**7. Robert Boyle’s natural kind realism**

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The Aristotelian hylomorphic account of nature, adopted and expanded by the Scholastics,[[1]](#endnote-1) claims that all natural material substances are a composite of matter and form. The Scholastic concept of ‘form’ is of an imperceptible, immaterial essence that imposes organizational unity and structure onto the matter with which it is joined and makes it a member of a natural kind, imbuing it with all of its relevant characteristics, i.e., its essential properties and resulting qualities. ‘Essential properties’ are those features that tell us to what species or genus an object belongs, e.g., being warm blooded is an essential property of mammals, being rational is an essential property of humans, being yellowish and heavy are essential properties of gold. In this way, then, the substantial form of any object in the Scholastic theory plays three roles: (a) it tells us to what natural kind the substance belongs; (b) it accounts for the substantial unity of the substance; and (c) it causes the sensible qualities and properties of the substance. For example, according to the Scholastic theory, a lump of gold is an instance of *gold* because its matter possesses the substantial form of gold which causes all of the properties of gold, e.g., malleability, yellowish colour, heaviness, etc. So, on this view, classifying natural substances and organisms based on their observable properties will always result in a taxonomical scheme that matches reality.

What this means is that the Scholastic ontology is committed to realism about natural kinds. To say that a kind is *natural* is to say that a grouping of similar individuals exists independently of human classification decisions. For the Scholastics, this independent natural grouping is effected by the form. That is to say, each individual member of the kind shares the same substantial form. This is why the Aristotelian tradition thinks of the substantial form as a *formal cause*, it is what makes an individual the kind of being that it is.

On this view, the task of each scientific discipline is to identify as many natural kinds as possible within its domain and to determine their properties accurately. The difference between a natural kind and a species or genus is that nature creates kinds with substantial forms, humans create taxonomies which include species and genera. According to the Scholastic theory, when human classification practices are done correctly, our classifications of individual substances that sort them into their species and genus will be coextensive with—at least roughly—the kinds already existing in nature. An implication of this hylomorphic natural philosophy is that there is a conceptual distinction between the form and the *prime matter*, i.e., the matter as it is independently of the form.[[2]](#endnote-2) Prime matter—because it is devoid of any defining formal causes—is inert, it has no causal powers and lacks colour, mass, structure, solidity, scent, flavour, etc., and would be incapable of supplying a body with any qualities until it is *informed* by a substantial form.

Both of these theoretical commitments of Scholasticism, i.e., prime matter and substantial form, are criticized and rejected by Robert Boyle. According to Boyle, there are no non-material forms in nature (except the human soul; *Works*, 5: 300)[[3]](#endnote-3), and material particles are not inert but possess qualities and properties all on their own (ibid., 306-7). Nevertheless, like the Scholastics, Boyle does accept natural kind realism and he does believe that empirical methods of classifying substances into genera and species can result in taxonomies that match nature’s kinds.[[4]](#endnote-4) So the question we shall address in this chapter is: How Boyle can retain natural kind realism and empirical classification methods without accepting substantial forms?

In order to answer this question, I shall show that Boyle argues that because matter naturally possesses size, shape and mobility, it can be organized into structures that have qualities that exceed what the particles themselves have. These structures can become an essence or ‘corpuscular form’ that accounts both for the properties of the body and its membership in a natural kind. Similarly, increasingly more complex structures can result in the production of organisms that are also members of natural kinds. In this way, Robert Boyle is arguing for a version of natural kind realism that is based on the structure of the underlying matter and discovered empirically *via* the resulting properties. This understanding of Boyle’s natural kind realism will help show why he is an important figure, both in the Scientific Revolution and in the debate over natural kinds. It will also help explain how Boyle’s view relates to the realism of Francis Bacon and the antirealism of John Locke.[[5]](#endnote-5)

1. **Boyle’s rejection of Scholastic substantial forms**

Before we dive into Boyle’s critique of substantial forms, it will be helpful to say a bit more about prime matter. The Aristotelian natural philosophy argues that without a substantial form, matter would not be a substance and it would not have any properties because it would have no essence, i.e. there would be nothing to supply it with any of the powers of its kind because it has no kind. Boyle, along with the other mechanists, rejects this view and argues that matter is a substance all on its own with its own essential properties:

So that now we have found out, and must admit three Essential Properties of each entire or undivided, though insensible part of Matter, namely, *Magnitude*, (by which I mean not quantity in general, but a determin’d quantity, which we in English oftentimes call the *Size* of a bodie,) *Shape*, and either *Motion* or *Rest*. (Ibid., 307)

Far from admitting prime matter, Boyle insists that matter is a substance that is extended, i.e., has size and shape, and can be at rest or put into motion.[[6]](#endnote-6) In fact, as we shall see in Section 3 below, it is because of the nature of matter that Boyle brings us closer to bridging the gap between what we now understand as physics and chemistry. However, before we can do justice to this innovation, we must first see how Boyle argues for his natural kind realism.

Boyle’s polemics against substantial forms in the *Origne of Formes and Qualities* (hereafter *Forms and Qualities*) contains a series of layered critiques:

*First*, That I see no necessity of admitting in Natural things any such substantial Forms, Matter and the Accidents of Matter being sufficient to explicate as much of the *Phænomena* of Nature, as we either do or are like to understand. *The next*, That I see not what use this puzling Doctrine of substantial Forms is of in Natural Philosophy; the Acute *Scaliger*, and those that have most busied themselves in the Indagation of them, having freely acknowledg’d…That the true Knowledg of Forms is too difficult and abstruse to be attain’d by them…*third*, which is, That I cannot conceive, neither how Forms can be generated, as the Peripateticks would have it, nor how the things, they ascribe to them, are consistent with the principles of true Philosophy, or even with what themselves otherwise teach. (Ibid., 340)

Here we see that Boyle is presenting an empirical challenge to the Scholastic doctrine of forms. A slight reordering of the passage will help reveal each of these elements as working together to undercut the justification substantial forms seem to enjoy:

1. Because substantial forms are non-physical and unobservable, they are unknowable (even their staunchest defenders admit that no knowledge of them is to be had).

2. The doctrine of substantial forms is not only inconsistent with other Scholastic theoretical commitments, it suffers from serious internal consistency problems.

3. Substantial forms cannot play an explanatory role in natural philosophy.

4. Substantial forms are theoretically unnecessary (everything they were postulated to explain can be explained by appealing exclusively to ‘matter and the accidents[[7]](#endnote-7) of matter’).

