THE IDEA OF NATURAL LAW THE IDEA OF NATURAL LAW

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From essence to law

The aim of this paper is to investigate the transition in natural science from the search for the *essence* of matter to the search for the *laws* to which matter is subject. Starting about 1600, this transition meant a change of perspective, the introduction of a new metaphysical view of the world. A scientific worldview has at least four components, its ontology, epistemology, logic and heuristic,[1] which I shall discuss with respect to the idea of natural law.

The idea that nature is governed by laws is relatively new. The rise of science in the 16th and 17th centuries meant the end of Aristotelian philosophy, having dominated the European universities since the 13th century. According to Aristotle, four causes, form, matter, potentiality and actuality determine the essence of a thing and the way it changes naturally. Each thing, plant or animal has the potential to realize its destiny, if not prohibited by the circumstances. The aim of medieval science was to establish the essence or nature of things, plants and animals, their position in the cosmic order, and their use for humanity.

Although essentialism is still influential, since the 17th century it was to be replaced by the search for laws. During the Middle Ages it was common sense to distinguish positive law, given by people, from (mostly moral) natural law, given by God, but this was never applied in science. In a scientific context the word law was introduced about 1600 by Brahe ('the wondrous and perpetual laws of the celestial motions ... prove the existence of God'[2]), Bruno ('Nature is nothing but the force inherent in the things, and the law according to which they pursue their orbits'[3]), and Galileo ('Nature ... never transgresses the laws imposed upon her. '[4]). Descartes considers laws to be established by God in nature.[5]Leibniz speaks of natural laws as rules subordinate to the supernatural law of general order.[6] (; For Newton, axiom and law of motion are synonymous.[7]

Kepler was the first to formulate a law as a generalization in the form of a mathematical relation:

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[1] Stafleu, M.D., 1998, *Expenmentele filosofie,* Amsterdam: Buijten en Schipperheijn, 30-3l.
[2] Barrow,J.D., 1988, *The world within the world,* Oxford: Oxford U.P., 59. As a precursor in the 13th century. Roger Bacon used the expression *lex* or *regula* to describe regularity in nature. not divine decrees, see Barrow, 58.
[3] Clay, J., 1915, *Schets eener kritische geschiedenis van het beg;n:p natuurwet in de nieuwere wijsbegeerte.* Leiden: Brill, 42.
[4] Galilei, G., 1615, 'Letter to the Grand Duchess Christina', in: S.Drake (ed.), 1957, *Discoueries and opinions of Galileo,* Garden City, N.Y.: Doubleday, 182.
[5] Descartes, R., 1637, *Discoyrse de la methode,* Oeuvres VI, Paris 1973: Vrins, 4l.
[6] Leibniz, G.W., 1686, 'Metaphysische Abhandlung', par. 16-17, *Hauptschriften zur Grundlef5'kig der Philosophie* (trans!. A.Buchenau, 1904-06), Hamburg 1966: Meiner, n, 156-160. 7 Newton, I., 1687, *SiT Isaac Newton's Mathematical principles of natural philosophy* (trans!.:
[7] A.Motte 1729, revised by F.Cajori 1934), Berkeley 1971: U. California P., 13; Newton, 1.,1704, *Opticks,* New York 1952: Dover, 5.

1. The orbit of a planet is an ellipse, with the sun in one of its focal points.[8]
2. Each planet traverses in equal times equal areas, as measured from the sun.[9]

Apparently, the first law does not differ very much from the view, accepted since Plato, that the orbits of the celestial bodies are circular, albeit with the earth at their centre. After all, both circles and ellipses are geometrical figures. But circular motion was put forward as being the *essential form* of celestial motion, not as a generalization from observations and calculations. Astronomers from Hipparchos (2nd century BC) up to Copernicus (early 16th century), have tried to reconcile the observed motions with a combination of circular orbits. In his elaborate analysis of Brahe's observations, Kepler found the orbit of Mars to be an ellipse, with the sun in a focus rather than at the centre. He assumed this could solve many problems for the other planets, too. The Platonic circular motion was a rational hypothesis *a priori,* imposed on the analysis of the observed facts. Kepler's elliptical motion was a rational generalization *a posteriori,* a mathematical formulation of a newly discovered natural law.

Kepler's second law contains another novelty. No doubt, medieval philosophers were interested in change. It belongs to the essence of each thing to actualize its potential, but theories of change were never quantitative. Planets were supposed to move at a constant speed. The astronomers knew very well that planets have variable speeds and applied various tricks to fit the observed facts to the Platonic idea of uniform circular motion. Kepler accepted changing velocities as a fact, connected them to the planet's varying distance to the sun as expressed in its elliptical path, and established a constant relation: equal areas in equal times. The area law was later shown .to be a consequence of the law of conservation of angular momentum.

The introduction of the area law is the first instance of a method to become very successful in natural science, to relate change to a magnitude that does not change, a constant. It means formulating several conservation laws, of energy, linear and angular momentum, electric charge, *etc.* These laws impose restraints on any changes to occur.

