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Adriaenssen, Han Thomas; Nauta, Lodi

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Robert Boyle and Natural Kinds

One of those perennial philosophical problems that gained renewed attention and urgency with the rise of corpuscular philosophy in the seventeenth century, was the reality of natural kinds. According to Aristotelian natural philosophy, a natural body is a compound of matter and a substantial form in virtue of which it ranks among the members of some given natural kind of bodies. But if substantial forms can no longer be accepted, and if all bodies are fundamentally alike in being composed of minute particles of the same universal matter, in virtue of what is it that a body belongs to this or that natural kind? Are there still objective criteria to group together certain individuals and to demarcate kinds from one another? Or should we conclude that, with the elimination of substantial forms, kinds become products of human convention rather than nature?

One famous attempt to come to grips with the problem of kinds is Robert Boyle's mechanical reinterpretation of the concept of form. Boyle rejected the substantial forms of the Aristotelian scholastics, but continued to use the word 'form' to refer to the mechanical arrangement of the corpuscles that compose a body (*Works* 5: 372).¹ It is forms so understood, Boyle claimed, that entitle bodies to their 'Denominations', and which constitute them as members of some 'Determinate kind' or sort (*Works* 5: 329 and 324).

Claims like these give the impression that Boyle was committed to a form of corpuscular realism about natural kinds: the view that individual bodies cluster into nature-given classes on the basis of their corpuscular make-up. Thus according to Jan-Erik Jones (2005), Boyle was committed to the reality of natural kinds to which individual bodies belong in virtue of their corpuscular constitution.² According to Jones (2007) indeed, Boyle's account of kinds was diametrically opposed to Locke's. Whereas, for Locke, kinds are products of human conceptual

¹Following common notation, we refer to Boyle (1999–2000) as *Works*, followed by volume and page number. On Boyle's reinterpretation of form, see Emerton (1984: 73–75 and 143–46).

²Boyle did not draw a sharp distinction between natural and artifactual kinds. See *Works* 5: 325 and 360. As Jones explains, Boyle held that 'artifactual kinds produced in the lab are just as natural as those produced in nature because they too are produced by the rearrangement of corpuscular structures' (Jones 2005: 180). See also Banchetti-Robino (2020: 103). As we will see, Boyle often uses examples involving artefacts to clarify his views on kinds in general.

schemes and conventions, for Boyle they are products of nature herself.³ In a similar vein, Robert Pasnau submits that Boyle was among the ‘defenders of natural kinds’ (2011: 646). On his reading, Boyle maintained that bodies ‘cluster into a small number of cohesive classes, and that there is an objective fact about what these classes are’ (2011: 644).

The realist reading of Boyle is not universally accepted, however. Thus Nicholas Jolley (1999: 145) has suggested that Boyle may have been a conventionalist about kinds, and according to Michael Ayers, Boyle denied that there is an objectively ‘right way to sort’ bodies (1981: 264) that is ‘determined by objective boundaries between kinds’ (1997: 171). Again, Roger Woolhouse submits that Boyle in his discussion of kinds ‘does explicitly avow relativism’ (1971: 99), and according to Dan Kaufman, Boyle was committed to ‘a conventionalist account of essences, kinds, or species’ (2006: 192).

In this paper, we argue that Boyle’s position is more complicated than available interpretations acknowledge. We argue that realist interpretations of Boyle need to be qualified in light of the many passages in his works in which he stresses the conventional nature of human classificatory schemes and practices. Contrary to recent suggestions in the literature, we argue that in these passages Boyle is not merely criticizing the classificatory schemes and practices of the Aristotelians, but providing a general account of how classifications are arrived at. Moreover, we point out that Boyle presents several hard cases of bodies whose composition and modification seems compatible with more than one way of classifying them. At the same time, however, Boyle held that there are limits on what counts as an acceptable way of classifying the bodies around us, and that our classificatory schemes and practices are subject to constraints. We will identify some of these constraints by turning to Boyle’s discussion of the late scholastic debate about the plurality of forms, in particular the contributions of Jacopo Zabarella and Daniel Sennert. In this way, we aim to offer a reading of Boyle that does justice to both the realist and conventionalist aspects of his corpuscular philosophy.

1. Corpuscular Realism

In broad outlines, corpuscular realism is the view that bodies consist of particles of matter, or corpuscles, and that it is in virtue of the way its corpuscles are arranged or organized that a body

³A number of commentators have recently begun to qualify the conventionalist reading of Locke on natural kinds. See, for instance, Anstey (2011: 204–18); Pasnau (2011: 661); and Kuklok (2018).

belongs to some given kind of bodies. More precisely, the view can be summarized in four claims.

First, according to the corpuscular realist, a body belongs to some given kind of bodies if and only if it instantiates the qualities essential to that kind. For instance: a body is a specimen of gold if and only if it instantiates the qualities essential to gold, or if it instantiates the qualities that define what it is to be gold.

Secondly, for a body to instantiate the qualities essential to some given kind of bodies, is for that body to possess a certain corpuscular structure. For a body to instantiate the qualities essential to gold, for instance, is for that body to have a certain corpuscular structure. This corpuscular structure can also be called a form, provided that this term be used to refer to a certain arrangement of material parts, and not to the substance-like entity that the Aristotelians had taken to account for bodily identity and kind-membership.

Thirdly, according to the corpuscular realist, the boundaries between kinds are sharp. A body that has all the essential qualities of gold except for one is not gold. Since for a body to possess the essential qualities of gold is for it to have a certain corpuscular structure, this means that a small difference in corpuscular form can determine whether or not a given portion of matter can be classified as a specimen of gold.

Finally, the corpuscular realist holds that, ultimately, there is a single correct way of grouping individuals into kinds and genera that carves nature at its joints. What constitutes a good classification of bodies thus is a matter of natural fact, not human convention. Our classifications aim at mapping onto this real, essential order of nature, and one classification might be called 'better' or 'more natural' when it comes closer to the natural order than another classification does.

