QUALITIES

Samuel C. Rickless

[To appear in *The Routledge Companion to Seventeenth Century Philosophy*]

1. Introduction

One of the more interesting philosophical debates in the seventeenth century concerned the nature and explanation of qualities. In order to understand this debate, it is important to place it in its proper historical-philosophical context.

In the Aristotelian metaphysics inherited by seventeenth century philosophers from their late medieval Scholastic predecessors, the natural world is a world of substances (human beings, sheep, geraniums, statues, rocks), themselves combinations of matter and substantial form. A human being is made of flesh, blood, and bone (its matter), and is made into the kind of thing that it is by its soul (its substantial form); a statue is made of, say, bronze (its matter), and is made into the kind of thing that it is by its shape (its substantial form). A human body without a soul is not a human being; a lump of bronze without its distinctive shape is not a statue. On the Scholastic picture, human beings and statues also possess accidental forms (or simply, accidents), namely characteristics of substances that are not substantial and that the substances can lose without ceasing to be the kinds of substances they are. But what exactly are the accidents of substances?

Accidents divide into two main categories: the manifest and the hidden. There are, first, the sensible characteristics of substances, properties or qualities that can be perceived by means of the five senses (sight, hearing, smell, taste, and touch).[1] These

properties include motion (and rest), shape, size, position, texture, color, sound, odor, flavor, and tangible qualities (including heat, cold, dryness, wetness, roughness, and smoothness). But there are also occult characteristics of substances, qualities that cannot be perceived by means of the senses. The most important occult qualities were thought to be gravity (or weight, the tendency to fall towards to the center of the earth), magnetism, and (static) electricity. Aristotelians had fairly well worked out accounts of the nature and explanation of sensible properties, but struggled (understandably) to account for occult phenomena. In the seventeenth century, the opponents of Aristotle offered competing accounts of sensible properties, and thought it might be possible to vindicate their theories by accounting for occult phenomena as well.

The story of the seventeenth century is the story of a scientific revolution, prompted in part by the gradual replacement of the fundamental presuppositions of Aristotelian science by the basic principles of corpuscularian mechanism, namely matter and motion. Although the mechanists did not do away with substances, they either did away with immaterial substantial forms or found the need to appeal to such entities explanatorily redundant. But the elimination of substantial forms does not automatically translate into the elimination of accidental qualities: from the fact that a material substance (such as a statue) does not (or need not be understood to) consist in a composite of matter and substantial form, it does not follow that the statue does not have a shape, or size, or color, or smell. The new mechanists of the seventeenth century were therefore left with the following question: What is the place of accidental qualities in a mechanistic ontology?

In order to answer this question, mechanists needed to decide where, if anywhere, in the world accidental qualities exist. Are they in or on the material objects of perception (such as flowers and statues)? Are they in or on some perceptual medium (such as air or water) that lies between perceivers and the objects they perceive? Are they in the perceiving body's sense organs? Or are they in the (incorporeal) minds of perceivers themselves? Given their shared assumptions about the ultimate furniture of the physical world and the proper form of scientific explanation, one might have expected the mechanists to converge on one answer (or, at least, on a small number of similar answers) to these questions. But, perhaps surprisingly, there was no convergence; indeed, there was a veritable explosion of alternatives.

On some, but by no means all, of these alternatives, the realm of sensible qualities divides neatly into two: there are primary qualities (such as shape, size, motion, and position) and secondary qualities (such as color, sound, odor, taste, and tangible characteristics).[2] For those who make this distinction, primary qualities are explanatorily basic: the existence of any secondary quality associated with a material object (and, indeed, the existence of any occult quality) is to be explained by the existence and arrangement of the object's primary qualities (or by the existence and arrangement of the primary qualities of the object's insensible material parts)[3], but not vice versa. It is widely believed that because mechanists were the first to distinguish between primary and secondary qualities, the distinction is a consequence or natural outgrowth of mechanism. But this, as we will see, is a mistake.

The purpose of this essay is to articulate, and reconstruct some of the main reasons for and against, the various positions taken by seventeenth century philosophers

on the question of the nature, location, and explanation of sensible qualities.[4] Part of my aim is to understand why there was so much disagreement in the context of widespread agreement on fundamentals.

This chapter is divided into the following sections. In section 2, I discuss the Aristotelian picture in opposition to which the new mechanists of the seventeenth century defined their theories of sensible qualities. In section 3, I discuss the intellectual seeds of mechanism that lie in ancient Greek and Roman atomism (as represented by Democritus, Epicurus, and Lucretius). In section 4, I explain how the new mechanists understood motion and rest (with some brief discussion of shape and size), and how their views contrast with the corresponding Aristotelian picture. In section 5, I focus on the new mechanists' theories of light, in large part because these theories shape their theories of color. In section 6, I discuss the new mechanists' theories of color. In section 7, I turn to the new mechanists' theories of sound, noting that their theories of other sensible qualities (such as odor, flavor, and tangible qualities) are modeled in large part on their theories of color and sound. In section 8, I explain how some, but not all, of the new mechanists thought that primary qualities (motion, shape, size, position, texture) are ontologically distinct from secondary qualities (color, sound, odor, flavor, and tangible qualities). In section 9, I outline and evaluate the reasons for the primary/secondary quality distinction advanced by two of its influential proponents. And in conclusion, I summarize and explain the significance of the seventeenth century debate about the nature, location, and proper explanation of sensible qualities.

2. The Theoretical Background: Aristotle

The idea of dividing the world into substances and their various characteristics derives from Aristotle. In the *Categories*, Aristotle claims that there are two fundamentally different kinds of entities. There are, in the first place, entities that are not in (that do not inhere in) any other entity: these are substances (*Cat*. 3a; *Phys*. I.2, 185a). And there are, in the second place, entities that are in (that do inhere in) other entities: these are (following the Scholastic tradition) accidents. Thus, Socrates is a substance, inasmuch as he does not inhere in anything else. But the paleness and size of Socrates are accidents inasmuch as they inhere in Socrates.

Seventeenth century philosophers were well aware of Aristotle's theories of the nature and explanation of sensible qualities and, within the category of occult qualities, of gravity.[5] Perhaps the most important sensible quality within the burgeoning mechanism of the seventeenth century is motion. For Aristotle, local motion, which is an accident of body, is a species of the more general category of motion (or change). Change is always with respect to one of the four main categories: substance, quantity, quality, or place. Change with respect to substance is coming-to-be (as in the building of a house); change with respect to quantity is increase or decrease; change with respect to quality is alteration (as in the change from white to black); and change with respect to place is local motion (or locomotion). Striving for a characteristic that all of these forms of change have in common, Aristotle arrives at a general definition of change as the fulfillment (or actualization) of what is potential as potential (*Phys*. III.1, 200b-201b); so, for example, building, which is a kind of change with respect to substance, is the putting together of (say) bricks and mortar, insofar as they are potentially a house.

Famously, Aristotle claims that there are two kinds of local motion: natural and violent. A body moves naturally when it derives its motion from itself; it moves violently when it derives its motion from something else, as when it is pushed, pulled, carried, or twirled (*Phys*. VIII.4, 254b; *Phys*. VII.2, 243a). On Aristotle's view, everything in the sublunary world is composed of four elements: earth, water, air, and fire (*GC* II.3, 330a-b). The superlunary world is composed of a fifth element: ether. Each of the four sublunary elements has a natural place, a place in which it naturally belongs and to which it naturally moves without being pushed or pulled, in a straight line. (Ether's natural motion is circular.) Earth and water naturally move downwards, air and fire naturally move upwards (*DC* I.2, 268b-269b).[6]

Aristotle's account of light and color, sound, odor, flavor, and tangible qualities (hot and cold, wet and dry, smooth and rough, and so on) was also very influential. For Aristotle, sensible qualities do not differ in ontological status. Just as shape and size belong to the body with that shape and size, so redness belongs to the red body and sweetness belongs to the sweet body, regardless of whether it is perceived to be red or sweet. Sensible qualities do differ epistemically, but only in the sense that some qualities (the "common sensibles", motion, rest, shape, and size) can be perceived by more than one sense (e.g., motion and shape can be both seen and felt), while other qualities (the "proper sensibles", color, sound, odor, flavor, and heat/wetness/roughness) can be perceived by no more than one sense (color by sight, sound by hearing, odor by smell, flavor by taste, and heat/wetness/roughness by touch).

Let us begin with Aristotle's theory of light. According to Aristotle, some media (such as air and water) are potentially transparent. That is, they have the capacity to

become transparent under certain conditions. Light, as Aristotle defines it, is no more than the actuality of what is potentially transparent, an actuality that is itself brought about (or constituted) by the presence of a fiery element in the relevant medium (*DA* II.7, 418a-419a; *DS* 3, 439a). But Aristotle is adamant that light is to be identified neither with this fiery element nor with any kind of body, including purported corporeal emanations or effluvia, and criticizes Empedocles' doctrine that light travels on the grounds that we do not see it move, not even across vast distances (*DA* II.7, 418b). Indeed, it is an important aspect of Aristotle's theory that light is incorporeal.

