

Article

# Nature, Artifice, and Discovery in Descartes' Mechanical Philosophy

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**Abstract:** It is often assumed that in the collapse of the Aristotelian distinction between art and nature that results from the rise of mechanical philosophies in the early modern period, the collapse falls on the side of art. That is, all of the diversity among natures that was explained previously as differences among substantial forms came to be seen simply as differences in arrangements of matter according to laws instituted by the “divine artificer”, God. This paper argues that, for René Descartes, the collapse occurs on both sides. Natures are artefacts of God, and human artefacts, under some conditions, can be classified as natures or, at least, continuous within nature. Drawing on developments across both horticulture and engineering in the 16th and 17th centuries, as well as Descartes' mechanical philosophy, this paper explores challenges to the Aristotelian nature/art distinction. The question then is what, in the advent of this collapse, are human artificers doing when they construct artefacts? Are they replicating God's powers by creating new natures, or are they doing something else, and if so, what might that be? It is argued that we should view human invention for Descartes not as creating new natures so much as discovering them. These findings have consequences for how we interpret Descartes' use of the term “nature” in relation to automata and other artefacts produced by human hands.

**Keywords:** Descartes; nature/art distinction; automata; discovery; artisans; horticulture; mechanics; Aristotle



**Citation:** Brown, D.J. Nature, Artifice, and Discovery in Descartes' Mechanical Philosophy. *Philosophies* **2023**, *8*, 85. <https://doi.org/10.3390/philosophies8050085>

Academic Editors: Henrik Lagerlund, Sylvain Roudaut and Erik Åkerlund

Received: 26 June 2023

Revised: 16 August 2023

Accepted: 23 August 2023

Published: 14 September 2023



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## 1. Introduction

Shakespeare's *The Winter's Tale* was first performed in 1611. Act 4, scene 4 contains an interesting debate about the relationship between nature and art—a sign of the currency of the question in the 17th century. The young heroine, Perdita, was born Princess of Sicily but immediately abandoned by her father, King Leontes, who suspects (falsely) that she is the bastard child of his wife and Polixenes, King of Bohemia. Perdita is found on a shore and raised by Bohemian shepherds until, at the age of 16, she meets and falls in love with Prince Florizel of Bohemia. None too happy about the rumoured liaison between a shepherdess and the prince, King Polixenes attends the sheep-shearing festivities in disguise, seeking to confirm the rumour. Perdita presents Polixenes with a winter bouquet of rue and rosemary and apologises for not giving him “carnations or streaked gillyvors”, the fairest flowers of the season. Cultivated winter flowers, she says, are unnatural. She refuses to “set one slip of them” or grow any of “nature's bastards”. Ironically, Polixenes takes the opposite view on the question of hybrids. At least where plants are concerned, the mixing of a base with a nobler race can, he says, “mend” nature—a view Perdita confirms that she has heard about. Here is part of their exchange:

Perdita:

For I have heard it said

There is an art which in their piedness shares

With great creating nature.

Polixenes:

Say there be;  
 Yet nature is made better by no mean  
 But nature makes that mean. So, over that art  
 Which you say adds to nature, is an art  
 That nature makes.<sup>1</sup> [1]

Polixenes' argument seems to be that nature's powers are not rivalled by art, because nature creates art. Still, art can improve upon nature. The art of horticulture is merely "great creating nature" working through art.

Politeness:  
 You see sweet maid, we marry  
 A gentler scion to the wildest stock,  
 And make conceive a bark of baser kind  
 By bud of nobler race. This is an art  
 Which does mend nature—change it rather—but  
 The art itself is nature.<sup>2</sup> [1]

This exchange reflects the prevalent instability in the concepts of both nature and art in the 17th century. Technological advancements in the period produced two kinds of effects on nature: augmentation (e.g., horticulture), and automation, replicating nature's effects mechanically. For those of us familiar with René Descartes' philosophy, the distinction between art and nature—a cornerstone of Aristotelian philosophy—collapses on the side of art.<sup>3</sup> Ref. [2] Everything is a product of the "divine artificer" and, thus, every arrangement of matter is both nature and artefact. But the collapse falls on the other side as well, as things traditionally classified as artefacts begin to be included within the extension of at least one sense of the term "nature".

This paper proceeds in four phases: First, I explore the Aristotelian foundations of the nature/art distinction, which are important background for early modern discussions. Second, I examine the developments in accounts from the 16th and 17th centuries of the relationship between nature and art from two sources: first, from discussions about fashionable gardens and grottoes and associated horticultural techniques; and second, from Descartes' identification of artificially created automata and organic systems. While both discussions lead to the conclusion that a sharp dichotomy between nature and art is untenable, questions remain about what sort of distinction, if any, there is between nature and art, as well as what it is exactly that artisans are doing when they endeavour to imitate the effects of nature. Whether artisans are creating new natures, or whether artefacts are simply one kind of manifestation of nature itself, is an open question. In the third part, I reconstruct Descartes' answer to this question. I argue that a key move that he makes is to reject the distinction between the *coming to be of a thing* and *what the thing is*. While he does seem to allow that new composites, especially automata, can constitute new natures, I argue that it does not follow that artisans are accorded the powers of creation. Drawing on his theory of ideas, I argue that for Descartes what an artisan is doing in augmenting or automating nature is more appropriately an act of discovery than an act of creation.

## 2. The Aristotelian Background

Aristotle's *Physics*, II, opens with the distinction between things said to exist "by nature" and those that exist by art. The former includes all composite, organic bodies and their parts, as well as simple bodies or elements:

§ 1 · Of things that exist, some exist by nature, some from other causes. By nature the animals and their parts exist, and the plants and the simple bodies (earth, fire, air, water)—for we say that these and the like exist by nature. [3] (II.1, 192b9-11; p. 329.)