Simultaneously with the increasing emphasis on natural laws the use of essence in scientific language diminished. Galileo criticized essentialism as a play of words. When in his famous *Dialogue* (1632) the Aristotelian Simplicio says that the cause of fall is known to be gravity, Galileo's mouthpiece Salviati replies:

> 'You are wrong, Simplicio; what you ought to say is that everyone knows that it is called "gravity"'.[10]

In particular Newton replaced the search for the essence, the being or. the nature of things, by the question of which laws they satisfy. Newton researched gravity

[8] Kepler, j., 1609, *Astronomia nova; Neue AstTonomie* (M.Caspar, trans!.), Miinchen 1929: Oldenbourg, 34 (Introduction), 267 (chapter 44), 345 (chapter 58).
[9] Kepler 24 (Introduction), 247 (chapter 40). Only later on, these statements became known as Kepler's first and second law, but in his Introduction, Kepler calls the second one a law.
[10] Galilei, G., 1632, *Dialogue concerning the two chief world systems* (S.Drake, transl.), Berkeley 1953,1974, U.California P., 234.

without defining its essence.[11] In Aristotelian philosophy all substances (things, plants, animals and human beings) have the potential to realize themselves. Hence, a substance has a measure of independence over against God.[12] This view collides with Newton's protestant confession that all things are absolutely dependent on God's creation and support. He assumed matter to be completely passive, subject to God's laws. Therefore, Newton rejected the insinuation that he ascribed an active principle of gravitation to material things. In 1693 he wrote to Bentley:

> 'You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me, for the cause of gravity is what I do not pretend to know and therefore would take more time to consider of it'.[13]

In Newton's thought essence was gradually replaced by universality.[14] Gravity is not essential, but universal, and universality is the hallmark of a natural law. It is not necessary to know what gravity 'essentially' is:

> 'And to us it is enough that gravity does really exist, and act according to the laws which we have explained, and abundantly serves to account for all the motions of the celestial bodies, and of our sea.'[15]

Ontology

Scientists usually respond positively to the question of whether natural laws have an existence independent of mankind. Aimed at finding regularities, the empirical method is firmly rooted in the prevalent scientific worldview. Laws discovered in the laboratory are declared universal, holding for the whole universe at all times. With the purpose to study the law-conformity of reality, science takes the existence of laws as a point of departure not to be proved.

Whereas some philosophers deny the existence of natural laws,[16] others acknowledge natural laws not to be invented but discovered.[17] Law-conformity [91]

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[11] Contrary to Popper, K.R., 1963, *Conjectures and refutations,* London 1976: Routledge & Kegan Paul, 103-107, I don't believe Newton or Cotes (see below) was an essentialist. More than Newton, Cotes understood that gravity as a force between particles contradicts the neoPlatonic idea of matter being passively subject to laws. On essentialism, see Popper, K.R., 1972, *Objective knowledge,* Oxford: Clarendon, 194-196; Popper, K.R., 1983, *Realism and the aim of science,* London: Hutchinson, 134-137.

[12] See Barrow 58; Dooyeweerd, H., 1953-1958, *A New Critique of Theoretical Thought,* 4 vols., Amsterdam: Paris (henceforward: NC), 1,112-113.

[13] Newton, I., 'Letter to Mr.Bentley', in: Thayer, H.S. (ed.), 1953, *Newton's philosophy of nature,* New York: Hafner, 53-54. McMullin, E., 1978, *Newton on matter and activity,* Notre Dame: of Notre Dame P., 57-59.

[14] Newton, 1704,401; McMullin, 8-9.

[15] Newton, 1687,547.

[16] Fraassen, B. van, 1989, *Laws and symmetry,* Oxford: Clarendon, 183; Cartwright, N., 1983, *How the laws of physics lie,* Oxford: Clarendon.

[17] Popper, K.R., 1959, *The logic of scientific discovery,* London 1968: Hutchinson (orig.: *Logik derForschung,* Wien 1934), 438; Popper, 1972, Ch.5; Popper, 1983,80,118,131-149; Bunge, M., 1967, *Scientific research,* Berlin: Springer, I, 345; Swartz, N., 1985, *The concept of physical law,* Cambridge: Cambridge U.P., 10-11: 'the existence of determinate laws of Nature is virtual axiomatic in the contemporary worldview.'

cannot be proved scientifically or philosophically. Its acknowledgement depends on someone's scientific worldview. This also applies to the view that the natural laws are mutually consistent, antinomies are excluded, as Dooyeweed states.[18]

Dooyeweerd, too, has a realistic view of laws, which he considers to provide conditions for the existence of everything in reality. But his realism does nl imply that the laws have an independent existence. Nothing in reality is independent or autonomous, everything depends on God. Reality is not characterized by *independent being,* but by *dependent meaning;* where meaning has the sense of pointing to, giving direction, aiming at.[19] Hence Dooyeweerd takes distance from essentialism, although the way he treats the 'meaning kernel' i the modal aspects shows traces of essentialism.[20] Moreover, the laws al mutually dependent as well; there are all kinds of connections between laws.

Because science studies law-conformity and takes the existence of natural laws for granted, it is confronted with the law as a boundary of its activity.[21] Neither science nor its philosophy is able to say anything meaningful about what is hidden behind that boundary. Knowledge of the origin of lawful reality is not gained in a scientific or philosophical way, not even a theological way, but from God's revelation only. The bible does not provide us with a view on natural laws or natural science; the idea of natural law even hardly existed before the 17th century. The metaphor of the law as a boundary is on intended to call attention to a restriction on scientific activity, and has n other meaning. In particular, the view that God does not restrict himself t proclaiming and preserving laws implies that the laws do not constitute boundary for God's interference in his creation.[22]

Ante rem, post rem, in re?

The idea of natural law is a metaphor, which is often taken literally, as prescription given by God, such as the Ten Commandments. The idea of law [92] as developed during the Renaissance was inspired by the idea that matter has no existence independent of God, but ran the risk of hypostatizing the laws with respect to reality being subject to the laws. By considering the law as the will of God for the creation, the law seems to stand apart from the creation, as if God has called to order an otherwise unordered reality ('the earth was without form and void', Genesis 1, 1). This problem reminds one of the medieval distinction between

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[18] The *princiPium exclusae antinomiae,* Dooyeweerd, NC n, 37 cannot be proved by tll statement that the occurrence of mutually inconsistent laws would be unthinkable, becaw human thought itself is subject to laws. Rather, this being unthinkable is a consequence of tll said *princiPium*

[19] Dooyeweerd, NC n, 4, 96, 99, 108.