Was Boyle committed to these claims? A number of passages suggest that he was. Firstly, a number of passages intimate that there are indeed qualities essential to some given kind: qualities an individual must instantiate in order to be a member of that kind, and which it cannot lose without thereby ceasing to be a member of that kind:

So when a Body comes to lose *all* or *any* of those Accidents that are *Essential*, and necessary to the constituting of such a Body, it is then said to be *corrupted* or destroyed, and is no more a Body of *that Kind*, but loses its Title to its former Denomination. (*Works* 5: 329)

Secondly, Boyle sometimes appears to claim that for a given body to be a member of a certain kind, and to possess the qualities essential to that kind, is for that body to have a certain corpuscular structure:

Parts, by being so and so dispos'd in relation to each other, constitute such a determinate kind of Body, endow'd with such and such Properties,⁴ whereas, if the same parts were otherwise disposd, they would constitute other Bodies, of very differing Natures. (*Works* 5: 372)⁵

This corpuscular structure, which entitles certain portions of matter to certain kind-memberships, Boyle often refers to as a '*Stamp*', '*Essential Modification*', or indeed '*Form*':

For the Form of a Natural Body, being according to us, but an Essential Modification, and, as it were, the *Stamp* of its Matter, or such a convention of the Bigness, Shape, Motion (or Rest,) Scituation and Contexture, (together with the thence resulting Qualities) of the small parts that compose the Body, as is necessary to constitute and denominate such a particular Body. (*Works* 5: 353)

Again, we may think of the form of a body as its

Specificical or its *Denominating State*, or its *Essential Modification*, or, if you would have me express it in one word, its *Stamp*: for such a Convention of Accidents is sufficient to perform the Offices that are necessarily requir'd in what Men call a *Forme*, since it makes the Body such as it is, making it appertain to this or that Determinate Species of Bodies, and discriminating it from all other Species of Bodies whatsoever. (*Works* 5: 324)

⁴ 'Property' for Boyle is a technical term. A property or *proprium* is a feature a body of a certain kind cannot fail to instantiate (*Works* 5: 308).

⁵ Passages such as these must be read against the background of Boyle's claim that many physical qualities have a '*Relational Nature*' (*Works* 5: 309). According to Boyle, whether or not a body or material actually possesses some given quality will often depend, not only on the corpuscular make-up of that body or material itself, but also on that of the bodies and materials that surround it. For example, a body will actually possess the quality of being soluble in *Aqua Regis* – arguably one of the essential qualities of gold – only if *Aqua Regis* actually exists. For discussion, see Anstey (2000: 94–105); Kaufman (2006); and Pasnau (2011: 523).

As Pasnau (2004: 61) points out, passages like this give the impression that Boyle is retaining a number of core elements of the Aristotelian doctrine of substantial form. Like the substantial form of the Aristotelians, mechanical form in Boyle serves an inner source from which the properties of a body originate. And like the substantial form of the Aristotelians, mechanical form serves as an inner principle that distinguishes a body from other bodies and constitutes it as a member of some given kind:

Since those Qualities, as we have seen already, do themselves proceed from those more Primary and Catholick affections of Matter, Bulk, Shape, Motion or Rest, and the Texture thence resulting, why may we not say, that the Form of a Body being made up of those Qualities united in one Subject, doth likewise consist in such a Convention of those newly nam'd Mechanical Affections of Matter, as is necessary to constitute a Body of that Determinate kind. (*Works* 5: 324)

Thirdly, the claim above that the loss of ‘*all*’ or even ‘*any*’ of the qualities essential to gold will make a body cease to be a member of that kind suggests that boundaries between kinds for Boyle are sharp indeed. Since to possess certain qualities is for a body to have a certain corpuscular structure, it is no surprise to find him claiming that small changes in corpuscular structure can be decisive for a body’s membership of a certain kind:

A slight change of Texture, without the introduction of a substantial Form, may not only make a Specific difference betwixt Bodies, but so vast a one, that they shall have differing *Genus'es*, and may (as the Chymists speak) belong to differing Kingdoms. (*Works* 5: 369)⁶

Again:

That which is commonly call'd the Form of a concrete, which gives it its Being and Denomination, . . . may be in some Bodies but a Characterization or Modification of the Matter they consist of; whose parts, by being so and so dispos'd in relation to each

⁶ Early modern chymistry combined concepts and practices from what we would now call chemistry and alchemy. See Principe (2012: 85).

other, constitute such a determinate kind of Body, endow'd with such and such Properties; whereas, if the same parts were otherwise dispos'd, they would constitute other Bodies, of very differing Natures. (*Works* 5: 372)

Finally, Boyle in some places draws a distinction between 'essential' and 'extra-essential' qualities. For instance:

For here it is to be considered, that besides that peculiar and Essentiall Modification which constitutes a Body, and distinguishes it from all other that are not of the same Species, there may be certain other Attributes that we call *Extra-essentiall*; which may be common to that Body with many others. (*Works* 5: 280)

The distinction between essential and extra-essential qualities again seems to support Boyle's belief in natural kinds. If, in individual bodies, there is a distinction between essential qualities on the one hand and accidental qualities on the other, then surely that determines on the basis of which qualities we ought to group individual bodies. Surely, the correct classification is the classification that groups bodies by their essential qualities.

Boyle's formulations often suggest that, even if we may often be mistaken about what is essential to a body, there ultimately is one correct way of grouping individuals into kinds – if only we would have enough words to denominate all these kinds, and enough stamina to probe into the structure of the world:

there may be an incomprehensible variety of Associations and Textures of the Minute parts of Bodies, and consequently a vast Multitude of Portions of Matter endow'd with store enough of differing Qualities, to deserve distinct Appellations; though for want of heedfulnesse and fit Words, Men have not yet taken so much notice of their lesse obvious Varieties, as to sort them as they deserve, and give them distinct and proper Names. (*Works* 5: 332)

It seems understandable, then, that scholars have read Boyle as a corpuscular realist according to whom nature produces natural kinds by means of corpuscular structures. As Jones summarizes, according to Boyle, 'the peculiar arrangement of parts is sufficient to denominate a body of a certain kind' (2005: 179) and it is the corpuscular structures that nature endows bodies with that do 'the classificatory work' (2005: 182).