The criterion immediately offered for the distinction is that only things that exist by nature have an internal principle of motion and rest:

All the things mentioned plainly differ from things which are not constituted by nature. For each of them has within itself a principle of motion and of stationariness (in respect of place, or of growth and decrease, or by way of alteration). On the other hand, a bed and a coat and anything else of that sort, qua receiving these designations—i.e., in so far as they are products of art—have no innate impulse to change. But in so far as they happen to be composed of stone or of earth or of a mixture of the two, they do have such an impulse, and just to that extent—which seems to indicate that nature is a principle or cause of being moved and of being at rest in that to which it belongs primarily, in virtue of itself and not accidentally. [3] (II.1, 192b9-23; p. 329.)

It is not denied that artefacts have natural motions. A bed moves towards the centre of the Earth as much as a rock, but it only has these motions insofar as it is composed of natural substances, not insofar as it is a bed. Artefacts have only accidental being, in the sense of being composed of substances in accidental arrangements. They are not substances themselves<sup>4</sup>, whereas the subjects of natural motions are substances:

[I]f you planted a bed and the rotting wood acquired the power of sending up a shoot, it would not be a bed that comes up but wood, which shows that the arrangement in accordance with the rules of art is merely an accidental attribute, whereas the substance is the other which persists continuously through the process. [3] (II.1, 193a13-16; pp. 329–330.)

In this discussion, Aristotle uses the terms “substance” and “subject” interchangeably:

Nature then is what has been stated. Things have a nature which have a principle of this kind. Each of them is a substance; for it is a subject, and nature is always in a subject. [3] (II.1, 192b33-34; p.329.)

And it is due to form that something exists by nature, since form is what actualises (prime) matter into being:

The form indeed is nature rather than the matter; for a thing is more properly said to be what it is when it exists in actuality than when it exists potentially. [3] (II.1, 193b7-8; p.330.)

What a thing is—its nature—is due to its substantial form, but it should be clear from the above that *how it comes to be*—namely, without the interference of artistic arrangement—is part of the story behind why it has a nature.

Already the art/nature distinction is problematic. First, against the sufficiency of self-motion as a criterion, there were, even in antiquity, artificial automata, such as those for which Heron of Alexandria was famous, which moved on their own accord and had their own distinctive motions. A static body like a bed seems a question-begging example upon which to base a strict dichotomy of nature and art. Second, the sense in which the elements are self-movers is attenuated at best. A body at the centre of the universe can have no inclination to move; thus, it became a question in subsequent discussions of Aristotle’s physics whether it really is an internal principle rather than place that is the cause of elemental motion [4]. Third, the criterion of self-motion is in tension with another tenet that is crucial to Aristotle’s argument for the existence of the unmoved mover, namely, that nothing moves unless moved by something else. Aristotle seeks to render these consistent by defining the self-mover as a body composed of multiple parts, the first of which is moved by something else and which, in turn, imparts motion to the other parts [3] (VIII.5, 258a2-4; p. 431). This seems to imply, however, some heterogeneous differentiation among parts, but such differentiation is absent in simple bodies like the elements. The condition of being moved only when moved by something else is satisfied, moreover, even when a body has no natural inclination to move in a given direction. In the case of unnatural or violent motions, like a stone thrown up into the air, the body only moves when and because it is moved by something else, but its innate impulse is to resist the force by which it moves [3]

(VIII.4, 254b25-27; p. 425). Such considerations raise questions about a strict dichotomy between nature and art based on the self-mover/non-self-mover distinction.

Aristotle proceeds to offer a second criterion for existing by nature, namely, teleology. Things that are by nature exist “for the sake of something” and, thus, have a cause that is “determinable and knowable”, whereas the causes of things that happen by chance are innumerable and indeterminable [3] (II.1, 196b18-196b32; p. 335). The latter include accidental arrangements like the bed or a coat and chance occurrences, like coincidentally meeting a creditor at the market one has gone to for other reasons. The suggestion is that there is no natural unity among the things that exist by chance and, thus, no single account can be given of them in natural philosophy. Think of all of the different ways of making beds or coats! An object for which there is an open-ended disjunction of possible causes is not a genuine object of scientific inquiry.

As a basis for distinguishing art from nature, the appeal to teleology is, however, confusing, since Aristotle includes in the class of things that exist “for the sake of something” things produced by thought or intention, which include artefacts. The objects of deliberate design have final causes, and so why not appeal to these final causes to unite an otherwise disparate groups of objects (all of the beds, for example) into a single kind? Beds are things that are built for the sake of providing something upon which humans can sleep comfortably. But having a purpose is only one of the criteria appealed to in order to distinguish nature and art. Perhaps having an end or purpose is only intended as a necessary (not sufficient) condition for existing by nature. Perhaps the final cause must operate *immanently* within nature, not by “extrinsic denomination” through a designer’s intentions. We must remember, after all, that the unmoved mover does not operate for Aristotle as the demiurge does for Plato—as an efficient cause—and so the picture of the universe is not based on assumptions about intelligent design. If it were so based, the teleological criterion would not offer a way of discriminating between things made by art and those made by nature, since both would be products of intelligent design. Either way, we need to say more than that things that are by nature exist for the sake of some purpose to differentiate nature from art. Otherwise, to exclude one category of things that exist for the sake of something from being part of nature would be arbitrary.

The elements also again prove problematic in relation to the teleological criterion, since they do not appear to act for the sake of anything “determinable and knowable”. Some Aristotelians were, however, prepared to bite the bullet on this point, accepting that everything that exists by nature seeks to perfect and reproduce its substantial form. Aquinas, for example, proposed that fire seeks to rise higher and multiply itself and counts for this reason as a substance (*Summa Theologiae* I, q. 80, a.1). But this seems to be a conflation of what fire does and what it ought to do, and it is not at all clear in what sense the other elements can be said to be striving to perfect (let alone reproduce) their forms.

How important the capacity for reproduction is to the notion of an Aristotelian nature is obscure, but in any case, it does not seem to be a criterion that would suffice to distinguish nature from art. While it is true that the automata of Descartes’ or Heron’s epochs are not self-replicating machines, there are no essential barriers to automata including among their functions the capacity to produce copies of themselves. Currently, there are endeavours to produce self-replicating machines, some based on the principles of Von Neumann’s cellular automata—e.g., synthetic, self-replicating molecules [5] (p. 35)—and others that do not rely on copying a self-description (analogous to the genome), thus imitating the evolution of the earliest organisms [5] (p. 39). The realisation of self-replicating machines is, of course, by no means a given. The challenge in identifying principles of self-replication is to build self-replicating machines that are complex enough to simulate the reproduction of components that work in tandem in such a way that the whole is greater than the sum of the parts, as in living creatures. But the idea of machines capable of regenerating themselves and others of their kind remains a live option.

