finally, in the discourse "Free Considerations about Substantial Forms," annexed to the second edition of *The Origin of*

---

[42]Alexander notes that the schoolmen regarded substantial forms as causes while Aristotle did not. See Alexander 51.

Forms and Qualities, which was published in 1667,[43] Boyle uses the phrase "laws of nature" to denote the order or orderliness of nature. The context is Boyle's discussion of the word "form" which he says usually only accounts for a few of the attributes that we associate with a particular body. He continues:

> Now the form of a body being really no more than a convention of accidents, whereby the matter is stamped and denominated, it is very consonant to reason, that oftentimes hostile agents or causes may deprive the matter of those accidents, which constituted the specifick form, and yet leave the rest, which, according to the law of nature, ought to continue there, till some competent agent put the body out of that state, wherein, upon the form's decease, it was left (III:123).

Again Boyle substitutes the function of the laws of nature for the function of forms. It is not apparent here whether Boyle meant to place the word "law" in the singular or whether this has any significance.

The next work of Boyle's to follow chronologically, is *A Free Inquiry into the Vulgarly Received Notion of Nature*. It was published in 1686 but Boyle says in the preface that it was written in 1666 (V:159).[44] However, in the conclusion he says that the work is a collection of papers written at very different times and in very different circumstances (V:253-254). This factor could be important later on in this discussion of Boyle. This discourse is perhaps Boyle's most important philosophical work. In it, he deals

---

[43]J.F. Fulton, *A Bibliography of the Honourable Robert Boyle*, in *Oxford Bibliography Society Proceedings and Papers*, vol. 3, 1931 - 1933 (Oxford: Oxford University Press, 1933) 58-59.

[44]Boyle also says in the preface that the work was edited closer to the time of his writing the preface which is dated September 29, 1682. See V:160, 161.

with the nature of things, preferring to discuss nature in general rather than the specific works of nature (V:158). He also says that he is writing against atheists who ascribe too much to nature and against Christians who think that nature's only value is as proof of the existence and of the providence of God (V:158-159).

The work also contains an excellent study in the semantics of the word "nature." Boyle criticizes the "vulgar" idea of nature, the idea that nature is a creature, a semi-deity, as a "notional" thing (V:161, 218, 220), meaning that it is imaginary. The work is dedicated primarily to showing the problems and contradictions of the vulgar notion of nature and secondarily to presenting in its place the mechanical view. In the course of this project, Boyle makes more references to the laws of nature than in any other work.

Boyle begins by outlining his position. Phenomena are produced by matter in motion, acting according to the "laws of local motion" rather than by "an intelligent overseer, such as nature is fancied to be" (V:162). Boyle's assertion, though, does not rule out the idea of God's providence. It is more worthy of God that he establish a machine-like universe that runs on its own, than that God must interpose for every event. Boyle says that the vulgar notion views nature as a puppet which requires God's continuous intervention, while his view is that nature is like a clock, particularly the one at Strasburgh, where statues perform at certain occasions because of the inner mechanism of the clock (V:163). Boyle notes that contemporary Aristotelians ascribe the regular motion of the planets to the "ordinary course of nature"

rather than to "intelligent and immaterial beings" as did Aristotle and most of his followers and that this is not considered as a challenge to the idea of God's providence (V:163).[45]

Boyle argues that a place for providence still exists in his mechanical philosophy. First, God "prescribed" (V:177; cf V:170) or "established" the laws of nature (V:170, 189, 197, 199, 220, 222, 223, 224, 226, 251, 252), or they were "settled" by him (V:176, 177, 179, 200, 200, 218, 222, 236, 251, 252). Second, God preserves the laws of nature. They are "upheld" (V:162) or "maintained" by him (V:179, 199, 200, 218, 223). Boyle also speaks of God's "ordinary and general concourse" (V:162, 179, 189, 222), and in one instance says that if God "but continue his ordinary and general concourse, there will be no necessity of extraordinary interpositions" (V:163). The *Oxford English Dictionary* writes that in the seventeenth century the word "concourse" was used to denote the "concurrence in action or causation, cooperation; combined action," and indicates that Boyle's use of it was in no way unique.[46] In one particular instance, Boyle states that the laws

---

[45]If one takes what Boyle means elsewhere by the "ordinary course of nature," he is saying here that contemporary Aristotelians ascribe the regular motion of the planets to the "laws of nature" in the prescriptive sense.

[46]"Concourse," *The Compact Edition of the Oxford English Dictionary*, 1971, 775, def. 6. In a different definition of the term, "3. The running, flowing together, or meeting of things (material or immaterial)," the dictionary notes that the phrase "Fortuitous concourse of atoms," used in the seventeenth century by several authors, came from the Latin phrase by Cicero, *concursus fortuitus*, meaning the action whereby the universe came into being according to the atomic theory of Leucippus and Democritus. For Boyle's use of this phrase see *Origin of Forms and Qualities* III:48.

of nature are "upheld by his [God's] ordinary and general concourse" (V:162). If we take into consideration the dictionary definition of the word "concourse," this passage could be rewritten to say that the laws of nature exist in their own right, but are only efficacious with God's assistance. This discussion of the connection between God's concourse and the laws of nature will be extended in the next chapter.

Boyle also feels that he has to deal with the problem of anomalies, not of the mechanical philosophy but apparent anomalies in the reckoning of God's providence. He cites things such as eclipses which would appear to the average observer to contradict the idea that the universe is strictly governed by God, or earthquakes and floods which pose a more serious moral problem. If, as Boyle claims, all these events are merely the unfolding of the mechanical universe, then God must have planned all these events to happen and as such is morally responsible.

However, Boyle states that he is not directly addressing the question of God's providence, but only indirectly addressing it as far as it touches natural philosophy (V:196-197). This of course brings him into the problem of miracles. It is such cases of providence, Boyle says, that "transcend the power, or at least over-rule the physical laws of motion in matter" (V:197). He notes that God is not bound by the laws of nature, for God, "when he made the world, and established the laws of motion, gave them to matter, not to himself" (V:197).

That God is capable of performing miracles is one thing, but

Boyle argues that it is still for the good of man:

> God... may exercise as much wisdom, nay, and as much providence (in reference to men, the noblest visible object of his providence) in sometimes (as in divine miracles) receding from what men call the laws of nature, as he did at first establishing them" (V:197).

God's general providence, the upholding of the common course of nature, and his special providence, miracles, can both be beneficial to man. However, Boyle notes that the present order of the universe is not completely favourable to man because of the Curse, which resulted from the Fall, and that some events which seem to contradict the idea of God's care for man and nature are severe in an attempt to drive man back to God. Boyle also says that sometimes God "over-rules" the regular motions of matter within the present system in order to execute justice (V:198). Furthermore, he states that God's providence is not such that every man or creature is always free from harm. If this was the case, then in certain circumstances, God would have to alter "the settled frame, or the usual course of things," or "some general law of motion" would have to be "hindered from taking place" (V:199). Boyle intimates that such could be done, but that God chooses to preserve the more general and important things such as the ordinary course of nature.

Later on in the discourse, Boyle briefly returns to the question of miracles. Miracles are occasions where the "instituted order" has been "violated" such as when the sun stood still in the days of Joshua, or the Red Sea was parted in the days of Moses (V:223). Boyle says that such occasions are rare and done "for

weighty ends and purposes, by the peculiar intervention of the First Cause, either guiding or over-ruling the propensities and motions of secondary agents" (V:223). Note that miracles are caused not only by over-ruling the motion of matter, which undoubtedly means over-ruling the laws of nature, but also by over-ruling the propensities of matter by which he seems to mean the affections of matter. Elsewhere, while accepting that miracles occur among men, Boyle states that in the far reaches of the universe, away from man, God "does seldom manifestly procure a recession from the settled course of the universe, and especially from the most catholic laws of motion" (V:215). Here he claims that the laws of motion are a subset of the "course of the universe" which he elsewhere calls the laws of nature meaning the orderliness of nature. This is important since it indicates that what we have been showing here to be two concepts of the laws of nature, that is, laws of nature as the order or orderliness of the universe and as the rules of motion, are for Boyle the same thing. Clearly by this Boyle reveals that he believes that the orderliness of the universe is reducible to the descriptive laws of motion.

In another scenario, the laws of nature are over-ruled not by God but rather by other laws of nature:

> we may sometimes and usefully distinguish between the laws of nature, more properly so called, and the custom of nature, or, if you please, between the fundamental and general constitutions among bodily things, and the municipal laws (if I may so call them) that belong to this or that particular sort of bodies (V:219).

What Boyle is setting up here is a hierarchy of laws. Later he says that when God established the laws of nature he subordinated

some laws to other laws (V:251). In the passage just given, "municipal laws" are the lowest or least important and "catholic laws," "grand laws," or "general laws" are the highest or the most important (V:219-220). In Boyle's example, water falls to the ground by virtue of the "custom of nature," but in a pump, suction, by virtue of "a more catholic law of nature," forces the water upward, contrary to and over-riding the custom of nature (V:219-220). He explains this by saying that "a greater pressure, which in our case the water suffers from the weight of the incumbent air, should surmount a lesser, such as is here the gravity of water..." (V:220).

Boyle then goes on to explain preternatural phenomena, phenomena which are contrary to nature, by this distinction. A spring that is forcibly bent is said to be in a preternatural state because it seeks to return to its former or "natural" state. However, Boyle claims that it is merely one state of the spring being over-ridden by another state which is equally "natural" because it is "agreeable to the grand laws... that such a spring should remain bent by the degree of force that actually keeps it so..." (V:220).

Boyle also objects to the idea that it is nature that makes water ascend in a tube in order to avoid a vacuum as though nature were conscious:

> Sometimes, when it is said that nature does this or that, it is less proper to say, that it is done by nature, than that it is done according to nature: so that nature is not to be looked on as a distinct or separate agent, but as a rule, or rather a system of rules, according to which those agents, and the bodies they work on, are, by the great Author of things,

determined to act and suffer (V:219).

Rather than nature making water ascend in a tube it is air pressure acting according to the laws of nature that makes it do so. Also, nature is not a separate entity but only a name given to a system of rules, or a system of laws. Boyle avers that to say that nature makes the water rise is only a figure of speech; it is like saying that geometry measures land and architecture constructs buildings (V:219).

When Boyle does define his notion of nature, he distinguishes between the particular and universal nature of things (V:177). The particular nature is the complex of mechanical affections, the "bigness, figure, order, situation, contexture, and local motion" of its parts. The notion of the universal nature of things that Boyle offers is as follows: "that nature is the aggregate of the bodies, that make up the world, framed as it is, considered as a principle, by virtue whereof they act and suffer, according to the laws of motion prescribed by the Author of things" (V:177).

In Boyle's mechanical philosophy, nature is not conscious and matter is brute. He says that matter, acting in accordance with the "catholic laws of motion," "without any knowledge of what it does," can account for what some philosophers ascribe to an animate nature (V:163). It is important to remember that in the mechanical philosophy, Boyle was trying to reduce all phenomena to matter in motion.

A little later, while discussing ancient axioms concerning nature, in particular the idea that nature always acts in the

shortest way, Boyle avers that it is not nature as an entity deciding on the shortest route: "But the truth is, that at least inanimate bodies, acting without knowledge or design of their own, cannot moderate their own action, but must necessarily move as they are determined by the catholic laws of motion..." (V:225).