Therefore, substantial forms should be rejected and replaced with a material equivalent.

While all of these premises deserve careful evaluation, for the sake of brevity we shall focus most of our attention on premise (4) and touch only lightly on (1)-(3), and only insofar as they are relevant to our main concern, i.e. Boyle’s natural kind realism based on corpuscular forms.

Boyle’s rejection of (1) is rather brief and takes the form of a challenge to his Scholastic opponents:

First then they thus argue. *Omne Compositum substantiale* (for it is hard to English well such Uncouth Terms) *requirit materiam & formam substantialem, ex quibus componatur. Omne corpus naturale est compositum substantiale. Ergo &c*.[[8]](#endnote-8) In this Syllogisme some do plausibly enough deny the Consequence, but for brevities sake, I shall rather choose to deny the Minor, and desire the Proposers to prove it. For I know not any thing in Nature that is compos’d of Matter, and a Substance distinct from Matter, except Man…. (Ibid., 343)

Boyle is presenting an empirical challenge to the Scholastics: he argues that he has no evidence that anything in nature (except in the case of the human body and soul) is a composite of matter and immaterial form, and until he is given convincing evidence of the existence of immaterial forms in nature, he sees no reason to accept it.

As we shall see below, his expression ‘distinct from matter’ will come up regularly in his polemics against the doctrine of substantial forms. It is a fundamental commitment of Boyle’s natural philosophy that matter and motion are the primary explanatory concepts and so his aim is to reduce all natural phenomena to matter and motion. Indeed, on his view, nothing but matter and motion can explain purely natural phenomena: ‘to say, that…Effects are perform’d by the substantial Forms of the respective Bodies, is at best but to tell me, what is the Agent, not how the Effect is wrought’ (ibid., 352). In essence, Boyle is arguing that appeals to substantial forms fail to provide an adequate explanation of natural phenomena because *how* the form does its work remains mysterious. For example, in *Notion of Nature* he put it thus: ‘For to explicate a *Phænomenon*, it is not enough to ascribe it to one general Efficient, but we must intelligibly shew the particular *manner*, how that general Cause produces the propos’d Effect’ (*Works*, 10: 558). And again in the *Excellency of the Mechanical Hypothesis*:

These, I say, when they tell us of such indeterminate Agents, as the *Soul of the World*, the *Universal Spirit*, the *Plastic Power*, and the like; though they may in certain cases tell us some things, yet they tell us nothing that will satisfie the Curiosity of an Inquisitive Person, who seeks not so much to know, what is the *general* Agent, that produces a *Ph*æ*nomenon*, as *by what Means*, and *after What Manner*, the *Ph*æ*nomenon* is produc’d. (*Works*, 8: 108)

Here we see Boyle’s commitment to (3): he repeatedly insists that appeals to non-physical entities fail to intelligibly explain the causes and effects in nature, and since substantial forms are non-physical entities, they cannot play an explanatory role in natural philosophy.

A brief word on ‘explaining how’ for Boyle.[[9]](#endnote-9) A well-known feature of his negative polemics is that, by Boyle’s lights, if the *explanans* is more mysterious than the intended *explanandum*, then the purpose of explanation has not been achieved. An adequate scientific explanation will appeal only to entities or processes that are non-mysterious, or in his word, *intelligible*. An explanation of ‘how’ is intelligible, on Boyle’s view, if the entities and processes appealed to are familiar from experience. In this sense, Boylean explanations are to be understood in terms of his general corpuscularian programme[[10]](#endnote-10) where he tries to reduce as many natural phenomena as possible to the primary qualities of bodies. This is why, for Boyle, adequate explanations exclusively identify physical causes. Take for example, this passage from the *Excellency of the Mechanical Hypothesis*:

if the proposed [explanatory] Agent be not intelligible and physical, it can never physically explain the *Phænomena*, so if it be intelligible and physical, it will be reducible to Matter and some or other of those only Catholick affections of Matter already often mentioned. (Ibid., 109)[[11]](#endnote-11)

It seems that the two important features that make the explanatory agent intelligible are that they are physical *and* their properties are among those familiar properties of matter.[[12]](#endnote-12) These two components allow for an adequate explanation of *how an effect is wrought by an agent* simply because we are already familiar with material objects and how they operate on one another. At no point does Boyle require that an intelligible explanation of ‘how’ include a complete account of causation, only that the account appeal to physical entities and familiar processes, e.g., collisions, motion, etc. We can now see why he concludes that the operations of immaterial forms on physical corpuscles would not yield intelligible explanations, but mechanical explanations would.

Concerning premise (2), one of the internal consistency problems Boyle singles out for critical treatment is the inability of the Scholastic theory to consistently hold on to the doctrine of prime matter as inert and to insist that the matter produces the form in cases of generation. According to Boyle, the Scholastics claim that when a generated body comes into existence, in the case of reproduction for example, the newly created offspring must either acquire its substantial form from the matter out of which it was produced, or it must be created *ex nihilo* at the time of generation. Boyle finds the latter option unacceptable because it requires God to perform innumerable miracles at each moment. As for the former option, Boyle says that the common opinion among Scholastics is that matter is partly *eductive*, in that the efficient cause extracts the form from the matter itself, and partly *receptive*, in that it has the power to receive the new form. But, says Boyle, since the Scholastics do not accept the view that the form was preexistent within the matter, and that there is no conceivable way for matter to produce (or educe) an immaterial being, there is no adequate explanation of the origin of the new form. (*Works*, 5: 340-342)

Before turning to premise (4), I should point out that Boyle’s critique of the Scholastic natural philosophy also applies to their accounts of essential definitions and taxonomical practices. I shall begin by looking at his criticism of their taxonomical practices. By his lights, the concept of *substantial* *form* in the Scholastic tradition yields an arbitrary theory of classification:

if You ask Men what they mean by a Ruby, or Niter, or a Pearl, they will still make You such Answers, that You may clearly perceive, that 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 than 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* of Natural Bodies. (Ibid., 323)

His point is that the Scholastics are theoretically committed to the view that substantial forms distinguish bodies into their natural species and genera, but the Scholastics do not (and cannot) appeal to the unobservable substantial forms in their classification practices. The result is that the Scholastics classify according to non-theoretical criteria established by convention. Boyle’s argument in the *Forms and Qualities* is that this arbitrary practice ought to be replaced by a philosophically and empirically sound one. He makes a similar claim in the *Sceptical Chymist*, where he argues that the inadequate accounts of the Aristotelians and chymists would be greatly improved if they took advantage of the explanations available in the mechanical hypothesis. Their unwillingness to appeal to mechanical principles, Boyle argues, results in their giving ‘us but a very imperfect account of the Origine of very many mixt bodies’(*Works*, 2: 232).