At the turn of the 17th century, the coherence of the form/matter distinction at the heart of Aristotelian metaphysics was already in question. The attack was underway in

the 14th century in the debate between Scotists and Thomists about whether one had to admit a real distinction between form and matter, lest the two principles of nature collapse into one, and carried into 16th century Jesuit discussions, including Francisco Suárez's *Disputationes Metaphysicae* (1597/1861), [6] which Descartes is purported to have read, albeit carelessly. <sup>5</sup> Refs. [7–9] Descartes adds fuel to this debate, disparaging the occult status of substantial forms as early as *la Dioptrique* (published in 1637), where he dismisses “those little images flitting through the air, called ‘intentional forms’, which so exercise the imagination of the philosophers” (AT 6: 85; CSM 1: 153–154) <sup>6</sup> [10]. Without the edifice of substantial forms, the distinction between art and nature begins to appear arbitrary, because if matter is the only principle of (non-rational) nature, whether matter is organised by nature or by hand makes no difference to the principles according to which it moves or behaves. Matter is uniform in nature and governed by the same universal laws no matter what arrangement it finds itself in. The Cartesian attack on final causation dispensed with the idea of an immanent, natural teleology differentiating the natural from the artificial, although Gassendi, the Cambridge Platonists, Boyle, and Leibniz questioned whether one could understand organic development without presupposing the ends that God sets for nature. <sup>7</sup> Ref. [2] The principles of the new science of mechanics in the late 16th and early 17th centuries are indifferent to the origins of the collections of matter whose movements they explain. These principles, as Des Chene (2001) [11] has argued, replace the question of origins and purpose with a focus on the *operations* of machine parts. But before the mechanical philosophy comes into its own as the dominant scientific paradigm, the nature/art distinction is already arousing contention, with the attack coming from an unlikely place—the Renaissance garden.

### 3. Gardens, Grottoes, and the Idea of a “Terza Natura”

The early modern world is surprisingly interconnected. *The Winter's Tale* was performed in 1613 at the wedding of Elisabeth Stuart and Frederick V, later King of Bohemia, whose daughter, Elisabeth, was one of Descartes' principal correspondents. The French garden architect and engineer, Salomon de Caus, designed and produced automata for the Hortus Palatinus (Garden of the Palatinate) at Heidelberg for Elisabeth and Frederick, having served as the Queen's drawing master in England. De Caus dedicated Book II of his 1615 *Les Raisons des forces mouvantes* to her, explicating the hydraulic principles on which fountain automata were based. Descartes' views about animal and human physiology—the *bête machine* hypothesis of *L'homme*, for example—were inspired by his observations of automata in the grottoes of the Royal Gardens at Saint-Germain-en-Laye around 1614 or 1615. These automata were created by Italian engineers—the Francini brothers, Tommaso and Alessandro. The point of intersection between De Caus and the Francini brothers is likely to have been Bernardo Buontalenti, stage designer at the Uffizi Theatre and garden architect to the Medici. The Francinis learned their trade working on Buontalenti's projects in Florence and Pratolino, where Buontalenti constructed grottoes for the Grand Duke, Francesco. De Caus visited Pratolino and appears to have copied some of its designs [12].

According to Malgorzata Szafranska ([13], p. 76), the fashion for elaborate gardens featuring synthetic grottoes in the ancient Roman “rustic style” <sup>8</sup> [14]—rough, unhewn stone surfaces decorated with shells, pumice, corals, gems, pearls, decorative and synthetic stucco rocks, foliage, and imitation stalactites—dates to the second half of the 15th century. The idea was to create the illusion of a naturally forming grotto, blurring the distinction between nature and art by combining naturally and artificially sourced materials, as well as by attracting birds and animals to rest or forage alongside the automata. Bernard Palissy, French ceramicist and garden architect to Catherine Medici, described his method thus:

On the outside of the aforementioned enclosed space are to be left great jagged pieces of unhewn rock, in such fashion that the elevations of this space may not show forth the form of a building. . . [and] I shall have mounted upon the aforementioned numerous species of fruits that are good for birds to eat, together with certain plants, the seeds of which are much loved [by birds], in such wise

to accustom birds to rest here a while and sing their songs within the shrubs and bushes. ([15], p. 60; cited in [13], pp. 76–77)

Grottoes typically also featured mythical themes—nymphs (symbolising the Muses), satyrs, and earthly or heavenly deities such as Perseus and Andromeda, Athena, Hermes, Neptune, Orpheus, Dionysius, and Diana—sometimes as sculptures and sometimes as automata, to create spaces for reflection on classical themes and reconnection with nature ([13], p. 79; [16], pp. 367–368). Earth and water, the life-giving elements, featured predominantly, but other elements were sometimes represented, including the effects of air (light) on water to produce rainbows, as well as fire. De Caus' automata included steam-driven fountains or aeolipiles ([17], p. 2) capturing the elements of air and fire, which were a likely source of Descartes' knowledge of the aeolipile [18].

The 16th century saw a dramatic rise in the popularity of hydraulic automata in gardens, reflecting the same themes of natural magic, mythology, and illusion. In the case of these “moving statues”, the aim was to recreate the outward appearance of life in dynamic form—birds singing; fish or dolphins diving into water; classical heroes playing music, slaying dragons, or darting in and out of bushes. As Szafranska ([13], p. 82) notes, coral was a popular adornment, including in the Hortus Palatinus, reflecting the possibilities for natural metamorphosis in its plant–animal–mineral transmutations. It should not strike us as surprising that grottoes were often adorned with alchemical symbols, or that architects like Palissy and de Caus, a Rosicrucian, dabbled in alchemy ([13], p. 83; [16], pp. 366–367). The gardens appeared to live up to the alchemical promise that it was possible to transmute matter of one kind into another, including from non-living to living things.