Further on in the discourse, Boyle picks up the theme again. Boyle is trying to force those who hold the vulgar notion of nature into asserting a contradiction. After deciding that most thinkers would call nature a substance rather than an accident, Boyle asks whether nature is corporeal or immaterial (V:241). If immaterial, he asks then whether it is created or not. If not, then it is God by another name. But if nature is created, Boyle asks "whether or no she be endowed with understanding, so as to know what she does, and for what ends, and by what laws she ought to act?" (V:241). If now the answer is no, Boyle suggests that the vulgar notion of nature is unintelligible and of little use in accounting for things. If the answer is yes, Boyle goes on to explain that this notion of a soul for nature again does little to explain the phenomena. But if nature is corporeal, then, following Descartes, Boyle asks how it can think and posses wisdom such as to guide the motions of bodies (V:242). He continues:

> it may likewise be asked, how the laws of motion come to be observed or maintained by a corporeal being? which, as merely such, is either uncapable of understanding them, or of acting with respect to them, or at least is not necessarily endowed with any knowledge of them, or power to conform to them, and to make all the parts of the unquestioned mundane matter to do so too (V:243).

Boyle carries on the argument to the final result that his position

is the best of all the choices.

This leads to perhaps the most revealing discussion on the laws of nature in the discourse *The Notion of Nature*. After outlining the different uses of the word "nature," and rejecting the vulgarly received notion of nature, Boyle states that the word "nature" should not be used by philosophers because it is a confused term (V:170). He then confesses, in so many words, that he too misuses the phrase "laws of nature":

> And even I sometimes scruple not to speak of the laws of motion and rest, that God has established among other things corporeal, and now and then, (for brevity's sake, or out of custom) to call them, as men are wont to do, the laws of nature (V:170).

He does not mean to imply here that the laws are supplied by nature as from a rational being. Rather, he reveals firstly that the laws of nature are a collective term for the laws of motion and secondly that all laws of nature are ultimately reducible to the laws of motion.

Boyle goes on to say that his use of the word "law" is figurative:

> But to speak strictly, ...to say, that the nature of this or that body is but *the law of God prescribed to it*, is but an improper and figurative expression: for... I must freely observe, that, to speak properly, a law being but a *notional rule of acting according to the declared will of a superior*, it is plain, that nothing but an intellectual Being can be properly capable of receiving and acting by a law.... But I cannot conceive, how a body devoid of understanding and sense, truly so called, can moderate and determinate its own motions, especially so, as to make them conformable to laws, that it has no knowledge or apprehension of; and that inanimate bodies, how strictly soever called natural, do properly act by laws, cannot be evinced by their sometimes acting regularly, and, as men think, in order to determinate ends: since in artificial things we see many motions very orderly performed, and with a manifest tendency to particular and pre-designed

> ends; as in a watch.... And when a man shoots an arrow at a mark, so as to hit it, though the arrow moves toward the mark, as it would if it could and did design to strike it, yet none will say, that this arrow moves by a law, but by an external, though well directed, impulse (V:170-171).

In this passage, Boyle rejects the idea that the nature of things derives from God's law for the use of the word "law" is figurative. He states that matter, being brute, has no intelligence to understand a law or will to choose to fulfil it. Furthermore, the idea that bodies act according to laws because they exhibit orderly motions and seemingly determined ends is false. Boyle counters that a machine, such as a clock, will act orderly and to determined ends and yet is not alive or conscious in any way, and certainly could not be said in a literal sense to be following laws or seeking a determined end. In this analogy, and in the analogy of the shot arrow, Boyle indicates that the orderliness and apparent purposefulness of these "artificial things" result from both the original design and the motion imparted. The clock is first designed in a certain way and then set in motion as the arrow is first aimed and then set in motion.

Besides using the laws of nature as synonymous with the laws of motion, Boyle uses several other equivalent phrases. The most common is "mechanical laws," which, interestingly, only appears in the sixth and seventh sections of this eight-sectioned work as though it was a term he turned to later (V:208, 215, 215, 216, 216, 216, 226, 236, 239). This is the second occurrence of the phrase

"mechanical laws" in the works of Boyle;[47] it is also not uncommon in his later works. This term seems to be a conflation of the ideas of the mechanical philosophy and the laws of nature. It is perhaps, an unconscious admission of the inherent connection between the two ideas. In some instances, though, it is probably just a reference to the laws of mechanics which undoubtedly is from the idea of law as a guideline or a rule. Boyle also interchanges "laws" with "rules" (V:179, 199), and he twice uses the term "principles" for "laws." In one instance he simply refers to the "mechanical principles" and in the other he interchanges the two: "physico-mechanical principles and laws" (V:240, 215). This, as mentioned, is probably an extension of the influence of mathematics into natural philosophy. That is, it is an instance of the merely descriptive use of "law" and not an instance of the prescriptive use. In a situation similar to an earlier one, Boyle equates "custom" to the subordinate laws of nature (V:200, 226), and finally, as indicated earlier, Boyle at least once uses the phrase "the ordinary course of nature" for the laws of nature. When speaking of his contemporary Aristotelians, he says that "they now ascribe to the ordinary course of nature those regular motions of the planets..." (V:163).

In addition to this, Boyle explicitly connects God to physical laws. Speaking of God, he declares, "by whose laws the grand agents in the universe were impowered and determined to act..."

---

[47]See *The Excellency of Theology* IV:68-69. Due to the difficulty in dating Boyle's work's, this may well be the first occurrence of the phrase.

(V:164). This is a clear case of the prescriptive view of the laws of nature; these are God's laws.

Despite the fact that Boyle said that he was not interested in talking about the works of nature, there are also a few references to specific laws of nature in this discourse. Boyle speaks of the "laws of heavy bodies," the "laws of gravity," and twice about the "laws of the aequilibrium of liquors" (V:194, 225, 219, 229). It is important to note that of these references to specific laws, only the "laws of gravity" cannot be reduced to the laws of motion. Boyle said earlier that gravity is an occult force, meaning that it is an unknown force, and till Newton it was unacceptable for a mechanical philosopher to leave the explanation of phenomena without reducing an occult force to a mechanical force. Now prima facie it seems, then, that the use of "law" with gravity is simply a case of a descriptive law but, if the argument of this paper is correct, the origin of the term "law" in connection with gravity came not from the descriptive use of law but from the prescriptive use. That is, the origin of the descriptive use of the term "law," as shown by Ruby, is those sciences connected with mathematics such as optics, mechanics, and astronomy, whereas the origin of the prescriptive use of the term "law" is the idea that the orderliness of the universe, what Boyle calls the "common course of nature," results from divine legislation. So, as the law of gravity cannot be reduced to the laws of motion, and hence to the descriptive origins of "law," it can only be explained be recourse to the orderliness of nature and hence to the prescriptive origins of

"law."

Boyle closes his work on *The Notion of Nature* by trying to show that his view of nature is better for religion than any of the other views (V:250-253). He makes several points about God that justifies his definition of providence as well as saves the phenomena. He claims that God, as a free agent, "created the world, not out of necessity, but voluntarily," and established among bodies certain "general and constant laws" which suited God's purposes, and subordinated some laws to others so that the care of the whole is more important than the care of particular creatures (V:251).[48]

In the *Essays of the Strange Subtility, Great Efficacy, Determinate Nature of Effluviums*, there are only two references to the laws of nature. This work was published in 1673 but in the publisher's advertisement it is claimed on the one hand that it was written just after Boyle's work on qualities, that is, *The Origin of Forms and Qualities*, which was published in 1666, and on the other hand that it was written several years before the year it was published, 1673 (III:659-660). The publisher also says that several parts of it were published anonymously in 1669. It is safe, then, to date the work from around 1667-1668. The first reference in the work to physical laws is to the "laws magnetical" (III:670). This is also a reference to an occult force and so could possibly be explained the way the laws of gravity were. In

---

[48]Note that Boyle's use of the word "constant" in connection with "laws" is the same as his use of the word "fixt" in an earlier passage. See *The Usefulness of Natural Philosophy* II:37.

the other reference, Boyle uses laws in a new but perhaps completely expected way when he says that effluviums may be "promoted by the fabrick and laws of the universe itself..." (III:688). That is, this is the first time Boyle connects "laws" to the "universe" rather than to "nature" or "motion" or some specific law. The importance of the phrase "laws of the universe" will be discussed more thoroughly in regard to its use in the next discourse.

Tracts about The Cosmical Qualities of Things is a loose collection of six tracts published in 1671. The only two that concern us here are "Of the Systematical or Cosmical Qualities of Things" and "Cosmical Suspicions" which is an appendix to the former tract. The first discourse, "Cosmical Qualities," seems to be a sequel. In fact, Boyle says that he touched upon some of the topics in the discourse "Origin of Forms" (III:307).

He begins "Cosmical Qualities" by distinguishing between what is sometimes called primary and secondary qualities (III:306). The former, such as size, shape, and motion, he calls "primitive modes and catholic affections of matter itself." The latter he calls here simply "qualities" and states that they result from the relations of bodies to other bodies. That is, they consist of the powers bodies have over other bodies or of the capacity of bodies to suffer from other bodies such as mercury having the power to dissolve gold and silver and the capacity to suffer dissolution from aqua fortis. It is clear that these qualities are chemical. For Boyle they indicate that nature is interconnected; he claims

this is why he uses the name "systematical or cosmical" to describe the qualities. It is not surprising then that in the next couple of pages he thrice uses the phrase "laws of the universe" (III:307, 308, 312).[49] That is, his reference to the universe implies that laws reach to the whole of creation, the cosmos, and this in turn implies its interconnectedness.

In the beginning of the discourse, Boyle twice in the same paragraph refers to the coupled terms, the "laws and customs of nature" (III:307), which seems to echo the earlier idea of a hierarchy of physical laws. Elsewhere, Boyle addresses the issue of a peculiar quality, that of magnetism. He speaks twice about the "established laws of nature" and once about a specific law, the "laws magnetical" (III:313).

In the same essay, while discussing his concept of cosmical qualities, Boyle says:

> and to prevent mistakes, I shall add, that under the name of catholick and unminded causes or agents, I comprehend not only divers invisible portions of matter, but also the established laws of the universe, or that which is commonly called the ordinary course of nature (III:307).

Three important things can be concluded from this passage. First, the laws of nature here are causal laws. They are, as such, explanatory laws; they explain why certain phenomena appear. Furthermore, as such, they can not be merely descriptive laws for

---

[49]Due to the difficulty in dating Boyle's works, these references to the "laws of the universe" may predate the references in the previous discourse. Nonetheless, the use of the phrase emerged at approximately the same time. It is also the only time in Boyle's works that the phrase was used, perhaps reinforcing the idea of its special meaning.

reasons already discussed. Second, these laws are prescriptive laws; they are "established" by God. Third, Boyle equates the "laws of the universe" with the "ordinary course of nature." The importance of this will be discussed in the next chapter.

In the essay on "Cosmical Suspicions," Boyle refers to the essay "Cosmical Qualities" and states that in it he tried to take the "laws of the universe" into consideration when giving an account of the qualities of things. He confesses, though, that there may be many more "laws" and of different kinds that are yet to be discovered (III:318). Furthermore, Boyle claims that the known "laws of nature" are not well enough distinguished:

> some of them being general rules that have a very great reach, and are of greater affinity to laws properly so called, and others seeming not so much to be general rules or laws, as the customs of nature in this or that particular part of the world; of which there may be a greater number... (III:318).

Again we see that for Boyle, there seems to be a hierarchy of laws. That is, the order, from highest or farthest reaching to the most limited, goes from "laws," to "rules," to "customs." Also, it is clear that in this instance Boyle does not find term "rules" to be equivalent to the term "laws," although elsewhere he does, and that in order to be a law, a pattern of behaviour must be universal in scope.