The arbitrariness of Scholastic classificatory practices is a theme that Boyle repeats in several places in *Forms and Qualities*:

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. For I confesse, that I have not yet, either in Aristotle, or any other Writer, met with any genuine and sufficient Diagnostick and Boundary, for the Discriminating and limiting the Species of Things…. (*Works*, 5: 356)

His complaint is that the Scholastics have failed to provide a sufficient philosophical account of species individuation—based on their philosophical commitments—rendering their methods arbitrary.

Building on this practical failure of their theory, Boyle further argues that the Scholastics have failed to produce the one bit of scientific knowledge of nature that they are so fond of discussing: real definitions. According to the Aristotelians, a scientific account of anything requires the philosopher to identify the four causes that jointly reveal the true nature of the species. The method is to use a syllogism that allows the philosopher to deduce a definition of the relevant species that identifies both the genus and essence of that species. The result of this process is a ‘real definition’. A real definition, according to the Aristotelian tradition, is one that accords with the hierarchy of natural kinds and identifies the essence of the species or genus, e.g., ‘man is the rational animal’ (*reason* being the essence of the species, *animal* being the genus).

A nominal definition, by contrast, is a pseudo-definition that identifies the members of the species or genus, but fails to capture the *essence*, e.g., ‘man is a featherless biped’. All humans might be featherless and bipedal, but that is not what *makes* us humans; and there could be another species of featherless bipeds that we have not yet discovered. To be a real definition, it must pick out the essence of the species, and the essence is provided by the substantial form. In the case of humans, the rational soul is our substantial form and it is both what causes us to be humans and to exhibit rationality. For this reason, humans are essentially rational, but only accidentally featherless and bipedal. So, a true science of nature for Aristotle and the Scholastics consists of real definitions and not mere nominal ones.

By the time Boyle wrote *Forms and Qualities*, a standard criticism of the Scholastic science was that four centuries of effort had only produced one real definition (which Boyle refers to as a ‘substantial definition’): ‘Man is the rational animal’. But this failure—Boyle insists—is rooted in the Aristotelian ontology:

[S]ince the Peripateticks themselves confess the Forms of Bodies to be of themselves unknown, all that this Argument seems to me to conclude, is but this, *That* if we do not admit some things, that are not *in* *rerum* *natura*, we cannot build our Definitions upon them: nor indeed could we, if we should admit substantial Forms, give substantial Definitions of Natural things, unlesse we could also define Natural Bodies by things that we know not; for such the substantial Forms are (as we have already seen) confess’d to be, by the wisest Peripateticks, who pretend not to give the substantial Definition of any Natural *Compositum*, except Man. (Ibid., 334)[[13]](#endnote-13)

According to Boyle, the Scholastics are building their definitions on unknown (and likely nonexistent) entities, and thus lack a principled account of their classifications of species. And any natural philosophy that appeals to unknown entities is unlikely to yield knowledge. So, Boyle concludes, their inability to progress in providing real definitions is a good reason to look for a different way to construct definitions that are based on entities that are knowable. Happily, Boyle has a suggestion: instead of appealing to immaterial forms, we should instead appeal to material ones.

1. **Boyle’s corpuscular kinds**

We are now ready to take up premise (4), that is, the claim that substantial forms are unnecessary in natural philosophy because anything they were posited to explain can be done by appeal to matter and its qualities.[[14]](#endnote-14) An interesting feature of Boyle’s positive account is that he claims that species deserve to be sorted in a specific way: there are ‘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’ (ibid., 332). By employing terms like ‘heedfulness’, ‘fit’, ‘deserve’, etc., he implies that if we were to pay careful attention to the properties of bodies we could accurately sort things into their natural classes. In other words, nature’s hierarchy is empirically accessible to us so long as we are careful and attending to the proper features of material substances.

In *Forms and Qualities*, Boyle argues that the difficulties which beset the Scholastic doctrine of natural species can be avoided by redefining ‘forms’. This is the point of the second-half of the first edition[[15]](#endnote-15) of *Forms and Qualities*; he is explaining what, on the corpuscular hypothesis, forms are. This is also why he states his target thusly: ‘the summe of the Controversy betwixt Us and the Schools is this: whether or no the Forms of Natural things (the Souls of Men alwaies excepted) be…true substantial Entities, distinct from the other substantial Principle of Natural Bodies, namely Matter’ (ibid., 340). In his rejection of substantial forms, Boyle sees the need to replace them with something that can play all of the roles of a form, i.e. account for the substantial unity of bodies, account for natural kinds, and cause the observable qualities of bodies. Indeed, on his account, forms are material and that the Scholastic mistake was to not allow for material forms in the first place:

Indeed, if [the Scholastics] would admit the Form of a Natural Body to be but a more fine and subtle part of the Matter…then the Eductive Power of Matter might signifie something; and so it might, if with us they would allow the Form to be but a Modification of the Matter; for then it would import but that the Matter may be so order’d or dispos’d by fit Agents, as to constitute a Body of such a sort and Denomination…. (Ibid., 341)

Here Boyle brings his corpuscular solution to the problem of eduction and natural kinds into contact with his critique of substantial forms. Forms, for Boyle, are naturally repeated material structures of bodies that determine their kind. We also see Boyle emphasizing that the form is nothing distinct from the matter (in its particular arrangement) that makes up the body. Moreover, he insists that the philosophical problems he has identified in the Scholastic claim that matter has an ‘eductive capacity’ and can ‘educe’ the form is solved by postulating a material form. Matter does not magically educe an immaterial form that somehow bestows unity, properties and an essence to the object. Rather, matter has its own properties, and a structure of material components can play all three of the roles of a formal cause. In other words, matter constitutes a ‘form’ for Boyle, in that when it is ordered in specific structures, it can do all of the work for the corpuscular natural philosophy that substantial forms did for the Scholastics.