2. Classification and Tacit Agreement

Boyle also stresses the conventional character of classificatory schemes, however:

It was not at randome, that I spoke, when, in the foregoing Notes about the Origine of Qualities, I intimated, That 'twas very much by a kind of tacit agreement that Men had distinguish'd the *Species* of Bodies, and that those Distinctions were more Arbitrary than we are wont to be aware of. (*Works* 5: 356)

Again, in other passages, we read that the identification of the essential qualities that define a certain kind is, to some degree, a matter of convention:

For if in a parcel of Matter there happen to be produc'd . . . a Concurrence of all those Accidents . . . that Men by tacite agreement have thought *necessary* and *sufficient* to constitute any one Determinate *Species* of things corporeal, then we say, That a Body belongs to that *Species*. (*Works* 5: 328)

Passages such as these suggest that the individuation of kinds is, at least to some degree, a matter of convention, or a tacit agreement among people.

According to Jones, however, the passages in which Boyle suggests that the individuation of kinds is the result of convention and tacit agreement always occur in the context of his anti-Aristotelian polemics. On his reading, Boyle in these passages is not claiming that all classification is the product of human convention and tacit agreement. Rather, the point in these passages is that Aristotelian methods of classification had relied on convention and tacit agreement. The Aristotelians had failed to formulate adequate definitions of kinds and as a result of this, their taxonomies had become reflections, not of real boundaries in nature, but of the conventions and tacit agreements of learned men (Jones 2005: 175).

Now it is certainly correct that, according to Boyle, convention and tacit agreement are crucial, in practice if not in theory, to the Aristotelian method of classification. In theory, the Aristotelians hold that kinds are defined by substantial forms and the essential qualities they produce in the bodies they inform. But in practice, what the Aristotelians take to be the defining features of kinds is determined by human convention and tacit agreements:

Whatever Men talk in Theory of Substantial Forms, yet That, upon whose account they really distinguish any one Body from others, and refer it to this or that *Species* of Bodies, is nothing but an Aggregate or Convention of such Accidents, as most men do by a kind of Agreement (for the Thing is more Arbitrary then we are aware of) think necessary or sufficient to make a Portion of the Universal Matter belong to this or that Determinate *Genus* or *Species*. (*Works* 5: 322–23)

Jones is correct, then, that Boyle diagnoses an element of arbitrariness in Aristotelian methods of classification. We disagree, however, with the further claim that Boyle

reserves the terminology of ‘arbitrariness’ and ‘tacit agreement’ . . . for his discussion of the actual practice of classification among the Scholastics, not as part of the correct program he endorses. (Jones 2005: 176)

On the contrary, we submit that, according to Boyle, conventions and tacit agreements play a role in all methods of classification, including his own. To substantiate this claim, we will look at a few passages that have been taken as criticisms of the scholastics only.

The first passage is the one just quoted from the *Origin of Forms and Qualities*, where Boyle clearly distinguishes between ‘Men’ who ‘talk in Theory of Substantial Forms’ (that is, the Aristotelians) and ‘most men’ who arrive at classifications by ‘a kind of Agreement’. When he writes that classification is ‘more Arbitrary then we are aware of’, he refers to ‘most men’ and that, as we will see, includes Boyle himself. We find the same picture in the following passage, where Boyle describes the origins our sortal concepts as follows:

We may now advance somewhat farther, and consider, that Men having taken notice, that certain conspicuous Accidents were to be found associated in some Bodies, and other Conventions of Accidents in other Bodies, they did for conveniency, and for the more expeditious Expression of their Conceptions agree to distinguish them into several Sorts, which they call *Genders* or *Species*. (*Works* 5: 322)

The picture Boyle is drawing here appears to be the following. On the basis of repeated observations, men at some point concluded that the qualities of being yellow, malleable, and indissoluble in *Aqua Fortis* are constantly found together in certain specimen of matter (*Works*

5: 323). For convenience, they then decided that the bodies in which these qualities are found together shall be treated as belonging to one kind. The identification of this and similar kinds then led to the formulation of taxonomies ranking individuals into kinds and classes.

In formulating these taxonomies it was decided, again for convenience, that the members of each kind or class shall be referred to by means of a single term. Thus, *gold* became a shorthand for any specimen of matter having the qualities of being yellow, malleable, and indissoluble in *Aqua Fortis*. This linguistic convention, according to Boyle, led some writers to believe that, just as there is a single noun to refer to bodies that are yellow, malleable, and indissoluble in *Aqua Fortis*, there also is a single causal origin in these bodies from which these qualities flow. This single causal origin was the substantial form of the Aristotelians:

Because Men have for their convenience agreed to signifie all the Essentials requisite to constitute such a Body by one Name, most of the Writers of Physicks have been apt to think, that besides the common Matter of all Bodies, there is but one thing that discriminates it from other kinds, and makes it what it is, and this for brevities sake they call a *Forme*; which because all the Qualities and other Accidents of the Body must depend on it, they also imagine to be a very Substance, and indeed a kind of Soule. (*Works* 5: 322)

The anti-Aristotelian polemics here are clear. For a mechanist such as Boyle, nothing could be more wrong than to trace back the material qualities that identify a body as a member of some given kind to a soul-like substance or form. It is crucial, however, not to confuse Boyle's rejection of substantial form with his general description of how kinds are defined. Boyle denies that bodies owe their kind-specific qualities to soul-like forms. But he nowhere denies that human convention plays a central role in the identification of these qualities, or in the individuation of kinds. On the contrary, convention and tacit agreement play an undeniable role in his own method of classification as well.