[20] Dooyeweerd, NC n, 31: ' ... *'meaning'is* nothing but the creaturely mode of being undl the law, consisting exclusively in a religious relation of dependence on God'. However, instea of defining the meaning kernel as the characteristic *law* for a modal aspect, Dooyeweerd trio to catch the meaning of each aspect (as well as its anti- and retrocipations to other aspects) i one or a few *words,* such as 'discrete quantity' or 'continuous extension'. Thereby he easily fal into the trap of essentialism.

[21] Dooyeweerd, NC I, 99-100.

[22] Peursen, C.A.van, 1959, 'Enkele kritische vragen in margine bij "A new critique (theoretical thought"', *Phil.Ref* 24: 160-168, 164. Van Peursen observes that the law can also t seen as the covenant of God with his creation, as a sign of his immanence instead of h transcendence. Dooyeweerd, H., 1960, 'Van Peursen's critische vragen bij "A new critique (theoretical thought"', *Phil.Ref* 25: 97-150. 113 agrees.

idealists, realists and nominilists with respect to *universalia,* abstract universal concepts related to *essentialia.*

Like Plato, the 13th-century idealists Bonaventure, Grosseteste and Bacon, were of the opinion that the observable world is an image of a higher, ideal, invisible but knowable reality. Universals like goodness and justice are inborn. In rank, universals precede the visible world, being *ante rem* Aristotelian realists, like Thomas Aquinas and Albertus Magnus, assumed that the forms, the nature of things, can be discovered from observation, all knowledge starting from sensorial experience. The universals are found in being, they are *in re.* Plato and Aristotle considered the ideas or forms to be eternal, necessary, rationally determined concepts, but the 14th-century nominalists, including William of Ockham, Buridan and Oresme, rejected the logical necessity of the universals, which they considered to be at variance with God's omnipotence. They stated the world to be contingent, created by God in a certain way, which could have been different. God is not bound to the eternal forms of Aristotle or Plato.

The nominalists appealed to the authority of bishop Tempier of Paris, who in 1277 had condemned a number of Aristotelian theses, assumed to contradict God's power. For instance, Aristotle stated on rational grounds that the cosmos has necessarily a spherical shape. The nominalists said that the cosmos may very well be spherical, but God could have made it non-spherical as well. The actual shape of the cosmos should be established by observation, not by reasoning alone. They considered universals to be human inventions. Only individual, concrete things are real. Universals like animal, motion, beauty, are nothing but names (*nomen* = name), thought up by people, in order to get a rational grip on reality. The universals are *post rem,* ranked below the things.

With the introduction of natural laws in the 16th century, important shifts in these positions can be observed. The nominalists achieved an increasingly critical attitude towards Plato and Aristotle, more than before relying on their own research. Even more than the realists, the nominalists stressed the relevance of observation as a reliable source of knowledge. Being empiricists, they played an important part in the transition from ancient and medieval thought to the Renaissance and modern science. In its most extreme form, in which only observables have reality and laws are human inventions, nominalism probably never exerted much influence on scientists. Among the philosophers, Kant came close to nominalism. As to their form, he assumed natural laws to be a necessary product of human thought. [23] Positivists like Mach considered natural laws to be logical-economic constructs, intended to create [93] some order in the otherwise chaotic reality consisting entirely of observable phenomena.[24] Hence they considered natural laws to be *post rem*.

Platonism exerted influence on Copernicus, Brahe and Kepler in the and on Galileo, Descartes and Newton in the 17th century. After his works were printed in 1543, the neo-Platonist Archimedes made a deep impression by his mathematical approach to physical problems, and by his skilful use of idealized thought-

[23] See Dooyeweerd, NC I, 109
[24] Dooyeweerd, NC I, 1l0.

experiments. In the 16th century, someone was called a Platonist if, contrary to the Aristotelians, he valued mathematics as a useful instrument in science.[25] To these neo-Platonists or neo-Pythagoreans we owe the mathematization of science. Newton's use of the word 'axiom' as a synonym of 'law' springs from the view that science ought to be performed in a mathematical way, *more geometrico.* The idealistic view of universals (*ante rem*) is easily recognized in the idea that the laws are commands given by God to the creation, conceived of as an initially unordered reality. Descartes resolved

> ' ... to speak only of what would happen in a new [world], if God should now create, somewhere in imaginary space, enough matter to make one; and if he agitated the various parts of this matter without order, making a chaos as confused as the poets could imagine, but that afterward he did nothing but lend his usual support to nature, allowing it to behave according to the laws he had established.'[26]

Ostensibly, the 17th-century Aristotelians were the losers, they became the targets of attack by the adherents of new insights. Bacon, Galileo, Descartes, Boyle and many others took distance from the Peripatetics. But the realistic vision on universals, *in re,* comes close to the implicit worldview of present-day scientists concerning natural laws: reality is intrinsically lawful, and the laws can only be discovered in the facts.[27] The laws cannot be disengaged from reality, they cannot be found by *a priori* reasoning, but only by empirical research *a posteriori.* Below, we shall discuss the relevance of the difference between this view and the Neo-Platonic one, that matter is passively subject to laws.

The philosophy of the cosmonomic idea is not unanimous about position of laws, although it rejects the nominalist view.[28] According Vollenhoven the law is *ante rem,* he places the law between God and the [94] 'subjècte' (*i.e.,* whatever is subject to law),[29] but according to Dooyeweerd the law is *in re.* He says that created reality has a law side and a subject side, to be distinguished but never to be separated. Laws are not above reality.[30]

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25 Koyre, A., 1939, *Etudes Galiliennes,* Paris: Hermann; *Galileo studies,* Hassocks 1!
Hazvester, 3, 36, 201-202.

