

## 2

# Scholastic Qualities, Primary and Secondary

*Robert Pasnau*

### 1. Fundamentals of the Scholastic theory<sup>1</sup>

The distinction between two kinds of qualities, primary and secondary, is one of the core doctrines of Scholastic natural philosophy. Far from being an invention of the modern era, it is something to which any student of Aristotelian philosophy—which is to say anyone who studied philosophy in a European university up until the eighteenth century—would have been introduced at a tender age. The distinction is, moreover, every bit as important for Scholastic philosophers as it would become in the seventeenth and eighteenth centuries, since the primary qualities, on the Aristotelian tradition, are the fundamental causal agents of the natural world.

The *locus classicus* for the Scholastic idea is the beginning of Book II of *On Generation and Corruption*, where Aristotle attempts to tease out the fundamental qualities of the natural bodies around us. Considering Empedocles's proposal that there are four basic elements—Earth, Water, Air, Fire—Aristotle argues that this thesis can be proved correct by establishing that there are four basic qualities:

Hot, Cold, Wet, Dry.

These qualities, in their various possible combinations, give rise to the four elements. For generations of later Aristotelians, these are the primary qualities, and the secondary qualities are those further features of things—texture, color, flavor, odor, etc.—that the primary qualities explain.

The basic thesis behind the distinction is that the primary qualities, after prime matter, are the most basic principles of the natural, sublunary world (see *Gen. et Cor.* II.1, 329a32–34). The restriction to the realm beneath the moon is necessary, because the Scholastics held that the heavenly bodies are made of a fifth kind of stuff, and work

<sup>1</sup> There is almost no literature on Scholastic theories of the primary and secondary qualities. The best extended discussion remains Maier, *An der Grenze*, pp. 3–22 (translated in Sargent, *On the Threshold*, ch. 6).

42 PRIMARY AND SECONDARY QUALITIES

in fundamentally different ways. If we confine our attention to the bodies around us, however (as I will hereafter tacitly do), then we arrive at prime matter as the most basic explanatory principle, inasmuch as it lies beneath all change. Beyond prime matter lie the four primary qualities, which are the most basic principles responsible for shaping matter. These are prior even to the four elements inasmuch as they explain those elements, according to the following scheme:

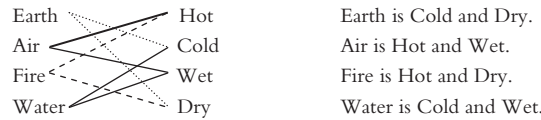


Fig. 2.1 The four elements and the four primary qualities

This is not to say that the primary qualities define the four elements, or (equivalently) constitute their essence. The standard Scholastic view was that these qualities are accidents of the elements, and that the elements have some further substantial form, unknown to us, that gives rise to these qualities. Still, the four qualities are explanatorily basic, for it is in virtue of them that the elements function as they do. And since these elements are the building blocks of the natural world—as Thomas Aquinas puts it, they are “the cause of generation and corruption and alteration in all other bodies” (*In De gen. et cor. prooem.*, n. 2)—the primary qualities get pride of place in an account of the natural world.

To say, as Aquinas does, that the elements cause “generation and corruption” and “alteration” is to make them explanatorily basic with regard to both substantial and accidental change. (“Alteration” is the technical term for qualitative accidental change, whereas “generation and corruption” refers to substantial change). Hence the primary qualities are explanatorily basic in two sorts of ways: with respect to both substances and other qualities. Eustachius a Sancto Paulo puts the first idea quite clearly in his early seventeenth-century textbook: “these qualities are called primary because from their blending (*temperie*) results the nature of a mixed body, and when this blending is dissolved, the mixed body is necessarily dissolved” (*Summa philosophiae quadripartita* III.2.2.1.1, II:208). Several factors make this aspect of the account less straightforward than it initially seems. First, although bodies are always the result of a mixture of the four elements, and their associated primary qualities, there are other factors at play in the natural realm, such as substantial forms, spiritual qualities, occult qualities, and the heavenly bodies (see below). All of this, to be sure, serves to make the account less austere reductive in its explanatory character. Second, it was controversial whether the elements, or even their qualities, continue to exist within the mixture. It was commonly claimed instead that, having been mixed together so as to constitute a body of a certain kind, the elements merge together so as to become such a body, and no longer themselves actually exist. Third, the elements are never found in isolation. Of course we do find ordinary earth, air, fire, and water existing separately, but these are

mixed bodies, each one a composite of the four elements. The elements, therefore, as Aristotle makes clear, are distinct from (albeit similar to) the ordinary bodies that we customarily refer to as *earth* etc. (*Gen. et cor.* II.3, 330b22–25). (To mark this difference, it is useful to capitalize the names of the elements and their attendant qualities.) An important consequence of this last point is that both the elements and the elemental qualities, since they never appear separately, have the status of a theoretical postulate, and so were vulnerable to the seventeenth-century charge of obscurity, and to their attempt to replace these universal qualities with primary qualities of a very different sort.

The primary qualities are also explanatorily basic with respect to other qualities. As Albert the Great puts it, “the primary qualities of tangible things are the cause of all the other sensible qualities” (*In Gen. et cor.* II.1.1). Walter Burley puts the same claim this way: “secondary qualities are caused by a mixture of primary qualities” (*De formis* pars post. p. 65). This notion of two classes of qualities—one basic and the other dependent on the first—was a commonplace of Scholastic discussions from the thirteenth into the seventeenth century, to be found in virtually any Scholastic discussion of the elemental composition of bodies. According to the late sixteenth-century Coimbra commentary on *Generation and Corruption*, for instance, “colors, flavors, smells, and other secondary qualities arise from the various temperaments and proportions of the primary qualities” (I.10.4). The Protestant Christoph Scheibler, writing in the early seventeenth century, holds that primary qualities do not depend on others, whereas “after the primary qualities follow the secondary qualities, which arise from the primary” (*Philosophia compendiosa* III.13.1).

Whereas it is a straightforward task to list the Aristotelian primary qualities, it is more difficult to say what the secondary qualities are. As a first approximation, we might say that the secondary qualities are the non-primary sensible qualities. But this is liable to mislead and is only roughly correct. First, it is liable to mislead, because Scholastic authors do not count as qualities—primary or secondary—any of the various geometric-kinetic properties. These are not *qualities* at all, inasmuch as they fall into some other genus in Aristotle’s category framework, whether that be Quantity or Action or some other category (see §3 below). Second, this rough account admits of a much more fine-grained taxonomy, inasmuch as there are many kinds of qualities. Scholastics authors routinely accept the following broad division:

- a. the four basic, elemental, primary qualities: Hot, Cold, Wet, Dry;
- b. the non-basic tactile qualities: heavy, lightweight, hard, soft, viscous, brittle, rough, smooth, course, and fine (cf. *Gen. et cor.* II.2, 329b20);
- c. the other sensible qualities: color, sound, smell, taste;
- d. occult qualities, such as magnetism;
- e. the so-called spiritual or intentional qualities, such as light or color as it exists in a medium or sensory organ;
- f. wholly immaterial qualities, such as thoughts and volitions.