This is perhaps clearest from his discussion of generation and corruption in *The Origin of Forms*. By generation and corruption, Aristotelian natural philosophy had meant the processes in which substances come into existence and go out of existence respectively. So

understood, Boyle believes, no generation and corruption take place in nature.⁷ The only real material substances, according to Boyle, are the corpuscles God created when he made the world, and no natural processes will make these corpuscles go out of being, or bring new corpuscles into being. The concepts of generation and corruption, however, can be reinterpreted in corpuscular terms. When corpuscles come to be configured in such a way that the qualities essential to some given kind are realized, we may say that a member of this kind has been generated. When these same corpuscles are afterwards reconfigured in such a way that one or more of these qualities are lost, we may say that a member of this kind has been corrupted. Crucially, however, what counts as a quality essential to some given kind is, at least in part, determined by agreements and conventions:

When a portion of matter. . . happens to obtain a *concurrence of all* those Qualities, which Men commonly agree to be *necessary* and *sufficient* to denominate a body, which hath them, . . . and to rank them in any peculiar and determinate *species*, . . . then a Body is said to be Generated. (*Works* 5: 328)

Again:

A body is said to be *generated*, when it first appears clothed with all those Qualities, upon whose Account Men have been pleas'd to call some Bodies *Stones*, others, *Salts*, etc. So when a Body comes to loose *all* or *any* of those Accidents that are *Essential*, and necessary to the constituting of such a Body, it is said to be *corrupted* or destroy'd, and is no more a Body of that *Kind*, but looses its title to its former Denomination. (*Works* 5: 329)

Conventions play a central role in Boyle's own method of classification as well, then. Part of what this means is that when Boyle speaks of bodies being 'entitled' to certain denominations, we cannot simply take this as evidence of realism about natural kinds in Boyle. What entitles a body to the denomination *F* is its possession of the qualities necessary and sufficient for calling

⁷ For a brief discussion of the rejection of the Aristotelian concepts of generation and corruption in Boyle and other early-modern mechanical philosophers, see Conn (2003: 85-86); Des Chene (1996: 54); and Emerton (1984: 72-73).

something an *F*. But what those qualities are, depends on what men ‘commonly agree’ on, and on account of what men are ‘pleas’d to call’ a body an *F*.

Boyle’s view thus appears to be that human convention is a feature of classification in general, not just of the Aristotelian method of classification. Indeed, immediately after having said that it was ‘very much by a kind of tacit agreement, that Men had distinguish’d the *Species* of Bodies’, he goes on to point out that natural philosophers from Aristotle to his own days have universally failed to come up with a ‘genuine and sufficient’ classification of natural bodies, or to formulate a ‘genuine and sufficient Diagnostick and Boundary, for the Discriminating and limiting the *Species* of Things’ (*Works* 5: 356).

It is no surprise then, that we continue to face considerable difficulties as we try to group individual bodies into kinds. In *The Origin of Forms*, Boyle writes that ‘it hath been, and is still, both very *uncertain* as to divers Bodies, whether they are of different *Species* or of the same’, and provides an impressive list of hard cases:

On this occasion, I would propose to be resolv’d, whether Must, Wine, Spirit of Wine, Vinegar, Tartar, and Vappa, be Specifically distinct Bodies? and the like question I would ask concerning a Hens Egg, and the Chick that is afterwards hatch’d out of it: As Also concerning Wood, Ashes, Soot, and likewise the Eggs of Silkworms, which are first small Caterpillars, or (as some thing them) but Worms, when they are newly hatch’d, and then *Aurelia*’s, (or husked Maggots,) and then Butterflies. (*Works* 5: 356–57)

Criteria that work in some cases will fail us in others, and what is essential to kind-membership in one case may not make much of a difference in another. Boyle concludes: ‘Whether the Answer to these Quæries be Affirmative or Negative, I doubt the reason, that will be given for either of the two, will not hold in divers cases, whereto I might apply it’ (*Works* 5: 357).

Admittedly, the fact that Boyle is aware of the existence of hard cases, by itself, does not show that he believes that there is a principled reason why they could never be settled. The existence of hard cases does not rule out the possibility that, ultimately, there is one correct classification, based on the essential accidents of a body. Did Boyle indeed hold this conviction?

3. Essential Qualities and Human Conventions

According to the corpuscular realist, there is indeed but one correct classification of the bodies we see around us. We may so far have failed to discover that one correct classification, but in principle, if not in practice, there is a natural way of grouping individual bodies carving nature at its joints. In this section, we argue that this kind of realism does not sit comfortably with some of the claims Boyle makes about the essential-accidental distinction. In outline, our argument is as follows. According to Boyle, a body belongs to a certain kind in virtue of its essential qualities. But it is not clear that, according to Boyle, nature dictates what the essential qualities of a body are. Hence it is not clear that, according to Boyle, there is a natural fact of the matter as to how bodies must be classified.

That Boyle believes bodies belong to some given kind in virtue of their essential qualities is clear enough. According to Boyle, the form of a body is the ‘*Essential Modification*’ that ‘*discriminates it from all other sorts of Bodies*’ (*Works* 5: 334). Again: it is the ‘*Essential Differences of things, which constitute them in such a sort of Natural Bodies*’ (*Works* 5: 344). But talk of essences and essential differences cannot be taken at face value. The crucial question is what, according to Boyle, the source of these essences and essential differences is. Are they nature-given? Or are essences and essential differences to some degree the product of human convention?