The power of the grottoes to transport visitors back into nature depended on preserving the illusion that the encounter was genuinely one with nature. But while there might have been some intention to create *inganni* (deceptions) (Werrett 2001, p. 134), for some thinkers the grottoes represented not a false nature but a “third nature” (*terza natura*). Although, as Scholl ([19], p. 177) observed, the idea of a “third product”—cultivated plants blending qualities of both parents—can be found earlier in Pliny the Elder's *Historia Naturalis* and Virgil's *Georgics*; the pressure to regard the products of human artistry as part of nature ramped up in the 16th century. The context for 16th century discussions of third nature was horticultural, reflecting advances in grafting techniques that went beyond the traditional, Stoic notions of “first” and “second nature”. First nature is uncultivated nature; second nature is cultivated, directed nature. Cicero characterises second nature in *De natura deorum* 2.152 as follows:

We delight in the fields and the mountains. Ours are the rivers, the lakes. We bring forth the fruits of the earth and the trees. We give fecundity to the land by bringing in water. We dam, direct, and divert the rivers. In short, with our hands we undertake to produce as it were a second nature within the natural world ([20], p. 329).<sup>9</sup>

If the second and third natures both involve cultivation, however, what is the difference between the two? As Paolo Savoia ([21], pp. 74–75) notes, the distinguishing feature of discussions of third nature seems to be that the practice of gardeners brings forth *new things*—new varieties, new qualities—whereas second nature does not necessarily bring forth anything new, but only makes what was already there more fecund. On third nature, the Italian Humanist Jacopo Bonfadio (1508–50) wrote the following:

And the fruits are more flavorful here than elsewhere, and all things born of the earth are better. As for the gardens that are in this region... the industry of the peasants has been such that nature incorporated with art is made an artificer, and the connatural of art; and from both of them is made a third nature, which I would not know how to name ([22], pp. 327).

Bartolomeo Taegio (1520–73), Italian jurist and author of *La Villa* (1559)—a popular book on the virtues of gardens—makes explicit the connection between the terminology of “third nature” and grafting techniques:

Here are without end the ingenious grafts that show with great wonder to the world the industry of a wise gardener, who by incorporating art with nature brings forth from both a third nature, which causes the fruits to be more flavorful here than elsewhere ([23], p. 327).

Grafting involves inserting the shoot of one variety of plant (the scion) into a wound cut into another (the stock) to produce new, more abundant, or more flavourful varieties.

While the suggestion that art and nature combine to produce a third nature was perhaps most prominent in the literature on gardens and grafting techniques, it did not stay confined there. Savoia [21] documented how grafting provided the model for developing medical techniques in plastic surgery using skin grafts in the 16th century. The idea of a third nature was also transferred to the grottoes and fountain automata themselves, not just to the plants featured therein. Describing the ingenious art of making fountains and grottoes, the Italian philologist, Claudio Tolomei (1492–56), in a letter of 1531, observed that

(m)ingling art with nature, one cannot discern whether it is a work of the former or the latter; on the contrary, now it is a natural artifice, then an artificial nature ([24], II, p. 48).

What is this “natural artifice” or “artificial nature”, and what, if anything, is the difference between the two? Given the intention of designers to create experiences of nature blended with art to the point where the difference between the two is indiscernible, one plausible answer is that there is no difference *in nature* for Tolomei, only a difference in how each comes to be. In a grotto, there would be things that have come to be by nature (“natural artifice”—e.g., rough stones, shells, foliage, etc., arranged to represent a naturally forming grotto) and things that have come to be by art (“artificial nature”—e.g., automata, stucco fixtures, sculptures, etc.), but the difference is not significant. Although Tolomei did not use the language of “terza natura” himself in this letter, he was connected to both Bonfadio and Taegio ([23], p. 61), and the context is clearly parallel to the horticultural contexts that Bonfadio and Taegio were describing. The production of a grotto, from this perspective, can be seen as a kind of grafting of art onto nature to produce something that is neither one nor the other but a fusion of the two.

There is, however, an obvious problem with the notion of third nature and, indeed, with the whole stratification of first, second, and third nature. Since new hybrids or varieties can occur in first nature without human intervention, what entitles us to classify the hybrids and crossbreeds of the gardener in a category distinct from that in which we place the hybrids and crossbreeds of first nature? Despite the challenges that the discussion of “third nature” poses to the Aristotelian distinction between nature and art, the very idea of a third nature reflects a residual attachment to the Aristotelian idea that how a thing comes to be determines what kind of thing it is. Otherwise, it would not be third nature that the gardeners produce, but simply nature by a different means. Savoia ([21], pp. 81–82) describes the ambiguity that emerged in medical discussions of restorative surgery about the status of plastic surgery as an art. Was this art imitating, perfecting, or producing (new) nature? The surgeon and professor of anatomy and surgery at Bologna, Gaspare Tagliacozzi, in his *De curtorum chirurgia per insitionem* (1597), spoke of plastic surgery as “almost subjugating nature”, and of its restorations being unable to succeed without subtle artificial care, while elsewhere acknowledging nature’s superiority over art and the subordination of surgical practices to the laws of nature ([25], p. 160; [21], 82). The sticking point was a reluctance to abandon the idea, as Savoia ([21], p. 82) puts it, “that Aristotle was right and that only nature had its internal principle of motion” despite “a surplus of human artistry that...challenged the art versus nature divide”. It is in Descartes, having abandoned the last vestiges of Aristotelianism, that we find a more radical and unambiguous challenge to the distinction between nature and art. The true collapse of nature and art could not come about until philosophers and practitioners had entirely abandoned the idea that the way in which something comes to be determines what kind of thing it is.