26 Descartes, 42; see Westfall, R.S., 'The rise of science and the decline of ortho Christianity: A study of Kepler, Descartes and Newton', in: Lindberg, D.C., Numbers,] (eds.), 1986, *God and nature, Historical essays on the encounter between Christianity and scU* Berkeley: U. California P.: 218-237. Westfall, 233: 'Newton's conception of nature still app' to me very similar to Descartes's in the dominance of law within it.'

27 Hiibner, K., 1983, *Critique of scientific reason,* Chicago: U. Chicago P. (orig.: *Kritik wissenschaflichen Vernunft,* Freiburg 1978: Karl Alber). chapter 9: when Huygens 'correc! Descartes' laws of impact, he thereby rejected Descartes' criterion of truth, to view only th statements as scientifically demonstrated which are *claire et distincte* when considered in light of reason. Huygens emphasized his laws of impact to be in complete agreement v ex~rience, not as a matter of fact, but as a matter of method.

28 Woudenberg, R. van, 1992, *Gelovend denken,* Amsterdam: Buijten en Schipperheijn, 46.

29 Vollenhoven, D.H.Th., 1950, *Geschiedenis der wijsbegeerte,* 1, Franeker: Wever , 25-26; Tol, A., Bril, K.A. (red.), 1992, *Vollenhoven als wijsgeer,* Amsterdam: Buijten en Schipperheijn, 55, 113.

30 Dooyeweerd, NC I, 96, 508; Dooyeweerd, 1960, 113; Hoeven,].van der, 1981, 'Wetten en feiten', in: Blokhuis, P. e.a. (red.), 1981, *Wetenschap, wijsheid, fiwsoferen,* Assen: Van Gorcum: 99122 and Troost, A., 1992, 'De tweeerlei aard van de wet', *Phil.Ref* 57: 117-131 endorse Dooyeweerd's view.

To be sure, Dooyeweerd never used the expression *in re.* As observed he stresses the absolute lack of self-sufficiency of the creation, to which he does not assign independent being. On the contrary, reality derives its being from the origin, the *arche* of everything, such that reality, both at its law side and its subject side, is characterized by meaning rather than by being.

The origin of natural laws

During the 17th, 18th and early 19th century, natural laws were generally conceived of as expressions of God's will. In the preface to the second edition (1713) of Newton's *Principia,* Roger Cotes summarized the view of natural laws developed during the 17th century:

> 'Without all doubt this world, so diversified with that variety of forms and motions we find in it, could arise from nothing but the perfectly free will of God directing and presiding over all. From this fountain it is that those laws, which we call the laws of Nature, have flowed, in which there appear many traces indeed of the most wise contrivance, but not the least shadow of necessity. These therefore we must not seek from uncertain conjectures, but learn them from observations and experiments. He who is presumptuous enough to think that he can find the true principles of physics and the laws of natural things by the force alone of his own mind, and the internal light of reason, must either suppose that the world exists by necessity, and by the same necessity follows the laws proposed; or if the order of Nature was established by the will of God, that himself, a miserable reptile, can tell what was fittest to be done.'[31]

The flowering physico-theology welcomed each scientific result as a new proof of the existence of a benevolent Creator.[32] The belief in God was increasingly built on the progress of science. In particular the argument of design was popular. The effectiveness and usefulness of nature demanded as an explanation the existence of a suitable building plan and a conscious designer. Both Hume and Kant rejected the argument of design, but their views being purely philosophical exerted little influence on the scientific community. Darwin definitively refuted the argument from design, not because he criticized the idea of God as a prime mover or first cause, or as a principle to explain an ordered creation, but because he explained biotic evolution on the basis of chance events.

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Besides, God was required to explain all phenomena that could not be explained by natural laws. Generally, two sources of knowledge of God were acknowledged, the Holy Scripture as word revelation, and nature as creation revelation.[33] Since the end of the 19th century the two appeared to lead to contrary views, and many people

[31] Newton, 1687, XXXII

[32] Lindberg, Numbers; Brooke,].H., 1992, 'Natural law in the natural sciences', *Science and Christian Belief,* 4: 83-103.

[33] I believe that God reveals himself only through his written word as the creator and redeemer of the world, and that he is not knowable through nature. The 17th-century project to find the 'God of the philosophers' was already critized by Pascal.

started to consider science the competitor of religion, with its own view of creation, fall into sin and redemption. The 20thcentury physical 'theory of everything' provides the temptation to find God through science.[34] In this view the biblical revelation plays no part anymore. But this pretension is subject to critique, as follows.

The aim of science is to find and explore the laws and their connections, and to design possible applications in concrete reality. Hence, the laws constitute a boundary for scientific activity. The origin and meaning of laws is hidden for science.[35] To assign meaning to reality is a non-scientific task. The search for the origin of laws is meta-physical, meta-mathematical, meta-logical, and even meta-philosophical, because it is religious. It finds its legitimacy and certainty only outside science. The Christian confession, saying that reality (both law side and subject side) is created, fallen into sin, and redeemed through Jesus Christ, is not subject to scientific or philosophical scrutiny, but finds its ground in God's revelation only.