#### 44 PRIMARY AND SECONDARY QUALITIES

Although one sometimes finds other usages, the most common practice is to treat (b–c) as secondary qualities. The list in (b) comes straight from Aristotle, and he is perfectly clear (329b33) that all of these can be derived from (a). (Even here, however, there is doubt regarding heavy and lightweight. For despite their inclusion on Aristotle’s canonical list, they are in other contexts treated as basic, active powers, toward or away from the center of the Earth.) The sensible qualities in (c) are also standardly described as secondary qualities. (Or, at any rate, color, smell, and taste are. I discuss sound in the following section.) We have already seen the Coimbrans claiming as much, and it is easy to find the claim in earlier authors. Here, for instance, is Albert of Saxony in the fourteenth century:

The other sensible qualities, pertaining to the other senses—such as color, flavor, and odor—do not belong to the pure elements. This is proved, because such qualities are caused by a mixture of the primary qualities of the tangible qualities. But there is no such mixture of contraries, neither formal nor virtual, in a pure element—otherwise it would not be simple. Therefore etc. (In *Gen. et cor.* II.1, p. 184)

Hence the four elements, if they were to exist in isolation, could not have any color or other such sensible qualities, because that would require them to have a mixture of all four primary qualities.

The remaining qualities (d–f) are not usually described as secondary, and do not arise from the primary qualities. Those in (f) obviously do not, since they lie outside the realm of body altogether. The occult qualities (d) are likewise famously resistant to any sort of more fundamental explanation.<sup>2</sup> The qualities in (e) are yet another story. Despite their name, intentional/spiritual qualities are a part of the physical world, and interact with bodies in a straightforward way. In contrast to the case of the occult qualities, however, Scholastic authors in this case take themselves to have something of an idea of how the process works. Light (*lumen*) in the air, for instance, is the product of the light (*lux*) of the sun or a flame. (Latin usefully distinguishes between a light source [*lux*] and light in a medium [*lumen*].) Colors and other sensible qualities in the air (*species in medio*) are caused by the sensible qualities on the surfaces of objects. Still, despite being relatively well understood, these cannot be wholly explained in elemental terms.<sup>3</sup>

<sup>2</sup> Scheibler refers to occult qualities as “tertiary qualities” and offers this useful definition: “The tertiary or occult qualities are said to be certain hidden (*absconditae*) powers by which natural things act or are acted on by something, but whose character (*ratio*) cannot be given by primary or secondary qualities” (*Philosophia compendiosa* III.13.4).

<sup>3</sup> See Nicole Oresme: “Those accidents are called material that follow the conditions of matter, as are the primary qualities and those that follow them, and whose transmutation gives rise (*disponit*) in its own right to generation and corruption, and that have a contrary. The others, which do not follow the primary qualities nor have a contrary nor give rise to generation and corruption are said to have spiritual existence—for example, light (*lumen*), influences, the species of color in the air and in the organ, acts of the soul, and such things” (*In De anima* III.13, p. 412).

## 2. Three Scholastic theses

The main idea behind the Scholastic primary–secondary distinction is that of explanatory priority: the primary qualities are the fundamental explanation of natural change, both substantial and accidental. After prime matter, they are the most basic level of explanation in natural philosophy. There are three further theses, however, that are extremely important for understanding the Scholastic distinction. The first is the thesis of *universality*, that the primary qualities are present in all bodies. This is to say that, in the sublunary realm, all bodies are a mixture of the four elements and their attendant qualities. The universality thesis had been articulated explicitly by Aristotle (*Gen. et cor.* II.8), and was, so far as I can find, maintained without exception by Scholastic authors. To be sure, given the familiar (and eventually notorious) Scholastic commitment to the separability of qualities from their subjects, the universality thesis can obtain only as a matter of natural, rather than metaphysical necessity. Yet it is far from clear why the thesis should hold of necessity, even in this weaker sense. For even granted that the primary qualities are explanatorily basic, it seems clear that there could be a certain primary quality that occurs only in certain sorts of entities—a special basic quality, for instance, that is found only in living beings. This, however, was not the Scholastic view. Following Aristotle, they supposed that each and every body would contain each of the primary qualities.

A second core thesis is *supervenience*: that no change is possible to secondary qualities without a change to the primary qualities. Here, for instance, is Boethius of Dacia from around the start of our period:

In the case of these last states there can be no alteration unless there is an alteration in the primary qualities, and the primary qualities are the causes of these. For instance, this body is soft, because it is half Dry and twice Wet. If this were always to be so, then that body would not become hard. The same is evident for young and old: unless there is a change in primary qualities, a body is not changed from young to old (nor vice versa); rather, that mixed body would always remain at the same point. (*In Gen. et cor.* I.16c)

And here is Giles of Orleans, from around the same time, on the consequences of denying that there is change at the level of the primary qualities:

It would also follow that there could be no alteration in secondary qualities—that is, in colors, flavors, white and black, etc The reason is that every alteration in secondary qualities is caused by some alteration made in the primary qualities. But there is no alteration in primary qualities, or so we are supposing. Therefore there could not be alteration in secondary qualities. (*In Gen. et cor.* I.6c)

What both passages make explicit is that no change is possible to the secondary qualities without a change to the primary qualities. This is what, in modern parlance, we can describe as the supervenience of secondary on primary qualities.

Although supervenience, all by itself, is not a causal relationship, it reflects in the present case the degree of Scholastic commitment to the explanatory priority of the

46 PRIMARY AND SECONDARY QUALITIES

primary qualities. Even so, Scholastic authors do not suppose that the secondary qualities can be *reduced* to the primary qualities, if by that one means that to have a color is nothing more than to have a certain mixture of primary qualities. Although the Scholastics believe that objects have colors because of the way their primary qualities mix, they think that to have a color is to have a further, secondary quality: a real accident from the Aristotelian category of Quality.