Concerning substantial unity, Boyle says relatively little apart from his claim that material structure is sufficient to account for the unity of aggregate bodies:

in the Notion, that divers Learned men have of an *Ens per Accidens*, namely, that tis That which consists of those things, *quae non ordinantur ad unum*, it may be said, That though we do not admit substantial Forms, yet we need not admit Natural Bodies to be *Entia per Accidens*; because in them the several things that concur to constitute the Body, as Matter, Shape, Scituation, and Motion, *ordinantur per se et intrinsece* to constitute one Natural Body. (Ibid., 344)[[16]](#endnote-16)

Later on, he adds that substantial unity is also aided by the close proximity of the constituent parts: ‘the contrivance of conveniently figur’d parts, and in some cases their juxta-position…be sufficient…’ (ibid., 350). In other words, the mechanical affections of the matter suffice, on this view, to order a body into a unified whole.[[17]](#endnote-17)

One of the philosophical problems associated with this view is how particles cohere to create a unified body. As Locke would later put it, if a body is ‘nothing, but the cohesion or continuity of solid, separable, moveable Parts’ (2.4.5) and we have no explanation of how these parts bond together, then we cannot account for the unity of bodies mechanically. For example, if the claim is that bodies bond because there are little hooks on the corpuscles that grip onto the hooks of other corpuscles, then the question of how the hooks cohere (as opposed to break up) must be answered.[[18]](#endnote-18) For this reason, Locke argues that we are as much in the dark about cohesion of corpuscles as we are about how a soul thinks:

Tis *as easie* for him *to have a clear* Idea*, how the Soul thinks, as how Body is extended*. For since Body is no farther, nor otherwise extended, than by the union and cohesion of its solid parts, we shall very ill comprehend the *extension* of Body, without understanding wherein consists the union and cohesion of its parts; which seems to me as incomprehensible, as the manner of Thinking, and how it is performed. (2.23.24)

This problem threatens the very concept of a composite body. If we cannot account for the cohesion of parts, there is no philosophically satisfactory way to explain what a body is.[[19]](#endnote-19) Clearly aware of this problem, Boyle suggest in his *Chemist’s Doctrine of Qualities* that cohesion could be the result of an attractive force between the corpuscles, like an internal gravitational pull: ‘and the cohesion of those parts, by virtue of their gravity and fitness to adhere to one another’ (*Works*, 8: 393). Though, even this suggestion is inadequate without an account of the source of the attraction.

As for the denomination, properties, and sorting of species, corpuscular structure explains these for Boyle:

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)

Notice the two claims here. First, *form* consists in *corpuscular form*,[[20]](#endnote-20) which not only includes the corpuscular structure, but the resulting properties necessary to classify it. Second, these material structures and resulting properties are sufficient to constitute class membership. Elsewhere, he reiterates this view:

since those Qualities…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…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. And so, though I shall for brevities sake retain the word Forme, yet I would be understood to mean by it, not a Real *Substance* distinct from Matter, but onely the Matter it self of a Natural Body, consider’d with its peculiar manner of Existence [corpuscular structure], which I think may not inconveniently be call’d either its *Specifical* 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….(Ibid., 324)

Here we see that Boyle is redefining the concept of ‘form’ in a mechanically respectable way, i.e. as a corpuscular structure that performs the same duties as substantial forms. In fact, as we saw above, the reason we can successfully classify objects ‘as they deserve’ is because the internal structure reveals itself *via* the observable properties. What diversifies kinds is the corpuscular form, which includes both structure and the resulting properties by reference to which we classify. Moreover, Boyle argues that since corpuscular forms are like substantial forms (in that they constitute an essence; they make the object what it is, imbue it with its characteristic properties, and account for substantial unity), it follows that lacking the form is sufficient to destroy the object *qua* member of its 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 destroy’d, and is no more a Body of *that Kind*, but looses its Title to its former Denomination. Not that any thing *Corporeal* or Substantial *perishes* in this *Change*, but onely that the Essential Modification of the Matter [its corpuscular structure] is destroy’d…. (Ibid., 329)

Again later, he says that the properties of bodies result from the essential form. It is an ‘essential form’ because without it, the body would not have the properties—and species class—it in fact has. Thus, like his Scholastic counterparts, all these forms and their properties are essential in analogous ways:

But neither in this, nor in any kind of Corruption is there any thing *substantial* destroy’d…but onely that *special connexion* *of the Parts*, or *manner of their Coexistence* [corporeal structure], upon whose account the Matter, whilst it was in its former state, was, and was call’d, a Stone or a Mettal, or did belong to any other Determinate *Species* of Bodies. (Ibid., 335)

We see here again that in both generation and corruption, corpuscular structure is all there is, and nothing more, i.e., an immaterial form, is added or lost in these processes. This frequent appeal to ontological parsimony is one of the striking features of his polemic and it is all in service of premise (4), that substantial forms are unnecessary in natural philosophy.

One might think, however, that this rejection of substantial forms in favour of corpuscular forms might lead to some philosophical difficulties. For example, if all there is to a natural kind is a material structure then how do we get repeated material structures without the guidance of an immaterial form? A related problem is ‘why is the world not populated by an infinite array of corpuscular forms?’ The short answer to both questions is ‘God’. But to see the long answer, we shall have to look more closely at how Boyle addresses the question of how nature achieves hard-edged kinds. And as we shall see, Boyle does not think that the infinite potential of matter to be rearranged to create an infinite amount of possible structures implies that there are no natural species. As long as there are repeated corpuscular structures in nature, and as long as similar structures result in similar properties, there will be discoverable natural kinds. Moreover, Boyle argues that artificially produced substances (such as vitriol, i.e. sulfuric acid) that share their qualities with a naturally occurring substance are structurally similar to their natural counterparts, and so they are members of the same natural kind. This is his entire reason for discussing the results of his experiments with vitriol; nature continues to regularly produce instances of natural kinds by means of mechanical reconfigurations of corpuscular structures.

I will pitch, for the illustration of the Mechanical Production of Forms, upon Vitriol. For since Nature her self, without the help of Art, does oftentimes produce that Concrete, (as I have elsewhere shewn by Experience,) there is no reason why Vitriol, produc’d by easie Chymical Operations, should not be look’d upon as a Body of the same Nature and Kind. (Ibid., 360)

He is arguing that nature produces forms *via* mechanical means: by the mechanical alterations of corpuscular structures nature regularly produces natural kinds. The instances produced in the lab are just as natural as those made by nature because they too are produced by the rearrangement of corpuscular structures.

It is difficult to overestimate the importance of passages like these for Boyle’s project. The whole reason he focuses so intently on the results of mechanical experiments in *Forms and Qualities* and elsewhere is that he is arguing that form *just is* the corpuscular structure (along with the mechanical powers of the matter) and that this explains how we can make real vitriol in the laboratory as reliably as nature does. That is what *The Origin of Forms and Qualities* is: it is an explanation of the mechanical origin of forms. The world is an ‘orderly and well-contrived fabric’ of regularly and mechanically produced natural kinds whose properties and classes are empirically knowable.