This distinction between "laws" and "rules" seems to reflect a use indicated by Ruby. Ruby notes that Roger Bacon in the thirteenth century had interchanged the terms "laws" (*lex*) and "rules" (*regula*) but that in his work on perspective, as on logic, there was a subtle difference between the uses. She says:

> In the paragraph in which he [Bacon] uses both terms, *lex* is for the more fundamental principle of multiplication; and while he uses *lex* far more often than *regula* to designate the general principles of both multiplication and perspective, for variants under specific conditions he never uses *lex*, but instead either *regula* or its naturalized Greek equivalent, *canon*.[50]

The second volume of *Some Considerations touching the Usefulness of Experimental Natural Philosophy* came out in 1671, eight years after the first volume. It was written later because Boyle felt himself not the master of their content and was preoccupied with other works (III:394). It contains only two references to the laws of nature, both of which occur in the chapter "Of the Usefulness to the Empire of Man over inferior Creatures." Both references also merely comment on the usefulness of the knowledge of the "laws of nature" to the trades (III:403, 404).

The discourse *Tracts. Containing New Experiments, touching the Relation Betwixt Flame and Air* was published in 1672. It is a collection of four essays. The content of the tract that first mentions physical laws is revealed in its title: "An Hydrostatical Discourse, occasioned by the Objections of the learned Dr. Henry More, against some Explications of New Experiments made by Mr. Boyle" (III:596). In this essay, Boyle twice refers to specific laws: "hydrostatical laws" and "statical laws" (III: 610, 612). Of greater interest, though, are the other two references to physical laws.

Early on in the essay, while trying to defend himself against

---

[50]Ruby 349-350.

More, Boyle states:

> yet all that I have endeavoured to do in the explication of what happens among inanimate bodies, is to shew, that supposing the world to have been at first made, and to be continually preserved by God's divine power and wisdom; and supposing his general concourse to the maintenance of the laws he has established in it, the phenomena, I strive to explicate, may be solved mechanically, that is, by the mechanical affections of matter, without recourse to nature's abhorrence of a vacuum, to substantial forms, or to other incorporeal creatures (III:608).

Here Boyle uses every term possible to speak of God's providential care of matter and the laws of nature. In addition, he seems to be suggesting that belief in physical laws is antithetical to the notion of substantial forms which for him are just the names of sensible qualities. This may be reversed to say that belief in substantial forms is antithetical to the concept of the laws of nature. He is also suggesting that in the broader context there can be more than one accounting for the phenomena.[51]

At the end of the same essay, Boyle tries to show that hydrostatics needs no *principium hylarchicum* as suggested by More. In arguing against this principle, he says:

> the generality of the heathen philosophers were convinced of the being of a divine architect of the world, by the contemplation of so vast and admirably contrived a fabrick, wherein, yet taking no notice of an immaterial *principium hylarchicum*, they believed things to be managed in a mere physical way, according to the general laws, settled among things corporeal, acting upon one another (III:628).

Boyle does not state who these heathen philosophers are or what he means by speaking of their supposed belief in physical laws. It is known, as he elsewhere states, that the ancient Greek precursors to

---

[51]Cf. *Hydrostatical Discourse* III:627.

the mechanical philosophy were such like Epicurus and Democritus, but these had no belief in physical laws nor in any God who "established" them. The only sect of the ancient Greeks who had a belief in the "laws of nature" were the Stoics, but their laws were not mechanical laws and they were not atomists.

In the next essay, "New experiments of the Positive or Relative Levity of Bodies under Water," there are only two references to physical laws. Both of these are to the same specific law, the "hydrostatical law" (III:636, 638).

Tracts, consisting of Observations about the Saltness of the Sea, published in 1674, is another collection of essays. The first tract, "Of the Positive or Private Nature of Cold," is a dialogue between four characters. All references in it to physical laws are by Carneades, who, as he states early on, has just read Boyle's "History of Cold" (III:733). What ensues can be taken as Carneades speaking for Boyle.[52]

In the first instance of the mention of a physical law, Carneades is trying to explain why the hand feels cold when plunged into cold water. He argues that the hand, finding the corpuscles of the cold water moving more slowly than before, transfers its motion to the water according to the "laws of motion" (III:741). The unspoken premise is that coldness is the deprivation of the motion of particles. Carneades, in a parenthesis, gives an

---

[52]Alexander notes that in *The Sceptical Chymist* Carneades is the corpuscularian, in other words, he is Boyle. See Alexander 21. Carneades is also the name of an ancient sceptic and the allusion would not have been lost on Boyle's contemporaries.

explanation of a law of motion: "according to which, a body, that meets another much more slowly moved than itself, communicates to it more of its motion, than if it were less slowly moved" (III:741). Later on in the same paragraph, he says that he must take into account that the blood in the hand, "according to the laws of its circulation" (III:741), is circulated throughout the rest of the body. Further on in the discourse, he talks about "a world so framed as ours is, and governed by such laws, respecting motion and rest, as are observed among bodies..." (III:744). The idea of laws regarding rest, has been, since Boyle's time, subsumed under the notion of the general laws of motion.

In the next essay, "Observations and Experiments about the Saltness of the Sea," which is not a dialogue, there is only one reference to physical laws, and this a specific law, "the laws of the true hydrostaticks" (III:768). Boyle again indicates that this is the law that he discovered, only this time he says that another person discovered it as well.[53]

Finally, in the discourse "A Paradox of the Natural and Preternatural State of Bodies, Especially of the Air," there are three references to physical laws. Here Boyle is trying to argue against the distinction between natural and violent, or preternatural, states. In so doing, he articulates the law of inertia without calling it that: "For when I consider that whatever state a body be put into, or kept in, it obtains or retains that

---

[53]For the other reference to this event, see *The General History of the Air* V:649.

state, according to the catholic laws of nature..." (III:782). Note that the laws of nature here are the prescriptive sense; it is the idea of orderliness, the "common course of nature," as Boyle says elsewhere. After this, he says that those bodies thought to be in a violent state are really in a natural state because they got into their violent state "no otherwise than according to the established laws of universal nature" (III:782-783). Again, this is a prescriptive sense of law. Boyle goes on to say that the people who adhere to this doctrine consider those bodies to be in a preternatural state because

> they do not consider the condition of the body, as it results from the catholic laws settled among things corporeal, and relates to the universe, but estimate it with reference to what they suppose is convenient, or inconvenient, for the particular body itself (III:783).

It appears from these references that Boyle is trying to argue that all phenomena must come under one set of laws as his use of "catholic" and "universal" as adjectives to describe these laws indicates, and that in this sense the world is truly interconnected, truly a universe.

Following this work, Boyle published another set of essays in 1674, *Tracts, Containing Suspicions about some Hidden Qualities of the Air*. In the essay "Of the Cause of Attraction by Suction," he argues that this example of attraction may be accounted for by mechanical means. He concludes that "it appears, that these phaenomena, without recourse to attraction [as an occult quality], may be explicated barely [solely] by the laws of aequilibrium of liquors" (IV:144). Again, it can be said that there seems to be an

antithetical relations between the concept of substantial forms and the concept of the laws of nature and that Boyle's use of the laws of nature here is both causal and explanatory.

Experiment, Notes, Etc. about the mechanical Origin or Production of divers particular Qualities, was ready for printing in the same year as the former work but was published in 1675 (IV:230). It contains three references to physical laws, each in a different essay. In the "Advertisement" to the essay "Of the Mechanical Origin of Heat and Cold," Boyle avers that the use of hypothesis is "to render an intelligible account of the causes of effects, or phaenomena proposed, without crossing the laws of nature, or other phaenomena" (IV:234). This is the second time he says that hypotheses must not cross the laws of nature.[54]

In another treatise, "Reflections upon the Hypothesis of Alcali and Acidum," Boyle argues for the superiority of the mechanical hypothesis. He finishes the seventh chapter of this tract by way of a reminder, set off in quotation marks for emphasis, or so it would appear: "'Those hypotheses do not a little hinder the progress of human knowledge, that introduce morals and politicks into the explication of corporeal nature, where all things are indeed transacted according to laws mechanical'"(IV:291). Boyle seems to be directing his criticism here against the "Duellists," those who try to derive "both the qualities of bodies, and the rest of the phaenomena of nature from

---

[54]For the other reference, see *The Excellency of Theology* IV:77.

what they call acidum and alcali" (IV:284), because they are involved in anthropomorphizing nature.

The final reference, in the tract "Experimental Notes about the Mechanical Production of Magnetism," states that "according to the magnetical laws," magnetic north repels magnetic north and attracts magnetic south (IV:342). Once again, this law is descriptive of the behaviour of bodies; it explains nothing and cannot be reduced to the laws of motion.

The next work, *Some Physico-Theological Considerations about the Possibility of the Resurrection*, also published in 1675, was annexed by the publisher to a discourse by another author titled "Reconcileableness of Reason and Religion." Boyle was aware of this and approved of the action (IV:191). As the title page indicates, the other work was written by "T.E. a Lay-man" (IV:151), but the identity of this person today is unknown.[55] "Reason and Religion" contains six references to physical laws and two discussions on miracles (IV:161, 161, 161, 169, 177, 179; IV:161-162, 163). However, as it was not written by Boyle, it will not be discussed here except to note that its use of the concept of the laws of nature is comparable to Boyle's.[56]

Boyle's work is an attempt to argue that the corpuscular philosophy does not preclude the possibility of the resurrection of

---

[55]Fulton, 84.

[56]One recent writer, Timothy Shanahan, has mistakenly quoted from this text as though it were Boyle's, perhaps because it is in his collected works. See Timothy Shanahan, "God and Nature in the Thought of Robert Boyle," *Journal of the History of Philosophy* 26 (1988): 565.

the body. He notes that resurrection does not happen by the "common course of nature," that is, by the laws of nature, and so must be miraculous by definition (IV:192). It is understandable then that the only reference in this discourse to the laws of nature has to do with a violation of the laws of nature. In talking about glorified bodies, the bodies of those raised from the dead, Boyle states:

> we may observe, that the power of God has already extended itself to the performance of such things... sometimes by suspending the natural acting of bodies upon one another, and sometimes by endowing human and other bodies with preternatural qualities. And... it cannot be incredible, that the most free and powerful author of those laws of nature, according to which, all the phaenomena of qualities are regulated, may... introduce, establish, or change them in any assigned portion of matter, and consequently in that, whereof a human body consists (IV:201).

He goes on to say that when Elisha's helve floated on the water "its native gravity was rendered ineffectual"; that when Peter walked on water "the gravitation of St. Peter's body was suspended"; and that when Daniel and his three companions survived Nebuchadnezzer's furnace "the operation of the activist body in nature, flame, was suspended..." (IV:201-202).

What amounts to a miracle in Boyle's accounts, then, are the suspension of the common affections of bodies, or as Boyle says, "the natural activity of bodies." In the three examples given of miraculous events, gravity is suspended or rendered ineffectual, and the operation of the flame is suspended. It seems that, because the "natural acting" of bodies is suspended, the laws which govern these affections, or as Boyle says, "according to which, all the phaenomena of qualities are regulated," are also suspended. In

this, Boyle seems to be recognizing a close link between the affections of bodies and the laws of nature, but he does not say that laws automatically flow from the affections of bodies but instead that laws regulate them. It seems that Boyle is claiming that the properties and affections of matter result from the laws God has established rather than laws resulting from the properties inherent in matter as would be thought today.