Consider now Aristotle's theory of color. A body's color exists whether the body is illuminated or not, but its color is not visible in the absence of light (*DA* II.7, 418b, 419a). For Aristotle, color is to be defined as the limit of the transparent in determinately bounded body (*DS* 3, 439b), and color makes itself seen by setting the actually transparent medium (e.g., air) in motion, motion that extends continuously from the colored body to the organ of sight, thereby setting the latter in motion (*DA* II.7, 419a). In some places, Aristotle characterizes light as the proper color of what is transparent (*DA* II.7, 418b) or the color of the transparent incidentally (*DS* 3, 439a). Although it is not clear that these definitions are mutually coherent, seventeenth century Aristotelians did not much mind. So, for instance, the Aristotelian corpuscularian physician, Daniel Sennert, writes both that "light it self inasmuch as it is said to be seen, is comprehended under colour, and is as it were a whiteness," and that color is "*the Extremity of a transparent thing terminated*" (*TBNP* VII.2, 372).

Aristotle's theory of sound is quite modern inasmuch as he identifies sound with the motion of air when its dissipation is prevented, as occurs in the ear canal (*DA* II.8,

420a). But his theory of odor is less modern. As he sees it, odor is an immersion or washing of dryness in the moist and fluid (*DS* 5, 445a). Aristotle even criticizes his predecessors for having proposed that odor is constituted by a vaporous or smoky exhalation or emanation from odoriferous bodies. For, on the one hand, water does not have an odor (as anyone can tell by smelling it), and aquatic creatures can smell odors in the absence of any smoky emanation (itself a combination of air and earth) (*DS* 5, 443a-b). Flavor is similar to odor, for it is produced (or constituted) by washing the dry and earthy in the moist and moving the moist by means of heat through the dry and earthy (*DS* 4, 441b).

Aristotle makes it quite clear that the qualities perceived by the sense of touch are manifold. They include the following pairs of contraries: hot-cold, dry-moist, heavy-light, hard-soft, viscous-brittle, rough-smooth, and coarse-fine (*GC* II.2, 329b). Heat and cold are defined, not by what they are in themselves, but rather by what they *do*: heat is what brings together homogeneous things, and cold is what brings together homogeneous and heterogeneous things alike (*GC* II.2, 329b). Dryness is defined as what is readily determinable by its own limit, while moistness is defined as what, though adaptable in shape, is not determinable by any limit of its own (*GC* II.2, 329b). All other tangible qualities are derivable from these four basic qualities—the fine, the viscous and the soft from the moist, the coarse, the brittle and the hard from the dry (*GC* II.2, 330a). Indeed, these qualities are basic, not only in being those from which other tangible qualities are derived, but also in being the factors that differentiate the four elements, fire being hot and dry, air being hot and moist, water being cold and moist, and earth being cold and dry (*GC* II.2, 330b). Indeed, it is the gaining and losing of these qualities that explains the

cyclical conversion of elements. Thus, air results from fire when the dry is overcome by the moist, water results from air when the hot is overcome by the cold, earth results from water when the moist is overcome by the dry, and fire results from earth when the cold is overcome by the hot (*GC* II.4, 331a-b).

3. The Theoretical Background: Atomism

Even before Aristotle, various atomists had articulated an influential account of the nature, structure, and properties of the physical universe. Democritus had argued that because nothing comes from nothing and because it is impossible for nothing to come from something (material), it follows that there has always been and there will always be something (material). Because matter cannot be dissolved into nothing, there must be indestructible material substances. Democritus called these indestructible substances "atoms" (from the Greek word meaning "uncuttable"). In addition to atoms (tangible, solid substance), Democritus reasoned that there must also be intangible substance (empty space, void, vacuum) for otherwise the universe would be packed solid and motion would be impossible. Atoms, which are invisible, form the building blocks of compound, visible bodies. They are infinitely many, and possess shape, size, and motion, but no color, sound, odor, flavor, or tangible qualities. Indeed, Democritus is famously quoted as having said that "by convention sweet and by convention bitter, by convention hot, by convention cold, by convention color; but in reality atoms and void".[7] On this view, atoms have no color, sound, and so on, but also compound bodies only possess such qualities "by convention." This strongly suggests that compound bodies possess color, sound, and so on, only insofar as humans ascribe these qualities to them. In the

absence of "convention", and so in the absence of human perceivers, compound bodies would have no color, sound, odor, flavor, heat or cold, and thus do not possess these qualities in themselves.

Later atomists, most notably Epicurus and Lucretius, agree with Democritus that atoms have no color, sound, odor, flavor, heat, or cold (*DRN* 2, 734-738). In order to possess any of these qualities, a body must emit particles that strike the organs of sense, and yet atoms, being indivisible, are incapable of emitting anything from themselves (*DRN* 2, 845-865). Unlike Democritus, however, Epicurus and Lucretius are not conventionalists about the proper sensibles, for they take all the qualities of compound bodies (including the proper sensibles) to be reducible to, and explicable by means of, the qualities possessed by their constituent atoms. Thus, for example, Lucretius claims that pleasant proper sensibles are produced by smooth and round atoms, that unpleasant proper sensibles are produced by rough and irregularly shaped atoms, and that hardness is produced by atoms that are hooked together (*DRN* 2, 381-477).

Indeed, part of the power of atomism lies in its ability in principle to explain a wide variety of different phenomena. Rare bodies are simply those that possess a great deal of void within their boundaries, while the atoms of dense bodies are more closely packed together. Heat and cold are both "continual streams of particles" (*DRN* 6, 924), particles of heat in the case of heat (*DRN* 5, 599), particles of cold in the case of cold. Lightning is produced when the clashing of clouds causes them to emit particles of fire (*DRN* 6, 160-161). Light itself is "composed of minute particles that hammer one another forward and, under the impulsion of blows from behind, unhesitatingly pass through the intervening air" (*DRN* 4, 185-190).

Unlike Democritus, Epicurus and Lucretius also postulate that atoms have weight that carries them downwards through the void, for otherwise it would be impossible to explain how they come to be in motion (*DRN* 2, 184-215). (If all atoms were at rest and possessed no more than shape and size, there would be no reason for them to move.) Atoms therefore move (downwards) of themselves, and exhibit a kind of natural motion (in Aristotle's sense), even if they are not drawn towards anything. (For the atomists, the infinite extension of the universe guarantees that the universe has no center.)[8]

Given that all bodies are combinations of atoms, it follows that the four elements of Aristotelian physics (namely, earth, water, air, and fire) are not the ultimate building blocks of material substances. Indeed, for the atomists it is a point in favor of their theory that it provides an explanation for the Aristotelian doctrine of cyclical conversion (*DRN* 1, 783-829). And the basic pairs of opposite tangible characteristics that differentiate between the elements in Aristotle's theory (namely, hot/cold and wet/dry) are also explicable on the atomists' theory as the outgrowth of atoms of different shapes, sizes, and weights.

Despite the considerable theoretical virtues of atomism, Aristotle's theory of substance and accidents reigned supreme in the learned world until the seventeenth century. Part of the reason for this was the considerable empirical support for Aristotelian hypotheses, though the alliance of Aristotelian metaphysics and science with Catholic doctrines also played an important role in explaining Aristotle's theoretical dominance. But by the dawn of the seventeenth century, natural philosophers had become increasingly aware of the limitations of Scholastic Aristotelianism. Aristotle's conception of the earth

remaining motionless at the center of the universe had been forcefully countered by Copernicus's heliocentrism. His account of bodily motion as inversely proportional to the resistance of the relevant medium was known to be contradicted by free fall experiments (in which bodies of different weights, and thus bodies incurring different grades of air resistance) left to fall from the same height at the same time were observed to hit the ground at the same time. And his distinction between natural and violent motion was known to be contradicted by the observation of projectile motion (in which heavy bodies that are thrown move upwards despite the fact that they appear to be neither pushed nor pulled). The limitations of Aristotelianism made the relative advantages of Lucretian atomism shine forth more brightly. Philosophers were well aware of the problem of explaining the possibility of motion in the absence of a void, of the fact that various phenomena (including evaporation and erosion) testify to the existence of insensible material particles, and of the fact that other phenomena (including the porous consistency of many bodies and variations in corporeal density) testify to the existence of a void. At the same time, philosophers were attracted to the relative simplicity of the basic form of atomic explanation in terms of the motion of particles of different shapes and sizes.

So it is against the background of the gradually diminishing influence of Aristotelian physics and the gradually increasing influence of atomic physics that the mechanists of the seventeenth century contributed some notable theories of sensible qualities.

4. Motion and Rest

Aside from philosophers who, like Sennert, rested many of their own views on the authority and arguments of Aristotle (see *TBNP* I.9), seventeenth century philosophers tended to ridicule Aristotle's general definition of change as the actualization of what is potential as potential. In *The World*, for example, René Descartes writes: "[Aristotelians] have not yet been able to explain [motion] more clearly than in these terms: *Motus est actus entis in potentia*, *prout in potentia est*. For me these words are so obscure that I am compelled to leave them in Latin because I cannot interpret them" (AT XI: 39; CSM I: 93-94). Similarly, Walter Charleton writes that "nothing can be more obscure than" Aristotle's definition of motion (*PEGC* IV.2, 438). And John Locke is, if possible, even more dismissive: "What more exquisite *Jargon* could the Wit of Man invent, than this Definition, *The Act of a being in Power*, *as far forth as in Power*, which would puzzle any rational Man, to whom it was not already known by its famous absurdity, to guess what Word it could ever be supposed to be the Explication of" (*E* III.4.8, 422).