In works such as the *Physico-Theological Considerations about the Possibility of the Resurrection* of 1675, Boyle emphasizes that what is essential in an individual body is a matter of discussion and, eventually, we may hope, tacit agreement:

Almost every Man that thinks, conceives in his mind this or that Quality or Relation, or Aggregate of Qualities, to be that which is essential to such a Body, and proper to give it such a Denomination; whereby it comes to pass, that, as one Man chiefly respects this thing, and another that, in a Body that bears such a name; so one Man may easily look upon a Body as the *same*, because it retains what he chiefly consider’d in it, whilst another thinks it to be chang’d into a new Body, because it has lost that which *he* thought was the denominating Quality or Attribute. (*Works* 8: 301)

Boyle makes a similar point in a section from the *Origin of Forms* in which he reviews some of the most important arguments in favor of substantial forms. One of these arguments goes as follows. There is a distinction between essential and accidental qualities. Essential qualities are ‘inseparable’ from a body, in that the loss of these qualities brings about the corruption of the body that possesses them. Others are accidental. They are ‘separable’ from the bodies that

possess them, in that these bodies will survive the loss of these qualities. But this distinction is grounded in substantial forms. Hence, unless bodies had substantial forms, there would be no distinction between essential and accidental forms:

I find it likewise urg'd, that there can be no reason, why whiteness should be separable from a Wall, and not from Snow or Milk, unless we have recourse to substantial Forms. (*Works* 5: 348)

Boyle responds to this argument as follows:

But in case men have agreed to call a thing by such a name, because it has such a particular Quality that differences it from others, we need go no farther to find a Reason, why one Quality is essential to one thing, and not to another. As in our former example of a Brass Sphaere, the Figure is that, for which we give it that Name, and therefore, though you may alter the figure of the Matter, yet by that very alteration the Body perishes in the capacity of a Sphaere, whereas its Coldness be exchang'd for Heat, without making it the less a Sphaere, because tis not for any such Quality, but for Roundness, that a Body is said to be a Sphaere. And so Firmness is an inseparable Quality of Ice, though this or that particular Figure be not, because . . . tis for want of fluidity, that any thing, that was immediately before a Liquor, is call'd Ice. (*Works* 5: 348–49)

In this passage, Boyle claims that, independently of human observers, bodies have features that discriminate them from all others. They do not, however, have essential features independently of the assignment of names to them. The essential qualities of a body, according to Boyle, are those qualities of an individual on the basis of which men have decided to impose a certain name on that individual. It is because we decided to name a certain portion of matter a sphere that its figure is essential to it, but its temperature is not. Had we imposed a different name on this same specimen of matter, other qualities would have come out as essential.⁸ This indeed seems to be one upshot of the example of a brass sphere Boyle had given in an earlier section:

⁸ An inseparable or essential quality here is a quality that is a necessary condition for membership of some class. For Boyle then, the identification of essential qualities so construed is a matter of convention and tacit agreement no less than the sorting of bodies into kinds.

As in *Aristotle's* newly mention'd example, though Roundnesse is but accidental to Brasse, yet tis essential to a brasen Sphere; because, though the Brasse were devoid of roundnesse, (as if it were Cubical, or of any other figure), it would still be a corporeal Substance. (*Works* 5: 324)

If some given individual body is described as a sphere, then its figure is essential to it, not the fact that it is made of brass. This same individual, however, may also be described as a specimen of brass. So described, being made of brass is essential to it, not the fact that it has a spherical shape. Passages such as these strongly suggest that, according to Boyle, nature on her own does not dictate what the essential qualities of a body are, or a single correct way of grouping individuals on the basis of their essences.

Further evidence for this comes from Boyle's *Free Considerations about Subordinate Forms*, which appeared as an appendix to the second edition of *The Origin of Forms*. There, Boyle argues that some bodies, in virtue of their corpuscular constitution, have qualities compatible with more than one way of classifying them. One example of such a body is *vitrum Saturni*:

When, for instance, I have . . . reduc'd Lead *per se* into a body like that which Chymists call *vitrum Saturni*, and which they make by the addition of Flints and Sand, tis not easie to determine whether this shall be one of those kind of bodies that are call'd Metals, and in our instance is onely disguis'd, or belongs to that other kind of Bodies we call Glasse: for it seems to have the properties of both. For like Lead tis very ponderous, and dissoluble in *aqua fortis* and spirit of Vinegar, which dissolve not common Glasse, it affords a very sweet Solution as Lead is wont to do, and, which is more, it may without addition by bare heat be quickly reduc'd in great part into true and malleable Lead. On the other side, it is a body fusible, transparent, and brittle, which are the three grand properties of Glasse; besides which I have observ'd in it some others that will be more properly taken notice of elsewhere. (*Works* 5: 469–70)

Depending on which of its observable qualities – its metallic ones or its glassy ones – we consider to be essential, a specimen of *vitrum Saturni* may be classified either as a metal or as a glass. Its corpuscular structure or form will not settle the matter in favor of either one of these

classifications, as it is precisely this structure or form that gave rise to both its metallic and glassy qualities in the first place. As Boyle provocatively concludes:

If I affected Paradoxes I might here add, that perchance there may be bodies, which as they may be diversly consider'd, seem to have a title to more than one Form, and upon that score may puzzle the Schools about the assignation of their Forms. (*Works* 5: 469)⁹

Again, the anti-Aristotelian polemics of this passage are clear. But it also reveals something about Boyle's own position. For if there are bodies whose corpuscular form is compatible with more than one way of classifying them, then the decision to classify them one way rather than another will have to depend on convention and tacit agreement, at least to some degree.¹⁰

4. Constraints on Classification

Even though nature may not have endowed individuals with essential qualities referring them to sharply delineated kinds and classes, and even though there may be no single correct way of carving nature at its joints for Boyle, it is clear that he also holds that some classifications are better, and more true to nature, than others. In this section, we argue that, in the *Free Considerations*, Boyle identifies a number of constraints on what constitutes an acceptable method of classification.¹¹

⁹ The schoolmen Boyle was primarily targeting in this work, Jacopo Zabarella and Daniel Sennert, both explicitly dismiss the suggestion that one individual could have more than one specific form. Sennert finds it 'absurdissimum' and writes: 'Nulla res naturalis datur, quae duas formas specificas habeat' (Sennert 1650: 218). According to Zabarella: 'potest una res habere plura esse generalia: non tamen plura specificalia, sed unum tantummodo' (Zabarella 1590: 359).