Moreover, like the Scholastics, he argues that nature does produce identifiable and hard-edged natural kinds.

And indeed, since to every Determinate *Species* of Bodies, there doth belong more than One Quality, and for the most part a concurrence of Many is so Essential to That sort of Bodies, that the want of any of them is sufficient to exclude it from belonging to that *Species*: there needs no more to discriminate sufficiently any One kind of Bodies from all the Bodies in the World, that are not of that kind…And I suppose it would be thought a Man’s own fault, if he could not distinguish a Needle from a File, or a Key from a pair of Scissors, though these being all made of Iron, and differing but in Bigness and Shape, are less remarkably diverse then Natural Bodies, the most part of which differ from each other in far more Accidents then Two. (Ibid., 323-4)

His conclusions are threefold. First, members of a kind share many properties, which are individually necessary and jointly sufficient to rank it within its kind. These essential properties are grounded in the corpuscular structure of the objects. Thus, distinctions between kinds are grounded in corpuscular structure. Second, these kinds are discernible; just as it would be ‘a man’s own fault’ if he could not distinguish between keys and scissors, he would be equally blameworthy if he failed to distinguish between a bat and a bird, or gold and iron pyrite. Finally, objects of differing natural classes typically differ in many observable properties, i.e. there are hard edges between at least some kinds. Just as what distinguishes a file from a needle are such noticeable properties as size, shape and configuration which are grounded in the differing physical composition of the items, what differentiates gold from iron pyrite is also a sizeable set of conspicuous properties grounded in their differing corpuscular structures.

Boyle’s use of iron tools is important to his argument by analogy. Although a key and scissors are both tools composed of iron, they differ in both physical structure and, therefore, in their essential properties. By analogy, instances of different natural kinds (though they are both composed of matter) with different arrangements of their constituent matter produce different properties. What makes a key not a pair of scissors *just is* the differing configurations of their constituent iron. In like manner, what makes iron pyrite not gold *just is* their different corpuscular configurations. What establishes the boundaries between kinds are corpuscular forms.

This reading is further supported by Boyle’s mathematical example where he discusses how his theory accounts for gaps in essential properties among kinds. The example concerns comparing the ways the properties of two distinct kinds of geometrical figures differ: “though Sphæres and Parallelopipedons differ but in Shape, yet this difference alone is the ground of so many others, that *Euclid* and other Geometricians have demonstrated, I know not how many Properties of the one, which do no way belong to the other….” (ibid., 323) From the fact that all the properties of a sphere and a parallelepipedon follow from their structure, or essences, it further follows that these two figures of distinct essential natures are going to exhibit a large number of diverging properties. How spheres and parallelepipedons differ is in essential mathematical structure, these differences in structure manifest themselves in their different essential properties. Again, Boyle is illustrating that what accounts for the relevant essential properties among substances is the configuration of their matter. Given that these objects possess distinct essential properties resulting from their structures, it follows that their essential properties map out natural gaps between kinds. The same goes for material objects.

Finally, for Boyle, unlike the problematic substantial definitions for the Scholastics, the mechanical account of forms allows for an empirically respectable taxonomy of species:

But it may suffice Us to have, instead of *substantial*, *essential* Definitions of things; I mean such as are taken from the Essential Differences of things, which constitute them in such a sort of Natural Bodies, and discriminate them from all those of any other sort. (Ibid., 344)

That is to say, on Boyle’s view, definitions of species are possible, not by producing what the Scholastics call ‘real definitions’, but by producing definitions of species that appeal to the essential properties—grounded in corpuscular structure—that discriminate that class of body from all others. Given the above analogies between the differing structures and properties of different species of material and mathematical objects, it is clear that Boyle is arguing that the observable differences among properties provide insight into the deep-structural, or formal, differences among kinds.

So, while Boyle does reject substantial forms, he does not reject formal causes. Indeed, on his model, all of the functions of form are performed by natural corpuscular structures. And by his lights, it is God’s creation that orders the matter into kinds and regularly produces them:

I do not at all believe, that that either these *Cartesian Laws of Motion*, or the *Epicurean causal Concourse* of Atoms, could bring meer Matter into so orderly and well contriv’d a Fabrick as This World; and therefore I think, that the wise Author of Nature did not onley *put Matter into Motion*, but when he resolv’d to make the World, did so regulate and *guide the Motions* of the small parts of the Universal Matter, as to reduce the greater Systems of them into the Order they were to continue in; and did more particularly contrive some portions of that Matter into Seminal Rudiments or Principles, lodg’d in convenient Receptacles, (and as it were Wombs,) and others into the Bodies of Plants and Animals…. (Ibid., 353-4)

God’s creation of the world not only included the creation of matter and its affections, it also included initiating regular types of motions that help constitute a mechanical natural order. In so doing, Boyle suggests, God also created the conditions for the regular production of organisms. It is God’s creation of the regularities in matter and motion that create the hierarchy of natural kinds and produces the ‘well contrived fabric’ of nature.

In referring to the universe as a ‘well contrived fabric’, Boyle is indicating that he rejects the randomness of the Epicurean ‘swerve in the void’ as a kind of blind causation, which he (and his contemporaries) took to imply atheism. Rather, Boyle insists that God is the first cause of all reality and that his construction of an orderly physical reality guarantees that there is regularity in nature and a hierarchy of natural kinds. Thus, referring back to our earlier concern, even though matter is infinitely changeable, there are natural regularities that were put into place by divine action that structure nature in an orderly (non-random) way. In this way, Boyle inserts God’s action into nature to play one of the roles of substantial forms; God is the one who imposes order on the matter. However, Boyle does not think that God imposes order on an individual basis; this would involve God in constant miracles, and as we saw in his polemic against substantial forms, that would be objectionable. Rather, Boyle sees the role of God as initiating the conditions in nature that regularly result in an orderly fabric. In this way, he avoids involving God directly in the mundane activity of the physical world, while still employing God in supplying the natural order that substantial forms were meant to provide.

1. **Boyle’s chemical kinds**

As we saw above, Boyle’s natural kinds are set up as a natural hierarchy and are founded in physical structures. This opens up the question of how the corpuscles contribute to the overall structure and resulting qualities of the bodies they comprise. That is to say, he has spoken a great deal about natural kinds among corpuscles, chemicals and even about plants and animals, but his view on the relationship between the physics of the small material particles, endowed with primary qualities like size, solidity, shape and mobility, and the causally rich worlds of chemistry and biology remains to be seen. Of course, there is too much to say about this issue for us to do it justice here, but we can say a few things that relate to the varieties of natural kinds in Boyle.