Many of Aristotle's opponents agreed with the atomists, who reduced all motion to *local* motion, namely change of place. Thomas Hobbes, for example, identifies motion as "*a continual relinquishing of one place*, *and acquiring of another*" (*DC* 108). Charleton claims that Aristotle's definition of motion is "much inferior in Perspicuity to that most natural and familiar one of *Epicurus*; that Motion is *the migration or Remove of a body from one place to another*" (*PEGC* IV.2, 439). And early in his career, Descartes agrees: "For my part, I am not acquainted with any motion except that which is easier to conceive than the lines of the geometers – the motion which makes bodies pass from one

place to another and successively occupy all the spaces which exist in between" (AT XI: 40; CSM I: 94).

But several years later, Descartes, who by this point had become more hostile to atomism, changed his mind. In the *Principles*, he distinguishes between two senses of the term "motion": the ordinary sense, which is in accordance with what we can imagine and is appropriately captured by the atomists' definition, and the strict sense, which is "in accordance with the truth of the matter." To understand the strict sense of "motion," it is important to note that, like most of his contemporaries, Descartes treats motion as a mode of substance, that is, as a way for substance to be. Motion is therefore something in the world, not something that is relative to one's perception of the world. But Descartes recognizes that whether one counts as moving in the ordinary sense depends on the frame of reference on which one chooses to focus. Thus, "a man sitting on board a ship which is leaving port considers himself to be moving relative to the shore which he regards as fixed; but he does not think of himself as moving relative to the ship, since his position is unchanged relative to its parts." In order to avoid the relativity of motion that is the natural corollary of the ordinary sense and that is inconsistent with the claim that motion is a mode of material substance, Descartes claims that, in the strict sense, "motion" should be defined as "*the transfer of one piece of matter, or one body, from the vicinity of other bodies which are in immediate contact with it*, *and which are regarded as being at rest*, *to the vicinity of other bodies*" (AT VIIIA: 53; CSM I: 233). This definition avoids the relativity problem Descartes discusses because it tells us that, strictly speaking, the man who is sitting on the ship is absolutely (non-relatively) at rest, given that he is not

being transferred from the vicinity of the ship (even if he is being transferred from the vicinity of the shore).[9]

But not all philosophers were happy with the atomists' definition of motion or with the epicycle Descartes added to it. Locke in particular faults both definitions for being circular and uninformative:

> The *Atomists*, who define Motion to be a *passage from one place to another*, What do they more than put one synonymous Word for another? For what is *Passage* other than *Motion*? And if they were asked what Passage was, How would they better define it than by *Motion*?…[This] is very far from a *Definition*, unless we will say, every English Word in the Dictionary, is the definition of the Latin Word it answers, and that Motion is a definition of *Motus*. *Nor will the successive Application of the parts of the* Superficies *of one Body, to those of another*, which the *Cartesians* give us, prove a much better definition of Motion, when well examined. [*E* III.4.9, 423]

Locke's own view is that the idea of motion is simple, and hence incapable of definition. What the motion of a body is in itself is something to be apprehended by sense experience, rather than by abstract ratiocination.

Many philosophers of the seventeenth century ridiculed not only Aristotle's definition of motion, but also his distinction between natural and violent motion. Natural motion is motion that has an internal cause and that tends towards a natural place. Thus, earth and water tend to move of themselves (without being pushed or pulled) towards the

center of the universe, while air and fire tend to move upwards (again without being pushed or pulled) away from the center of the universe. Violent motion is motion that has an external cause, as in the motion of a cart that is pushed or pulled along a road. It follows from Aristotle's theory that were an earthy object to move in a straight line towards the center of the universe, it would stop and remain at rest there.[10] For Francis Bacon, this consequence was too much to bear:

> Philosophers talk nonsense when they say if a hole were made through the earth, heavy bodies would stop when they came to the earth's centre. For it would surely be a wonderfully powerful and effective kind of nothing or mathematical point which had an effect on other things and which other things would seek; for body is acted on only by body. [*NO* II.35, 158][11]

Bacon here makes clear that the absurdity of the Aristotelian prediction stems from the assumption that bodies can be set in motion *of themselves* without an external material cause. The thesis that local motion (which, as most anti-Aristotelians agreed, is the only kind of motion there is) can only be produced by contact, and that there can therefore be no such thing as action at a distance, was one of the defining features of the new mechanism of the seventeenth century. Indeed, the thesis distinguished the new mechanists not only from Aristotle, but also from Epicurus and Lucretius, for whom atomic motion through the void is a natural result of their intrinsic weight.

Hobbes emphasizes the fact that no body can move of itself:

> *Whatsoever is at rest*, *will always be at rest*, *unless there be some other body besides it*, *which*, *by endeavouring to get into its place by motion*, *suffers it no longer to remain at rest*. [*DC* 115]

His reason for this is that a body that is initially at rest in empty space cannot begin to move unless it is moved, and that it must be moved by something external to it, given that "there was nothing in the body which did not dispose it to rest" [*DC* 115]. This argument is unsatisfactory because it simply begs the question against Aristotle (and, for that matter, against the atomists too). After all, why suppose that a body that is initially at rest is *not* disposed to move of its own accord?[12]

No doubt aware of this problem, Descartes attempts to *prove*, as his first law of nature, that "everything, in so far as it can, always continues in the same state," from which it follows directly that "if [a particular piece of matter] is at rest,…it will never begin to move unless it is pushed into motion by some [external] cause" (AT VIIIA: 62; CSM I: 241). The argument depends on Descartes' proof of the existence of God, who is the general cause of all motions in the world, and who, by reason of his immutability, operates "in a manner that is always utterly constant" (AT VIIIA: 61; CSM I: 240 – see also AT XI: 37-38; CSM I: 92-93). Here, too, the proof leaves something to be desired, for it is unclear why, if God's action is constant, there is any motion (or rest) at all. Isn't it more consistent with God's constancy to suppose (along with Heracleitus) that everything is always in motion or (along with Parmenides) that everything is always at rest?

The problematic proofs of the fundamental principle of mechanism suggest that the new mechanists ought to have taken it as an axiom, rather than as a theorem, of their system. Had they done so, it would have become clearer to all that mechanism is best vindicated by how well it explains and predicts natural phenomena.[13]

Before we leave the topic of motion, it is worth taking note of the fact that although there was widespread agreement among seventeenth century mechanists that all motion is local motion and that all motion requires an external cause, differences arose over the nature of the external agent(s) of bodily motion. Most assumed that the motion of bodies can be produced by the motion of other bodies (as occurs in collisions). But there were naysayers on this issue, most notably Nicolas Malebranche, according to whom "no [bodies], large or small, [have] the power to move [themselves]," and who concludes from this that "it is minds which move them" (*ST* VI.2.3, 448). Indeed, Malebranche goes so far as to embrace occasionalism, the doctrine that God (a perfect, infinite mind) is the only true cause, and hence all other things, including bodies and finite minds, are causally impotent (*ST* VI.2.3, 449-451).

So much for motion. But what did seventeenth century philosophers say about *rest*? According to Aristotle, rest is simply a privation, or lack, of motion (*Phys*. VIII.1, 251a). On this view, rest (like blindness, which is the privation of sight) is not a real and positive characteristic of a body. So if, as was widely accepted, everything that is real and positive has a cause, it follows that motion must have a cause, but it does not follow that rest must have a cause. Indeed, if rest is a privation, it becomes easier to understand how, in Bacon's thought experiment, it might be possible for a body to come to rest at the

center of the earth without being impeded in its motion. For the existence of an external, impeding cause need not be posited in order to explain the existence of a lack.

It is therefore no surprise to see that the doctrine of rest as privation came under concerted attack by anti-Aristotelians. And no attack was more significant than Descartes's. Already in *The World*, Descartes writes: "[Aristotelians say that rest] is nothing but the privation of motion. For my part, I conceive of rest as a quality too, which should be attributed to matter while it remains in one place, just as motion is a quality attributed to matter while it is changing place" (AT XI: 40; CSM I: 94). Later, in the *Principles*, Descartes emphasizes that "motion and rest are nothing else but two different modes of a body." His argument for this rests on his definition of motion as the transfer of a body away from its immediate vicinity. For, as he argues, "it is clear that this transfer cannot exist outside the body which is in motion, and that when there is a transfer of motion, the body is in a different state from when there is no transfer, i.e., when it is at rest" (AT VIIIA: 55; CSM I: 234). If rest is, as Descartes insists, a mode of corporeal substance, it follows directly that an explanation (in the form of an impeding cause) is required for a body's coming to rest from a state of being motion, and similarly, that an explanation (in the form of a motive cause) is required for a body's coming to move from a state of being at rest. The claim that rest is not a privation is therefore no mere anti-Scholastic curiosity, but in a very real sense one of the foundations of the new mechanistic physics.