¹⁰ The case of *virtrum Saturni* regards the taxonomic difficulty of ranking the members of a class (in this case *virtrum Saturni*) under higher-order classes (in this case metal or glass). In the same section, Boyle also discusses various examples on the species level, including 'trees that I have seen to bear more kinds of fruit'. All of these examples present problems for 'the vulgar Doctrine of Formes, at whose framing probably such Instances were not dreamt of' (*Works* 5: 470). They also illustrate the general point in Boyle that the inner constitution and resulting qualities of a body may not always dictate a single correct way of classifying it.

¹¹ According to Newman, Boyle in some works uses reduction to the pristine state experiments to discriminate between essential and extra-essential qualities. Thus, if we find that a piece of lead that loses its original color in the fire can afterwards be restored to its pristine state by mechanical means, we may conclude that the loss of its

Throughout that work, Boyle criticizes classifications that group individual bodies on the sole basis of the particular use they have for us. The following passage is exemplary:

I have doubted whether divers of those Forms by which such kinds are constituted be not a kind of *Metaphysical Conceptions*, by virtue of which bodies very differing in nature are compriz'd in the same Denomination, because they agree in a fitnessse for some *use*, or in some other thing that is common to them all (as whether a Bullet be Silver, or Brasse, or Lead, or Corke, if it swing at the end of a string, 'tis enough to make it a *Pendulum*), and whether a burn'd body be chalk, or Rag-stone (which is very hard and coarse) or Alabaster, which is soft and fine stone, or an Oyster-shell, or a cockle-shell, or a piece of Corall; yet if it have been calcined to whitenesse 'tis Lime, rather than such true *Physical Formes*, as are sayd to make the Bodies that have Formes of the same Denomination to be of the same specific Nature. (*Works* 5: 472)

It is artificial, Boyle claims in this passage, to group together specimen of silver, brass, lead, and cork under the heading *pendulum*, solely because they can serve us as pendulums. If we do this, we will group them together on the basis of an extrinsic feature they have, without sufficient regard for the considerable differences in corpuscular make-up of these bodies.

Additional constraints on what counts as an acceptable method of classification come to the fore in the critical discussion of the scholastic notion of subordinate forms in the *Free Considerations*. Below, we briefly outline the theory of subordinate forms as it is found in the principal addressee of that work, Daniel Sennert. We will then turn to Boyle's criticism and partial reinterpretation in corpuscular terms of that theory. This will help us to see in what way, according to Boyle, some classifications may be truer to nature than others.

4.1. Subordinate Forms

original color did not bring about a corruption of the lead, and that the possession of its original color was nonessential to the lead. See Newman (2006: 194–208). Also Banchetti-Robino (2020: 104–108). When Boyle discusses reduction to the pristine state experiments, however, his main concern appears to have been less with essences and kinds than with proving the existence of atomic particles that form semi-permanent, molecule-like aggregates.

As Boyle was well aware, Aristotelian hylomorphism came in many varieties. Indeed, as he points out in his *Free Considerations about Subordinate Forms*, scholastic Aristotelians disagreed about the precise make-up of hylomorphic compounds. Are bodies compounds of a portion of matter and a single substantial form making them the kind of body they are? If so, then how do we account for the heterogeneity of many bodies? Or are bodies compounds of matter and a plurality of substantial forms? If so, then how do we account for their unity?

Although, according to Boyle, ‘the generality of vulgar Philosophers’ had opted for the first position, early modern Aristotelians such as Jacopo Zabarella and Daniel Sennert had come to adopt pluralism (*Works* 5: 449). Thus in his *De rebus naturalibus* of 1590, Zabarella argued that no single substantial form can do justice to the heterogeneity of the living bodies of plants and animals. According to Zabarella, indeed, the blood, flesh and bones of an animal are materials of different kinds, whose natures result from different blends of the four elements. Zabarella concluded from this that animal blood, flesh and bones each have a form of their own, identifying them as the kind of materials they are. ‘There is one mixed form in flesh, another in the nerves, and another in bone’. Indeed, organic bodies are ‘of necessity’ composed by a plurality of forms (Zabarella 1590: 357).¹²

To account for the unity of bodies so composed by a multitude of parts each with a form of its own, Zabarella drew a distinction between ‘dominant’ and ‘subordinate’ forms. The individual organs and their forms, he explained, serve as the matter for a further form, namely the soul. This added form, makes use of the organs and their forms as if they were its instruments, and reigns over them in the way a king reigns over his subjects (Zabarella 1590: 362 and 367). This dominating form makes the parts of a living body work together so as to produce the operations that are characteristic of, and indeed define, the organism as a whole. In Zabarella’s words: it is the dominating form that properly ‘constitutes the thing, and places it in a kind’ (Zabarella 1590: 360).¹³ Again, it is from this ‘specific form’ only that the thing ‘derives its name’ (Zabarella 1590: 359).¹⁴

¹² ‘De corporibus vero animatis dissentio penitus a negantibus multitudinem formarum in quolibet vivente; credo enim in his ex necessitate plures formas inesse. . . . Alia namque est forma mistionis in carne, alia in in nervo, alia in osse’. On Zabarella’s pluralism, see Michael (1997); Pasnau (2011: 630–32); and Newman (2006: 108–110).

¹³ ‘Rem constituit et in specie collocat’.

¹⁴ ‘A sola speciali forma res sumit nomen’.