The third and most significant thesis is that of *causal primacy*: that the primary qualities are the primary causal agents in the physical realm. This is an aspect of how Aristotle had conceived of the elemental qualities from the start: Hot and Cold, he thought, are the two qualities in virtue of which bodies act on the world, and Wet and Dry are the two qualities in virtue of which bodies are acted on (e.g. *Meteor.* IV.5). What seems to have inspired Aristotle to give Hot and Cold this special status is that they, unlike other qualities, transfer their likeness to other bodies: a pink surface does not make other nearby surfaces pink, but a hot or a cold body does pass its temperature onto other nearby bodies. As doubtful a theoretical foundation as that is, it became unquestioned orthodoxy among Scholastic authors that the elemental qualities are the primary agents in nature. Thus, according to Albert the Great, “the primary qualities are primarily active and passive, and it is in virtue of them that whatever acts acts, and whatever is acted on is acted on” (*De praed.* 5.6; ed. Jammy I:162a). Eventually, it became common to treat all four elemental qualities as active, and it is in this form that the doctrine endured all the way through the Scholastic era. Here, for instance, is Benedictus Pererius in the late sixteenth century:

the four primary qualities [are] Cold, Hot, Wet, and Dry. From the alteration that occurs in these primary qualities results every alteration in the secondary qualities, which are based on the mixture of the primary qualities—namely, colors, odors, flavors, health, sickness, and others of this kind. The alteration of other things, which is properly change (*motus*), should be treated as that alone that occurs in virtue of the primary qualities alone, since it is here that there is properly acting, being acted upon, and contrariety. (*De communibus principiis* XIV.2, pp. 736–37)

This is a perfectly ordinary statement of standard Scholastic thinking in this area, and yet the doctrine expressed is quite extraordinary and underappreciated. It holds that the world as we perceive it is not the locus of causal efficacy: that change occurs in virtue of four underlying primary qualities on which the remaining sensible qualities supervene. The secondary qualities are epiphenomenal, involved in the spiritual–intentional processes that lead to sensation, but not otherwise playing a causal role in the natural world.

Since these claims were not particularly controversial among Scholastic authors, they were not subject to the sort of detailed scrutiny that one finds concerning vexed topics such as the status of prime matter or quantity, and the subject was particularly remote from the concerns of the theologians who have received the lion’s share of attention from modern scholars. Perhaps the best place to find a discussion of these issues is in authors whose interests in natural philosophy were more practical, and hence required

serious attention to causal mechanisms. Consider, for example, Paul of Taranto, the late-thirteenth-century alchemist who authored the influential *Summa perfectionis* (traditionally ascribed to “Geber,” Jabir ibn Hayyan).<sup>4</sup> In the theoretical prologue to his *Liber tam theoreticae quam practicae veritatis in arte alkimica*, Taranto provides a sketch of standard Aristotelian theory, so that readers will understand the proper method of attempting alchemical transformations. He begins with the claim—characteristic of Aristotelian thought but so antithetical to seventeenth-century mechanism—that “every power in nature is a certain quality” (p. 7). This leads to the now-familiar division between primary and secondary qualities, and then the crucial claim:

The aforesaid secondary qualities are not of themselves properly active on a given nature except *per accidens*. . . Taste acts on nature only through something else, namely Hot, Cold, Dry, and Wet, which are in the flavorful thing. Nor can any of the secondary qualities act within the nature and essence of anything, except through the primary qualities. . . [In contrast,] Hot, Cold, Dry, and Wet are nature’s hands, as it were, and principle powers, through which nature transforms and makes all generable things. (*Liber veritatis* pp. 8–9)

Like most Scholastic authors, Taranto treats all four primary qualities as active, rather than following Aristotle’s claim that Wet and Dry are merely passive. These are “nature’s hands,” an idea that leads Taranto to his main conclusion about how the alchemist should proceed:

The aforesaid points to the cause of defect and error in certain unskilled, fraudulent, and false artificers, who either have not arrived at the true arrangement of things or who through sophistry compose solely for external appearance. Whoever either does not know how or cannot use such powers (other than those of the secondary qualities) will never produce, through color and superficial operations, anything other than external accidents through vain appearance, and will arrive at no truth regarding these. But he who knows these capacities of nature lying in the pure elements through Earth, Water, Air, and Fire, and recognizes how to grasp them with the power of art—and knows how to join the mineral principles to the said powers . . . , will most truly be able to transform and bring about natural forms through art, . . . just as nature herself brings these things about in mines. (pp. 12–13)

If one wants to change the nature of things—to make true gold, for instance, and not just the appearance of gold—one must harness the primary qualities. Otherwise, one is simply scratching at the surface.

### 3. The mechanical affections

Viewed in a certain light, there is something thoroughly modern, or at any rate seventeenth-century, about Paul of Taranto’s proposal. A forerunner to Robert Boyle, Taranto wants to reform scientific practice in accord with a clearer theoretical

<sup>4</sup> Paul of Taranto is the recent discovery of William Newman—see, e.g. his *Atoms and Alchemy* ch. 1.

48 PRIMARY AND SECONDARY QUALITIES

understanding of the foundations of nature. The alchemists he criticizes have relied, unwittingly or perhaps deceitfully, on faulty philosophical presuppositions, and their project has accordingly been doomed to failure. By taking seriously the true causal forces at work in the world, we can use nature's own tools to transmute natural kinds. Of course, viewed in a different light, Taranto's ideas could not be farther from Boyle's, inasmuch as they disagree utterly on what those true causal forces are. Boyle rejects Aristotelian qualities across the board, primary and secondary. Taranto, meanwhile, does not even mention the "mechanical affections" that Boyle would make so much of. How could Taranto and the other authors we have considered simply ignore the geometric-kinetic properties that seventeenth-century authors would elevate to the status of primary qualities?

It is not exactly the case that Scholastic authors ignore the geometric-kinetic properties. Such properties are, instead, bracketed off as cases not subject to an account in terms of primary qualities. One can see this sort of bracketing strategy at work even among the sensible qualities themselves, in the case of sound.<sup>5</sup> Although one might suppose that Scholastic authors would count sound as a paradigmatic secondary quality, they do not. For whereas the color, odor, and flavor of a body supervene on the primary qualities, no one could suppose this about sound. Even if primary qualities play a role in the sound a body emits when struck, the sound itself depends on motion. It depends, first, on the motion of the body that emits the sound, which in turn is usually produced by the motion of another body, which strikes it. And since it was standardly supposed that sounds exist in the air or other medium, rather than in the body itself, the sound further depends on the motion of that medium, as it is put in motion by the vibrating object. Hence, in several ways, sound depends on motion, not just on qualitative features of a body. Few authors went so far as to identify sound with a certain sort of motion. But it was commonplace to describe sound as arising from motion, which is to say that it does not fit the usual paradigm of a secondary quality. Buridan makes this explicit, when he qualifies his account of secondary qualities by saying that "I do not speak of sounds, which are made not through Heat, Cold, Wet, etc., but through the local motion of the air" (*In Gen. et cor.* II.1c). It was up to the terminological preferences of a given author whether to conclude that sound should therefore not be a secondary quality, or whether the lesson instead is that some secondary qualities do not arise from primary qualities.

Sound is standardly assimilated to a larger set of cases. Here is Oresme, attempting to sort out the question of what counts as a secondary quality:

If all other qualities [beyond the four primary ones] are said to be secondary then a distinction must be drawn. There are some that follow from the primary qualities and their alteration—for example, whiteness and perhaps some flavors. Then there are others that, as it were, do not

<sup>5</sup> I have discussed the case of sound in some detail in "Sensible Qualities."



pertain to these, because they neither are those primary qualities nor do they follow from them—light (*lumen*), for example, and also rarity or shape, which follow local motion and are not properly called *secondary*. Also in this way, as was said, sound is not properly a secondary quality because it does not follow alteration but rather local motion with regard to velocity.