A Disquisition about the Final Causes of Natural Things, was published in 1688. In the preface, though, Boyle reveals that it was written before the death of Henry Oldenburg (V:393), the Secretary to the Royal Society, which occurred in 1677. It appears then that the discourse was either written in 1677 or just before.

In this work on final causes, Boyle finds himself arguing against two modern sects, both mechanical philosophers (V:392-393, 395). One sect is the followers of Epicurus -- except Gassendi -- who deny ends because the world is the result of chance. The other sect is the Cartesians who say that final causes cannot be discovered through natural reason because they are too high for man. When arguing against the former, Boyle says that things that are done in the corporeal world result from matter "acting and suffering according to the laws of motion established by the Author of nature," and that chance is a creation of man's intellect when unknown causes produce results different from those we would expect (V:409). Against Descartes, Boyle's argument is more complex, ultimately resting on the greater weight he gives to providence than does Descartes (V:395-402). Nonetheless, Boyle does not feel

that final causes are the domain of the natural philosopher who must "discourse merely upon physical grounds" and seek efficient causes (V:411).

Turning to the aid of revelation, Boyle claims that it is known that things were created for certain purposes and one of these purposes was the benefit of mankind; the sun gives light and warmth to the earth so man can survive and to plants and animals so they can grow for the advantage of man (V:411). Boyle continues:

> And it is not incredible, that God should have intended, that many of his other works should be serviceable to man; since by miraculous operations He hath sometimes suspended the laws of nature, and sometimes over-ruled them, upon the account of man... (V:412).

Boyle then addresses the question of how bodies without knowledge or rational faculties can attain to certain ends. He asserts that it is because an intelligent agent, God, acting through intermediary causes, intended such ends to be met. God framed things and "settled among them such laws of motion" not only that the present state of things was arranged but also that bodies "acting according to the laws of motion by Him established," should reach certain goals that God intended (V:412). Boyle goes on to say that it is not easy to believe that the phenomena of the world result from bodies obeying the "laws of nature" rather than from bodies acting to their own ends (V:414). However, he reminds his readers of God's omniscience and omnipotence. It seems then that the purposeless of nature often associated with mechanical philosophy cannot really be attributed to Boyle's version with his providential God.

Having set up this machine-like picture of bodies obeying the laws of motion as, to use Boyle's metaphor, in the mechanisms of a clock blindly achieving ends established by the creator, Boyle is then concerned with defending his position against the denial of miracles:

> Nor is this doctrine inconsistent with the belief of any true miracle; for it supposes the ordinary and settled course of nature to be maintained, without at all denying, that the most free and powerful Author of nature is able, whenever He thinks fit, to suspend, alter, or contradict those laws of motion, which He alone at first established, and which need his perpetual concourse to be upheld (V:414).

From this account of miracles, as well as from former accounts, several points can be drawn. The first is that the laws of nature were established and settled by God. This has been mentioned elsewhere but it should be explained that this meant that God both designed and implemented the laws of nature. Second, the laws of nature cannot exist without God's continuous support, his "concourse." This idea will be addressed further in the next chapter. Third, following from the two former points, God both has the right and the ability to suspend, alter, or contradict the laws of nature.

Finally, after musing about God's designed ends for the world, Boyle ponders the question of whether or not the existence of some things and of some phenomena might be the result not of God's primary intention but only of the consequences of his other choices. Boyle could then use this to account for some anomalies and some seemingly useless things and phenomena in nature. He says that some things might be made only "as productions, that will

naturally follow upon the establishment and preservation of those grand laws and rules of motion, that were most fit to be settled among things corporeal" (V:423), and that "some phaenomena may not belong to the primary intention of nature, but are only the necessary consequences and effects of the primitive constitution of the world, and the catholic laws of motion" (V:424).

An Essay of the Great Effects of even Languid and Unheeded Motion was published in 1685, but, being intended as part of an earlier work, was actually already printed in 1677 or 1678 (V:1). It has only two references to the laws of nature, both of which come on the first page of the discourse. Boyle says that it is for mechanical philosophy to "resolve the phaenomena of nature into matter and local motion" and then in a parenthesis goes on to explain that matter was "guided, at the beginning of things, immediately, and since regulated, according to settled laws, by the great and wise author of the universe" (V:2). Note that Boyle returns to the idea that in the first formation of things God was directly involved in guiding matter. That is, after creating matter, God designed the pattern it should have before setting it in motion according to the laws established by him. More importantly, though, note that for Boyle there is an ultimate meeting of the descriptive and prescriptive senses of the laws of nature. On the one hand, in the descriptive sense, Boyle says that the phenomena are to be reduced to "matter and local motion" or, in other words, to the laws of motion, which in the collective sense he elsewhere calls the laws of nature. On the other hand, in the

prescriptive sense, these laws were imposed by God, who must then for Boyle be the great mechanical philosopher just as God was for Plato the great geometer.

Following this discussion, Boyle goes on to say that a great many mathematicians and philosophers have worked hard to study the "nature and general laws of this motion" and that in this discourse he is going to examine the issue of local motion even further (V:2). Here Boyle acknowledges that the formulation of specific laws are to be expressed in mathematical terms.

The next work of Boyle's to refer to the laws of nature comes after an interval of several years during which many other works were published. *Of the High Veneration Man's Intellect Owes to God*, published in 1685, is a collection of loose sheets of paper, written at different times and places, and hastily tacked together, or so the publisher claims (V:130). This work suggests that of God's attributes which we are able to know, we have only an imperfect knowledge. Building on two imperfectly known attributes of God, wisdom and power, Boyle attempts to show that God is far beyond the grasp of man's intellect. The discourse is really a devotional. It contains at the same time, though, several references to the laws of nature, only one of which is a specific law, the "law of opticks" (V:141).

Early on, Boyle discusses what would result if God had made other worlds besides the one we know:

> Now in these other worlds... we may conceive, that there may be a vast difference betwixt the subsequent phaenomena, and productions observable in one of those systems, from what regularly happens in ours, though we should suppose no more,

> than that two or three laws of local motion may be differing in those unknown worlds from the laws, that obtain in ours (V:139).

It seems that Boyle is saying that there are not many logical possibilities for different laws of motion, only two or three laws may be different. He suggests that the ability of some bodies to move restlessly while not loosing power to still bodies might be more extensive in another world: "And the laws of this propagation of motion among bodies may be not the same with those, that are established in our world" (V:140).

So Boyle can imagine a world where the "laws of motion" are different, that is, another logically possible world. He states that this is not preposterous "for in the common philosophy, besides that the notion and theory of local motion are but very imperfectly proposed, there are laws or rules of it well, not to say at all, established" (V:140). In other words, although mechanical philosophy does not understand all that there is to know about local motion, certain laws are well known, or are established facts, and it is possible to speculate that these might be different in another world. This argument seems in part to be an attempt to establish God's freewill and omnipotence in settling the laws of nature.

Next Boyle turns to a topic that appears to reinforce this; he attacks the "Cartesian law of motion" (V:140). Boyle states that the proof for the conservation of motion that Descartes offers,

> being drawn from the immutability of God, seem very metaphysical, and not very cogent to me, who fear, that the properties and extent of the divine immutability are not so well known to us mortals, as to allow *Cartesius* to make it, in

our present case, an argument, *à priori* (V:140).

So while arguing against Descartes on the one hand that we should be able to know more of God's ends for the natural world, on the other hand, Boyle argues the opposite way against him in that we can not know God's attributes well enough to make them an *à priori* argument. Boyle also rejects Descartes's Law of the Conservation of Motion on *à posteriori* grounds because the universe is too vast and unknown to test the hypothesis. Boyle continues:

> So that the truth of the Cartesian rules being evinced neither *à priori*, nor *à posteriori*, it appears not, why it should be thought unreasonable to imagine, that other systems may have some peculiar laws of motion; only because they differ from those Cartesian rules, whereof the greatest part are, at least, undemonstrated (V:140).

Clearly Boyle is suggesting that Descartes's account of the laws of motion would restrict God's freedom in choosing the form of these laws both for this world and for other worlds. That is, Descartes is trying to explicate laws that are rationally necessary such that God would have to establish them in any world he created. For Boyle, though, we can not know what is necessary to God or nature; we can only come closer to knowing what is in the world. It is interesting to note that Boyle, although he does not say it explicitly, would consider Descartes's Law of the Conservation of Motion as an hypothesis and not as a law since it cannot be ascertained solely from the known facts of the universe.

Carrying on, Boyle claims that a God who can care for this vast universe, with its complex and mundane bodies "every moment sustained, guided and governed, according to their respective natures, and with exact regard to the catholic laws of the

universe," is worthy of great praise (V:140). Furthermore, the governance of angels and demons might be more difficult than the governance of matter according to the "primordial laws of motion," since bodies "have no wills of their own to make them swerve [from their commanded course]," and consequently display more of God's wisdom and power (V:142).

Later in the same discourse, Boyle speaks of the vast distance between the knowledge of God and the knowledge of man, who, along with the other creatures, is "but the limited and arbitrary production of his [God's] power and will..." (V:148). As a result of this, man may know only some of the "laws of motion,"

> but God knows particularly, both why and how universal matter was first contrived into this admirable universe, rather than a world of any other of the numberless constructions he could have given it; and both why those laws of motion, rather than others were established; and how senseless matter, to whose nature motion does not at all belong, comes to be both put into motion, and qualified to transfer it according to determinate rules, which itself cannot understand (V:149-150).

Here again Boyle is claiming that God was free to establish the structure of the world and the laws of nature found in it; but Boyle goes further in claiming that he does not understand how matter obeys the laws of motion.

Following chronologically, the next work of Boyle's is *The Christian Virtuoso*. The first volume was published in 1690. The second volume was published much later, in 1744, as part of Thomas Birch's first edition of Boyle's collected works.[57] It came out later than the first volume because while Boyle was working on it

---

[57]Fulton, 120.

he was called off to London where sickness, business, and visitors kept him busy (V:541). Presumably, he was unable to see it through to publication before he died in 1691, although he had already sent it to the publisher.[58] It is not clear whether or not the *Appendix to the First Part of the Christian Virtuoso* was first published in 1744 as well. In both the 1744 edition of Birch and in the second expanded edition of 1772, it appears next to the second part of *The Christian Virtuoso*. Nonetheless, the intent of all the works that come under this title is to show that being a virtuoso, a natural philosopher, is neither against Christianity nor a hinderance to being a good Christian.[59] These works also show Boyle's mature thought, especially on the concept of the laws of nature.

In the preface of part one of *The Christian Virtuoso*, Boyle claims that although he is not writing as a natural philosopher, some will think that he is wasting his time as only "the laws and phaenomena of nature" are worthy for philosophers to write about (V:510). In the work, he only mentions one specific law, the "law of optics" (V:517). Later he also mentions that there are far more "laws" in the universe than man with his dim and limited mind can reach (V:538).

Perhaps though, the most important discussion of the laws of nature occurs in an argument in favour of God's providence. Boyle had just argued for the existence of God and the immortality of the soul (V:515, 517). That is, he averred that these religious

---

[58]See *The Christian Virtuoso*, Part II, VI:716.