This belief may serve as inspiration to avoid traps, for instance fear for taboos, or attempts to take a position outside reality, or the temptation to hypostatize any aspect or part of reality. But this belief cannot serve as a starting point for empirical scientific research. Attempts to explain the idea of law and its origin in a scientific or philosophic way are in vain, because science takes the lawfulness of reality for granted. Nevertheless, the idea of law has the pretension to be *universa~* to hold for everyone under all circumstances. This means that the idea of natural law is not exclusively Christian, it is public. For science it is sufficient to accept the existence of laws as a starting point. Therefore, Christian science does not exist, though it is possible and may be fruitful to be a scientist or philosopher in a Christian context. The idea of natural law arose during the 17th century in a Christian community, it is a gift of Christianity to mankind, but it is not reserved for Christians.

Causality and determinism

During the 17th and 18th century natural laws were considered instruments of God's government. Therefore law-conformity was easily identified with causality, the laws were considered to be causes, with God as the first cause. Kant and his followers developed this idea.[36] Newton assumed that the natural laws were not sufficient to explain God's interference with the creation, [96] without his help the solar system could not be stable. When a century later Laplace proved that all planetary movements known at the time satisfied Newton's laws, the idea that God would correct the natural laws was pushed to the background of theological discussions about miracles. At present, causality is seen as a relation between events, one being the cause of the other, subject to laws. But a law itself is no longer considered a cause.

In the 18th and 19th century, natural laws were often identified with laws of force, interpreted in a deterministic way, as expressed by Laplace's famous dictum:

[34] Hawking,S., 1988, *A Brief history of time,* New York: Bantam.
[35] Popper, 1983, 152-153: the origin of natural laws is a mystery.
[36] Clay.

> 'We ought ... to regard the present state of the universe as the effect of its anterior state and as the cause of the one, which is to follow. [Assume ...] an intelligence which could know all the forces by which nature is animated, and the states at an instant of all the objects that compose it; ... for [this intelligence], nothing could be uncertain; and the future, as the past, would be present to its eyes.'[37]

Determinism believes nature to be completely determined by unchangeable natural laws, it hypostatizes laws of nature. Determinism has always been an article of faith rather than a well-founded theory, and is now refuted by the discovery of radioactivity and by the development of quantum physics and chaos theory. Scientists agree that things and events are subject to laws leaving a margin of indeterminacy, contingency or chance.

Epistemology

A realistic view of natural laws not only implies their existence, but also their knowability. It is important to make distinction between the laws, which govern nature, independent of mankind from laws as formulated by scientists. We shall call the former *natural laws* or *laws of nature,* and the latter *law-statements.*[38]

Newton's law of gravity is a law-statement, whereas the law of gravity is a natural law ruling the planetary motions. A law-statement is *true* if it is a reliable expression of the corresponding law.[39] Until the beginning of the 20th century, Newton's law-statement was considered to be true, but since the acceptance of Einstein's general theory of relativity, it is considered approximately true. The Newtonian expression is sufficient to solve many problems, and is often preferred because of its simplicity. For a similar reason one may prefer Galileo's law of fall, which Newton showed to be an approximation of his own statement of the law of gravity.

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According to some philosophers, both Galileo's and Newton's statements are falsified by Einstein, and therefore have become useless, but scientists have a more liberal opinion.

Indeed, in the context of a theory, being a collection of deductively connected statements, only statements which are asserted to be true can be admitted, *i.e.,* axioms and facts which are accepted to be true and theorems which truth is to be proved.[40] This is a consequence of the law of excluded contradiction. If a theory

[37] Laplace, P., 1814, *Essai philosophique sur les probabilitis; A philosophical essay on probabilities,* 1951, New York: Dover, 4-5.
[38] 'Law-like sentence' according to Goodman, see Hempel, C.G., 1965, *Aspects of scientific explanation,* New York: Free Press, 265. Swartz, 4, 11, calls laws of nature 'physical laws' and lawstatements 'scientific laws'. In physics, many other expressions are used for law-statements, like Pauli's principle, Schr6dinger's equation, Gauss's theorem, Einstein's postulates, and FermiDirac statistics.
[39] Nominalists would say that a law-statement is true if it confirms to observable facts. Realists would call this a *criterion* for the truth of a law-statement
[40] Stafleu, M.D., 1987, *Theories at work,* Lanham, New York, London: U.P. of America, chapter 1.

would contain a statement, which is asserted to be false, the truth of any other statement could be derived. Obviously, this would make the theory quite useless, it proves too much. But the user of a theory has a wide choice of axioms, facts *etc.* For instance, when studying a falling body, for the law of gravity he is free to choose between Einstein's, Newton's or Galileo's law-statement. He may assume friction to occur or not. For the deductive process the statements within a theory are not allowed to be mutually contradictory, but they may very well contradict statements which are not used in the theory. That is the basis of the use of law-statements and idealizations, which are known to be false, or approximately true.[41]

It has sense to say that a law-statement is true, or false, or approximately true, but it has no sense to say that a law is true.[42] A law *is valid* or *holds* for a specified range, which implies a relation to its subject matter. Hence, the *metaphysical* and *meta-logical* principle of excluded antinomies, mentioned above, must not be confused with the *logical* law of excluded contradiction, which only applies in a well-defined logical context, such as a theory.

Criteria for a law-statement

The philosophy of the cosmonomic idea never paid much attention to the question of when a statement has the status of a law-statement,[43] a question that is not easy to answer, as several philosophers have observed.[44] We don't have a comprehensive *concept* of law, it cannot be subsumed under more general concepts, but we have an approximating *idea* of law.

Universality is the foremost characteristic. Each law-statement is a generalization, but not every generalization is a law-statement. 'All flowers in my garden are roses' is a universal statement, yet it is a factual statement rather than a law-statement because of the restriction 'in my garden'. However, it is .not easy to give rules for the exclusion of such restrictions. One (disputed) rule is that a law-statement must state something that is necessarily the case, [98] but this should not be understood as a 'logical necessity'.[45] Clearly, the fact I hat all flowers in my garden are roses is not necessarily so.