(*In Phys.* II.5 ad 3)

On Oresme's usage, then, the true secondary qualities are only those that follow from the primary qualities. Other important qualities—light, rarity/denseness, shape, and sound—count as secondary qualities only in an improper sense. For each of these exceptions, some other account must be provided. Light—that is, *lumen*, the light propagated in a medium—is treated as spiritual quality, and rarity as a product purely of local motion.<sup>6</sup> Shapes, in contrast, although perplexingly located by Aristotle in the category of Quality (*Cat.* 10a11), plainly cannot be explained by the primary qualities. Hence they have to be excluded from the ranks of the properly secondary qualities.<sup>7</sup>

Paralleling the case of shape are the cases of size and motion. Clearly none of the three can be explained reductively in terms of the primary qualities, and so room has to be made for them somewhere else. If not quite ignored, then, the mechanical affections certainly were sidelined. This is to say that they were not only given a separate ontological status, but also regarded as derivative aspects of explanation in natural philosophy. We have seen this already, by implication, in the above-quoted passages identifying the Aristotelian primary qualities as the fundamental causal and explanatory principle in the natural realm. The case of Paul of Taranto is particularly clear: to bring about real changes in nature one must wield “nature's hands”—meaning not the size, shape, and motion of particles, but their four elemental qualities. Franciscus Toletus, to take another example, regards shape as even less of a causal agent than the secondary qualities, for whereas the secondary qualities are at least indirectly active, inasmuch as they are a product of the active primary qualities, “shapes are in no way active, neither in their own right nor in virtue of anything belonging to them, because they are not composed of the primary qualities” (*In Phys.* VII.3.3, IV:198rb). The Scholastics were so thoroughly persuaded that qualities are the primary natural causal agents that they could not accept identifying sound with motion: for if sound were motion then it would not be a quality, and in that case could not have the appropriate causal impact on the senses. More generally, this is why Scholastic authors never seriously considered

<sup>6</sup> It was controversial among Scholastic authors whether rarefaction and condensation could be explained purely in terms of local motion. Others would invoke accidents in the category of Quantity. Even on that view, however, it would not seem promising from the Scholastic perspective to reduce *quantitative* accidents to the primary *qualities*. I discuss quantitative accidents in considerable detail in my forthcoming *Metaphysical Themes 1274–1671*.

<sup>7</sup> Different authors try to handle geometric properties in different ways. Boethius of Dacia simply excludes from his supervenience claim those properties “caused by an external cause, such as that a body is square” (*In Gen. et cor.* I.16c). Paul of Venice argues that shapes are a distinct kind of real quality, distinct not just from the primary and secondary qualities, but also from the substance and the spatial structure of its parts (*Summa philosophiae naturalis* VI.20).

50 PRIMARY AND SECONDARY QUALITIES

eliminating real qualities from their ontology. As the primary causal agents in the natural world, they were utterly indispensable.

From a seventeenth-century perspective, all of this may seem quite incredible. Given the post-Scholastic confidence in the explanatory power of the geometrical properties of bodies, how could Scholastic authors not just embrace irreducible real qualities, but even allow them to overshadow size, shape, and motion? Again, it is useful to focus on a figure whose concerns are decidedly practical. Hieronymus Fracastorius was an early sixteenth-century Paduan physicist whose account of a germ theory of disease ought to have made him as famous today as his contemporary, Copernicus. (As it happens, we value the history of astronomy more than the history of medicine.) In a crucial chapter from his masterpiece *De contagione*, Fracastorius attacks the dismissive view that the spread of contagious disease is simply the result of occult properties. This is nothing more than an excuse to avoid dealing with the question, Fracastorius declares, since to appeal to occult properties is nothing more than to say that we do not know what the cause of contagion is. So he proposes to work through the various *possible* causes:

We must suppose that, although there are ten genera of all things, the only active principles are Substance and Quality. For it is evident that neither Quantity nor Relation nor Where nor, in short, any of the other categories produces any effect, except *per accidens*. Moreover, it is evident that substance produces nothing *per se* except for local motions up or down, rarefaction and condensation, and circular motions; for these motions are produced by the [substantial] form of things. All other actions come from qualities. (I.6, p. 22)

Although the scant literature on Fracastorius often describes him as a corpuscularian,<sup>8</sup> his philosophical views here are those of a mainstream Scholastic Aristotelian. Given the theoretical presuppositions he describes, there are only two possibilities for how diseases can spread: either by substance, or by quality. But all a substance itself can do is bring about locomotion, and Fracastorius goes on to dismiss this sort of causal explanation almost out of hand, remarking that “contagion is not *per se* a local motion, but rather the corruption of certain things and the generation of other things” (p. 24). The mechanistic explanations that would become ascendant in the following century strike Fracastorius as non-starters, and so he focuses on quality as the only viable kind of explanation. Here he draws the distinction registered earlier between ordinary material qualities and the spiritual qualities that pass through air and water.

It is clear that material qualities can bring about many things, for the so-called primary qualities generate and alter all things, whereas the so-called secondary qualities—light (*lux*), odor, flavor, and sound—bring about nothing among themselves, since they are not contraries, but still they move the senses by means of those qualities that are called spiritual. It is also clear that these spiritual qualities have many actions and are a power in nature. (pp. 23–24)

<sup>8</sup> See e.g. the bio-bibliography in the *Cambridge History of Renaissance Philosophy*, which remarks that Fracastorius “favoured a Democritean corpuscular theory.”

Which of these explains contagious disease? Not the secondary qualities, obviously. The spiritual qualities are plausible candidates, but Fracastorius argues that spiritual qualities are dependent on their sources in a way that the spread of contagion is not: the light in the medium ceases, for instance, when the light source is turned off, and odors fade as distances grow greater, whereas contagions endure without their source, and can spread “even across the sea” (p. 24). This leaves the primary qualities:

If they say that contagion is brought about by some material quality, then they will appeal to nothing that is unknown unless perhaps they invent some unknown kind of quality that is neither Hot, nor Wet, nor Dry. But this certainly cannot be imagined. (p. 24)

Fracastorius concludes that contagion must be explained in terms of the familiar primary qualities. But since such qualities cannot naturally float free of substances, these qualities must inhere in some kind of substance, a *seminarium* or germ, which is capable of generating further such germs and thereby spreading. The distinctive mix of primary qualities found in a given kind of germ acts on the germ’s host, thereby causing disease.

From our perspective, Fracastorius is indefensibly precipitate in holding that new primary qualities “cannot be imagined.” This is what it looks like, in retrospect, when one pins one’s theory to the best fundamental science of the day. When that science collapses—as sciences are prone to do—one’s theory collapses with it. Even so, by following the Aristotelian framework of the elemental qualities, Fracastorius was able to arrive at the germ theory of disease.