In Book II §§i–vii of his *New Organon*, Francis Bacon gives a version of corpuscular species realism by redefining the concept of ‘formal cause’ as both the material structure of bodies and the laws that govern the natural effects of these structures that accounts for their species and genus membership. For example, in II.ii he says, “For though nothing exists in nature except individual bodies which exhibit pure individual acts [powers] in accordance with law…It is this law and its clauses which we understand by the term Forms…” (Bacon 2000: 103). And later in II.iii: “But he who knows forms comprehends the unity of nature in very different materials” (ibid.). These Baconian forms, as they consist of both the structured particles of matter and the powers of material bodies, divide nature into two classes of material structures: the elements (what he calls ‘major associations’) and the genera and species of natural bodies (his ‘minor associations’):

We want elements to be understood in the sense not of the prime qualities of things, but of the major constituents of natural bodies. For the nature of things is so distributed that the quantity or mass of certain bodies is very great, because their structure requires the texture of an easy and common material…But the quantity of certain other bodies in the universe is small and occurs rarely, because the texture of their matter is very different, very subtle and for the most part delimited and organic; such are the species of natural things, metals, plants, animals. (Ibid., 226)

Bacon takes it that smaller, more general material structures convene to create larger—and more sparse—bodies, and given the ‘law and its clauses’ that correlate powers to these structures, these bodies have their natures and belong to a species or genus due to both their structure and the causal powers of their constituent parts.

As we know, Boyle too accepts that corpuscular structure is an important component of a material formal cause, however, there are other similarities as well. For example, Boyle builds up a natural hierarchy from the most basic particles. And, similarly to Bacon’s natural kinds, this hierarchy results in an increasing degree of physical complexity at each level.[[21]](#endnote-21) On Boyle’s theory, the basic components of matter are not *materia prima*, but what he calls *minima naturalia*:[[22]](#endnote-22)

That there are in the World great store of Particles of Matter, each of which is too small to be, whilst single, Sensible; and being Entire, or Undivided, must needs both have its Determinate Shape, and be very Solid. Insomuch, that though it be *mentally*, and by Divine Omnipotence divisible, yet by reason of its Smalness and Solidity, Nature doth scarce ever actually divide it; and these may in this sense be call’d *Minima* or *Prima Naturalia*. (*Works,* 5: 325-6)

These *minima naturalia* (smallest natural particles) make up the ‘corpuscles’ in nature, which, when structured in certain ways, account for something like an *element*[[23]](#endnote-23) or an *atom* and are the basic building blocks of more complex substances:

That there are also Multitudes of Corpuscles, which are made up of the Coalition of several of the former *Minima Naturalia*, and whose Bulk is so small, and their Adhæsion so close and strict, that each of these little Primitive Concretions or Clusters (if I may so call them) of Particles is singly below the discernment of Sense, and though not absolutely indivisible by Nature into the *Prima Naturalia* that compos’d it, or perhaps into other little Fragments, yet, for the reasons freshly intimated, they very rarely happen to be actually dissolve’d or broken, but remain entire in great variety of sensible Bodies, and under various forms or disguises…we see that even Grosser and more compounded Corpuscles may have such a permanent Texture…. (Ibid., 326)[[24]](#endnote-24)

These more complex substances, or compounded corpuscles, are larger primitive concretions built up out of *minima*, which are stable and resist natural dissolution. These larger primitive concretions can take on permanent textures so that they constantly behave in predictable ways. To illustrate this point, Boyle gives the example of all the ways mercury can be changed into different states, e.g., powder, liquid, or vapour, ‘and yet remain true and recoverable Mercury’. (ibid., 326.) By ‘true and recoverable’, Boyle is referring to some well-known chemical processes that can recover silver, gold, mercury, etc., even after these metals have been dissolved or in some other way mixed with other materials. One method Boyle employed was to dissolve the metal in an acid solution and then recover it by precipitating it out of the solution. This ability to recover all of the original metal suggested to him that the insensibly small particles of the metal remained intact as mercury, gold or silver throughout the process.[[25]](#endnote-25) Thus, these *minima* create corpuscles that are, in all reality, stable chemical elements, or what William Newman refers to as ‘chymical atoms’.[[26]](#endnote-26)

According to Boyle, these chemicals gain or lose properties and qualities depending on the ways their structures are altered or based on the textures of other bodies with which they interact:

And whether any thing of Matter be added to a Corpuscle, or taken from it in either case, … the Size of it must necessarily be alter’d, and for the most part the Figure will be so too, whereby it will both acquire a Congruity to the Pores of some Bodies, (and perhaps some of our Sensories,) and become Incongruous to those of others, and consequently be qualifi’d, as I shall more fully shew you hereafter, to operate on diverse occasions, much otherwise than it was fitted to do before. (Ibid., 326)

When a compound corpuscle is broken up or matter is added to it, that changes the size or shape of the corpuscle and therefore changes the kinds of interactions it can have with other bodies and the qualities it possesses. So, the chemical properties of a compound corpuscle are determined by the structure of that ‘chymical atom’ and the structures of the surrounding bodies.

What we see then is that, for both Bacon and Boyle, physical structures are built up from the most basic particles of matter (which possess a small set of essential properties, e.g., size, solidity, shape, mobility, etc). However, (as we saw in Bacon) Boyle extends this increasing physical complexity to constitute increasingly larger structures with a richer set of resulting qualities, i.e. chymicals (corpuscles endowed by their complex structure with chemical properties).[[27]](#endnote-27) And so Boyle has attempted to give us a way to bridge (what we might loosely call) the ‘physics’ of the *minima* to the ‘chemistry’ of the primitive concretions of corpuscles. In turn, these chymical atoms are the building blocks of the biological world. And this not only suggests that there are natural chymical kinds as well as biological kinds, it also suggests that there is a connection between the basic elements and the rest of the ontology of the natural sciences. In sum, Boyle believes that the world contains a hierarchy of natural kinds that begins at the ‘atomic’ level.

1. **Conclusion**

What we have seen is that Boyle’s rejection of the Scholastic substantial forms paved the way for him to demonstrate that corpuscular formal causes—understood as corpuscular structures—could play all the roles in the mechanical natural philosophy that substantial forms in Scholastic philosophy had, but without saddling the new science of mechanism with immaterial forms. Corpuscular forms account for natural kinds, the substantial unity of material substances, and cause the observable qualities and properties of the substance. Moreover, it allows for essential definitions in ways that the substantial forms could not. And each of these benefits of his theory count as arguments for rejecting substantial forms: immaterial forms can be replaced by material ones.