#### 4. Descartes and the Collapse of Nature and Artifice

There is much in the 16th century discussions of third nature that a metaphysician like Descartes would have found to be anathema. Mired often in alchemical speculation and the putatively occult-but-natural properties of the tradition of natural magic, the notion of third nature remained obscure. Some, indeed, embraced this obscurity. The wonder and magic of a garden depended on *not* revealing the secrets of its construction. As Simon Werrett ([26], p. 136) has documented, Giambattista della Porta (d. 1615), founder of the *Accademia dei Segreti* (Academy of Secrets) and a key figure in the natural magic tradition, actively advised garden architects, in his *Magia Naturalis* (1589), that

... if you would have your work appear more wonderful, you must not let the cause be known: for it is a wonder to us, which we see to be done, and yet know not the cause of it. For he that knows the causes of a thing done, doth not admire the doing of it; and nothing is counted unusual and rare, but only so far forth as the causes thereof are not known ([27], p. iv; cited in [18], p. 136).

It is possible that Descartes had the natural magicians in mind when he wrote in his unfinished dialogue, *The Search for Truth by Means of the Natural Light*, that wonder should never be so excessive that it prevents us from discovering the causes of things.<sup>10</sup> Ref. [11] Eudoxus, the representative of Cartesianism, announces that after explaining the nature and effects of the rational soul, the existence of God, how our senses work, and how to tell true ideas from false ones, he will dispel all of the secrets behind both machines and nature:

Then I shall lay before your eyes the works of men involving corporeal things. After causing you to wonder at the most powerful machines, the most unusual automata, the most impressive illusions and the most subtle tricks that human ingenuity can devise, I shall reveal to you the secrets behind them, which are so simple and straightforward that you will no longer have reason to wonder at anything made by the hands of men. I shall then pass to the works on nature, and after showing you the cause of all her changes, the varieties of her qualities, and how the souls of plants and animals differ from ours, I shall present for your consideration the entire edifice of the things that are perceivable by the senses. ([10] AT 10: 505; [28] CSM 2: 405)

The way to rethink the relationship between nature and art is not, for Descartes, to make art as obscure as nature, but to bring to both the same level of clarity and distinctness that he takes as the mark of his scientific method.

We can see this strategy at work in Descartes' mechanisation of the rainbow.

Among the most wondrous of spectacles created in Renaissance gardens was the artificial rainbow. There was a particular art to creating artificial rainbows in grottoes through sprays of water positioned to capture sunlight at certain angles emanating behind the spectator. On his tour of Italy, Montaigne observed a rainbow in 1577 in the garden of Cardinal Ippolito II (Cardinal of Ferrara) at the Villa d'Este, Tivoli [29], and considered it more remarkable than the many grottoes and automata that he had thus far witnessed. He describes the structure of the rainbow fountain thus:

There are several large water tanks, or reservoirs, with a margin of stone all round them; on this margin stand a number of high stone pillars, at about four paces one from the other. From the top of these pillars the water dashes out with great force; but instead of spouting up, the current discharges itself into the reservoir. These various streams cross each other midway in the air, and produce a continuous and heavy rain, which descends violently into the water below, and the rays of sun falling upon it, produce a rainbow well nigh as brilliant as that we see in the sky ([30], p. 688, Hazlitt translation).

As Werrett ([26], p. 130) notes, some observers considered rainbows to be magical or ethereal, resisting both artificial duplication and scientific explanation. Whether Montaigne would have regarded the artificial rainbow that he so admired as natural is less clear, since

he was renowned for endeavouring to preserve the distinction between nature and art, preferring both uncultivated societies and wild fruits to those bastardised and adapted for “the gratification of our corrupted taste” ([31]; p. 167).

For Descartes, by contrast, there is simply no relevant distinction between the artificial and natural rainbow. In the *Météores*, he uses the same method of explanation of the rainbow whether it occurs without human intervention or in an experimental context:

First, taking into consideration that this arc can appear not only in the sky but also in the air near us whenever there are drops of water in it that are illuminated by the Sun—as we can observe in certain fountains—it was easy for me to judge that it came merely from the way in which rays of light act against those drops, and from there tend toward our eyes (“De l’arc en ciel,” *Météores*, AT 6, 325 [10]; [32], 85).

Each rainbow is analysed as exemplifying the law of refraction or, more precisely, as instantiating a refraction–reflection–refraction sequence—refraction upon entering the new medium, reflection from the back of the drops, and refraction on leaving the medium. When light is refracted from the water drops at  $42^\circ$  to the incident rays, it appears red and splits into other colours as the angle decreases. Whenever this structure is repeated, regardless of whether it occurs in nature or is artificially produced, a rainbow will appear to the well-positioned observer.

To demonstrate the universality of his explanation of the rainbow, Descartes produced two experiments—one involving a glass flask shaped like a water drop, and the other a glass prism—each of which reproduced a rainbow.

Then, knowing that these drops are round, as we have demonstrated above, and seeing that their size does not affect the appearance of the arc, I decided to make a very large [drop] so as to be able to examine it better [10,32].

Descartes hypothesised that the rainbow effect was caused by changes in the velocity of the globules of light produced by their encounter with the new transparent medium. Neither the size of the drops nor the material of the medium is relevant to the explanation, as Descartes’ experiments showed.

We can see in this example how the mechanical philosophy challenged the presuppositions of Aristotle’s dichotomy between art and nature. Although the rainbow has many—perhaps “innumerably and indeterminably” many—causes (e.g., raindrops, fountains, glass flasks, and prisms), there is a common *structure* to each that accounts for how it is capable of producing the visual effects of a rainbow. The common structure is the only relevant cause. Differences in how the phenomenon came to be or the purposes behind the effect, if any, are simply irrelevant to what the phenomenon is or how best to explain it. It is the structure—the rearrangement of globules of light as they encounter the medium—that determines the effects of the rainbow. Its function or effect—the perceived bow of colours—can be *realised* in different materials and contexts, but only if the structural condition is met. This is an example of Descartes’ structure-determines-function principle at work.

The same pattern of explanation occurs in other contexts, including in Descartes’ physiology. In *Discourse on Method V*, Descartes makes the striking claim that an animal and an automaton could, under certain conditions, be said to possess the same nature:

I made special efforts [in the *Traité de l’Homme*] to show that if any such machines had the organs and outward shape of a monkey or of some other animal that lacks reason, *we should have no means of knowing that they did not possess entirely the same nature as these animals...* (AT 6: 56 [10]; CSM1: 139 [28]; my emphasis).