[59]See V:508.

beliefs are not contrary to natural philosophy, but rather conducive to its furtherance. He then argues for belief in providence:

> Nor will the force of all that has been said for God's special providence, be eluded, by saying, with some deists, that after the first formation of the universe, all things are brought to pass by the settled laws of nature. For though this be confidently, and not without colour pretended; yet I confess, it does not satisfy me. For, besides the insuperable difficulty there is, to give an account of the first formation of things, which any (especially Aristotelian) deists will not ascribe to God; and besides that the laws of motion, without which the present state and course of things could not be maintained, did not necessarily spring from the nature of matter, but depended upon the will of the divine author of things: besides this, I say, I look upon a law as a moral, not a physical cause, as being indeed but a notional thing, according to which, an intelligent and free agent is bound to regulate its actions. But inanimate bodies are utterly incapable of understanding what a law is, or what it enjoins, or when they act conformably to it; and therefore the actions of inanimate bodies, which cannot incite or moderate their own actions, are produced by real power, not by laws; though the agents, if intelligent, may regulate the exertions of their power by settled rules (V:520-521).

Several things are evident from this passage. First, Boyle asserts that there is a God who created the universe. Second, the laws of nature do not "necessarily spring from the nature of matter." Boyle is aware that this is an option open to those who deny what he asserts, that the laws of nature were freely and arbitrarily established by God. Third, Boyle implies that the "course of things," elsewhere called the common course of nature, exists because of the laws of motion. Fourth, Boyle suggests that for those Deists who claim that the first formation of things happened without God guiding and directing matter and that the laws of nature follow from the inherent properties of matter, there is an even greater problem: the idea that there are "laws" for motion is

notional. Boyle avers that obedience to laws can only properly be attributed to a rational creature and matter, being brute, cannot know or obey laws or commands. Therefore, the Deists, who say that God is not continuously involved with nature, cannot account for the law-like behaviour of matter. Boyle states that the actions of inanimate bodies are not produced by "laws" but by "real power." This "real power" is none other than God acting directly in nature regulating the actions of bodies. Perhaps Boyle is closer to More's position, elucidated earlier, than he admits, or perhaps this assertion can be understood within the context of Boyle's thoughts on God's "concourse" which will be discussed in the next chapter.

In the *Appendix to the First Part of the Christian Virtuoso*, Boyle returns to the problem of miracles. The work is a dialogue between four characters. Eleutherius, whose role seems to be that of expanding on the arguments of Justinus, the main figure, who says that the phenomena of nature are the production of matter in motion, acting "according to settled laws" (VI:679).[60] He goes on to say that it is

> unreasonable to deny, that the grand author of nature, who freely and arbitrarily established those laws, may, either by suspending, or altering them, or by a more immediate guidance of the motions of the minute parts, or greater portions of matter, or by way unknowable to us, as those by which he, being an incorporeal substance, can give motion to matter: a virtuoso, I say, that knows and considers these things, will easily grant, that this divine agent may, by divers ways... bring such things to pass, as the ordinary course of nature

---

[60]Alexander says that in *The Sceptical Chymist* Eleutherius represents the common man. There is no Justinus in this dialogue. See Alexander 21.

would never produce... (VI:679-680).

Boyle here goes beyond earlier accounts of miracles and asserts that they may be produced by God's direct action in moving corporeal bodies or by ways unknown to us. This echoes Boyle's reference to God as a "real power," but it must be noted that in this case, God's actions only result in miracles which operate outside of the laws of nature and are not the reason for the laws of nature. For this reason, it is unlikely that Boyle's earlier reference to "real power" means that he sees the laws of nature as merely the human description of God's direct and continuous activity in nature. Rather, it seems that for Boyle the laws of nature do really exist as such.

Boyle carries on in the mouth of Justinus to reply to those who say that belief in Christianity forces one, as a natural philosopher, to hold to mysteries that are incomprehensible. He says that some natural phenomena are unable to be comprehended by anyone, and that even in the mechanical philosophy "the general explications supposed such a fabrick of the world, and such an origin, and such laws of motion, as involve difficulties that confound our weak understanding" (VI:693).

Finally, in the same discourse, but after the dialogue, Boyle says that belief in miracles is warranted for the following reason:

> It is one thing to contradict a catholic or metaphysical principle, or dictate of reason, and another to contradict a physical one; since the laws of nature, as they were at first arbitrarily instituted by God, so, in reference to him, they are but arbitrary still (VI:714).

Boyle states that religion is not contrary to reason or logic; it

is only contrary to the laws of nature when it asserts the belief in miracles, but as physical laws were freely and arbitrarily established by God, he can without contradiction or difficulty change or suspend them. However, Boyle seems to be implying that God is bound by reason and logic as these were not freely and arbitrarily instituted by God. They are necessary while the laws of nature are not.

In the second part of *The Christian Virtuoso*, Boyle has several references to the laws of nature. He refers to three specific laws: the "laws of opticks" and the "laws of the refractions, and reflexions of light" (VI:736, 737). He also calls plants and animals "living machines," and talks about how they are reproduced by a few simple "laws of local motion" (VI:725-726), and how from a simple egg, "by virtue of the general laws of motion" and the fabrick of the egg, the beauty of a peacock's feathers should appear (VI:730). He goes on to speak about how the phenomena of the world are produced by matter and "the guidance of the local motions of the greater and smaller fragments of it according to a few laws which they are not disposed to disobey..." (VI:731). Boyle asserts that, as matter is brute, it cannot arrange itself into such a wonderful fabrick as the world and cannot disobey laws as can creatures who possess intelligence and will. A little later on, Boyle mentions matter's "regular conformity to laws" (VI:764).

Boyle also discusses the relationship between the separate substances of mind and the body and speaks of the "laws" of their

union (VI:754). He goes on to mention "laws" three more times in this context (VI:754, 754, 755). He then claims that all the phenomena in nature are explicable in terms of "mechanical laws" except for the workings of man who has a rational soul and free will (VI:754). That is, the motions of man's limbs and other parts are not derivable from "the general laws of motion," or the "merely mechanical laws of motion," and do not follow from the "laws of motion established among things corporeal" (VI:756). Instead, they result from man's free will. Presumably, there is a mechanical law for matter and man's body in as much as it is part of the material world, and a law for the relation between mind and body, but their is no law for the mind, being immaterial, and for the workings of the mind in as much as it is evidence of the workings of man's free will.

Earlier, in another discourse, Boyle had turned to the question of whether or not there were other logically possible worlds, existing at the same time as our world, with different laws of nature.[61] In this discourse, Boyle asks whether or not another world, separated from our world by time, might have different physical laws:

> And who knows, but that in that *new heaven, and new earth*... that God will substitute for [our world], the primordial frames of things, and the laws of motion, and consequently, the nature of things corporeal, may be very differing from those that obtain in the present worlds [sic]" (VI:788-789).

Again Boyle is affirming that the laws of motion found in this world were freely and arbitrarily chosen by God and that other

---

[61]See *High Veneration* V:139.

logically possible worlds, with other laws of motion, could exist. It is not clear whether Boyle meant for "worlds" to be plural or whether this has any significance.

From this survey of Boyle's works, several things are evident regarding his concept of the laws of nature and his use of the phrase. First, in this regard, Boyle is for the most part consistent throughout his life. Second, for Boyle, the phrase "laws of nature" is figurative since matter is brute and has neither the intelligence to obey laws nor the will to disobey them. Third, Boyle uses the phrase "laws of nature" in two different ways. On the one hand, for Boyle, laws were imposed by God; they were established freely and arbitrarily by an omnipotent God. As such, there could have been other logically possible worlds. Also, these laws imposed by God were arranged hierarchically. On the other hand, laws are descriptive of the regular behaviour of bodies. However, for Boyle, laws are rarely merely descriptive since he usually holds that they are causal and explanatory and as such they have metaphysical implications. Laws for Boyle really exist; they are not constructs of the human mind.

Furthermore, it seems that Boyle's two uses have two different origins and these correspond to his coupling of both the "order among corporeal" and the "rules of motion" as the laws of nature.[62] That is, on the one hand, the idea that the laws of nature means the "order among things corporeal" has its origins in the idea of divine legislation reflecting the ancient Greek and Biblical uses

---

[62]See *Excellency of Theology* IV:68-69.

of the phrase. It is God who establishes and maintains the common course of nature. On the other hand, the idea that the laws of nature means the "rules of motion" has its origins in the idea from the thirteenth century of the mathematical description of the behaviour of bodies without any prescriptive connotations. This use of law derived from the notion of a rule or guideline inherent in the nature of the object. Both traditions influenced Boyle but both seem to come together as he feels that all laws describe the laws God has prescribed and that the order in the universe will eventually be reducible to the rules of motion, to mathematical laws. All laws are then explained by the laws of motion. Boyle hoped that even the laws of gravity would be reduced to the laws of motion. Nonetheless, the laws of motion themselves are only explanatory on one level since they find their ultimate source in the will of God.

However, when Boyle articulates his concept of the laws of nature, he draws on some other traditions. That is, although there are two origins to Boyle's use of the word "law" in connection with nature, there are other sources upon which he draws for his concept of the laws of nature that are necessary to consider in order to have a better grasp of what Boyle meant. The next chapter will turn to this discussion.

CHAPTER II

CLOCKS OR PUPPETS:

BOYLE'S CONCEPT OF THE LAWS OF NATURE

In order to better understand Boyle's concept of the laws of nature, it is important to place his thought in its proper intellectual context. That is, in articulating his concept, Boyle draws upon two intellectual traditions that reach back to the late middle ages but that were current in his day. The first tradition is the medieval doctrine of voluntarism. Francis Oakley, Eugene M. Klaaren, and J.E. McGuire have placed Boyle's thought on nature in this context. As Oakley says, the idea of divine omnipotence, which is the crux of voluntarism, is not only the religious tradition in which Boyle stood, it is also the philosophical and scientific tradition in which he stood.[63] The other intellectual tradition necessary to understand Boyle's thought is known as concurrentism. The exponent of this position is Timothy Shanahan.

The first tradition developed out of the theological debates in the thirteenth century. The crucial date and event usually given in any account of the development of voluntarism is the Condemnation of 1277 when the Bishop of Paris and the Archbishop of Canterbury published a list of 219 propositions that were condemned as contrary to the Christian faith. This event was brought on by the recovery of Aristotelian texts from the Arab world coupled with the introduction of Aristotle's Arabic commentators into Europe.

---

[63]Francis Oakley, *Omnipotence, Covenant, and Order* (Ithaca, N.Y.: Cornell University Press, 1984) 85.

Foremost among these Aristotelian and Arabic ideas that were condemned were the teachings of "metaphysical necessitarianism" which threatened the freedom and omnipotence of God.[64] Metaphysical necessitarianism taught that the world necessarily exists, and exists necessarily the way it is. There could be no other logically possible world, and, following this, all the rules governing phenomena must of necessity exist the way they are.

The Church reacted to the challenge of the freedom and omnipotence of God. In contrast to the Aristotelian-Arab position, Christian theologians asserted that God's powers were unlimited and as such God could freely choose to create the world and to create it such as it is. God was under no constraint or compulsion in either case, neither in regard to his power nor his will. However, God was not capricious, they taught, and would not just randomly change the order of the world he established. Rather, it could be trusted that the natural order would remain constant, not because it is so necessarily, but because God had promised in the Bible to keep the present order.

What was to eventually occur from this voluntarist position, and especially from the teachings of William of Ockham, was the rejection of the idea that the natural order rested on the notion of divine ideas as Plato had taught. Instead the natural order was seen to be the result of an autonomous divine will.[65] Although

---

[64]Oakley, "Laws of Nature," 438.