In his *Hypomnemata physica*, Sennert generalized this account, applying it to animate and inanimate bodies alike.¹⁵ In a mixture, the forms of earth, water, fire, and air remain intact. If they did not, we would not have a mixture of earth, water, fire, and air (Sennert 1650: 165).¹⁶ But once mixed, these forms are dominated by ‘a fifth form, really distinct from the forms of the four elements, and superadded to them’ (Sennert 1650: 147)¹⁷ It is to this superadded form that the mixture owes those qualities and operations that define the new blend. The elements ‘submit themselves to the reign of a more noble form’, which thereby ‘acquires the status of a specific form’ (Sennert 1650: 165).¹⁸ The same happens in living bodies, the heterogeneous parts of which each retain their own form, ‘but in such a way that there is one ruler and mistress that informs the living body, and from which the living body derives its name’ (Sennert 1650: 218).¹⁹

4.2. Boyle on Subordinate Forms

Although Boyle was critical of central elements of Aristotelian pluralism, he at the same time maintained that ‘wee . . . may yet in a sound sense admit that in some Bodies there may be subordinate Formes’ (*Works* 5: 473). To clarify in what sense, Boyle often uses the example of a watch. A watch is a clearly heterogeneous composite, which is built up out of a plurality of smaller bodies, such as its springs, wheels, and hands. Each of these bodies has a certain particulate structure of its own, in virtue of which it is a spring, wheel, or hand. In other words, each of the bodies that compose a watch has a corpuscular form of its own. According to Boyle, indeed:

And as in a Watch the Spring is really a Spring, and acts as a Spring whilst it is a part of the Watch, though by reason of its connexion with the other parts it is reduc’d to concur with those other parts towards exhibiting the *Phaenomena* proper to the whole

¹⁵For a detailed treatment of Sennert on dominating and subordinate forms, see Michael (1997). For discussion, see also Newman (2006: 108–110) and Blank (2011).

¹⁶ ‘Si elementa per formam non sunt in misto, nullo modo insunt’.

¹⁷ ‘Formam mistionis esse quintam formam, re distinctam a quatuor elementorum formis, et illis superadditam’.

¹⁸ ‘Dominio nobilioris formae sese submittunt, quae superveniens . . . formae specificae ratione obtinet’.

¹⁹ ‘Mihi vero magis consentaneum videtur, in corporibus viventibus plures formas succenturiatas esse, et subordinatas, ita tamen, ut una sit princeps et domina, quae vivens informat, et a qua vivens nomen habet’.

Engine: . . . so in many compounded bodies, besides the specifick Form which the Body has as such, and which may be call'd its total or General Form, particular bodies (by whose association and conjunction tis made up) may enjoy their own distinct Forms. (*Works 5: 461*)

As this passage also makes clear, however, apart from the forms of its constituent parts, a watch also has what Boyle calls a total or general form: a mechanical form that results from the conjunction of the smaller bodies that jointly go to constitute the watch.

This total or general form gives rise to operations and qualities that are different from those of the body's constituent parts individually. These operations, Boyle writes, are the operations proper to, and specific of, the composite body as a whole:

Notwithstanding these several parts, whereof the compounded Body consists, do in the proper, and if I may so call them, *Specifick* Actions of the Body so concur as to performe them *jointly*, . . . yet these thus conspiring Bodies may each of them retain those attributes or that modification, which made it a distinct Natural Body before it came to be associated with those others, with which it makes up a more compounded Body. (*Works 5: 453*)

It is in virtue of the fact that its composing parts jointly realize these operations and qualities that the composite constitutes a genuine unity:

If the parts of a Body, whether merely natural or factitious, be by their union or conjunction brought to become the principle of a Property or Operation which belongs to neither of them single, I see not why such a Body may not passe for *unum per se*. (*Works 5: 574*)

Boyle cites the case of gunpowder as an example here. Gunpowder is composition of, among others, sulphur, nitre, and coal. The combination of these diverse materials in a certain proportion constitutes a unified body, insofar as the combination as a whole gives rise to effects that none of the ingredients individually could have given rise to:

Neither of the ingredients (whether the Sulphur, the Nitre, or the Coal) is apart able to produce effects any thing neer like those of Gun-powder. (*Works 5: 460*)

Boyle agrees with the pluralists, then, on at least two scores. First, many bodies have components that have a form of their own, which stays intact as parts are integrated into the composite. Second, these bodies constitute genuine unities, insofar as they have actions and operations that none of their components individually could have given rise to. (On Boyle on the unity of composite bodies, see briefly Jones 2019: 208–209).

He disagrees with the pluralists, however, on the source of these actions and operations. In contrast to Zabarella and Sennert, he does not take these actions and operations to flow from a dominant causal agent over and above the components that make up a composite, but simply from the mechanical connection of, and interaction between, these components:

Those actions which *Sennertus* and others attribute to the conspiring of subordinate Forms to assist the specific and presiding Form, we take to be but the resultant actions of several bodies, which being associated together are thereby reduc'd in many cases to act jointly, and mutually modify each others actions, and that which he ascribes to the dominion of the specific Form, I attribute to the structure and especially to the connexion of the parts of the compounded body. (*Works* 5: 459)

As we can now see, Boyle's corpuscular reinterpretation of formal pluralism suggests a constraint on what counts as an acceptable classificatory scheme. When we classify some given body, we must do so on the basis of features that are specific to it. But when do we say that a feature of a body is a specific feature of that body? The above discussion of composite bodies and what Boyle calls their specific actions suggests the following answer. A feature is a specific feature of a body only if it results from the union of its components, and not from any single one of them on its own. A specific feature of a body must result from 'the structure and especially the connexion' of its components, and from the way in which these parts 'mutually modify each others actions'.

This provides some insight in how Boyle would evaluate the following situation:

And so if an ordinary Watch, that shoves onely the houres and their Quarters, being hung at a string were made to swing as a Pendulum, to an Astronomer or some other that were to make nice observations it would be most usefull in the Capacity of a Pendulum, because, as That, it may divide a minute into seconds, and a second it selfe into halfe or fourth parts: but for other men, who though they need an Instrument to

measure time, need not such minute Subdivisions of it, the little Engine we speake of will be much more useful and considerable in the capacity of a Watch then of a Pendulum. (*Works* 5: 478)

Arguably, the astronomer's practice here is problematic in at least two regards. First, the watch is ranked into a group on the sole basis of a use it has for the astronomer. As a result, it is grouped together with a wide range of structurally very different bodies – indeed with any bullet of 'Silver, or Brasse, or Lead, or Corke' that can be made to behave like a pendulum (see *Works* 5: 472). Second, the quality of the watch on the basis of which it is grouped together with the pendulums, its roundness, is a quality it owes to only one of its components in isolation, namely its case. Its roundness, and hence its aptness to behave like a pendulum, is not a 'Property or Operation' belonging to none of the parts 'single'. Hence, it is not a candidate for being among what we have seen Boyle call 'the proper, and if I may so call them, *Specifick* Actions' of the watch, or the '*Phaenomena* proper to the whole Engine'.