#### 4. Projection

In contrast to at least some seventeenth-century formulations, the Scholastic distinction between primary and secondary qualities is completely unrelated to the appearance–reality gap. This has given rise to a great deal of nonsense about what the Scholastics thought about the relationship between our sensations and the sensible qualities of objects. Admittedly, it is hard to know exactly what they thought in this area, because they hardly ever talk about phenomenal experience. They talk about acts of sensation and thought, to be sure, and they talk about the representational content of those acts, but the what-it-is-like of the experience itself is not usually a subject of interest. Even so, two sorts of quite erroneous claims have frequently been made about Scholastic thought in this domain: first, that color and the other secondary qualities are primitive, *sui generis* features of reality; second, that they are exactly like our experience of them.<sup>9</sup>

<sup>9</sup> For primitiveness, see Peter Alexander, *Ideas, Qualities and Corpuscles* p. 41: “Questions such as ‘What makes this substance yellow?’ were likely to be regarded as the most fundamental kind of question about natural phenomena and as representing the point at which questioning had to stop because we are at the limits of observation.” For exact resemblance to experience, see Robert Adams, “Flavors, Colors, and God” p. 246: “We do not think there is any quality in physical objects that resembles the peculiar qualities or qualia that make the difference between experiencing red and yellow, or between the taste of sugar and salt. . . . But the

## 52 PRIMARY AND SECONDARY QUALITIES

The first of these can be dispelled quite quickly. Although it is true, as we will see in §6, that Scholastic authors were hardly ever even tempted to deny the reality of the secondary qualities, they certainly did not treat those qualities as primitive in the sense of being explanatorily basic. Instead, as we have seen, it is the Aristotelian primary qualities—Hot, Cold, Wet, and Dry—that are basic. The secondary qualities were so-called precisely because they are causally dependent and supervenient on those elemental qualities. (Even heat, as we perceive it, can be explained in terms of an elemental mixture in which the primary quality of Heat is particularly prominent.) Moreover, and for the same reason, the secondary qualities were as far from being *sui generis* as is possible within the Aristotelian scheme. To categorize them as qualities was to group them with the primary causal agents in the natural, sublunary world, the elemental qualities that underlie all alteration, generation, and corruption. Color and the rest were therefore given as naturalistic a treatment as one could hope for at the time, embedded squarely within the best available natural science.

The second misunderstanding is trickier. The usual term for the thesis that the secondary qualities are exactly like our experiences of them is *Projection*. Ordinarily, Projection is understood as an error theory in the philosophy of perception: it is the view that we erroneously project characteristics of our sensory experiences out onto the external world. But the Scholastics are often charged with holding Projection as an affirmative thesis: that we rightly project features of experience out onto the world, because the world really does possess the various phenomenal characteristics of our sensory experiences. One possible basis for what we might call Veridical Projection is the standard Scholastic thesis that all cognition requires a likeness between cognizer and cognized. The likeness thesis was a frequent target of criticism in the seventeenth century.<sup>10</sup> Yet for it to yield Veridical Projection, it would have to be construed in a very strong and implausible way. When a perceiver sees color, for instance, and so has a phenomenal experience of a color, the color would have to resemble the phenomenal experience itself: the colors would then be exactly as the experience is. The word “exactly” here can mean only one thing: that the qualities in the world are like our sensations all the way down to the phenomenal experience itself: that the experience

typical opinion of Aristotelian Scholastics was that phenomenal qualia are similar to, and produced by, physical qualities that we perceive in bodies by means of the qualia. There is a qualitative ‘form’ in the sugar that is like the quality of the taste of sugar that makes it different from the taste of salt. The quality of the appearance of red that makes it different from the appearance of yellow resembles a form or quality that is present on the surface of a typical ripe apple.” John Cottingham, “Descartes on Colour” p. 238, gets both these notions into the same sentence: “What is denied is the inherence of redness *qua* redness—redness construed as a certain sort of *sui generis* quality supposed to inhere in objects in a way that exactly matches our sensory awareness of it.”

<sup>10</sup> Locke’s attack on resemblance seems to describe the doctrine of Veridical Projection exactly: “Flame is denominated hot and light; snow, white and cold; and manna, white and sweet, from the ideas they produce in us: Which qualities are commonly thought to be the same in those bodies that those ideas are in us, the one the perfect resemblance of the other, as they are in a mirror; and it would by most men be judged very extravagant, if one should say otherwise” (*Essay* II.8.16).

itself is somehow in the external world. If less than that is meant—if the claim is merely that our experiences in some respect or another resemble the sensible qualities they represent—then the thesis is far from being implausible, and may even be true. The Scholastics, however, were committed only to this weaker thesis, not to exact resemblance. We can see as much by looking more closely at the likeness thesis as they formulated it. First, it is motivated not by a theory of what the secondary qualities are, but by a general Aristotelian principle about causality: that all effects resemble their causes. That this is the motivation is clear from how authors defend the likeness thesis, and also from their willingness to apply the likeness thesis to all cognition, sensory and intellectual. Second, the very fact that the likeness thesis gets applied to intellectual cognition should make us extremely wary about understanding it in a crude and literal fashion: what would it be for the essence of horse to be exactly like our idea of horse? Third, many Scholastic authors make it clear that they understand likeness in very broad terms that do not require the cognition itself to be exactly like the thing it represents. Suárez, to take just one example, while accepting that the objects of cognition are a formal likeness of the intentional species in the cognitive faculty that represents them, denies that these species have to be “of the same kind” as objects in the world. Ordinary resemblance may require sameness of kind, but “representational likeness” is special, and can obtain between very different sorts of entities (*In De an.* 5.2 concl. 2).

Creating a *sui generis* category of representational likeness is doubtless unhelpful if one is trying to explain mental representation in terms of some better-understood concept. Even so, the passage makes it clear that Scholastic talk of likeness between cognizer and cognized does not require supposing that the secondary qualities are exactly as they appear to be. Admittedly, here, as always, one has to be cautious in overgeneralizing about Scholastic views. Suárez is responding to Durand of St. Pourçain, who did insist that likeness requires sameness of kind. Durand was probably the inspiration for William Crathorn, a few years later in the early fourteenth century, who notoriously insisted that we can perceive colors and other sensible qualities only if the sensory faculty literally takes on the quality in question, becoming red and round, for instance.<sup>11</sup> But even these authors who take likeness quite literally are not endorsing Veridical Projection. Crathorn thinks that the visual power becomes red when it sees red, but this does not mean that phenomenal experiences are projected out onto the world. On the contrary, for Crathorn, the world’s sensible qualities are projected into the mind. In general, then, the

<sup>11</sup> Durand of Saint-Pourçain relies on his insistence on sameness of kind to show that angels do not have intelligible species (*Sent.* II.3.6 n. 17), and that human beings cannot perceive God through any species that serves as a likeness of God (*ibid.*, IV.49.2 n. 13). For Crathorn, see *Sent.* I.1 (tr. Pasnau, *Cambridge Translations* pp. 285–90; see also my *Theories of Cognition* pp. 101–5). Aquinas, like Suárez, insists that the resemblance found in cognition is distinct from ordinary resemblance (see, e.g. *Quaest. de veritate* 2.3 ad 9). Brower and Brower-Toland, “Aquinas on Mental Representation,” have recently argued that he treats cognitive resemblance as “primitive or *sui generis*.”