The corpuscular forms of Boyle also play an important role in the history of the debate over natural kinds. Boyle’s question of how nature—without the aid of substantial forms—can organize physical reality into a hierarchy of kinds is still an important question, not just in philosophy but in biology, chemistry, psychology, and the social sciences.[[28]](#endnote-28) Boyle’s contribution not only provides a fecund and provocative suggestion for how to account for kinds, but also of how to connect experimental and observational data to the theory. So, Boyle’s account of natural kinds is worthy of careful examination in its own right.

Furthermore, there are also instrumental reasons for looking at Boyle’s position carefully. An important philosophical legacy of Robert Boyle is how his account of natural kinds laid the groundwork for one of the most enduring discussions of the epistemology, semantics and metaphysics of scientific taxonomies in John Locke’s *An Essay concerning Human Understanding*. John Locke was a close friend and associate of Boyle who assisted him in his laboratory in Oxford. And although this is controversial territory, I read Locke’s *Essay* as containing a series of arguments criticizing Boyle’s version of natural kind realism.[[29]](#endnote-29) And so, by my lights (and, perhaps regardless of one’s interpretation of Locke’s account of kinds), getting Locke’s contribution to the discussion on classification and natural kinds right also means that we must understand Boyle’s contribution to realist theories of natural kinds. In sum, Boyle is a key figure in the seventeenth-century debate over natural kinds who deserves scholarly attention.