[65]Oakley, "Laws of Nature," 439.

this was a rejection of the ultimate intelligibility of the world,[66] it helped to give rise to empiricism since in rejecting the notion of divine ideas it rejected the notion of necessary connections between distinct things and hence there is no way to deduce the order of the world a priori; the order of things can only be discovered from what de facto is.[67]

The two phrases that in the medieval period came to signify this voluntarist doctrine were *potentia absoluta* and *potentia ordinata*. *Potentia absoluta*, God's absolute power, stressed that God was not restricted or limited in any fashion in creating the world save logical contradiction. God could have created any world with any natural order; he could have created one different from the one that exists and he could have created separate worlds with different natural orders, and God could in the future create a different world with a different natural order. The only thing God could not do is change logic.

Potentia ordinata, God's ordained power or ordinary power, stressed that God would not change the world randomly, that he had promised in the Bible to keep the present order till the end of the

---

[66]Oakley, *Omnipotence* 55.

[67]Oakley, "Laws of Nature," 442. Ernst A. Moody says: "But if the world is out-and-out contingent, there can be no a priori reasons for its existence or for its de facto order; empiricism is thus a logical consequence of belief in the Christian doctrine of divine freedom."; Moody, "Empiricism and Metaphysics in Medieval Philosophy," *Studies in Medieval Philosophy, Science, and Logic: Collected Papers, 1933-1969* (Berkeley: University of California Press, 1975) 229.

world.[68] *Potentia ordinata* came to be seen as the idea of a covenant since, as Oakley says, "The only force... capable of binding omnipotence without thereby denying it is the omnipotent will itself."[69] Because of God's covenant in the Bible whereby he binds himself, the order of the world could be trusted to remain constant. God normally condescends to act within the ordained order but still has the freedom to over-ride this order and such constitutes a miracle.

In speaking about God's absolute power and his ordained power, Eugene M. Klaaren interprets this as crucial to the development of modern science and especially of the concept of the laws of nature. It is important to note, though, that he is speaking about the conceptual origins of the laws of nature here and not about the origins of the phrase "laws of nature" although the latter would seem to naturally follow. Klaaren says:

> Within this dialectical orientation [*potentia absoluta* and *potentia ordinata*], the order of creation was conceived in terms of law, and entities subject to law, rather than in terms of symbols with varying degrees of mind and soul which participated in the divine Logos. Fully developed, this shift from *logos* to law acquired epoch-forming proportions, for law in this tradition had its own character. In principle, law was dependent chiefly upon God's will rather then His reason,

---

[68]It is interesting to note what *The Compact Edition of the Oxford English Dictionary* lists for the use of the terms "ordain" and "ordinary" in Boyle's time, both words coming from the Latin roots *ordina-re* and *ordinarius* respectively. Definition 13 for "ordain" states: "Of the Deity, fate, or supernatural power: To appoint as part of the order of the universe or of nature; to decree, predestine, destine" (180), and definition 9 for "ordinary" writes: "A formula or rule prescribing a certain order or course of action" (187). So when Boyle is speaking about the "ordinary course of nature" he is speaking about the order of nature.

[69]Oakley, *Omnipotence* 62.

> although the latter was not neglected. Since there was no easy or natural transition from God's power to the created order, obedience reinforced the sense of a transcendent Lawgiver. Like the ancient Jewish understanding of law, the voluntarist view presupposed God distinct from His creation, which he orders by law.[70]

Elsewhere, Klaaren says that with voluntarism, the "order of creation became the law imposed by God."[71] Furthermore, he equates the idea of *potentia ordinata* with the notion of the common course of nature.[72] Klaaren suggests, then, that the seventeenth century shift from the search for substantial forms to the search for laws originated from the voluntarist rejection of the Greek notion of divine ideas and of the natural order as the reflection of the great chain of being. Instead, the natural order came to be seen as the result of God's command, his will, and that this order, the *potentia ordinata*, is the common course of nature. So God's imposed law, the laws of nature, is the common course of nature.

Such terminology was actually common among the early voluntarist theologians and continued through till Boyle's time. Ockham never uses the equivalent Latin phrase "laws of nature" or "natural laws" in a scientific sense but he does use "law" to indicate the fixed order of God's ordained power: he uses the expression "by the common law" as synonymous with "in the present

---

[70]Eugene M. Klaaren, *Religious Origins of Modern Science* (Grand Rapids, Michigan: William B. Eerdmans Publishing Company, 1977) 36.

[71]Klaaren 33.

[72]Klaaren 37.

order" or "given the divine order."[73] Pierre d'Ailly in the fourteenth century uses phrases such as "by the common course of nature," "by the common laws and naturally," and "naturally or by ordained law." He even speaks of God having ordained "a natural law" in the physical world.[74]

In the seventeenth century, Walter Charleton, who brought Gassendi's atomism to England, and who was a major source of ideas for Boyle,[75] speaks of the "rules prescribed by his [God's] will" which he called the "laws of Nature";[76] and the English Federal theologian, William Ames, talks about the "order in natural things" as being "the laws of nature common to all things."[77] Even Francisco Suarez, the Spanish Jesuit author of the late sixteenth and early seventeenth centuries, describes God's ordinary power as that power by which "he operates in accordance with the common laws which he has established in the universe," and as "the ordinary law which he has imposed upon himself."[78]

So both Oakley and Klaaren argue for an enduring intellectual tradition that not only supplied in part the concepts for Boyle's

---

[73]Oakley, "Laws of Nature," 444. Unfortunately, Oakley does not give the original Latin for these passages.

[74]Oakley, "Laws of Nature," 444.

[75]Robert Kargon, "Walter Charleton, Robert Boyle, and the Acceptance of Epicurean Atomism in England," *Isis* 55 (1964): 184-192.

[76]Oakley, "Laws of Nature," 445.

[77]Oakley, "Laws of Nature," 446.

[78]Oakley, "Laws of Nature," 446.

definition of the laws of nature, but also was one possible source for the phrase "laws of nature." That is, Boyle knew and could easily have drawn upon the long Biblical tradition of the notion of God as the divine lawgiver. This tradition, though, became especially articulated in the thirteenth and fourteenth centuries because of the perceived threat to the ideas of God's freedom and omnipotence from Aristotelianism. The developed voluntarist doctrine, then, not only became a possible source of the phrase "laws of nature," it also became a source of Boyle's conception of God's relation to the natural order and of the laws of nature.

As has been discussed, Boyle asserts that God freely and arbitrarily established the laws of nature, and that these could have been different; in other words, he avers that there are other logically possible worlds. Boyle's thinking, however, most clearly exemplifies the voluntarist tradition if we consider the case of miracles. For Boyle, the laws of nature, the natural order, are not absolute but can be over-ruled by God in the case of miracles. Boyle says that as God created the laws of nature, he is free to change, over-ride, or suspend them. To further support Oakley and Klaaren's claims regarding Boyle, it can be seen that Boyle also clearly articulates the voluntarist position in regard to the moral order:

> But when I find any thing enjoined in the scripture, my consciousness to its being imposed by that *father of spirits*, (who has both right to enact laws, which must be therefore just, because he enacts them, and power to punish the trangression [sic] of them, with no less than eternal death;) I then leave roving, and see where to cast anchor (II:289).

Oakley says that the doctrine of voluntarism fits the idea of

imposed law,[79] and it seems to fit both Boyle's moral teachings and his concept of the laws of nature.

The other writer who placed Boyle's thought in the context of voluntarism is J.E. McGuire. He tries to counter what he sees as the "received" tradition regarding Boyle's concept of God's relation to nature which of course includes Boyle's concept of the laws of nature.[80] McGuire outlines the received view as that which holds God to be only the first efficient cause so that nature is independent of God, is self-contained. Timothy Shanahan, in criticizing McGuire's account, calls this "metaphysical deism" and explains it as

> the technical philosophical view according to which God, or a First Cause, created the matter of the universe, instituted immutable and universal laws of nature that preclude alteration, and thereafter does not interact with the natural world. This view is primarily concerned to deny God's continued causal activity in nature.[81]

What McGuire attacks is the view that the rise of the mechanical philosophy was coupled with the rise of secularization and hence with the decline in the belief in providence.[82] Some of the people he is countering are Richard S. Westfall, David Kubrin, and Marie Boas Hall. One person who clearly held this view in regard to

---

[79]Oakley, "Laws of Nature," 440.

[80]J.E. McGuire, "Boyle's Conception of Nature," *Journal of the History of Ideas* 33 (1972): 524. McGuire also notes that the terms *potentia absoluta* and *potentia ordinata* were usually expressed by seventeenth-century writers as God's "extraordinary and ordinary concourse" but does nothing to explain what Boyle meant be God's concourse; McGuire 526, fn 8.

[81]Shanahan 551.

[82]McGuire 524.

Boyle was E.A. Burtt. Burtt says that Boyle argues for just the idea of secondary causes but then finds difficulty reconciling this with Boyle's position on God's concourse, which Burtt recognizes is a form of the doctrine of providence, and so blames Boyle for not being consistent.[83]

McGuire lists four themes that he is trying to argue in his paper. First, he suggests that the mechanical philosophy was not just the revival of atomism but also "a reformulation of a nominalist ontology arising mainly from the reformed theology of the Calvinists."[84] He later explains this "nominalist ontology" as the idea that there is no inherent connection between contingent particulars and that this results from an omnipotent voluntarist God.[85] We have already seen this point argued by Oakley. Following this, McGuire claims that "physical laws are categories imposed upon nature by the human mind in light of the observed regularities of experience, or of those experimentally produced."[86] In other words, he is arguing that Boyle had a descriptive view of the laws of nature. Third, he suggests that "God's Will... is the only causally efficacious agency in nature,"[87] but is hard pressed to explain how this is not occasionalism. Fourth, McGuire says that the intellectual context in which to see this interpretation

---

[83]Burtt 191, 192.

[84]McGuire 525.

[85]McGuire 527.

[86]McGuire 525.

[87]McGuire 525.

of the mechanical philosophy is the theological doctrine of voluntarism. Following from this, he suggests that nature is dependent on God's providence "such that it is the mere exemplification of rules or laws continually imposed by the latter [God]."[88] The important thing here to note is that the imposition of laws by God in McGuire's accounting is continual. Laws are not established at creation and left to operate on their own; they must be continually re-created.

It seems, though, that in arguing for a voluntarist position for Boyle, McGuire has gone too far. That is, McGuire sets up a false dilemma between two conceptions of providence: "there are no secondary causes in nature which are miraculously dispensed with by Providence; rather, Providence is God's continual action in nature."[89] He is arguing that either secondary causes account for the actions produced in the world or God does. Later, we will see that there is another option.

McGuire is right in not attributing the position of metaphysical deism to Boyle. As we have seen, Boyle avers that God does not leave the laws of nature to operate on their own once established but that God preserves or upholds them. Furthermore, Boyle's God is active in the universe through special providence or miracles. McGuire is also right in arguing that Boyle rejects the "bloated ontologies" which postulate substantial forms, plastic

---

[88]McGuire 525.

[89]McGuire 525-526.

natures, or a world soul.[90]

In addition to this, McGuire says correctly that Boyle does not consider the laws of nature to be an inherent part of nature, if he means by inherent that the laws of nature were established by God, but he concludes from this that Boyle did not "substantialize laws,"[91] meaning that laws do not exist as such. In other words, McGuire claims that both the laws of nature and causality are the creation of the mind of man observing the regular patterns or behaviour of bodies. He says that "Boyle implicitly expressed the view that causation is something imposed upon observed regularity in nature by the conceptualizing power of the human mind."[92] McGuire goes on to say that "a law of nature is the conceptualization of similarity observed between phenomena, arising from the fact that the human mind observes phenomena as similar."[93] So McGuire asserts that, for Boyle, the laws of nature are merely descriptive laws with no actual causal implications since causes are also conceptualization.