Motion and rest represent the fundamental currency of the mechanistic physics of the seventeenth century. Natural philosophers from Galileo Galilei to Robert Boyle accepted that the explanation of natural phenomena depends entirely on the motion (and

rest) of insensible material corpuscles of varying shapes and sizes. It is largely because of the perceived fruitfulness of mechanistic explanation in terms of matter and motion that atomism experienced such a profound and wide-ranging revival. Once Aristotelian forms (whether substantial or accidental) were no longer needed to explain natural phenomena, the stage was set for a battle between mechanistic proponents and mechanistic opponents of atomism. And it was largely in the context of this battle that philosophers of the seventeenth century proposed and defended new accounts of the nature and explanation of sensible qualities, both proper and common. However, aside from motion and rest, there was no disagreement among working philosophers over the nature of the common sensibles of shape and size. All were agreed that these are modes of body, inasmuch as a body's shape or size cannot exist independently of the body whose shape or size it is. For Descartes and many others, shape and size are merely different ways for a body to be extended (in length, breadth, and depth – see AT VIIIA: 25; CSM I: 210-211).

Locke makes clear, however, that, like the fact of being extended, the fact of having some shape or other, as well as the fact of having some size or other, is an essential property of every body (*E* II.8.9, 134-135). The claim that shape, size, and mobility are essential to (inseparable from) bodies captures part of Descartes' claim that extension is the principal attribute of material substance (AT VIIIA: 25; CSM I: 210-211). But it is important to note, as will become clear when we come to discuss the nature of the distinction between primary and secondary qualities, that the essentiality or inseparability of shape, size, and mobility is true of them as determinable, but not as determinate, qualities. It is shape *as such* (size *as such*, mobility *as such*), not the

particular shape (size, motion or rest) that it happens to have, that a body cannot lose. Importantly, it is possible for a body to lose the determinate shape, size, and motion (or rest) it possesses, as when a block of putty is flattened or thrown across the room.[14]

5. Light

Recall the Aristotelian account of light as the (incorporeal) actuality of what is potentially transparent (through the presence of a fiery element in the relevant medium). Opposed to it is the atomist account, according to which light is nothing but a stream of light atoms. For the new mechanists of the seventeenth century, the Aristotelian account is profoundly mistaken. But this agreement masks significant disagreement on the nature of light.

According to some, the atomist account is essentially correct and only requires defense against alternatives. This is the view of Pierre Gassendi and his followers (including Charleton). According to Gassendi, light is a flux of very subtle (fluid, violently agitated, and tiny) corpuscles of a particular shape that are transmitted through air (or some other medium) with ineffable speed (*OO* 422; *APG* 149). Charleton's account is substantially the same.[15] Gassendi and Charleton are most concerned to establish the corporeality of light. In defense of this claim, they adduce the following phenomena (*OO* 427-430, *PEGC* III.5.2, 204-205): (1) locomotion, i.e., that light is "deradiated" from the lucid body to the eye; (2) resilition [i.e., reflection]; (3) refraction; (4) coition [i.e., union] of rays that "become so violent as to burn any thing applied"; (5) disgregation [i.e., dispersal] and debilitation as a result of diffraction; and igniety, "since Light seems to be both the Subject, and Vehicle to Heat, and those speak incorrigibly, who call Light, Flame attenuated."[16,17]

On the Gassendist picture, light exists between the luminous (or illuminated) body and the eye. But others, as hostile to Aristotle's theory as Gassendi and Charleton, locate light in the organ of sight itself. Hobbes, a materialist but also an opponent of the atomist doctrine of the existence of the void (*DC* 414-425), argues that light is "the proper phantasm of sight" (*DC* 404). Here Hobbes helps himself to an Aristotelian term, "Phantasm," meaning a perceptual trace in the imagination, but gives it his own special materialistic twist. Hobbes claims that there is such a thing as endeavour, namely "*motion made through the length of a point, and in an instance or point of time*" (*DC* 206), where motion is "*a continual relinquishing of one place*, *and acquiring of another*" (*DC* 109). Some endeavours are actions, but others reactions, where a reaction is an "endeavour in the patient to restore itself to that situation from which it was forced by the agent" (*DC* 348). On Hobbes's account, luminous bodies (such as the sun) by their motion cause circumambient substances to move, which motion is propagated straight to the eye, and thence to "the innermost part of the organ of sight, namely, to the heart." Being acted upon in this way, the heart then *re*acts, and the resulting endeavour proceeds back towards the eye, "ending in the endeavour outwards" of the retina, which is "the thing which is called light, or the phantasm of a lucid body" (*DC* 448).[18]

Yet others, as Gassendi aptly notices (*OO* 423), attempt to find a middle ground between Aristotelianism and atomism. Descartes likens light (as it exists outside the mind) to the action of a blind man's stick:

> I would have you consider the light in bodies we call 'luminous' to be nothing other than a certain movement, or very rapid and lively action [i.e., tendency to

> move], which passes to our eyes through the medium of the air or other transparent bodies, just as the movement or resistance of the bodies encountered by a blind man passes to his hand by means of his stick. [AT VI: 84; CSM I: 153]

Descartes's picture of the physical relationship between the luminous body and the organ of sight is similar to Hobbes's. But whereas Hobbes locates light in the eye, Descartes locates it as a quality of luminous bodies. Descartes agrees with the atomists that light is not incorporeal, but agrees with Aristotle that "there is no need to suppose that something material passes from objects to our eyes to make us see…light" (AT VI: 85; CSM I: 153).[19]

Yet others split the difference between Hobbes on the one hand and the atomists on the other. Jacques Rohault, a follower of Descartes whose physics textbook was widely relied on before Isaac Newton's *Principia* displaced it, claims that the word "light" is ambiguous: it can mean either the sensation we have when we perceive a luminous or illuminated body or it can mean whatever it is on the part of external objects by means of which they are able to excite this sensation in us (*TP* I.27.1-2, 291-292).[20] In the second sense, Rohault agrees with Descartes that light consists in "a certain motion of the parts of luminous bodies that renders them capable of pushing in all directions the subtle matter that fills the pores of transparent bodies" (*TP* I.27.15, 298).[21] This way of approaching the matter appeals to Locke, who notes that "the *Cartesians* very well distinguish between that Light which is the Cause of that Sensation [of light] in us, and the *Idea* which is produced in us by it, and is that which is properly Light" (*E* III.4.10, 424).

Yet Locke also identifies light with a capacity possessed by the luminous or illuminated body. As he puts it: "[Light is] nothing, in truth, but [a power] to excite [the sensation of light] in us" (*E* II.31.2, 375-376). This view differs from the view that light is the cause of sensations of light inasmuch as the cause of something is not to be identified with the power (or possibility) of causing it (see *E* II.21.1, 233). It is, in fact, a different, specifically dispositionalist, "third way" between Hobbesianism and atomism. As Locke sees it, light is in the world, not in the eye (and not in the mind or soul). But it is not a body, or even a property of body: it is a dispositional relation between luminous and illuminated bodies and the creatures that perceive them.

6. Color

Recall Aristotle's claim that color is the limit of the transparent in determinately bounded body. On this view, color is on (or in) the bodies that are seen as colored, and the existence of light is required, not for the *existence* of color, but rather for its *visibility*. This picture is opposed both by the Democritean (subjectivist) view, according to which colors exist "by convention", and the Epicurean/Lucretian view, according to which bodies are colored inasmuch as they emit streams of atoms of a certain kind. On the Democritean picture, colors depend for their existence on the existence of *perceivers*; on the Epicurean/Lucretian picture, colors depend for their existence on the existence of *light*. As Lucretius asks, rhetorically: "What color can there be in blinding darkness?" (*DRN* 2, 799-800). Because many seventeenth century mechanists tied their theories of color to their theories of light, it is no surprise that they disagreed with Aristotle, some allying themselves with the atomists, others not.

Galileo and Hobbes were the most prominent Democriteans. According to Hobbes, the relationship between color and light is that between species and genus, and hence color is no more than a kind of endeavor (instantaneous outward motion) in the retina: "*Colour* is light, but troubled light, namely, such as is generated by perturbed motion" (*DC* 459). For example, "*Whiteness* is light, but light perturbed by the reflections of many beams of light coming to the eye together within a little space" (*DC* 463). Blackness, on the other hand, is no more than the privation of light (*DC* 464). Thus Hobbes's color is no less perceiver-dependent than is Hobbes's light. Color, for Hobbes, is in the eye, not in or on the objects seen.

Galileo's Democriteanism extends to all the proper sensibles, including colors, sounds, odors, tastes, and heat/cold. His view is that these qualities, "so far as their objective existence is concerned, are nothing but mere names for something which resides exclusively in our sensitive body" (*Assayer*, 57). For Galileo there is no more reason to believe that redness is a property of the body that causes in us a sensation of red than there is to believe that 'ticklingness' is a property of the body that causes in us a tickling sensation (*Assayer*, 57).

On the side of objectivist atomism, we find Gassendi (and, of course, Charleton). Like Hobbes, Gassendi identifies color with light (*OO* 432; *APG* III.1.14, 173). But Gassendi's light is not a phantasm in the sentient, but rather a stream of light particles. So Gassendi's position is essentially the same as the one taken by Epicurus and Lucretius. Gassendi therefore admits that bodies have no color in the dark. But he goes on to point out that bodies in the dark remain *disposed* to appear colored when illuminated (*OO* 434; *APG* III.1.14, 174).