It cannot be required to exclude all specific data in a law-statement. For instance, 'below 1234 K, silver is solid' is a law-statement, because being its melting- point, 1234 Kelvin is specific for silver. On the other hand, 'below] 000 K, silver is solid', although true and universal, is not a law-statement, because the temperature 1000 K is in no way specific for silver and can be replaced by any value between 0 and 1234 K.

[41] Swartz, chapter 1.
[42] Both Swartz, 3, and Carroll, J.W., 1994, *Laws of nature,* Cambridge: Cambridge V.P., 22-23, state a law of nature to be a (true) proposition, which I believe to be a categorical mistake.
[43] But see Hart, H., 1984, *Understanding our world,* Lanham: V.P. of America, chapter 1-2, on universality.
[44] Nagel, E., 1961, *The stmcture of science,* New York: Harcourt, 48; Hempel, 264-278, 291-
[45] Swarlz argues extensively against the necessitarian view of laws (maintaining that all laws are necessary, they ('*11"''-' wlhlt *must* occur in particular circumstances), favouring the rq~lI!arisl view (laws express only what *does* occur). See also CarroIl, 24-25. Swartz, 37-38, mentions and dismisses a third and older view, the prescriptivist one that laws have been issued by God. 11 appears that none of these views ca,'. be proved, and the choice between them depends on one's scientific worldview.

The rule that a law holds independent of a certain place or time is much too strong-, for the validity of a law is often restricted to certain circumstances, fill' instance as realized at the surface of the earth since a couple of billion years. The theory of relativity states that natural laws, besides being independent of place and time, ought to be formulated independent of the motion of the frame of reference. This might not be a general criterion for a lawstatement, but a consequence of the mutual irreducibility of the physical and the kinematic aspects, providing a restriction on the formulation of *Physical* law-statements only.

In a theory, a law-statement is not only intended to describe a certain state of affairs, it should also enable one to make predictions and explanations.[46] Therefore, it must allow of *counterfactuals,* it must be able to function in a hypothetical situation which is actually not the case.[47] A *disposition,* such as 'glass is breakable', applies to any glass even if it is not broken. Newton's first law of motion, the law of inertia, is counterfactual, because bodies on which no flllTes act do not exist. Its validity can be established only if we apply this law in combination with, *e.g.,* the law that forces can balance each other, which makes the statement 'If no *net* force is exerted on a body, it has no acceleration' a testable consequence of Newton's first law. The law of conservation of energy, stated as 'the energy of a closed system is constant', is counterfactual, because closed systems do not exist, but it has important consequences if applied to real systems. Hence, there is some truth in Cartwright's proclamation Ihat the laws of physics lie.[4H]

Finally, we accept a proposition as stating a law only if it is connected to other law-statements. The law of Titius-Bode should not be called a lawstateJl1ent.[19] It conceflls a regularity in the distances of the planets to the sun,

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11, Slafleu, 19H7, rl1apler 2.

17 Nagel, 51; 1I{'mpcl,.11!1; SWarl? TiiL c'.!apter H; CalTolI, 4.
IX Cartwright,:\: 'Blit fi-iiTI1,"lclIlaT equations are meant to explain, and paradoxically (,lIollgh I he cost of {'xplanalOry power is descriptive adequacy. Really powerful explanatory laws of lhe sorl fOil lid ·;ilTITI·l1Tl'l1Carphysics do not state the truth'. According to Swartz, cha~)I('r I, virtllally all !aw-slalenJenlS are false.
1. Ni,'lo, M:M:.~ '/1/1' *Tilil/l-&r&c.Ir"" "(!Ilanetary di.<tanres,* Oxforrl: Pel1!'amon.

but (apart from the fact that the stated regularity is not very convinci nobody has ever been able to connect it to other laws.

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Law and subject
Carroll observes ' *... if there were no laws, there would be little else ...* ' counterfactuals, no dispositions, no causality, no chance, no explanations properties.50 'Nearly all our ordinary concepts ... are conceptually intertwi with lawhood.'51
In ordinary language, a law is seldom distinguished from its subject ma but in science this distinction is abundant.[52] It is a characteristic of scienc disrupt reality, of which the distinction of law and subject is the first insta But even in science, law and subject cannot be separated; the law is *i* Knowledge about laws of nature can only be achieved by studying its sub}
e.g., in experiments or observations.
If the laws would have existence apart from their subject matter *(ante* our knowledge of laws could be independent of empirical research. Such the opinion of the (Neo-) Platonists, who assumed that true knowledge oJ laws can be achieved on the basis of intuition and thought, or that knowh of laws is inborn, and can be recollected by *anamnesis.* Generally, presenl scientists do not share this view, although some theoretical physicists ex that in the near future natural laws can be founded exclusively on logical mathematical principles, such as symmetries.

Logic
Both Platonic idealism and Aristotelian realism were dominated by the that the order in the cosmos is primarily rational. This was criticized *by* nominalists stating that God's power cannot be restricted by reason. cosmos being as it is could have been different. Luther en Calvin shared nominalist critique of rationalism, but feared that a one-sided emphasi God's omnipotence would lead to the idea that God's acts are arbitrar; particular Calvin complemented the idea of God's power with the ide God's being faithful to his creation and his laws.[53] The reformers rejected view that Platonic ideas or Aristotelian forms are logically transparent, accepted nature to be open to empirical research, in which human though operates with observation and experiment.[54]

The rationalistic views were still shared by Galileo and Descartes, albeit had a different *(i.e.,* mechanistic) view on what should be considered logi transparent. But Kepler's and Newton's laws are not intuitively evident, the derivable from the observed facts by a thorough analysis. A century later, :