McGuire's interpretation of Boyle is for the most part mistaken. First, Boyle speaks of the laws of nature as things which exist in and of themselves. He says that God established them, that God preserves them, and that in the case of miracles, God over-rules, alters, or suspends them. It does not seem that

---

[90]McGuire 534.

[91]McGuire 535.

[92]McGuire 536.

[93]McGuire 536.

for Boyle these are figurative expressions. Second, Boyle many times uses the clock analogy which cannot be associated with the position that McGuire is describing. The clock analogy was contrasted by Boyle with the position, similar to the one McGuire is ascribing to Boyle, that nature is like a puppet with God interposing for every action:

> And methinks the difference betwixt their [the school-philosophers] opinion of God's agency in the world, and that, which I would propose, may be somewhat adumbrated by saying, that they seem to imagine the world to be after the nature of a puppet, whose contrivance indeed may be very artificial, but yet is such, that almost every particular motion the artificer is fain (by drawing sometimes one wire or string, sometimes another) to guide and sometimes over-rule the actions of the engine; whereas, according to us, it is like a rare clock, such as may be that at *Strasburgh*, where all things are so skilfully contrived, that the engine being once set a moving, all things proceed, according to the artificer's first design, and the motion of the little statues, that at such hours perform these or those things, do not require, like those of puppets, the peculiar interposing of the artificer, or any intelligent agent employed by him, but perform their functions upon particular occasions, by virtue of the general and primative contrivance of the whole engine (V:163).

On McGuire's behalf, though, Boyle does say that idea of "law" applied to nature is "notional" (V:170-171), and McGuire uses this fact to support his claim,[94] but it seems that Boyle here is rejecting the use of the word "law" which ascribes the obedience of a free will to an inanimate object. Boyle is not, contra McGuire, rejecting the notion that certain rules have been laid down by God, rules that convention calls the laws of nature. Therefore, we have seen that neither the position of metaphysical deism nor the position of occasionalism, which McGuire has articulated, fits

---

[94]McGuire 534.

Boyle's concept of God's relation to nature and consequently Boyle's thinking on causes and the laws of nature. Boyle's seemingly contradictory position, that laws of nature operate on their own yet God is needed for the laws of nature to operate, can be exemplified nicely in a passage from Boyle where he says that if God "but continue his ordinary and general concourse, there will be no necessity of extraordinary interposition" (V:163). In other words, the laws of nature operate without interposition of God as long as God maintains his concourse. It remains to be seen, then, what Boyle meant by "ordinary and general concourse."

Another author who finds problems with McGuire's position is Timothy Shanahan. Shanahan likewise feels that despite McGuire's claims to the contrary,[95] in outlining his interpretation of Boyle McGuire is attributing an occasionalist position to Boyle.[96] Shanahan rejects both the deist and occasionalist interpretations of Boyle. In place of them both, he suggests a middle position which he terms "concurrentism": "Concurrentism in any of its versions can be understood as an attempt to cut a middle way between the extremes of deism and occasionalism by recognizing the causal contributions made to natural phenomena by both God and

---

[95]McGuire 525.

[96]Shanahan 556-557. Edwin McCann also feels that McGuire is wrong in ascribing an occasionalist position to Boyle. See Edwin McCann, "Lochean Mechanism. Appendix: Was Boyle an Occasionalist?" in *Philosophy, Its History and Historiography*, ed. A.J. Holland (Dordrecht: Reidel, 1985): 209-231.

natural entities."[97] Although Shanahan takes issue mainly with McGuire's and others' interpretations of Boyle in regard to the issue of causality, what he has to say is relevant to our discussion of the laws of nature.

The position of concurrentism was held among others by Thomas Aquinas (1225-1274), and Luis de Molina (1535-1600).[98] Aquinas articulates his position as such: "God is the cause of everything's action inasmuch as he gives everything the power to act, and preserves it in being and applies it to action, and inasmuch as by his power every other power acts."[99] For Aquinas, God and natural objects do not each offer part of the cause but the cause is offered wholly by both. In this definition, each is a sufficient cause.

For Molina, God and the natural agent both act simultaneously to produce the effect but in such a fashion that "the action of each is a necessary condition for the production of the effect, and together they are sufficient."[100] Molina says that

> It follows that God's general concurrence is *not* an action of God's *on* the secondary cause, as though the secondary cause

---

[97]Shanahan 560. This term is Shanahan's. It does not appear to have been a distinctly articulated doctrine at the time although Shanahan does take the term from the Latin word *concursus* whose literal meaning is "running together." The English equivalent, "concourse," we have already discussed in relation to Boyle.

[98]Shanahan 560. Shanahan says that Francisco Suarez, whom we have mentioned earlier, held this position and notes that Boyle quotes extensively from his works *Disputationes Metaphysicae* which contains this position; Shanahan 560, fn 41.

[99]*De Potentia* q.3, a.7; cited in Shanahan 561.

[100]Shanahan 563.

> acted and produced its effect after having been moved; rather, it is an action immediately *with* the cause *on* its action and effect.[101]

In the case of miracles, God has only to withhold his concourse, his cooperation, from either causes, or from the laws of nature. This fits Boyle's position on miracles where his general view of the laws of nature are evidenced. In one instance Boyle says that "we may observe, that the power of God has already extended itself to the performance of such things... sometimes by suspending the natural acting of bodies upon one another..." (IV:201). This is clearly a case were causes are suspended, and the language Boyle uses lends itself to the interpretation that the causes need God's assistance to be efficacious, but nonetheless they are real. In regard to the laws of nature, Boyle says that

> the universe being once framed by God, and the laws of motion being settled and all upheld by his incessant concourse and general providence, the phaenomena of the world thus constituted are physically produced by the mechanical affections of the parts of matter, and what they operate upon one another according to mechanical laws (IV:68-69).

Here Boyle is saying that the laws of nature need God's concourse, his cooperation, in order to be efficacious. It is clear from these passages that both causes and the laws of nature would not be efficacious without God's "concourse," without his cooperation. Boyle is articulating in regard to both causes and laws the concurrentist position described by Shanahan. Shanahan concludes that for Boyle, God, after creating the world,

> continues to sustain the order of the universe by maintaining the laws of motion which govern the mechanical interactions of

---

[101] *Concordia*, part II, q.14, disp. 26; cited in Shanahan 563.

> the part of matter. God's "incessant concourse and general providence" consists in conserving these laws of motion, and consequently the effects associated with natural bodies. Natural bodies can be said to possess causal powers in virtue of the motion they can impart to one another through impact, but they are incapable of sustaining the lawful order of the universe without the continued assistance of God.[102]

In Boyle's concept of the laws of nature, the doctrines of voluntarism and concurrentism blend to make a whole. The idea of voluntarism stresses God's absolute and ordinary powers and has to do with the distinction between God's power and potential and the existing natural order. In other words, it makes room for the teaching on miracles, God's special providence. The idea of concurrentism has to do with God's involvement with the natural order. It maintains the teaching of the internal integrity of the natural order while it makes room for the doctrine of God's general providence. In other words, it allows for the idea that God is continuously and intimately involved in the affairs of the natural world without attributing so much to God that natural causes would not be sought, and hence that science would not be performed.

Both these doctrines can be seen in a passage from Boyle about the mechanical philosophy:

> Nor is this doctrine [mechanical philosophy] inconsistent with the belief of any true miracle; for it supposes the ordinary and settled course of nature to be maintained without at all denying, that the most free and powerful Author of nature is able, whenever He thinks fit, to suspend, alter, or contradict those laws of motion, which He alone at first established, and which need his perpetual concourse to be upheld (V:414).

What Boyle has done, then, is translate the scholastic discourse regarding voluntarism and concurrentism into the context of the

---

[102]Shanahan 567.

mechanical philosophy.

CONCLUSION

It has been argued in this paper that Boyle had two concepts of the laws of nature and that for each of these concepts there was a different origin for the use of the word "law" in connection with nature. The first concept of the laws of nature is that of the natural order. This concept includes the notion of a divine legislator imposing laws on nature which constitutes the common or ordinary course of nature. This use has a long tradition reaching back to the Bible and the ancient Greeks. In the Biblical tradition, it was expanded by the development of the doctrine of voluntarism in the thirteenth and fourteenth centuries. The idea of the natural order as the laws of nature was well known in seventeenth-century England. In this instance, Boyle views the use of the word "law" as figurative since matter is brute.

The second concept of the laws of nature is that of the collective laws of motion. These laws are descriptive of the behaviour of bodies and are expressed in mathematical terms. As Ruby has shown, there is a long tradition of the use of "law" with such description, reaching back to the thirteenth century. In this case "law" meant a rule as in a standard or guideline, something inherent to the nature of the thing. It had no connotation of command or divine legislation. This use developed in connection with the mathematizing of physics and mathematics itself is probably the ultimate source of the descriptive view of the word "law."

It has also been argued in this paper that Boyle brought these two concepts together; both are referred to as the laws of nature.

That is, Boyle makes no formal distinction between the two concepts but the two concepts can be deduced from his writings. Boyle feels that laws which are prescriptive, that is, by which God has established the natural order, will be all ultimately reducible to descriptive laws, that is, specific laws which describe the behaviour of bodies and expresses these in mathematical terms.

However, Boyle rarely considers these specific laws as merely descriptive. That is, Boyle does not feel that laws are just the summary of the behaviour of bodies: laws are deeper than this. Rather, they imply causality and contingent necessity, and hence are also explanatory and predictive. As mentioned earlier, the medieval idea of substantial forms had a notion of causality; they were what caused certain behaviour in bodies. Boyle exchanges for this the idea of the laws of nature. For him, laws are what cause the behaviour in bodies which had been ascribed to substantial forms.

This thinking, though, was not specific to Boyle but reflected a larger trend in regard to the conception of the natural order. Up till the seventeenth century, the idea of natural order was for the most part accounted for by substantial forms.[103] After this, in the seventeenth century, the idea of natural order was accounted for by laws, nature was subject to law; these laws of nature did not merely describe the behaviour of bodies, they were thought to

---

[103]Gerd Buchdahl, *Metaphysics and the Philosophy of Science* (Oxford: Basil Blackwell, 1969) 49.

be the cause of the order.[104]

Laws were also seen in the seventeenth century to denote an inner necessity to nature; nature has an immanent structure.[105] This inner structure can be described by laws but it was prescribed by God and so it carries a deeper metaphysical weight than a merely positivist descriptive law. That is, this inner necessity of nature is the order established by God, the *potentia ordinata* or the common course of nature. Laws are descriptive of a deeper order to nature.

Because these laws are causal, they are also explanatory. That is, actions and events in nature can be explained by recourse to the laws of nature as things with ontological reality; they are not mere conceptualizations of the human mind. Furthermore, since laws are explanatory they have a predictive quality. That is, they can be used to tell how things must unfold. Gerd Buchdahl, says that laws in the seventeenth and eighteenth centuries were not just summary laws but were predictive so that "many would hold that the proper logical form of such a law is best expressed through the hypothetical-conditional 'if-then', rather then the categorical 'all ... are'."[106]

These general trends parallel movements within Boyle's own concept of the laws of nature. From what has been said then, it is clear that Boyle was a realist in regard to physical laws: the laws

---

[104]Buchdahl 44.

[105]Fraassen, 5, 6; Buchdahl 34.