If, in other words, an automaton exhibited the very same observable functions as a monkey, such that we could not tell the difference between them, then, as with the rainbow, we ought to conclude that they are the same thing and operate according to the same principles of nature. Descartes’ particular targets here are those who think that an organic

thing requires a special kind of substantial form—a soul (psyche; anima)—to animate matter and organise its parts. <sup>11</sup> Refs. [11,33] One might think that the above passage does not exactly assert that a mechanical monkey would have the same nature as a monkey, only that we could not tell whether it did or not. But what is implied by this passage is that were the behaviour produced by similar mechanical causes, bearing a similar kind of structure, on my reading, then the difference between nature and art would collapse.

The barriers to collapsing art and nature in the physiological domain are, for Descartes, neither metaphysical nor epistemological but technological. Writing to Mersenne (30 August 1640), Descartes asserted

It is possible to make a flying machine like a bird, metaphysically speaking, because birds, according to me, are such machines; but not physically or morally speaking, for they are made of small bits of matter so subtle and together so strong, that they are scarcely able to be fabricated by humans (AT 3: 163 [10]).

Here, Descartes arguably misses an opportunity to transfer the lesson of his experiments involving the rainbow to the question of whether artificial life is possible. Supposing that to duplicate a bird would require duplicating arrangements at the corpuscular level is to think about what a bird is at too granular a level, just as to think about the rainbow at the level of the corpuscles of one medium (e.g., water or glass) would be too granular. Consider instead the wing of a bird. This, at least, is something that we now think of as having been duplicated artificially. It occurs either naturally in all creatures capable of aerodynamic life, or artificially in aeroplane wings. What enabled this technological development was the discovery of the kind of structure that enables aerodynamic lift ([34], 7)—the particular shape of the wing—the description of which involves a degree of abstraction from considerations of the “small bits of matter” that make it up in any of its particular manifestations.

Nonetheless, God, who can arrange the small bits of matter, could make an automaton equivalent to the human body, as the fable of *L'Homme* makes clear, and this, Descartes claims, shows that a naturally forming human body is operationally nothing but an automaton itself. All of its functions, except those that rely on the rational soul—presumably, language and flexible or intentional actions <sup>12</sup> [35,36]—can be mechanically explained without appealing to any vegetative or sensitive soul.

[I]t is not at all necessary to conceive for their operation any other vegetative or sensitive soul or any other principle of movement and life than its blood and spirits, agitated by the heat of the fire which burns continuously in its heart and is in no way of another nature than all the fires that are in inanimate bodies (AT 11: 202 [10]; CSM 1: 108, trans.alt. [28]).

Such a being is not a *human* body unless it exists in union with a rational soul, but it has the same nature as the machine of *L'Homme*. In a letter to Mersenne (30 July 1640), Descartes draws on the analogy between animal bodies and automata that “perfectly imitate” them:

Yet suppose that we were equally used to seeing automatons which perfectly imitated every one of our actions that it is possible for automatons to imitate; suppose, further, that in spite of this we never took them for anything more than automatons; in this case we should be in no doubt that all the animals which lack reason were automatons too. For we would find that they were different from us in all the same respects. . . [and] In my *World* I explained in great detail how the bodies of animals contain all the organs which an automaton needs if it is to imitate those of our actions which are common to us and the beasts (AT 3: 121 [10]; CSMK: 149 [37]).

“Perfect imitation” of an animal, like the perfect imitation of a rainbow in a grotto, would be duplication of the structures responsible for their defining functions. There is no metaphysical difference between an artificially produced lifeform and a naturally occurring organism. It is sameness of structure, I submit, that Descartes looks for when deciding

whether things made by nature and things made by art are (or could be) equivalent in nature, irrespective of how they came to be<sup>13</sup> [11,33].

### 5. Art and Discovery

We have only now to consider what human artisans are doing when they recreate the structures of things that occur by nature or, by augmenting or hybridising nature, create new ones. Do they thereby acquire the power of creation? Or are they, as Polixenes suggests, mending or augmenting nature from within? To answer this question, we need to look at what Descartes says about how someone might come to have the idea of an intricate machine. But before that, we need to understand what, for Descartes, ideas represent.

The core notion in Descartes' theory of ideas is that of "objective reality" (or "objective perfection", "objective being", or "objective existence".) An idea is a mode of mind, but it is the idea that it is—an idea of the Sun, say—not because it stands in some external relation to the Sun in the Heavens, but because the Sun exists "objectively" in the intellect. Ideas have both formal and objective reality—formally as modes of mind, and objectively by virtue of what they represent—and the objects of those ideas have both formal and objective modes of being—formally, as objects in re, and objectively, as the objects of ideas.<sup>14</sup> Refs. [6,38] Descartes, rather unhelpfully, does not explicate further what he means by objective being, except to say to Caterus that it "does not signify other than to be in the intellect in the way in which objects are accustomed to be in it" (AT 7: 102 [10]; CSM 2: 74–75 [28]). Similarly, in the geometrical exposition of the *Meditations* in the *Second Replies*, objective reality is defined as "the being of the thing (*entitatem rei*) represented by the idea, insofar as this is in the idea" (AT 7: 161[10]; CSM 2: 113 [28]). Such comments can seem more like a restatement of the problem than an explication of its solution.

The notion of objective being had a long history prior to Descartes, being used to explain how objects appear in mirrors as well as in thought, and to account for ideas that do not have corresponding objects existing in reality. There is some suggestion that Descartes was following tradition when, in the *Fifth Meditation*, he described the objective being of the clear and distinct idea of the triangle as an essence, even if no such triangle formally exists. This seems to imply that we can infer from any clear and distinct idea that what the idea represents is at least possible because it could be created by God (AT 7: 116 [10]; CSM 2: 83 [28]). The essence of the triangle must have some being to support all of the truths that there are about triangles—for example, that their internal angles add up to 180°—whether triangles actually exist or not. Objective being belongs to ideas "by their nature" (AT 7: 42 [10]; CSM 2: 29 [28]) and is being, even if "much less perfect" than that which actually exists (AT 7: 41–2 [10]; CSM 2: 28–9 [28]; AT 7: 161 [10]; CSM 2: 113 [28]).