Descartes and his followers split the difference. Descartes distinguishes between "what is called colour in objects" and "the colour of which we have sensory awareness" (AT VIIIA: 34-35; CSM I: 218). The latter is merely a sensation of a particular kind in the incorporeal mind. But colors in the former sense "are nothing other than the various ways in which…bodies receive light and reflect it against our eyes" (AT VI: 85; CSM I: 153).[22] Black bodies "break up the light-rays that meet them and take away all their force; white bodies "cause the rays to be reflected without bringing about any other change in their action"; and bodies of other colors (red, yellow, blue, and so on) "bring about an additional change similar to that which the movement of a ball undergoes when we graze it" (AT VI: 91-92; CSM I: 156).

What is the ontological status of these ways of receiving and reflecting light rays? Descartes does not say. On one interpretation, his view is that colors are causal *powers* that belong to bodies. Some have thought this interpretation confirmed by the following passage:

> The properties in external objects to which we apply the terms light, colour, smell, taste, sound, heat and cold…are, so far as we can see, simply various dispositions (*dispositiones*) in those objects [in the shapes, sizes, positions and movements of their parts][23] which make them able to set up various kinds of motions in our nerves <which are required to produce all the various sensations in our soul>[24]. [AT VIIIA: 322-323; CSM I: 285]

But the word "disposition", in both Latin and French, is ambiguous: it can mean "power" or "arrangement". Descartes could be saying that the red color of an apple, say, is a power (call it "P") in the apple, grounded in the shapes, sizes, positions, and movements of its parts, to produce the sensation of red in us; but he could also be saying that this color is nothing but the arrangement of corpuscles at the apple's surface (with their various shapes, sizes, positions, and motions) that grounds P. Indeed, his intellectual successor, Rohault, takes the latter, rather than the former, position. For example, Rohault claims that "the essence of whiteness consists only in the asperity [i.e., surface roughness] of the body one calls white" (*TP* I.27.55, 323).

There is evidence that Descartes and his contemporaries did not draw a sharp distinction between a disposition or power and its grounds. Witness, for instance, Kenelm Digby:

> [T]he colour of a body, is nothing else, but the power which that body hath of reflecting light unto the eye, in a certaine order and position: and consequently, is nothing else but the very superficies [i.e., surface] of it, with its asperity, or smoothnesse; with its pores, or inequalities; with its hardnesse, or softnesse; and such like. [*TT* I.29.6, 262]

This refusal to distinguish extends at least to Boyle. Boyle claims that the proper sensibles "are not in the bodies that are endowed with them any real or distinct entities [as the Scholastics believe], or differing from the matter itself furnished with such a determinate bigness, shape, or other mechanical modifications" (*OFQ*, 24). But Boyle

also likens the proper sensibles to the power that gold has of being dissoluble in *aqua regis* [a combination of nitric acid and hydrochloric acid] but not dissoluble in *aqua fortis* [a solution of nitric acid in water], which properties "are not in the gold anything distinct from its peculiar texture [i.e., arrangement of insensible parts]" (*OFQ*, 24). So for Boyle, as for Digby (and possibly also for the Cartesians), there is no sharp distinction to be drawn between powers and their grounds.[25]

But there are also reasons for thinking that Boyle *should* have drawn this distinction, especially in the case of colors. For Boyle, like his Democritean contemporaries, assumes that bodies would have no proper sensibles (including color) if there were no perceivers in the world.[26] But Boyle *also* assumes (along with every one else) that bodies would retain their common sensibles (shape, size, motion, position, and texture) if all perceivers were annihilated. Boyle's position is therefore incoherent. It is left to Locke to clear up the potential confusion, by making it clear that colors (and other proper sensibles) are powers in bodies to produce certain sorts of sensations in us, powers that are grounded in, but distinct from, the textures of those bodies (*E* II.8.9-26, 134-143).

There is therefore a plethora of different mechanist theories of color in the seventeenth century. Some think that colors are instantaneous outward motions in our eyes, some that colors are streams of corpuscles emitted by bodies, others that colors are textures of the surfaces of those bodies; some think that colors are merely sensations in incorporeal minds, others that colors are powers in bodies to cause these sensations. Some think the word "color" sometimes means one of these things, and sometimes another; and some simply fail to distinguish between powers and textures. One would think that this is enough metaphysical variety in the midst of widespread agreement on

the basic principles of scientific explanation. But there is one more view, crucial to posterity and the development of optics, that we have not yet considered.

In 1671/72, Newton published a letter in the *Philosophical Transactions of the Royal Society* detailing his experiments with light and prisms. From these experiments, he drew several conclusions: first, that "Light it self is a *Heterogeneous mixture of differently refrangible Rays* [i.e., rays differently susceptible of refraction]"; second, that "as the Rays of light differ in degrees of Refrangibility, so they also differ in their disposition to exhibit this or that particular colour"; third, that consequently "[c]olours are not *Qualifications of Light*, derived from Refractions, or Reflections of natural Bodies (as 'tis generally believed), but *Original* and *connate properties*, which in divers Rays are divers"; and fourth, that because "Colours are the *qualities* of Light" and no quality "may be the subject of and sustain another," it follows (a) that there are no colors in the dark, and (b) that light is a body. So this is yet another view. Color, for Newton, is not a body, but an accident of body. But it is not an accident of the perceiver's body (or any of its parts), nor an accident of bodies that are perceived as colored, nor a power in those bodies to produce a sensation of color: it is, rather, an accident of light itself, indeed an accident of the individual rays of which (white) light is quite literally composed.

7. Sound

There are almost as many disagreements among seventeenth century mechanists on the nature of sound as there are on the nature of color. The main difference consists in the somewhat greater receptiveness to Aristotle's theory of sound. Aristotle's view is that sound is the motion of air when its dissipation is prevented, whereas Lucretius's picture

is that sound is a stream of particles emitted by sonorous bodies (see, e.g., *DRN* 1, 354-355, 490; *DRN* 2, 854-859). This disagreement reappears quite neatly in the works of seventeenth century philosophers. Digby, for example, agrees with Aristotle: "*motion* and *sound* are in themselves one and the same thing, though expressed by different names, and comprised in our understanding under different notions" (*TT* I.28.9, 257). Gassendi, on the other hand, follows Lucretius in thinking that sound is "nothing other than corpuscles of a particular shape transported at great speed from the sonorous body to the ear, moving the organ, and causing the sensation we call *hearing*" (*OO* 414; *APG*, III.1.12, 131).[27]

But there are also other views, similar to views already discussed in conjunction with light and color. Hobbes, for instance, claims that "the motion of the medium is not the sound itself, but the cause of it." Sound itself is but the outward reaction of the organ of hearing, or phantasm, produced by the motion of the medium created by the sonorous body (*DC* 485). Descartes splits the difference again, claiming that there is on the one hand the sensation of sound and on the other "a certain vibration of air which strikes our ears (AT XI: 5; CSM I: 82).[28] Descartes also characterizes sounds, as he does all other proper sensibles, as "dispositions in those objects [in the shapes, sizes, positions and movements of their parts] which make them able to set up various kinds of motions in our nerves" (VIIIA: 322-323; CSM I: 285). Rohault claims that the word "sound" is ambiguous in roughly the way Descartes suggests, though he makes clear that what causes in us the sensation of sound (and, so, the referent corresponding to one sense of the word "sound") is, as Aristotle suggests, a particular sort of motion in the sonorous body and in the air surrounding it (*TP* I.26.1-12, 270-274).[29] However, Locke thinks of

sound on the model of all the other proper sensibles, namely as a power in sonorous bodies to cause auditory sensations in our minds (*E* II.8, 132-143); and Boyle treats sound, as he does all the proper sensibles, indifferently as Lockean powers or as textures (*OFQ*, 31 ff.). And substantially the same pattern of disagreement recurs for the other sensible qualities, namely odor, flavor and the tangible qualities (including heat and cold).

8. The Primary/Secondary Quality Distinction

The question now arises whether there is, for the philosophers of the seventeenth century, a distinction to be drawn between different kinds of qualities. Aristotle had distinguished between the proper sensibles and the common sensibles on *epistemic* grounds. For many of the new mechanists, this distinction is no more. Digby, for instance, emphasizes "that odors may be tasted; that the relish of meates may be smelled; that magnitude and figure may be heard; that light may be felt; and that soundes may be seene" (*TT* I.28.9, 256). And, indeed, if any quality is reduced to motion, or to a stream of particles, or to texture (e.g., roughness), then it follows that it is no longer a *proper* sensible, for it is either unperceived or perceivable (at least in principle) by more than one sense. But the lack of an epistemic distinction does not entail the lack of a *metaphysical* distinction. And, indeed, at least some seventeenth century mechanists favored the making of such a distinction. But, naturally, they did not all characterize the distinction in the same way.

Let us then divide up the qualities into two groups. Let us count shape, size, motion/rest, position, and texture as *primary qualities*; and let us count color, sound, odor, flavor, and tangible qualities (such as heat and cold, roughness and smoothness) as

secondary qualities. Is there any metaphysical difference between the primary qualities and the secondary qualities? If so, what is the proper criterion for the primary/secondary quality distinction? If there is such a distinction, does it make a difference? If so, what kind of difference?