[106]Buchdahl 27.

of nature really exist and can be known by man. If this characterization of Boyle and the seventeenth century is correct, then perhaps Keith Hutchison is also right when he says that Boyle's natural philosophy is a blend of naturalism and supernaturalism: "it involved naturalistic *explanations* inside the supernaturalistic *ontology*."[107]

The question remains, though, as to why the use of the phrase the "laws of nature" rose to such prominence in the seventeenth century. In the introduction to this paper, it was mentioned that Francis Oakley says that the phrase came from a transfer of concepts from the moral realm to the physical realm. However, he never really explains why the concept rose to such prominence in the seventeenth century; he only explains a possible source for the phrase. Likewise, it was mentioned that Edgar Zilsel and Joseph Needham say that the use of this phrase arose because of sociological reasons, because of the existence of a strong central government and a comparison made between the state and nature. However, their view is unlikely since it does nothing to account for the use of "law" in connection with nature by Roger Bacon in the thirteenth century.

Like Zilsel and Needham, in more recent articles, James and Margaret Jacob and Stevin Shapin argue in favour of sociological factors in accounting for the rise of the new conception of nature in Boyle, and by implication, the rise of the concept of the laws

---

[107]Keith Hutchison, "Supernaturalism and the Mechanical Philosophy," *History of Science* 21 (1983): 325.

of nature. James and Margaret Jacob state that conservative reformers in England at the time of the Restoration, such as Boyle,

> developed a metaphysics of God and matter that authorized a conservative interpretation of the social hierarchy and answered the radicals by rendering their social views untrue in terms of the conservative metaphysics. In other words, a conservative matter theory was constructed which 'outlawed' radicalism from the universe.[108]

Likewise, Stevin Shapin suggests:

> To the social group for whom Boyle spoke the radical sectarian threat had to be opposed, and one way of opposing it was to produce and disseminate a philosophy of nature and God which insisted that material entities were 'brute and stupid,' that God was not immanent in nature, and that, therefore, nature like a congregation and civil society generally, required for its activity the superintendence of external ordering and animating agencies.... The natural philosophy of Boyle and the early Royal Society was generated with a view to these social and moral uses; it was evaluated pertly on the basis of how well it could be used in those contexts.[109]

From this it can be concluded that they would account for Boyle's use of the laws of nature, an integral part of a conservative matter theory, by sociological factors. They would probably not say that Boyle invented the notion of the laws of nature out of thin air, but that in articulating his position for sociological reasons, he drew on certain medieval traditions, one of which was the idea of the imposed laws of nature.

However, the Jacobs and Shapin view is unlikely because although it might be able to partially account for why Boyle accepted the new philosophy it does not explain the existence of a

---

[108]J.R. and M. Jacob, "The Anglican Origins of Modern Science: The Metaphysical Foundations of the Whig Constitution," *Isis* 71 (1980): 253-254.

[109]Stevin Shapin, "History of Science and its Sociological Reconstructions," *History of Science* 20 (1982): 182.

"conservative matter theory" elsewhere in Europe in the seventeenth century and in England before Boyle. A recent article by Gary B. Deason has suggested that such a conservative matter theory existed during the Reformation, and in part it developed because of the Reformers theory of God's radical sovereignty.[110] Furthermore, even such a noted social contextualist historian as Charles Webster has doubts about such a thesis as the Jacobs and Shapin assert which he says "transforms the mechanical philosophy into a political weapon, self-consciously forged with a view to sweeping away the republic and restoring a stable monarchy."[111] Webster goes on to say that this view is based on supposition rather than direct evidence.

Finally, it is unlikely that sociological factors alone can account for the rise of the use of the phrase "laws of nature" in Boyle and generally in the seventeenth century because a more plausible explanation exists. If one considers the second concept of the laws of nature in Boyle's thought, one can see that it is associated with mathematics and has a history of being associated with the mathematizing of physics. In Aristotelianism, mathematics had been relegated to a peripheral position. However, in the new physics which emerged in the sixteenth and seventeenth centuries, mathematics came to the centre of natural philosophy, and as it did so, it is likely that it brought phrases and terminology associated

---

[110]Deason 167-191.

[111]Charles Webster, "Puritanism, Separatism, and Science," *God and Nature*, eds. David C. Lindberg and Ronald L. Numbers (Berkeley: University of California Press, 1986) 212.

with it also to the centre of natural philosophy. So if the descriptive use of the word "law" was part of the mathematical tradition of science, when this mathematical tradition came to centre stage, it brought to prominence the descriptive use of the word "law." It was easy, then, to join this use of law with the long tradition of law as prescribed by a divine legislator. However, why the new science itself arose may ultimately have to be accounted for by sociological reasons.

Zilsel and Oakley had long ago said that the question of the rise of the use of the phrase was not synonymous with the rise of modern science. Instead, they said that the question was why mechanical regularities were articulated in terms of imposed laws. If the arguments of this paper are correct, then there is a clear answer to this question: there was a long tradition of the use of "law" with the idea of descriptive regularities, and this use is what lead to the easy blending of the notion of mechanical regularities with the idea of imposed laws. If this accounting is correct, then a new question needs to be asked: is it indeed first with Boyle that the notion of laws as the mathematical, non-prescriptive, description of the behaviour of bodies, merges with the prescriptive use of laws as the order of the world imposed by God? That is, is Boyle's extended analysis of the mechanical philosophy the place in which the scholastic discourse of voluntarism and concurrentism are translated for the first time into a discourse of the mechanical philosophy and the laws of nature?

BIBLIOGRAPHY

Alexander, Peter. *Ideas, Qualities and Corpuscles: Locke and Boyle on the External World.* Cambridge: Cambridge University Press, 1985.

Armstrong, D.M. *What is a Law of Nature?* Cambridge: Cambridge University Press, 1983.

Boas, Marie. *Robert Boyle and Seventeenth Century Chemistry.* Cambridge: Cambridge University Press, 1958.

---. "The Establishment of the Mechanical Philosophy." *Osiris* 10 (1952): 412-541.

Boyle, Robert. *The Works.* 6 Vol. Ed. Thomas Birch. 2nd Ed. 1772. Hildesheim: Georg Olms Verlagsbuchhandlung, 1965.

Buchdahl, Gerd. *Metaphysics and the Philosophy of Science.* Oxford: Basil Blackwell, 1969.

Burtt, E.A. *The Metaphysical Foundations of Modern Physical Science.* 2nd Ed. 1932. London: Routledge and Kegan Paul Limited, 1972.

Cassirer, Ernst. *The Individual and the Cosmos in Renaissance Philosophy.* Trans. Mario Domandi. Philadelphia: University of Pensylvania Press, 1963.

Collingwood, R.G. *The Idea of Nature.* 1945. London, Oxford, New York: Oxford University Press, 1981.

Deason, Gary B. "Reformation Theology and the Mechanistic Conception of Nature." In *God and Nature.* Eds. David C. Lindberg and Ronald L. Numbers. Berkeley: University of California Press, 1986: 167-191.

Fraassen, Bas C. van. *Laws and Symmetry.* Oxford: Claredon Press, 1989.

Fulton, John F. *A Bibliography of the Honourable Robert Boyle.* In *Oxford Bibliographical Society Proceedings and Papers.* Vol 3. 1931-1933. Oxford: Oxford University Press, 1933.

Green, Robert A. "Henry More and Robert Boyle: On the Spirit of Nature." *Journal of the History of Ideas* 23 (1962): 451-74.

Hall, Marie Boas. "Boyle as a Theoretical Scientist." *Isis* 41 (1950): 261-268.

Hutchison, Keith. "Supernaturalism and the Mechanical Philosophy." *History of Science* 21 (1983): 297-333.

Jacob, James. "Boyle's Atomism and the Restoration Assault on Pagan Naturalism." *Social Studies of Science* 8 (1978): 211-233.

---. "Boyle's Circle in the Protectorate: Revelation, Politics, and the Millennium." *Journal of the History of Ideas* 38 (1977): 131-140.

---. "The Ideological Origins of Robert Boyle's Natural Philosophy." *Journal of European Studies* 2 (1972): 1-21.

Jacob, J.R. and M. "The Anglican Origins of Modern Science: The Metaphysical Foundations of the Whig Constitution." *Isis* 71 (1980): 251-267.

Kargon, Robert Hugh. "Walter Charleton, Robert Boyle, and the Acceptance of Epicurean Atomism in England." *Isis* 55 (1964): 184-192.

Klaaren, Eugene M. *Religious Origins of Modern Science: Belief in Creation in Seventeenth-Century Thought*. Grand Rapids, Michigan: William B. Eerdmans Publishing Company, 1977.

Leff, Gordon. *The Dissolution of the Medieval Outlook*. New York, 1976.

Leyden, W. von. *Seventeenth-Century Metaphysics: An Examination of Some Main Concepts and Theories*. London: Gerald Duckworth and Co. Ltd., 1968.

Lindberg, David C. "On the Applicability of Mathematics to Nature: Roger Bacon and His Predecessors." *British Journal for the History of Science* 15 (1982): 3-25.

McCann, Edwin. "Lochean Mechanism. Appendix: Was Boyle an Occasionalist?" In A.J. Holland, Ed. *Philosophy, Its History and Historiography*. Dordrecht: Reidel, 1985: 209-231.

McGuire, J.E. "Boyle's Conception of Nature." *Journal of the History of Ideas* 33 (1972): 523-542.

Moody, E.A. "Empiricism and Metaphysics in Medieval Philosophy." *Studies in Medieval Philosophy, Science, and Logic: Collected Papers 1933-1969*. Berkeley, Los Angeles, London: University of California Press, 1975.

Needham, Joseph. "Human Laws and the Laws of Nature in China and the West." *Journal of the History of Ideas* 12 (1951): 3-30, 194-230.

Oakley, Francis. "Christian Theology and The Newtonian Science: The Rise of the Concepts of the Laws of Nature." *Church*

History 30 (1961): 433-457.

---. *Omnipotence, Covenant, and Order: An Excursion in the History of Ideas from Abelard to Leibniz.* Ithaca, N.Y., London: Cornell University Press, 1984.

Osler, Margaret J. "Descartes and Charleton on Nature and God." *Journal of the History of Ideas* 40 (1979): 445-456.

---. "Eternal Truths and the Laws of Nature: The Theological Foundations of Descartes' Philosophy of Nature." *Journal of the History of Ideas* 46 (1985): 349-362.

---. "John Locke and the Changing Ideal of Scientific Knowledge." *Journal of the History of Ideas* 31 (1970): 3-16.

---. "Providence and Divine Will in Gassendi's Views on Scientific Knowledge." *Journal of the History of Ideas* 44 (1983): 549-560.

Ruby, Jane E. "The Origins of Scientific Law." *Journal of the History of Ideas* 47 (1986): 341-360.

Shanahan, Timothy. "God and Nature in the Thought of Robert Boyle." *Journal of the History of Philosophy* 26 (1988): 547-569.

Shapin, Stevin. "History of Science and its Sociological Reconstructions." *History of Science* 20 (1982): 157-211.

Wallace, William A. "The Certitude of Science in Late Medieval and Renaissance Thought." *History of Philosophy Quarterly* 3 (1986): 281-291.

Webster, Charles. "Puritanism, Separatism, and Science." In *God and Nature*. Eds. David C. Lindberg and Ronald L. Numbers. Berkeley: University of California Press, 1986: 192-217.

Westfall, Richard S. "Unpublished Boyle's Papers Relating to Scientific Method." *Annals of Science* 12 (1956): 63-73, 103-117.

Whitehead, A.N. *Adventures of Ideas*. New York, 1937.

Zilsel, Edgar. "The Genesis of the Concept of Physical Law." *Philosophical Review* 51 (1942): 245-279.