Since objective being is being, it must have a cause. The Sun does not exist in the intellect in the way that it formally exists in the Heavens, but it still has a mode of being in the intellect, and that is not nothing. Descartes accepts the Scholastic principle that there must be at least as much formal reality in the efficient and total cause as in the effect, and he transfers this principle to the objective reality of ideas. Whatever degree of reality is contained objectively in an idea must have a cause that instantiates at least that degree of reality formally. Hence, the idea of a substance cannot be caused by a mode, and the idea of God, which has an infinite degree of objective perfection, cannot have a finite cause (AT 7: 40–41 [13]; CSM 2: 27–28 [28]; see also [6], disp. 26, sec. 1. 2, 5–6). Descartes' first proof for the existence of God in the *Third Meditation* hangs crucially on this account of how and what it is that ideas represent.

It is only in the case of the idea of God, however, that essence entails existence, and thus it may seem as if we can be responsible for the contents of all of our other ideas. But this is not obviously so. Since objective being is being, and since only God is the author of being, this seems to imply that God is the author of all of our other clear and distinct ideas as well.

... I find within me countless ideas of things which even though they may not exist anywhere outside me still cannot be called nothing; for although in a sense

they can be thought of at will, they are not my invention but have their own true and immutable natures. . . even if perhaps no such figure [a triangle] exists outside my thought, there is still a determinate nature, or essence, or form of the triangle which is immutable and eternal, and not invented by me or dependent on my mind (AT 7: 64 [10]; CSM 2: 44–45 [28]).

This may seem confusing because many of our ideas are, as Descartes says, adventitious—i.e., derived from experience—or factitious—i.e., constructed (AT 7: 37 [10]; CSM 2: 26 [28]). But it is only the fictitious ideas, like those of a chimaera, that we should infer are constructed by us alone. These do not represent possibilia (AT 5: 160 [10]; CSMK: 343–344 [37]). In supporting the principles behind his causal argument for the existence of God, Descartes uses the analogy of the idea of an intricate machine, which he says has more objective perfection than that of any simpler machine, and so it must have a cause with the same degree of perfection formally. In *Principles of Philosophy* I, 17, he wrote

All the intricacy which is contained in the idea merely objectively—as in a picture—must be contained in its cause, whatever kind of cause it turns out to be; and it must be contained not merely objectively or representatively, but in actual reality either formally or eminently, at least in the case of the first and principal cause (AT 8A: 11 [10]; CSM1: 198–199 [28]).

But the causes that account for having an idea with a certain amount of objective intricacy may be many and varied:

For in order for the idea of the machine to contain such and such objective intricacy, it must derive it from some cause. . . Now admittedly there could be various causes of the intricacy contained in the idea of the machine. Perhaps the cause was a real machine of this design, which was seen on some previous occasion, thus producing an idea resembling the original. Or the cause might be an extensive knowledge of mechanics in the intellect of the person concerned, or perhaps a very subtle intelligence which enabled him to invent the idea without any previous knowledge (AT 7: 104 [10]; CSM 2: 75 [28]).

What is going on here? Perhaps unwittingly, Descartes is stepping into the debate between Thomists and Scotists over whether or not the possibles have being. The Thomists denied that there were possible natures, claiming that talk of possibilities was simply talk of the ways in which God could be imitated in nature and not of anything real, whereas the Scotists held that God's conceiving of something entailed that it was possible and, thus, had some degree of being, even though it took an act of will by God to make it actual ([39], *Ordinatio* I, Dist 43, n. 18). Descartes seems here to be on the side of the Scotists in asserting that an essence, like the possible being of a triangle, is something "not invented by me or dependent on my mind" (AT 7: 64 [10]; CSM 2: 44–45 [28]). This possible being is what serves as the truthmaker for the truths about the triangle. Given Descartes' acceptance of divine providence—that "fate or immutable necessity" through which nothing happens except what has been determined "from all eternity" (AT 11: 438 [10]; CSM1: 380 [28])—it seems natural to conclude that all possible being—the objective reality of all of our ideas—is always the product of God's thinking. This includes all of our thoughts, not the least of which could be entertained if God had not "wished and willed from all eternity that it enter therein" (To Elisabeth, 6 October 1645; AT 4: 314 [10]; CSMK: 272 [37]; see [38]).

So, what are we to say about what seem to be the inventions of engineers or artisans, whose ideas of intricate machines, Descartes says, may come either from experience or from knowledge of mechanics or a person's ingenuity? If I have an idea of a possible intricate machine, about which truths can be derived, whether the machine ever comes to exist or not, then however the idea comes to be in my thought, its objective being too should be something "not invented by me or dependent on my mind". A parallel distinction between how a thing comes to be and what the thing is could thus be said to operate at the level of ideas, as well as in things outside the mind. There might be many causal pathways to a person tokening the idea of God—going to church, listening to one's religious parents,

etc.—but there is only one cause of the infinite nature represented in the idea of God, namely, God. So too, there may be many ways in which someone may think up the idea of an intricate machine, but if it represents a possible thing, a nature, then the author of that nature is God. What the engineer is doing then is not inventing a new nature, but discovering it, collaborating with God’s plan for how the nature of the universe will unfold. This is not rivalling or bastardising nature but working within “great making nature” to augment it. Now *that* is something truly wondrous.