## 54 PRIMARY AND SECONDARY QUALITIES

Scholastic commitment to analyzing mental representation in terms of likeness provides no evidence for the thesis that they endorse Veridical Projection.

There is, however, more than just a lack of evidence here; there is also a kind of pragmatic impossibility. We could justly ascribe the thesis of exact likeness—that is, Veridical Projection—to the Scholastics only if we could find an author who sets the thesis out in reasonably explicit terms. But Veridical Projection is a thesis that, as soon as it is set out in explicit terms, shows itself to be incoherent. Anyone who gets far enough along to distinguish phenomenal experiences from things in the world, and then considers whether the latter might be exactly like the former, has to see immediately that the thesis is impossible. There could certainly be isomorphic elements between sensation and object—that is what the likeness thesis in its weak and plausible form must maintain—but it is simply incoherent to think that inanimate objects could be exactly like phenomenal experiences. George Berkeley surely put it too strongly when he famously remarked that “an idea can be like nothing but an idea; a colour or figure can be like nothing but another colour or figure” (*Principles* I.8), but the claim is manifestly true when directed at the sort of exact likeness that Veridical Projection insists on. Inanimate objects cannot be characterized in terms of phenomenal experiences—that follows directly from their being *inanimate*. So not only is there no evidence that the Scholastics endorsed Veridical Projection, but it is actually impossible that they could have explicitly done so. This is not to deny that many people throughout history have been implicitly under the spell of Projection: no doubt there are many who, failing to grasp the appearance–reality gap, have treated the appearances as if they were reality. Perhaps even some philosophers have been under the spell. But there is a pragmatic impossibility in ascribing Veridical Projection to someone as a philosophical thesis, because even to articulate the thesis requires enough sophistication to see immediately that the thesis is incoherent.

### 5. Revelation

Although it is not plausible to suppose that any Scholastic authors defend Veridical Projection, I think it can be shown that they often defend a different thesis, *Revelation*. I use this label in the same way it is used in modern discussions, as the thesis that sensory experience reveals the very nature of the sensible qualities.<sup>12</sup> To have a standard visual experience of red, for instance, is to know essentially what red is. One might suppose that the only way to believe Revelation is to embrace either Veridical Projection or Anti-Realism, where the latter is the thesis that sensible qualities do not exist in the external world. If sensible qualities either are nothing other than sensory experiences, or else exactly resemble those experiences, then Revelation might plausibly be maintained. Could it be maintained otherwise? I believe that Scholastic authors commonly

<sup>12</sup> The classic statement of Revelation is in Mark Johnston, “How to Speak of the Colors.”

supposed so. The idea would be that while the senses do not reveal everything about the secondary qualities of material objects, they reveal enough to give us a clear sense of what those qualities are.

From the Scholastic perspective, there is a great deal that the senses could not conceivably reveal about the secondary qualities. They could not, for instance, reveal that these qualities are accidents, or that they belong to the Aristotelian category of Quality. These are metaphysical, not empirical results. The senses also could not reveal that the secondary qualities are caused by, and supervene on, the primary qualities, or that the different hues of color are caused by black and white intermingling in different degrees (see Aristotle, *De sensu* ch. 3). These are theses of natural philosophy that are not immediately revealed to sensation. One might well wonder just what content that leaves for the thesis of Revelation. What it leaves, most notably, is that the senses reveal the quality spaces of the different secondary qualities. This is to say, for instance, that although vision does not show anything about the metaphysical status or causal bases of color, it does show everything there is to be shown about the differences among the colors. Orange is similar to red; red is similar to purple; purple is more similar to blue than to green. These are important facts about color that anyone knows just by looking at the colors; indeed, it is plausible to say that they are in some sense the essence of the colors. No doubt there are other facts about color that sight reveals, but these seem the best candidates for supporting Revelation.

These remarks regarding Revelation are somewhat speculative, because Scholastic authors do not discuss the issue in enough detail to get very clear about their view. Why, then, should we think they endorsed Revelation at all? One reason is their treatment of the secondary qualities as paradigmatic examples of manifest qualities. To be manifest involves more than simply being immediately observable; if that were all it meant, then magnetism—the paradigmatic occult quality—would count as manifest. The secondary qualities are manifest, then, because in seeing them one sees not just *that* they are, but further one sees *what* they are. Thus Aquinas remarks that “if there are things that are known to us in their own right—such as heat, cold, whiteness, and the like—these are not denominated by other things. Hence in such cases that which the name signifies is the same as that through which the name is imposed to signify” (*Summa theol.* 1a 13.8c). Most things get their reference fixed via some sort of accidental or extrinsic feature, but in the case of the secondary qualities we grasp immediately their very nature.

Further evidence comes from discussions of the Aristotelian dictum that one who lacks some sense must lack some corresponding knowledge (*Post. an.* I.18, 81a38). Scholastic authors understand this to mean that someone who lacks vision, say, will also lack knowledge about colors. But then the question arises of whether someone would truly be barred from knowledge of a certain secondary quality without the corresponding sense. If the secondary qualities were primitive, *sui generis* properties, then the answer might seem to be clearly yes. But given that this is not the Scholastic view, and that instead we understand their underlying causes, one might think that one

56 PRIMARY AND SECONDARY QUALITIES

*could* grasp the secondary qualities without being able to perceive them. Thus John Buridan remarks:

The entire difficulty in this question is why through a knowledge of the [primary] tangible qualities we cannot come to a knowledge of [e.g.] flavors or odors, since these are their causes, just as in many other cases we go from knowledge of causes to knowledge of effects, and conversely. (In *Post. an.* I.28c)

Buridan goes on to allow that this is possible: even someone blind from birth can acquire knowledge (*scientia*) about color. Such knowledge will be “confused,” however, in the technical sense of failing to discriminate between cases of different kinds. So Buridan’s final conclusion is that “if we lack a sense from birth then it is impossible for us, with respect to the sensibles proper to that sense, to acquire naturally a knowledge of the quidditative concepts of those sensibles” (ibid.). That is, only someone who has known what it is like to see colors can know what colors essentially are. This conclusion would seem to depend on Revelation. Although Buridan does not attempt to characterize these “quidditative concepts” of the secondary qualities that we grasp through the senses, his point is that the senses, and only the senses, show us the secondary qualities as they are.