It is crucial to note, however, that the concept of specific actions here, and the constraint it places on what counts as an acceptable classification, does not entail that there a single correct way of grouping bodies into kinds. For Boyle is open to the possibility that there could be bodies whose components jointly give rise to a set of qualities and operations compatible with more than one way of classifying them. According to Boyle, indeed, some bodies have a twofold, or manifold, modification. By 'modification', Boyle here means a 'Conjugation of Qualities' a body possesses (*Works* 5: 478). A body has a 'manifold' modification when it possesses two or more modifications each of which entitles it to some given denomination, or to membership of some given kind:

The nature and Fabrick of a Body may be such that it may have a manifold structure (if I may so speak) answerable to more then one of those respects, on whose score Bodies are *denominated*. (*Works* 5: 477).

We have already encountered one example of a material with a twofold modification. *Vitrum Saturni* is a composite material, whose components jointly modify it so as to be fusible, transparent and brittle, but also to be ponderous and dissoluble in *Aqua Fortis* and spirit of vinegar. In virtue of the first modification, *vitrum Saturni* qualifies as a type of glass. In virtue of the second, it qualifies as a metal.

Boyle also discusses the case of antimonial glass. On the one hand, the components of antimonial glass jointly modify it so that

one that would make Beads or Microscopes with it would readily find in it fusibleness and transparency; which . . . are enough to referre them to that sort of Bodies that are comprehended under the name of Glasse. (*Works* 5: 478)

But on the other hand,

besides this . . . *modification*, the Body we speak of has another, upon whose account it is yet to work upwards and downwards in a humane Body, upon which score, as the Artificer considers it onely as glasse, so the Chymist and Physician look upon it as a medicine. (*Works* 5: 478)

But if the components of antimonial glass jointly modify it so that it can qualify as a type of glass as well as a kind of medicine, how are we to decide what the best way to classify antimonial glass is?

To say that we must classify bodies with a twofold modification on the basis of the most noble of these modifications will not help to settle the matter. After all, the artificer on the one hand and the chymist or physician on the other will disagree about the nobility of the two modifications of antimonial glass no less than they disagreed about the best way to classify it in the first place:

One man may in the same body look upon one kind of modification, and another upon a quite differing one as the highest Forme of that Body. As in the lately mention'd Example of the melted Calx of Antimony, an Artificer may think its Noblest Forme to be that of Glasse, and a Chymist or a Physician that of Antimony. (*Works* 5: 478)

Moreover, insofar as nobility 'is rather a Civil or Political then a Physicall Qualification', it is hard to see how the decision to classify bodies on the basis of their most noble features would help us arrive at a natural classification (*Works* 5: 470).

Perhaps it could be said that artisanal classifications primarily look at the use materials have for us, and that this makes them less natural than chymical or medical classifications (see *Works* 5: 471 for a suggestion along these lines). But even if this kind of consideration may

help settle matters in the particular case of antimonial glass, the earlier case of *vitrum Saturni* illustrates that ambiguous cases can be found within a single discipline such as chymistry as well. The twofold modification of this material entitles it to two chymical denominations, neither of which seems in any way less natural than the other. Puzzling though it may sound to the Aristotelian natural philosopher, it would appear that, in Boylean chymistry, we do indeed find bodies that are modified so as to ‘have a title to more than one Form’.

5. Conclusion

In this paper we have argued that Boyle’s account of natural kinds is more complicated, and more subtle, than realist and conventionalist readings have acknowledged. Realist readings need to be qualified in light of the fact that conventions play a substantial role in the individuation of kinds, according to Boyle. The individuation of kinds is at least to some degree a matter of tacit agreement, and this holds true for Aristotelianism as well as the new corpuscular philosophy.

Moreover, Boyle at various occasions suggests that what is essential to a body is to some extent degree relative to the way in which it is described by us. It is not clear that, according to Boyle, nature dictates what the essential qualities of an individual are. Hence, it is not clear that he thinks nature dictates on the basis of what qualities individuals must be grouped. The hard cases he presents himself suggest that corpuscular forms will not settle the matter in favor of one classification over the other, as the form of a single body can give rise to, for instance, both metallic and glassy qualities. Hence, human convention and agreement will continue to play a role in grouping individual bodies into kinds and classes.

This does not mean, however, that our conventions and tacit agreements are unbound by constraints. First, Boyle maintains that to classify bodies on the sole use they have for us is problematic. Second, for composite bodies, Boyle appears to hold that we must sort them on the basis of their specific features, or those features that arise from the mechanical conjunction of and interaction between their component parts. The fact that some bodies have what Boyle calls a manifold modification, however, indicates that even these constraints will not eliminate all borderline cases.

We conclude that in his treatment of kinds and classification, Boyle combines realist and conventionalist elements in an interesting way. Perhaps, in the end, the total number of borderline cases is limited. Even so, Boyle in various works voices doubts and uncertainties

about classification in many cases. If he were convinced of a clear procedure that could easily deal with borderline cases and ambiguities, it seems unlikely that he would have voiced his doubts so often and so strongly.²⁰

Han Thomas Adriaenssen
University of Groningen
h.t.adriaenssen@rug.nl

Lodi Nauta
University of Groningen
l.w.nauta@rug.nl

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²⁰ We thank the anonymous readers of an earlier version of this paper.

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