50 Carroll, 3, 6-10. 51 Carroll,9-10.

52 Carroll, 3.
53 According 10 Calvin, God is neither subject to laws, nor arbitrary: *'Deus legibus soIut sed non exlex',* see Dooyeweerd, NC!, 93, 99.
54 Deason, G,B., 1986, 'Reformation theology and the mechanistic conception of na

considered the laws of nature again to be 'principles of necessity concerning the being of things',;';· attempting to prove Newton's law from metaphysical principles.
This is related to the supposition that logical laws are *a priori* valid, and so are the axioms of mathematics which can be derived from logic. However, in the 19th century it turned out that even the axioms of Euclidean geometry, the paradigm of an axiomatic theory, are not exclusively evident and nonEucIidean geometries were

developed. The question of whether mathematics is a branLh of logic is still not settled, nor the question of whether logic is *a jJriori* valid. ;,(j
The logical-cmpiricists distinguished logical and mathematical propositions, which are tautologies; empirical statements, being contingent; and untestable or metaphysical statements, considered meaningless. It is quite common to separate thinking and being, as if these two are entirely different, as if thought can be independent of being, as if a thinking human being can place himself outside reality, to study it from a detached position. The philosophy of the cosmonomic idea has a different view, it states that man is part and parcel of the creation, including his thought, and he cannot take a position outside reality, without prejudice. In particular, no creature can take the position of t he creator, and scientific knowledge can only be gained from within the creation.

Therefore, human thought is subject to the same kind of laws as the creation as a whole; this is even a condition for the achievement of knowledge. Logical laws are laws for human thought to be considered on a par with laws of nature and mathematical laws. Whereas natural laws are conditions for the existence of atoms, plants, *etc.,* logical laws are conditions for thought. The distinction of empirical versus tautological statements is in this view quite useless.

The justification of law-statements

From the fact that all attempts to justify the existence of natural laws on logical grounds have f;liled, empiricist philosophers like Van Fraassen conclude that natural laws have no existence outside an epistemological context, there are only law-statements. The logical-empiricists were mainly interested in the question of how law-statements can be justified on empirical grounds. At first being of the opinion that law-statements are nothing else but generalizations of observations, they gradually had to admit that the relation between lawstatements and empirical facts is less direct. Popper, who argued that a lawstatement could only be falsified, criticized their initial view that generalizations can be verified, *i.e.,* proved by induction. Within a theory, defined as a deductively connected collection of statements, theorems are proved, starting from law-statements and some facts. Theories are tested by comparing its theorems with statements derived from other theories or from observations or

Kant, I., 178li, *MrtajJhysi.\che An[angsgnlnde der Naturwissenschaft,* Leipzig 1900: Pfeffer, 5: 'Ces('lze, d.i. Prinzipil'n del' NOlhwendig-keit dessen, was zum Dasein eines Dinges gehort.'
h .long, W.R. de, 1982. 'Logika en ralionalileil', *Phil. Rer* 47:]34-154.

experiments. It has become clear, however, that no method is conclusive, there exists no definitive proof of a law-statement. Nevertheless, the methods of science reach a level of certainty that is much higher than any other method to achieve knowledge of laws.

Whereas the logical-empiricists denied the ontological status of natural laws, they maintained the objectivity of law-statements. In that respect, after 1960 they were attacked by the historicists (Hanson, Kuhn, Feyerabend, Lakatos), stating that law-statements are historically determined, and by the socialconstructivists (Latour, Pickering), who believe that law-statements are the results of negotiations between interested parties. Both deny the possibility to arrive at objectively true statements about natural affairs.

Realists agree with the logical-empiricists that law-statements are justified if they confirm all relevant facts. If a law-statement is firmly corroborated, it may be considered a true expression of a law.

Reduction of theories
Each theory has a number of basic law-like and factual statements, which cannot be proved within the theory, but serve as starting points for the deductive process. Sometimes the axioms can be proved in a different, more fundamental theory, in which case one says that the former is reduced to the latter. More often than not, the proven theorem in the fundamental theory is not identical to the axiom in the reduced theory, but shows some resemblance. For instance, Newton could derive statements that are very similar to Kepler's laws but not quite identical. Kepler assumed the sun to stand still, whereas according to Newton the sun moves around the solar system's centre of gravity. According to Kepler's laws the planets move independent of each other, whereas according to Newton they influence each other's motions. Hence, scientists say that Newton proved Kepler's laws to be approximately true. Because Kepler's laws were confirmed by observations, this counts as a confirmation of Newton's theory. Sometimes it is stated that Newton used Kepler's laws to derive his own theory, and philosophers demur that this cannot be right, because you cannot make use of statements which are proved to be false in the same theory."? In fact, Newton first showed that from Kepler's laws one can find the law of gravity, and next he used that law in a new theory to derive statements which are similar to Kepler's laws.

Philosophers deny these claims, because they do not accept a proof based on approximations.[58] They also reject the claim of physicists that classical mechanics is an approximation (at low speeds) of relativity physics. They argue that the classical concept of mass (being a constant of the motion of any object) is incompatible with the relativistic concept of mass (being convertible to energy), whereas physicists are content with the observation that at low speeds, relativistic mass is approximately constant.[5]\J

57 Stafleu, 1987, 108-112.
58 Popper, 1972, 197-202; Popper, 1983, 139-144, 148. For a critique, see Finocchiaro, M.A., 1973, *History a/science as explanation,* Detroit: Wayne State U.P. 180-188, 196-198 .