## 6. Conclusions

The advent of the mechanical philosophy in the late 16<sup>th</sup> and early 17<sup>th</sup> centuries did not, as we have seen, precipitate the challenge to the Aristotelian dichotomy between nature and art. That was already well underway in the grottoes and gardens of Renaissance estates. What it did, though, was challenge a more fundamental principle upon which Aristotle’s distinction between nature and arts rests, namely, the principle that how a thing comes to be determines what kind of thing it is. Descartes rejected this assumption and the distinction between nature and art that followed from it. He offered instead a method of scientific explanation—the *mathesis universalis*—that was universal in its scope when it came to understanding the material world and made no distinction between things on the basis of their origins. I have explored here how an underlying commitment to the structure-determines-function principle enabled Descartes to move fluidly between the realms of nature and art, abstracting from their differences in history and other irrelevant details to consider them from the point of view of a single explanatory framework. This lent power to the universality of mechanics as an explanation of nature, and in applied fields like engineering, architecture, and horticulture. While this may, in turn, seem to have given to artisans the power of creation that they had not been afforded on Aristotelian accounts, it is a mistake to confuse an act of discovery with an act of creation. The artisan discovers by making what only God is capable of creating. This does not mean necessarily that the artisan grasps the nature of their discovery with the sophistication of the natural philosopher. Nor do any of us necessarily grasp the true objective reality contained in our ideas, but this is no reason to rob the artisan of their contributions to discovery.<sup>15</sup> [40] The curiosity of artisans, like that of natural philosophers, makes explorers of them, not little gods, and therein lies their true glory.<sup>16</sup>

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The author declares no conflict of interest.

## Notes

- <sup>1</sup> Shakespeare, *The Winter’s Tale*, IV.iv, 101–107 [1]. I thank Brian Baigrie for drawing my attention to this discussion about nature and art in Shakespeare.
- <sup>2</sup> [1] (IV.iv 107–113).
- <sup>3</sup> A move reminiscent of Plato’s references in the *Timaeus* to the demiurge or divine craftsman. See, for example, Giglioni ([2], p. 258): “Granted that nature is a kind of art and not a vitally determined production process, the natural machine can be considered the product of the best kind of art, divine art. The first step was, once again, that of Descartes. . .”
- <sup>4</sup> Not in the sense of being among the nine categories of accidents that Aristotle describes in the *Categories*. I thank an anonymous referee for suggesting this clarification.
- <sup>5</sup> Roger Ariew ([7], p. 42) argues that Descartes is likely only to have re-engaged with Suárez’ texts (and not very faithfully) around 1640 or 1641 to defend himself against Jesuit attacks on the *Meditations*. See also [7] and Dennis Des Chene’s (2000) *Life’s Form* [9] for a discussion of Scholastic renderings of the form/matter distinction. On Descartes’ theory of distinctions and the history of distinctions, see Brown [8].

- 6 References to Descartes' texts are from *Oeuvres de Descartes*, 12 volumes, edited by Charles Adam and Paul Tannery (1897–1913)—hereafter “AT”. Unless otherwise indicated, translations are from *The Philosophical Writings of Descartes*, J. Cottingham, R. Stoothoff, and D. Murdoch, eds., vols 1–2, (hereafter, “CSM”) and J. Cottingham, R. Stoothoff, D. Murdoch, and A. Kenny eds., vol 3, (hereafter, “CSMK”).
- 7 On the backlash to the mechanists' rejection of teleology, see Giglioni [2].
- 8 Ginzburg ([14], p. 41) points out that the “rustic style” (naturalism) of grottoes, like the one Descartes visited at Saint-Germain-en-Laye, was transported to France by the architect Sebastiano Serlio in the 16th century.
- 9 A parallel distinction is drawn by Aristotle in *Nicomachean Ethics*, book VII, between our first nature—our natural endowments or inherited dispositions of character and temperament—and our second nature—our cultivated habits of virtue. In both the moral and horticultural contexts, second nature directs and improves upon first nature.
- 10 On the difference between stupefying wonder and wonder used to promote rational inquiry, see AT 11: 384; CSM 1: 354–355. On Descartes' use of simulation techniques to dispel illusion and doubt about the natural world, see Des Chene ([11], c. 5).
- 11 On the rejection of substantial forms by Descartes and its consequences for Descartes' thinking about organic systems, see Des Chene ([11], pp. 16–17; 108–11) and Brown and Normore ([33], pp. 65–70).
- 12 These are Descartes' two tests for intelligence, often referred to since Gunderson [36] as the language and action tests. Descartes denies that animals or machines are capable of passing these tests. See AT 6: 57; CSM 1: 140; AT 5: 276–278; CSMK: 365–366. See also Brown [35] for an analysis of Descartes' arguments against machine intelligence.
- 13 Des Chene ([11], p. 156) asserts that “the standard of resemblance cannot be that [God] reproduces the *nature* of our bodies... The standard is instead their *operations*.” I hope it is clear from the discussion here that Descartes does not distinguish between naturally and artificially produced machines as a distinction in nature—in fact, he allows that both may have the same “nature”. It is a good question what that implies. Brown and Normore ([33], pp. 51–61) explored the possibility that, for Descartes, complex machines, like complex geometrical figures, could have distinctive true and immutable natures—an approach compatible with the emphasis here on the notion of structure as capturing the level of abstraction needed to identify sameness of nature across naturally and artificially occurring forms.
- 14 On the distinction between formal and objective reality, see Brown [38]. A likely source for Descartes is Suárez's *Disputationes Metaphysicae* 2.1.1 [6].
- 15 See Gauvin [40] for an interesting discussion of the epistemic function of the “practice of simple métiers” ([40], 187) for Descartes in the progress toward knowledge. Despite Descartes' close working relationship with artisans like Jean Ferrier, with whom he worked on designing a lens-grinding machine, among other things, he came to the conclusion that artisans could never achieve the same results as those versed in the mechanical philosophy.
- 16 I would like to thank the four anonymous referees for their astute comments and helpful suggestions on how to improve this paper. I am also grateful to Brian Baigre, Brian Copenhaver, and Calvin Normore for stimulating conversations about the *ars natura* debates, and to the audiences of *The Mechanization of Nature* conference at the University of Stockholm (May 2023) and the Cornell Philosophy Department Colloquium (April 2023) for excellent discussions. Special thanks also to the editors of this volume, Henrik Lagerlund, Sylvain Roudout, and Erik Åkerlund, for driving this research focus, and for the editorial work involved in preparing this volume.

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