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1. By the time of Robert Boyle, the term ‘Scholastic’ came to refer to a method of teaching and learning within the Christian universities in Europe that included reconciling Christian theology with Aristotelian and Neoplatonic thought. The method of learning in the Scholastic tradition focused on dialectical reasoning and disputations to expand knowledge and to resolve contradictions. Boyle also uses the term ‘Peripatetic’, which refers generally to all followers of Aristotelianism. Because ‘Scholastic’ refers generally to individuals within a Christian Neo-Aristotelian tradition, the term ‘Peripatetic’ is sometimes used to refer to non-Christian Aristotelians. For the sake of simplicity, in this chapter we will use these three terms interchangeably (which Boyle sometimes does) and we will primarily use the term ‘Scholasticism’ and its various forms when referring to the main target of Boyle’s arguments. [↑](#endnote-ref-1)
2. According to the Aristotelian tradition, prime matter, because it is without a form of any kind, and thus undefined, cannot exist in reality *as* prime matter. Nevertheless, it remains a fundamental component of their ontology. [↑](#endnote-ref-2)
3. The quotations from Boyle are identified by ‘*Works,* volume number: page number’. The quotations often include italicized words or expressions, and those are all given in the original; I have not added any emphasis to the quotations. There are a few instances where I have made insertions into the quotations, and those are presented in square braces. [↑](#endnote-ref-3)
4. Both Norma Emerton (1984) and Peter Anstey (2000) attribute this type of natural kind realism to Boyle. On Emerton’s view, Boyle’s account of form consists in the regular structural and geometric properties of the matter. According to Anstey, “…for Boyle, form is merely the arrangement of parts of figure of an object. He calls it an object’s stamp. It is merely a structural property of the concretion of corpuscles that make up the body.” (p. 27) Emerton points out on pp. 73-4, corpuscularian form is intended by Boyle to closely follow the features of forms in Aristotle; form is immersed in matter in that it is the material structure. But Boyle’s forms are more Aristotelian than this. Even on his early view, form consisted not only in the ‘perspicuous and describable corpuscular structures’, but in those structures as the grounds of the properties, qualities, individuation of the object, and the criterion by which it belongs to a natural kind. In this way, form is not mere structure or matter in a certain shape, but the power of the matter so organized to ground its properties, unity, qualities and classification. [↑](#endnote-ref-4)
5. For Locke’s anti-realism about kinds, see Jones (2016). [↑](#endnote-ref-5)
6. Boyle offers different lists of primary qualities in different places. No attempt will be made here to reconcile them. [↑](#endnote-ref-6)
7. Throughout this chapter, the terms ‘quality’, ‘property’ and ‘accident’ will be used regularly. For Boyle, every material object has three kinds of qualities: *primary qualities*, e.g., size, shape, texture, mobility; *secondary qualities*, e.g., colours, odours, flavours, sounds, etc; and *tertiary qualities*, e.g., the ability of the primary qualities of one body to effect a change in the primary qualities of another body. *Accidents* are qualities that a body could gain or lose without being destroyed, e.g., a banana could change from green to yellow without ceasing to be a banana. A *property* is any quality that is grounded in the essence of the thing, e.g., conducting electricity is a property of any metal because metals share electrons freely, and a body could not lose a property without ceasing to be the kind of thing that it was, e.g., a metal could not lose the property of electrical conductivity without ceasing to be a metal. [↑](#endnote-ref-7)
8. Roughly, the argument runs as follows: ‘All substantial composites require matter and substantial form from which they are combined. All natural bodies are substantial composites. Therefore, [all natural bodies are composed of matter and form].’ [↑](#endnote-ref-8)
9. There are three highly general categories of explanation that are relevant to Boyle in this context: (i) *causal explanation*, where to explain how an effect arises from a cause is to give a description of the causal process such that all of the links are fully understood; (ii) *ontological explanation*, where we explain how an effect arises from its cause by identifying the relevant entities and mechanical processes (impact, rubbing, etc.) connecting the cause to the effect and giving experimental evidence that such entities and processes are involved in producing that type of effect; and (iii) *analogical explanation*, where one appeals to the kinds of explanans (what does the explaining) invoked in either ontological or causal explanations and attributes them by analogy to another set of explananda (what is explained). The important difference between (i) and (ii) is that, whereas (i) includes a description of the causal processes that produce the effect (so that knowing the nature of the bodies involved, and the natures of the causal connections that obtain, one could deduce the effect; that is, it is a kind of *scientia*), (ii) only concerns the relevant objects and the description of their relative motions. In what follows, I shall be referring to ontological explanations as Boyle’s preferred account of intelligible explanation. [↑](#endnote-ref-9)
10. See Anstey, ibid, pp. 54-8. [↑](#endnote-ref-10)
11. See also, *Christian Virtuoso* (*Works,* 12: 422). [↑](#endnote-ref-11)
12. In the *Excellency of the Mechanical Hypothesis*, Boyle points out that questions of mind-body interaction must also be answered by appeal to mechanical principles, which indicates that what makes those actions of the soul on the body intelligible is that they are physical effects (*Works,* 8: 116). [↑](#endnote-ref-12)
13. The expression ‘*rerum natura*’ refers to the nature of things as they are in reality (independently of human ideas); a ‘*compositum*’ is just a composite being, i.e., made out of two substances. [↑](#endnote-ref-13)
14. For another argument for this premise, see Newman (2006) pp. 166-9. [↑](#endnote-ref-14)
15. This only applies to the first edition. The second-half of the second edition of *Forms and Qualities* is a critique of Sennert’s doctrine of subordinate forms. [↑](#endnote-ref-15)
16. An ‘*ens per accidens*’ (plural ‘*entia per accidens*’) is an accidental substance, that is, a being that lacks true unity or is a mere aggregate, e.g., a flock of sheep. The opposite of an accidental being is an ‘*ens per se*’ (a being in itself), e.g., a human body is unified and functions as an internally organized substance and not as a mere collection of parts. Thus, the quotation could be read as saying: ‘in the Notion, that divers Learned men have of an *accidental entity*, namely, that tis That which consists of those things, *which are not organized together*, it may be said, That though we do not admit substantial Forms, yet we need not admit Natural Bodies to be *accidental entities*; because in them the several things that concur to constitute the Body, as Matter, Shape, Situation, and Motion, *are intrinsically designed in themselves* to constitute one Natural Body’. [↑](#endnote-ref-16)
17. Despite Boyle’s confidence here, philosophically speaking, the question of the causes by which a collection of particles ‘bond’ or cohere with each other is one Locke will take up in 2.23.23-27 of his *An Essay Concerning Human Understanding* (all quotations of Locke’s *Essay* are from Nidditch). However, this lacuna does not affect Boyle’s position uniquely; after all, the Scholastics too must answer that question while leaving unexplained how an immaterial form can cause material particles to cohere. Again, Boyle points to the fact that his mechanical account is more parsimonious and is not saddled with accounting for immaterial entities. He seems to reiterate this assertion in section IV of *Notion of Nature* (*Works,* 10: 465) by saying that the mechanical explanation of the function of a clock will suffice as an explanation and we can ignore the distinction between an *ens per accidens* or an *ens per se*. [↑](#endnote-ref-17)
18. Newton seems to have preferred a version of gravitation to explain cohesion, see for example, *Opticks*, Query 31, pp. 380-1. [↑](#endnote-ref-18)
19. For more on this, see James Hill (2004), p. 628. [↑](#endnote-ref-19)
20. In my (2005), I refer to these as ‘mechanical forms’ to emphasize the fact that the corpuscular structure plus the causal powers of matter constitute the form and that they are not mere material arrangements. However, here I call them ‘corpuscular forms’ to bring them in line with my terminology in my (2007) and (2016). [↑](#endnote-ref-20)
21. It is important to note that Boyle’s biggest influence where atomism and corpuscular kinds are concerned is Daniel Sennert, though he is also influenced by Descartes, Gassendi and Bacon. For more on Boyle and Sennert, see Newman (2006). I am not arguing that Bacon is the only influence on Boyle’s corpuscular kinds, only that there are some interesting similarities. Moreover, for Bacon, God imbues matter with fundamental desires and appetites that help explain natural organizations. See Guido Giglioni, 2013, pp. 45-51, 65-68. I would like to thank Peter Anstey for his help on this. [↑](#endnote-ref-21)
22. By ‘*materia prima*’ or ‘*minima naturalia*’ in this context, he means the most basic material particles in nature. He is not referring back to the Scholastic *materia prima*. [↑](#endnote-ref-22)
23. Although, as we shall see below, Bacon and Boyle use the term ‘element’ differently. Moreover, Bacon and Boyle differ on the causal agents in nature. Boyle’s matter in motion plus structural complexity leading to chemical powers is very different from Bacon’s physical ‘animate spirits’ and ‘inanimate spirits’ that mix with matter and interact with matter through chemical processes. Boyle is trying to explain the origin of chemical powers; Bacon does not explain their origin as much as employ non-mechanical chemical powers to account for the functions and powers of bodies. Due to considerations of focus, these aspects of Bacon’s philosophy will not be discussed here. For more on this, see Antonio Clericuzio (2000) and Steven Matthews (2008). [↑](#endnote-ref-23)
24. By the time he writes *Of The Atomicall Philosophy* (circa 1652-4), and certainly when he wrote *The Sceptical Chymist* (1661), Boyle had adopted a notion of atoms that are divisible by God but still function atomically ‘those primitive and simple Bodies of which the mixt ones are said to be composed, and into which they are ultimately resolved’. (*Works*, 2: 220) On his view, an atom (or to use his most influential term, ‘element’) is an insensibly small particle of matter that cannot be decomposed by any chemical means. For more on this definition of ‘atom’ or ‘element’, see William R. Newman (2009). In the *Forms and Qualities* Boyle says ‘…the Shape of Vitriol [crystals] depends upon the Textures of the Bodies, wherof it is compos’d’ (*Works,* 5: 368), indicating that shaped corpuscular concretions could account for crystalline structures. [↑](#endnote-ref-24)
25. See *The Sceptical Chymist*, *Works,* 2: 230. [↑](#endnote-ref-25)
26. See Newman, ibid. This concept of a corpuscular atom made up from minima and exhibiting more complex qualities than the minima alone is also part of Pierre Gassendi’s account of ‘molecules’. For more on this, see Antonio Clericuzio, ibid. [↑](#endnote-ref-26)
27. See Clericuzio, ibid., p. 117. A problem with Boyle’s view that we cannot take up here is how he could possibly connect the physics of the *minima* to produce a theory of chemistry wherein a ‘richer’ range of qualities results from a more complex structure. If shapes, solidity, orientation and texture are all the resources to draw on, then it becomes a little more difficult to say how the chemical properties of acids, bases, salts, metals, etc., are the result of just the physical qualities of the constituent parts. [↑](#endnote-ref-27)
28. For some excellent collections of articles on these issues, see Helen Beebee and Nigel Sabbarton-Leary (2010) and Alexander Bird, Brian Ellis and Howard Sankey (2012). [↑](#endnote-ref-28)
29. For my views on Locke and Boyle, see my (2005), (2007) and (2016). For an excellent argument contrary to mine, see Peter Anstey’s (2011), chs. 10 and 11. [↑](#endnote-ref-29)