Heuristic
With respect to the discovery of laws I briefly mention three historically important views. The deductivist view represented by Descartes holds that natural laws must be deduced from clear, intuitively irrefutable principles, from which the laws would derive a rational and necessary character. Descartes knew very well that not every law can be found in a deductive way, and he recognized experiment as a secondary heuristic.[no] Newton pointed out that even the most rational concepts of mechanical philosophy rest on generalizations of experience, and he stressed the contingent character of the law of gravity. fil This rejection of rationalism, interrupted by a

short period of Kantian revival, was reinforced by later developments of science. Repeatedly one had to admit that truths, supposed to be self-evident, were repudiated by scientific research. It appears that the natural laws transcend rational thought.

The inductivist vision, represented by Francis Bacon, saying that natural laws are nothing but generalizations of observations, is at variance with the starting point of science, that natural laws are universal, valid always and everywhere. Generalization never leads to universal validity.n2 Induction needs the presupposition that laws exist, in order to arrive at universal statements of law. Hence, laws transcend human experience.

Popper criticized inductivism, stating that a scientist poses challenging hypotheses, deduces their consequences, and subject them to severe tests with the aim to discover whether or not the hypothesis should be rejected. But Popper underestimates the heuristic significance of experiments. He thinks an experiment has only a place ill the context of justification, as a means to test a theory or hypothesis. Popper rightly states that a law-statement is a product of the human imagination, in which experience and rational analysis co-operate. But the laws to which these statements refer even transcend the imagination. In general, the far-reaching consequences of newly formulated law-statements cannot be predicted, and theories are usually much richer than even their inventors could imagine.

Induction, deduction and imagination are powerful means to find law-like propositions, but there are at least three more to be considered: the experimental method, the subject-subject relation, and structural laws.

Isolation of a field of science and the experimental method

More than the logical-empiricists, the historicists were interested in the heuristics of science. Kuhn observes that an important part of normal science is concerned with the solution of problems according to a generally accepted paradigm. fi~ Lakatos has become known because of his methodology of

60 Descartes, 63-!i4.
61 I Newton, 16117, 3911-100. Newton's 'Rules of reasoning in philosophy' represent his heUl'istic in condensed form.
62 Van Fraassen, 22.
63 Kuhn, dlaplers 2-4.

scientific research programmes, in which heuristics play an important part.[64] During the 17th-19th centuries the heuristic of natural science was characterized by the isolation of various fields of science.[65] The shift of emphasis from the *essence* of things to the *laws* relating a more or less well defined group of phenomena (electric, magnetic, chemical, thermal, optic, *etc.)* with their problems and theories turned out to be extremely fruitful. Under the flag of experimental philosophy, natural science made extensive use of the new experimental method, in which phenomena were studied in isolation from the rest of the world. This method relies on the idea that reality satisfies natural laws. An experiment is always performed at a certain place and time with specific instruments and well-chosen specimens, by a single experimenter, whose experimental skills, knowledge and imagination are decisive. Nevertheless, the experimental results are declared to hold for all places, times and comparable materials, independent of the personal properties of the researcher. Therefore, an experiment has to satisfy strict requirements. It must be reproducible by other scientists, using different instruments and materials at various places and times.

The experimental method is an activity transcending passive observation. In an experiment, matter is activated, contrary to Newton's view that matter is passive.

The subject-subject relation and structures

The heuristic of science relies on the relation of a natural law and its subjects. Without knowing it, Newton laid his hands on a powerful heuristic, to wit, the inter-subjective or subject-subject relation. Each piece of matter attracts any other one by the force of gravity, which according to Newton's third law is a reciprocal relation. If *A* exerts a force F on *B,* then *B* exerts a force -F on *A,* action and reaction being equal but in opposite directions. In the investigation of other interactions, Newton's third law played a leading part. After the middle of the 19th century it was supplemented by the conservation laws of energy and momentum, again expressing subject-subject relations. In the special theory of relativity, Einstein emphasized all motions to be relative, being kinematic subject-subject relations. The rise of biology in the 19th and 20th centuries was largely due to the shift of emphasis from the study of species to the discovery of laws concerning genetic relations.

In the philosophy of the cosmonomic idea the subject-subject relation is a heuristic tool in studying the modal aspects.

64 Lakatos, I., 1970, 'Falsification and the methodology of scientific research programmes', in: Lakatos, I., Musgrave, A. (eds.), *Criticism and the Growth of Knowledge,* Cambridge: CambridgeU.P.,91-196.

Conclusion

Newton's Neo-Platonic supposition that matter is passively subject to laws is also at variance with structural laws. The realist position, saying that matter is lawful, that each kind of matter has a structure, determining its conditions for existence and its functioning, found favour in atomic physics and chemistry during the second half of the 19th century.66

Present-day atoms arc far from passive, they are structured and their lawful structure determines in which way they interact with their environment. On a sub-atomic level, too, there is no unstructured matter, not even unstructured energy. In the search for structure, symmetries, transformations and invariances play an important parLIi7 The idea that everything in reality is lawful, having a typical structure determining its individuality, constitutes another powerful heuristic, both in science and in the philosophy of the cosmonomic idea.

The introduction and development of the idea of natural law, and the simultaneous downfall of essentialism, is a historical phenomenon, related to thc risc of modern science since the 16th century. The idea of natural law as a starting-point for science is truly a metaphysical principle, an unprovable but undeniable part of one's scientific worldview. The views, that natural laws exist apart from human experience, that law-conformity is a universal trait of reality, that nothing is law-less, that law and subject are intertwined and inseparable, allow us to account for the actual procedures of science, its ontology, epistemology, logic and heuristic. The view of science as an activity bounded by law makes clear that scientific knowledge is restricted to natural laws and to whatever is subject to law, and cannot be gained from any position outside reality. Hence, knowledge of God and of the origin of natural laws is outside the reach of science and its philosophy.