The same idea is spelled out somewhat more, two centuries later, in Domingo de Soto’s treatment of this same question. De Soto’s discussion, although quite different in its details, reaches essentially the same conclusion as Buridan’s. The congenitally blind can know something about colors: they can know, for instance, that one color dilates sight whereas another contracts it, that the stuff that is known by taste as milk is white, and that white is what dilates sight. Still, the congenitally blind cannot have knowledge of colors “through proper and quidditative concepts”:

This is proved, because the blind do not properly understand what it is for whiteness to dilate sight and for blackness to contract it,<sup>13</sup> but through a comparison to sound or taste. Nor do they understand the difference between white and black, red and green; instead, they have concepts of these that are just like those that I have when I discuss some sixth sense—whether, that is, God could make another sense by which I would perceive another sensible distinct from the five kinds of sensibles. (In *Post. an.* I q. 6, p. 388a)

De Soto mentions two shortcomings in a non-visual grasp of color. First, the knowledge that whiteness “dilates sight” (line 1) is not “proper” in the way it would be if one could actually sense whiteness. Second, a non-visual grasp of the colors does not reveal the differences between them. Given these remarks, however, which are all De Soto gives us, one might suppose that the blind *could* acquire a proper and distinctive grasp of the colors. Dilation and contraction are evidently mechanical events that can be grasped in all of their details without any visual information: why, then, couldn’t someone blind grasp the distinctive event that occurs when white acts on sight?

<sup>13</sup> See Plato, *Timaeus* 67d–e. (I owe this reference to Mark Smith.)



Similarly, given that the secondary qualities supervene on the primary qualities, why couldn't one arrive at a perfectly "proper" understanding of a given color by coming to grasp just what mixture of elemental qualities gives rise to it? What De Soto must be supposing, although he does not say so explicitly, is that even these sorts of determinate, uniquely specifying accounts would leave out the essence of what the colors are. One can specify just how much a given color dilates sight, but without having the experience, one is not grasping the "quiddity" of the color itself. Similarly, one could know what elemental mixture causes a given color, but a proper, quidditative grasp of color requires grasping the visual differences between the colors.

More would need to be said to make this line of thought plausible, but even in their schematic form, these passages are extremely good evidence for the doctrine of Revelation. Indeed, the texts are so suggestive that they might seem to betray a commitment to the much stronger doctrine of Veridical Projection. For why would one suppose that the essence of the secondary qualities is revealed only by perception, unless one thought that the perceptual experience itself is something that the quality in the world possesses? Admittedly, it is possible that this incoherent notion is what motivates either Buridan or De Soto. But this is something that they neither say nor are committed to, inasmuch as there is room to defend Revelation without Veridical Projection. One can think that the phenomenal features of experience display the essential features of the secondary qualities—the space of similarities between them—without taking the further, incoherent step of supposing that the secondary qualities *possess* the phenomenal features of experience. Accordingly, if charity is to count for anything as a principle of interpretation, it should lead us to read these authors as committed to Revelation, not Veridical Projection.

## 6. Realism

Realism, as I will use the term here, is the doctrine that the secondary qualities exist in the external world. (Anti-Realism is simply the denial of Realism.) Before Galileo, Anti-Realism is virtually unheard of—one needs to go all the way back to Democritus to find a defense of it. According to the usual misunderstandings of the Scholastic theory of the secondary qualities, it would have been quite inconceivable for the Scholastics to have taken an Anti-Realist position, inasmuch as the senses show the world to be populated with irreducible qualities that are exactly as they seem to be. In fact, however, Anti-Realism was a more tempting option for Scholastics authors than is ordinarily realized, and the reasons why they nevertheless resisted it are worth examining.

It is useful to distinguish two motivations for Anti-Realism. The first arises from the appearance–reality gap, and relocates the secondary qualities, moving them from external bodies into the mind. This is, in effect, a response to Projection: it amounts to supposing that we have been confusing the mental and the physical, and proposes to

untangle the mess by relocating the secondary qualities. The second form of Anti-Realism is eliminativist. It takes its inspiration from a reductive account of the secondary qualities in terms of other, primary qualities, and then decides that, in truth, there are no secondary qualities at all.

Although Scholastic authors were aware of both of these possibilities, the second option was by far the more tempting, inasmuch as various analogous cases made eliminativism look plausible. The four elements, for instance, along with their substantial forms, were usually thought to cease existing when mixed together. Within a mixture, according to the standard view, there is only the mixed body and its substantial form (gold, for instance, and the substantial form of gold). There are no further substantial forms for the elements, because the elements do not actually exist within the mixed body. The details here were hotly disputed, but the basic view was widely accepted. A similar sort of reduction was often proposed for the elemental qualities: that they too, being accidents of the elements, could no longer exist once the elements themselves were corrupted by mixture. Here too there was considerable disagreement, and some authors held that the elemental qualities do remain within a mixed body, but the issue was at any rate widely debated.<sup>14</sup>

If mixture results in the elements and their qualities ceasing to exist, then it is natural to wonder how much further this might go. No one proposed eliminating the primary qualities altogether, given their vital causal role in natural philosophy. But might the secondary qualities be reduced, or even eliminated, so that instead of supervening on the primary qualities they would, in fact, be nothing more than a mixture of primary qualities? Although this question was not widely discussed, authors with strong inclinations toward parsimony were sometimes tempted. Richard Fitzralph reports in his *Sentences* commentary (c.1328) that he himself had once succumbed:

Some say that every color is light (*lux*), that every flavor is a mixture of primary qualities, and that odor is flavor. Indeed I at one point did not believe that anything exists other than substance or the five qualities—namely, the four elemental qualities and light (*lux*)—supposing there to be a small number of things. The reason was that I was focused on these few things, and I could preserve those by this stance. Hence I believed it to be true, in accord with that principle stated above [that if something can be done through few just as it can through more, then it is better than it be done through few rather than more]. And in this way those who have been well trained in logic err in recognizing too few things, whereas others who are ignorant of logic ascribe to every statement a new entity (*res*), postulating more entities than God has ever established as real.  
(*Sent.* II.1.2, in Maier, *An der Grenze*, p. 16n)

Anti-Realism is here depicted as a natural consequence of the sort of parsimonious ontology that would come to be associated with nominalism. And indeed, once one gets down to an ontology of substances and qualities, the natural next step is to think

<sup>14</sup> For Scholastic disputes over mixture see Wood and Weisberg, “Interpreting Aristotle on Mixture.”

about whether one can make do with fewer kinds of qualities. Given that the secondary qualities both supervene on the primary qualities and yield almost all causal activity to the primary qualities, it is no wonder that Fitzralph was tempted to go farther and simply eliminate them.

Ultimately, Fitzralph changed his mind about this, and I have found no one else before the seventeenth century who comes so close to Anti-Realism. The main reason would seem to be that they played a limited but important causal role that was mentioned briefly earlier: they give rise to intentionally existing species in the surrounding medium, which in turn give rise to our sensations of those qualities. Here is Paul of Taranto, the late-thirteenth-century alchemist, in a passage already quoted in part:

The aforesaid secondary qualities are not of themselves properly active on a given nature except *per accidens*, for they are properly active of themselves on sense through their species, according to the spiritual and intentional existence that these species have, and not according to their natural existence, except *per accidens*. For color moves sight according to the intentional existence that it has in the transparent medium, and not according to the natural existence it has in natural things, and taste as taste, of itself, moves the sense and not nature, for a similar reason. And it is not taste that nourishes, but food and drink—namely, the substance that *has* the taste. Thus taste acts on nature only through something else, namely Hot, Cold, Dry, and Wet, which are in the flavorful thing. Nor can any of the secondary qualities act within the nature and essence of anything, except through the primary qualities.