There are some seventeenth century philosophers for whom there is really no metaphysical difference between the primary qualities and the secondary qualities. Hobbes, for example, thinks of secondary qualities as just particular kinds of primary qualities, for he identifies all secondary qualities with phantasms, that is, with outward-directed motions in the sense organs or perceivers. There is, of course, a difference in the *location* of these qualities: many primary qualities (though not all) are in the world external to perceivers, while all secondary qualities are in perceivers' sense organs, and hence inside their own bodies. Digby, who identifies colors with the surfaces of colored bodies and who identifies sounds with motions, is also someone for whom there is no metaphysical primary/secondary quality distinction.

At the same time, the difference in location could be taken as the source of one criterion for the distinction. For, on Hobbes's view if not on Digby's, secondary qualities are in perceivers, and depend for their existence on the existence of the perceivers they are in. Hobbes is committed to the view that if all perceivers were annihilated, there would be no color (sound, odor, flavor, etc.) in the world, though shape (size, motion, position, and texture) of corporeal substances other than perceivers would continue to exist. So it is possible to construct a primary/secondary quality distinction for Hobbes, one that is founded on the criterion of perceiver-dependence. It is exactly in this sense that there is a primary/secondary quality distinction for Galileo, who insists that, unlike

primary qualities, secondary qualities "are nothing but mere names for something which resides in our sensitive body, so that if the perceiving creatures were removed, all of these qualities would be annihilated and abolished from existence" (*Assayer*, 57).

The Cartesians (Descartes, Rohault, Desgabets, Cordemoy, Malebranche) are clearly a more complex case, for they distinguish between two senses of each word that is commonly thought to designate a single secondary quality. In one sense, secondary qualities are merely modes of incorporeal mental substance (i.e., sensations); in the other, secondary qualities are the corporeal (for Cordemoy and Malebranche, the occasional) causes of these sensations. In the latter sense, then, the Cartesians (despite their disagreements on the details) understand secondary qualities to be nothing but a subset of the primary qualities. In this way, the Cartesians and Hobbes find common ground. But in the former sense the Cartesians and Hobbes part ways. For the Cartesians understand secondary qualities in the former sense to be sensations, and, on this approach, secondary qualities (in the relevant sense) are not in the external world at all, but in the mind.

Indeed, this is the most radical way of distinguishing between primary qualities and secondary qualities: secondary qualities are in immaterial, primary qualities in material, substances. Insofar as material and immaterial substances are distinct, primary qualities and secondary qualities are distinct. For Descartes, primary qualities are modes of extension, different ways for bodies to be extended in length, breadth, and depth, whereas secondary qualities (in one sense) are modes of thought, different ways for minds to ideate. It follows, of course, that the annihilation of perceiving *minds* (though not of perceiving *bodies* or *sense organs*) would result in the annihilation of secondary qualities (in the relevant sense), but would not result in the annihilation of primary

qualities. Thus, despite their fundamental disagreement over the nature of mind—Hobbesians being materialists, the Cartesians dualists—both sets of philosophers converge on the view that some sense of perceiver-dependence distinguishes the secondary qualities (in one sense) from the primary qualities.

There is also a metaphysical primary/secondary quality distinction to be drawn within the atomist world-view. For Gassendi and Charleton, secondary qualities are streams or arrangements of atoms of different determinate primary qualities, atoms that themselves possess none of the secondary qualities inasmuch as they neither emit such atom-streams nor possess other atoms as parts. On the atomist picture, secondary qualities are therefore *substances* or *arrangements of substances*, rather than accidents (or properties, or modes) of substance. This is a metaphysical distinction of first importance, but it is completely unrelated to the criterion of perceiver-dependence that matters to Hobbes, Descartes, and Galileo. Indeed, it is an important aspect of the atomist picture that secondary qualities, like primary qualities, would not disappear if perceivers were annihilated.

There are other ways of drawing a metaphysical distinction between primary qualities and secondary qualities, ways that are commonly, though—I believe—mistakenly, attributed to Locke. Locke begins his discussion by distinguishing between ideas, namely the mind-dependent immediate objects of perception, and qualities, namely the powers to produce these ideas in our minds. Locke then characterizes primary qualities as "utterly inseparable from the Body, in what estate soever it be," and secondary qualities as "nothing in the Objects themselves, but Powers to produce various Sensations in us by their *primary Qualities*" (*E* II.8.8-10, 134-135).

At first, the picture seems straightforward: primary and secondary qualities are both powers to produce ideas in minds; secondary qualities are *mere* powers, in that they are *separable* from the objects that have them; primary qualities are *more than mere* powers, in that they are *inseparable* from the objects that have them. But this is almost certainly *not* the picture that Locke favors. Consider the difference between determinate and determinable qualities. Anything that has any shape at all possesses the *determinable* quality, Shape; the particular shape that anything with Shape possesses is its *determinate* shape. So, Shape is the determinable of which roundness and squareness are determinates. The basic problem with the separability criterion for the primary/secondary quality distinction is that, even though it works at the level of the determinables, it fails at the level of the determinates. On Locke's view, primary quality determinables are inseparable, while secondary quality determinables are separable, from bodies: every body must have Shape, but not every body must have Color (or Sound, or Odor, etc.). (After all, as Locke emphasizes, "'tis plain [*Porphyre*] *has no colour in the dark*"—*E* II.8.19, 139.) Unfortunately, primary quality determinates are just as separable as secondary quality determinates: just as an object can lose its particular color (as an almond can lose its white color when it is pounded—*E* II.8.20, 139), so an object can lose its particular shape (think of the same pounded almond). But Locke clearly holds that the distinction between primary and secondary qualities holds as much for determinates as it does for determinables. So it is unlikely that Locke's distinction is grounded in the separability criterion.

Locke is also commonly thought to have distinguished between primary and secondary qualities on grounds of *resemblance*. For he writes:

> [T]he *Ideas of primary Qualities* of Bodies, *are Resemblances* of them, and their Patterns do really exist in the Bodies themselves; but the *Ideas*, *produced* in us *by* these *Secondary Qualities*, *have no resemblance* of them at all. There is nothing like our *Ideas*, existing in the Bodies themselves. [*E* II.8.15, 137]

Locke is here picking up on a strong and continuous strand of seventeenth century opposition to Scholastic theories of perception. Even before Locke, Descartes had made a point of emphasizing the fact that there is no resemblance between secondary qualities (thought of as sensations) and their causes in the external world (see AT XI: 3-6, CSM I: 81-82; AT VI: 85 and 130-131, CSM I: 153-154 and 167-168; AT VIIIA: 34-35; CSM I: 218). This was important to Descartes, because it is one of the hallmarks of Scholastic theories of perception that there is such a resemblance. For the Scholastics, perception occurs in the soul when it receives an accidental form that is propagated through the relevant medium from a body that possesses that form. Indeed, on the Scholastic picture, there is not merely resemblance, there is also *identity*, between the immediate object of perception and its external cause.

In characterizing the primary/secondary quality distinction in terms of resemblance, Locke is therefore making a point to distance himself from the Scholastics. But what is significant about this way of drawing the distinction is that Locke takes it to follow immediately[30] from the following statement:

> [Secondary qualities], whatever reality we, by mistake, attribute to them, are in truth nothing in the Objects themselves, but Powers to produce various Sensations in us, and *depend on those primary Qualities*. [*E* II.8.14, 137]

Locke is telling us here that we mistakenly take secondary qualities to be *real* qualities, that it is in this sense that we take secondary qualities to be more than mere powers. The nub of the distinction, then, is that primary qualities are real while secondary qualities are not. And the resemblance criterion, properly understood, is that ideas of primary qualities resemble *real* qualities in objects while ideas of secondary qualities do not.

But what is it for a quality to be real? Locke writes that primary qualities "*are really in them*, whether any ones Senses perceive them or no: and therefore they may be called *real Qualities*, because they really exist in those Bodies" (*E* II.8.17, 137-138); that "*Motion and Figure are really in the Manna*, whether we take notice of them or no" (*E* II.8.18, 138); that size, shape, texture, and motion "may properly be called *real Original*, or *primary Qualities*, because they are in the things themselves, whether they are perceived or no" (*E* II.8.23, 141). For Locke, then, a quality is *real* when its existence in an object is independent of its being perceived to exist in that object. And Locke's fundamental way of distinguishing between primary and secondary qualities is that the latter are perceiver-dependent while the former are not.

Locke's way of drawing the primary/secondary quality distinction is therefore similar to the way in which Hobbes, Descartes, and Galileo draw it. But this agreement also masks significant differences of opinion with respect to the metaphysical facts that ground the distinction. For Hobbes and Galileo, secondary qualities exist in perceivers'

sense organs; for Descartes, such qualities (in one sense) exist in perceivers' immaterial minds. But for Locke, secondary qualities are (or include) *relations* between perceivers and the objects of perception. This is because secondary qualities are powers in the objects of perception to cause sensations in perceivers' minds, and, as Locke later points out, "*Power includes in it some kind of relation*" (*E* II.21.3, 234). From the metaphysical point of view, the important thing about relations is that they cannot exist in the absence of their relata: just as Sophie can't be to the left of Alice if Sophie or Alice doesn't exist, so a piece of chalk doesn't have the power to cause an idea of white in Dana's mind if Dana or the chalk doesn't exist (see note 24 above). Indeed, it is the latter metaphysical fact that explains *why* Locke is adamant that secondary qualities would disappear if all perceivers were annihilated (see *E* II.31.2, 376).[31]

As we have seen, there is some evidence that Boyle, in some moments at least, thinks of secondary qualities as textures, and the explanation for this is probably that he does not distinguish between powers and their grounds. There are also a few passages in which Locke makes the same identification, quite possibly for the same reason. For he writes that "whiteness or redness are not in [porphyry] at any time, but such a texture, that hath the power to produce such a sensation [of whiteness or redness] in us" (*E* II.8.19, 139). But this is not likely to be Locke's considered view. For textures are non-relational, perceiver-independent arrangements of corpuscles, and thus *real* (in Locke's technical sense) and hence metaphysically on a par with primary qualities. Indeed, Locke himself makes a point of including "texture" several times in his list of primary qualities (*E* II.8.10, 135; II.8.14, 137; II.8.18, 138).

The most widely recognized criterion for distinguishing between primary and secondary qualities in the seventeenth century, then, is the reality (or perceiver-dependence) criterion. But does this distinction among qualities *make a difference*? Some think that the significance of the distinction lies in the thought that secondary qualities are not proper objects of scientific investigation. This is certainly true of the Cartesians, who think of the world as divided into corporeal substances (the behavior of which is governed by immutable laws) and incorporeal substances (the behavior of which is often subject to the will, which is free and undetermined). But this difference stems not from the reality criterion itself, but rather from the specific Cartesian metaphysics underlying the reality criterion. The fact that secondary qualities are perceiver-dependent does not entail that they are beyond the reach of scientific enquiry. Indeed, for Hobbes, or Galileo, or Locke, or Boyle, it is in principle possible for science to tell us a great deal more about the nature of the secondary qualities. The significance of the distinction between primary and secondary qualities, then, does not concern the conduct of science, but rather concerns its impact on the demise of Scholastic theories of perception. For if there is one principle on which all advocates of the distinction are agreed, it is that the lack of resemblance between secondary qualities and their causes dooms the Scholastic picture of the relation between mind and world.

9. Arguments for the Primary/Secondary Quality Distinction

Did any of the seventeenth century mechanists who distinguished explicitly between primary and secondary qualities provide any arguments for the distinction independent of

the arguments for their accounts of the nature of individual sensible qualities? Galileo and Locke did so, and it is instructive to consider their reasoning.

Galileo's view is that secondary qualities, unlike primary qualities, are radically perceiver-dependent in that they are merely states of the sensing body. Galileo provides two reasons for taking this position. The first is that "if the perceiving creatures were removed, all [secondary] qualities would be annihilated and abolished from existence," whereas the same is not true of any of the primary qualities (*Assayer*, 57). Although this argument establishes at best a kind of perceiver-dependence, it does not establish that the secondary qualities are *in perceivers*. For it is possible to conceive of secondary qualities as Locke does, namely, as *relations* between perceivers and external objects. But the argument's most notable weakness, from our own point of view, is that few would now accept Galileo's assumption that colors, sounds, odors, flavors, and tangible qualities would disappear if all perceivers were annihilated. Still this is an assumption that was shared by a number of seventeenth century mechanists, who took the truth of the relevant counterfactual as a point in favor of their theories of qualities.

Galileo's second reason for accepting Democriteanism is that we are not "compelled to conceive of bodies as necessarily conjoined with such further conditions as being red or white, bitter or sweet, having sound or being mute, or possessing a pleasant or unpleasant fragrance" (*Assayer*, 56). But this argument is unpersuasive. For the most that could be concluded from the fact that *it is possible to conceive* of a body without color (flavor, sound, etc.) is that it is *possible* for a body to exist without color (flavor, sound, etc.), that color (or flavor, or sound, etc.) is not *essential* to bodies. But from the fact that it is possible for a body to exist without color (flavor, sound, etc.) it simply

doesn't follow that color (flavor, sound, etc.) is perceiver-dependent, any more than it follows from the fact that it is possible for a body to exist without its particular shape that that shape is perceiver-dependent. Now if primary qualities were essential to bodies while secondary qualities were not, this would establish the existence of some distinction between the two kinds of qualities. Unfortunately, as we have seen, this kind of argument works at best at the level of the determinables, and not at all at the level of the determinates. This is because primary quality determinates are no more essential to the bodies that have them than their secondary quality determinate counterparts.

What of Locke's reasons? Locke provides three separate arguments for the conclusion that secondary qualities are not real (in the technical sense). Assuming, as Locke does, that primary qualities are real, these arguments, if successful, would indeed establish the existence of an important distinction.

Here is Locke's first argument:

> Let us consider the red and white colours in *Porphyre*: Hinder light but from striking on it, and its Colours vanish; it no longer produces any such *Ideas* in us: Upon the return of Light, it produces these appearances on us again. Can any one think any real alterations are made in the *Porphyre*, by the presence or absence of Light; and that those *Ideas* of whiteness and redness, are really in *Porphyre* in the light, when 'tis plain *it has no colour in the dark*? [*E* II.8.19, 139]

Locke here tries to show that the redness and whiteness of porphyry are neither real in the dark nor real in the light. Assume first that redness is a real quality of porphyry in the

dark. In being real, redness is such that its existence does not depend on its being perceived. So porphyry must be red in the dark. But, as Locke insists, porphyry is colorless in the dark. By *reductio*, then, redness is not a real quality of porphyry in the dark. (Mutatis mutandis for whiteness.) Now assume that redness is a real quality of porphyry in the light. But, as Locke also insists, the presence or absence of light does not produce any *real* alterations in porphyry. Consequently, if redness is a real quality in the light, then it must be a real quality in the dark. But, as has just been established, redness is not a real quality in the dark. By *reductio*, then, redness is not a real quality of porphyry in the light (Mutatis mutandis for whiteness.) *Ergo*, redness and whiteness are not real qualities of porphyry, whether in the dark or in the light.

This argument, though valid, is only as persuasive as the assumption, shared, as we've seen, by several of Locke's contemporaries, that bodies have no color in the dark. Unfortunately, it is also an assumption that few of us take for granted nowadays. Locke's first argument, then, is dialectically ineffective.

Locke's second argument is brief:

> Pound an Almond, and the clear white *Colour* will be altered into a dirty one, and the sweet *Taste* into an oily one. What real Alteration can the beating of the Pestle make in any Body, but an Alteration of the *Texture* of it? [*E* II.8.20, 139]

The reasoning here is simple. The pounding of an almond changes its color and taste; but the only real quality in an almond that it is possible to change by pounding it is its texture; so the color and taste of an almond are either textures or not real qualities; but

neither the color nor the taste of an almond is identical to its texture; therefore, the color and taste of an almond are not real qualities.

The problem with the argument is also simple. For it begs the question against his opponents for Locke to assume that texture is the only real quality in an almond that can be changed by pounding it. Now it might be thought that this assumption is a consequence of mechanism. But it isn't. Mechanists are committed to the view that pounding changes the texture of the almond, inasmuch as pounding produces a rearrangement of the almond's constituent corpuscles. But mechanists are not *ipso facto* committed to the view that texture is the *only* real quality that the pounding can change, unless they assume what Locke is trying to prove, namely that colors and tastes are not real qualities.

Locke's third and final argument is also straightforward:

> *Ideas* being thus distinguished and understood, we may be able to give an Account, how the same Water, at the same time, may produce the *Idea* of Cold by one Hand, and of Heat by the other: Whereas it is impossible, that the same Water, if those *Ideas* were really in it, should at the same time be both Hot and Cold. [*E* II.8.21, 139]

The reasoning here is simple too. The same water (call it "W"), at the same time, produces an idea of heat when touched by one hand and produces an idea of cold when touched by the other hand; but anything that produces an idea of heat when touched by a hand has the quality, heat, and anything that produces an idea of cold when touched by a

hand has the quality, cold; so W, at the same time, has heat and cold; but heat and cold are opposites, and it is impossible for opposite real qualities to exist in the same substance at the same time; so heat and cold are not both real qualities; but heat is a real quality if and only if cold is a real quality; consequently, neither heat nor cold is a real quality.

The problem with this argument, as George Berkeley points out, is that it proves too much:

> Now, why may we not as well argue that figure and extension are not patterns or resemblances of qualities existing in matter, because to the same eye at different stations, or eyes of a different texture at the same station, they appear various and cannot, therefore, be the images of anything settled and determinate without the mind? [*PHK* 14]

Berkeley's point is that if Locke's argument succeeds in showing that heat and cold are not real qualities, then it also succeeds in showing that figure and extension are not real qualities. But, as everyone agrees, figure and extension are real qualities. Therefore, Locke's third and final argument fails.

The result of Galileo's and Locke's efforts is that the reasoning in favor of a primary/secondary quality distinction based on the reality criterion of perceiver-dependence is inconclusive. This should not surprise us. For even now there is a live debate on the metaphysical status of secondary qualities, a debate in which many of the

most influential positions are identical to, or direct descendants of, positions taken by many of the mechanists of the seventeenth century.