(*Liber veritatis*, pp. 8–9)

This was the standard Scholastic view: the secondary qualities do not act naturally on the world, but do act through spiritual/intentional qualities. This causal role is incompatible with Anti-Realism. For Scholastic authors, the principal test for the reality of any accident is whether the supposed accident does anything in the world, such that its elimination would leave a causal void. Applying this test to the case of the secondary qualities, Scholastic authors were universally realists.

The result is that color and other secondary qualities, just as much as the four elemental primary qualities, take their place among the real accidents that would be the subject of such ferocious criticism in the seventeenth century. In reading those criticisms, it is important to understand that the distinction between primary and secondary qualities is not being invented out of whole cloth. It is instead a familiar, even famous, Scholastic doctrine, which the seventeenth-century critics of Scholasticism would neither wholly accept nor wholly reject, but rather tailor to their own purposes.<sup>15</sup>

<sup>15</sup> The material in this chapter appears in a somewhat different form in *Metaphysical Themes 1274–1671*, where I go on to discuss the rejection of qualities in the post-Scholastic era. I owe thanks to Larry Nolan and an anonymous reader for helpful comments.

## Bibliography

- Albert of Saxony. *Questiones subtilissime in libros de generatione* (Venice, 1505; repr. Frankfurt: Minerva, 1970).
- Albert the Great. *Opera Omnia*, ed. P. Jammy (Lyon, 1651).
- Alexander, Peter. *Ideas, Qualities and Corpuscles: Locke and Boyle on the External World* (Cambridge: Cambridge University Press, 1985).
- Adams, Robert M. “Flavors, Colors, and God,” in *The Virtue of Faith and Other Essays in Philosophical Theology* (Oxford: Oxford University Press, 1987) 245–47.
- Aristotle. *The Complete Works of Aristotle: The Revised Oxford Translation*, ed. J. Barnes (Princeton: Princeton University Press, 1984).
- Benedictus Pererius. *De communibus omnium rerum naturalium principiis et affectionibus* (Paris, 1579).
- Berkeley, George. *Berkeley’s Philosophical Writings*, ed. D. M. Armstrong (New York: Macmillan, 1965).
- Boethius of Dacia. *Opera*, ed. J. Pinborg et al. (Copenhagen: DSL/Gad, 1969–).
- Brower, Jeffrey and Susan Brower-Toland. “Aquinas on Mental Representation,” *Philosophical Review* 117 (2008) 193–243.
- Collegium Conimbricense. *Commentarii Collegii Conimbricensis in libros de generatione et corruptione Aristotelis* (Cologne, 1606; repr. Hildesheim: G. Olms, 2003).
- Cottingham, John. “Descartes on Colour,” *Proceedings of the Aristotelian Society* 90 (1989–90) 231–46.
- Domingo de Soto. In *Porphirii Isagogen, Aristotelis Categorias, librosque De demonstratione absolutissima commentaria* (Venice, 1587; repr. Frankfurt: Minerva, 1967).
- Durand of St. Pourçain. In *Petri Lombardi Sententias theologicas commentarium libri quatuor* (Venice: ex typographia Guerraea, 1571; repr. Ridgewood, NJ: Gregg, 1964).
- Eustachius a Sancto Paulo. *Summa philosophiae quadripartita* (Cambridge, 1648) [first ed. 1609].
- Francisco Suárez. *De anima: Commentaria una cum quaestionibus in libros Aristotelis De anima*, ed. S. Castellote (Madrid: Sociedad de Estudios y Publicaciones, 1978).
- Franciscus Toletus. *Opera omnia philosophica* (Cologne: Birckmann, 1615–16; repr. Hildesheim: G. Olms, 1985).
- Giles of Orleans. *Quaestiones super De generatione et corruptione*, ed. Z. Kuksewicz (Amsterdam: B. R. Grüner, 1993).
- Hieronymus Fracastorius. *De contagione et contagiosis morbis et eorum curatione libri III*, ed. W. C. Wright (New York, Putnam, 1930).
- John Buridan. *Quaestiones super De generatione et corruptione*, ed. M. Streijger (Leiden: Brill, forthcoming).
- “Quaestiones in duos Aristotelis libros Posteriorum Analyticorum,” ed. H. Hubien (unpublished manuscript).
- Johnston, Mark. “How to Speak of the Colors,” *Philosophical Studies* 68 (1992) 221–63.
- Maier, Anneliese. *An der Grenze von Scholastik und Naturwissenschaft*, 2<sup>nd</sup> ed. (Rome: Edizioni di Storia e Letteratura, 1952).
- *On the Threshold of Exact Science: Selected Writings of Anneliese Maier on Late Medieval Natural Philosophy*, tr. S. Sargent (Philadelphia: University of Pennsylvania Press, 1982).
- Newman, William R. *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006).

- Nicole Oresme. “Quaestiones super libros Physicorum,” ed. S. Caroti et al. (unpublished draft).
- Pasnau, Robert. “Sensible Qualities: The Case of Sound,” *Journal of the History of Philosophy* 38 (2000) 27–40.
- *Cambridge Translations of Medieval Philosophical Texts. Volume 3: Mind and Knowledge* (New York: Cambridge University Press, 2002).
- *Metaphysical Themes 1274–1671* (Oxford: Oxford University Press, forthcoming).
- Paul of Taranto. *Liber tam theoricæ quam practicæ veritatis in arte alchimica*, ed. W. R. Newman, in *The Summa Perfectionis and Late Medieval Alchemy: A Study of Chemical Traditions, Techniques, and Theories in Thirteenth-Century Italy* (Ph.D. dissertation: Harvard University, 1986).
- Paul of Venice. *Summa philosophiæ naturalis* (Venice, 1503; repr. Hildesheim: Olms, 1974).
- Scheibler, Christoph. *Philosophia compendiosa*, 6th ed. (Oxford, 1639).
- Schmitt, Charles and Quentin Skinner (eds.). *The Cambridge History of Renaissance Philosophy* (Cambridge: Cambridge University Press, 1988).
- Thomas Aquinas. In *Aristotelis libros De caelo et mundo, De generatione et corruptione, Meteorologicorum expositio*, ed. R. M. Spiazzi (Rome: Marietti, 1952).
- *Summa theologiæ*, ed. P. Caramello (Rome: Marietti, 1950–53).
- Walter Burley. *De formis*, ed. F. Scott (Munich: Verlag der Bayerischen Akademie der Wissenschaften, 1970).
- William Crathorn. *Quæstionen zum ersten sentenzenbuch*, ed. F. Hoffmann (Münster: Aschendorff, 1988).
- Wood, Rega and Michael Weisberg, “Interpreting Aristotle on Mixture: Problems about Elemental Composition from Philoponus to Cooper,” *Studies in History and Philosophy of Science* 35 (2004) 681–706.