10. Conclusion

Philosophers of the seventeenth century who offered theories of sensible and occult qualities found their intellectual bearings within the background legacies of ancient atomism and Scholastic Aristotelianism. The gradual ascendancy of atomism and corresponding decline of Aristotelianism shaped the debate and gave birth to a new mechanism that embraced the explanatory primacy of primary qualities over secondary qualities. Although divided over the question of the existence of physically indivisible bodies and the possibility of empty space, the mechanists of the seventeenth century abandoned the Aristotelian conception of natural motion, reduced all motion to local motion, and strove to explain all natural phenomena, both manifest and occult, much as the ancient atomists had, namely, as the result of collisions among insensible corpuscles and their agglomerations. But this agreement on the proper model of scientific explanation masked serious metaphysical disagreements over the nature and location of the qualities of corporeal substances. Mechanism itself did not constrain the multiplication of proposals, and the speculative ingenuity of its numerous proponents filled the space of logical possibilities canvassed above.

Mechanism is now a defunct explanatory research program, but the dream of mechanism lives on in the shape of the hope for a unified physics based on a finite number of general principles. Interestingly, the abandonment of mechanism and its replacement by quantum mechanics and general relativity has not created any greater

convergence on a single theory (or family of theories) of sensible qualities. Indeed, secondary quality theorists have carved new positions in logical space that the mechanists of the seventeenth century could not have dreamed of. Perhaps the moral of the story is that metaphysics does not walk in the shadow of science; rather science and metaphysics walk hand in hand.[32]

REFERENCES

Primary Sources

Bacon, F., *The New Organon*, edited by L. Jardine and M. Silverthorne, Cambridge: Cambridge University Press, 2000.

Barnes, J. (ed.), *The Complete Works of Aristotle*, *Vol. 1*, *The Revised Oxford Translation*, Princeton: Princeton University Press, 1984. Abbreviations of Aristotle's works mentioned in the text are as follows: *Categories* (*Cat.*), *Physics* (*Phys.*), *On Generation and Corruption* (*GC*), *On the Heavens* (*DC*), *On the Soul* (*DA*), *Sense and Sensibilia* (*DS*), and *Metereology* (*Met.*).

Berkeley, G., *A Treatise Concerning the Principles of Human Knowledge*, in *The Works of George Berkeley*, *Volume 1* edited by A. A. Luce and T. E. Jessop, London: Thomas Nelson and Sons, 1948. Abbreviated as *PHK*.

Boyle, R., *The Origin of Forms and Qualities According to the Corpuscular Philosophy*, in *Selected Philosophical Papers of Robert Boyle*, edited by M. A. Stewart, Indianapolis: Hackett Publishing Company, 1991. Abbreviated as *OFQ*.

Charleton, W., *Physiologia Epicuro-Gassendo-Charltoniana*, London: Newcomb, 1654. Abbreviated as *PEGC*.

Cordemoy, G. de, *Oeuvres Philosophiques*, edited by P. Clair and F. Girbal, Paris: Presses Universitaires de France, 1968, 257-276. Abbreviated as *OP*.

Cottingham, J., R. Stoothoff, and D. Murdoch (eds.), *The Philosophical Writings of Descartes*, *Volume 1*, Cambridge: Cambridge University Press, 1985.

Desgabets, R. *Le Guide de la Raison Naturelle*, in *Oeuvres Philosophiques Inédites*, Analecta Cartesiana 5, edited by J. Beaude, with an introduction by G. Rodis-Lewis, Amsterdam: Quadratures, 1985, 101-150.

Digby, K., *Two Treatises*, Paris: Blaizot, 1644. Abbreviated as *TT*.

Galilei, G., *The Assayer*, in *The Scientific Background to Modern Philosophy*, edited by M. R. Matthews, Indianapolis: Hackett Publishing Company, 1989.

Galilei, G., *Dialogue Concerning the Two Chief World Systems, Ptolemaic and Copernican*, Second Revised Edition, translated by S. Drake, Berkeley: University of California Press, 1967.

Gassendi, P., *Opera Omnia*, Lyon: Anisson and Devenet, 1658. Abbreviated as *OO*.

Part of Gassendi's work was translated into French by François Bernier, *Abrégé de la Philosophie de Gassendi*, Lyon: Anisson, Posuel, and Rigaud, 1684. This work is abbreviated as *APG*.

Hobbes, T., *Elements of Philosophy*: *The First Section, Concerning Body*, in *The English Works of Thomas Hobbes*, edited by W. Molesworth, London: John Bohn, 1839. Abbreviated as *DC*.

Locke, J., *An Essay Concerning Human Understanding*, edited by P. H. Nidditch, Oxford: Clarendon Press, 1975. Abbreviated as *E*.

Lucretius, *On the Nature of Things*, translated by M. F. Smith, Indianapolis: Hackett Publishing Company, 1969. Abbreviated as *DRN*.

Malebranche, N., *The Search After Truth*, edited by T. M. Lennon and P. J. Olscamp, Cambridge: Cambridge University Press, 1997. Abbreviated as *ST*.

Newton, I., *A Letter of Mr. Isaac Newton*, *containing his New Theory About Light and Colours*, in *Philosophical Transactions of the Royal Society* 80 (19 February 1671/2), 3075-3087. Accessible online through The Newton Project at http://www.newtonproject.sussex.ac.uk/view/texts/normalized/NATP00006

Régis, P.S., *Cours Entier de Philosophie*, *ou Système Général Selon les Principes de M.*

Descartes, Final Edition, Amsterdam: Aux dépens des Huguetan, 1691. Abbreviated as *Cours*.

Rohault, J., *Traité de Physique*, Paris: Vve Savreux, 1671. Abbreviated as *TP*.

Rohault, J. *Entretiens sur la Philosophie*, Paris: Le Petit, 1671. Abbreviated as *Entretiens*.

Sennert, D., *Thirteen Books of Natural Philosophy*, London: Peter Cole, 1660. Abbreviated as *TBNP*.

Further Reading

Alexander, P., *Ideas*, *Qualities and Corpuscles*: *Locke and Boyle on the External World*, Cambridge: Cambridge University Press, 1985.

Allen, K., "Mechanism, Resemblance and Secondary Qualities: From Descartes to Locke," *British Journal for the History of Philosophy* 16 (2008): 273-291.

Anstey, P. R., *The Philosophy of Robert Boyle*, London: Routledge, 2000.

Ayers, M. R., *Locke*, London: Routledge, 1991.

Bolton, M. B., "Locke and Pyrrhonism: The Doctrine of Primary and Secondary Qualities," in *The Skeptical Tradition*, edited by M. Burnyeat, Berkeley: University of California Press, 1983, 353-376.

Clarke, D., *Occult Powers and Hypotheses*: *Cartesian Natural Philosophy under Louis XIV*, Oxford: Clarendon Press, 1989.

Cottingham, J., "Descartes on Colour," *Proceedings of the Aristotelian Society* 90 (1990): 231-246.

Curley, E. M., "Locke, Boyle, and the Distinction Between Primary and Secondary Qualities," *Philosophical Review* 81 (1972): 438-464.

Fisher, S., *Pierre Gassendi's Philosophy and Science*: *Atomism for Empiricists*, Leiden: E. J. Brill, 2005.

Garber, D., *Descartes' Metaphysical Physics*, Chicago: University of Chicago Press, 1992.

Garber, D., J. Henry, L. Joy, and A. Gabbey, "New Doctrines of Body and its Powers, Place, and Space," in *The Cambridge History of Seventeenth Century Philosophy*, edited by D. Garber and M. Ayers, Cambridge: Cambridge University Press, 1998, 553-623.

Jacovides, M., "Locke's Resemblance Theses," *Philosophical Review* 108 (1999): 461-496.

Jacovides, M., "Cambridge Changes of Color," *Pacific Philosophical Quarterly* 81 (2000): 142-163.

Jacovides, M., "Locke's Distinctions Between Primary and Secondary Qualities," in *The Cambridge Companion to Locke's Essay*, edited by L. Newman, Cambridge: Cambridge University Press, 2007.

Johnson, M. R., "Was Gassendi an Epicurean?," *History of Philosophy Quarterly* 20 (2003): 339-360.

Kaufman, D., "Locks, Schlocks, and Poisoned Peas: Boyle on Actual and Dispositive Qualities," *Oxford Studies in Early Modern Philosophy* 3 (2006): 153-198.

Keating, L., "Un-Locke-ing Boyle: Boyle on Primary and Secondary Qualities," *History of Philosophy Quarterly* 10 (1993): 305-323.

Keating, L., "Reconsidering the Basis of Locke's Primary-Secondary Quality Distinction," *British Journal for the History of Philosophy* 6 (1998): 169-192.

Keating, L., "The Role of the Concept of Sense in *Principles* IV, 189-98," *British Journal for the History of Philosophy* 12 (2004): 199-222.

Lennon, T. M. *The Battle of the Gods and Giants*: *The Legacies of Descartes and Gassendi*, *1655-1715*, Princeton: Princeton University Press, 1993.

LoLordo, A., *Pierre Gassendi and the Birth of Early Modern Philosophy*, Cambridge: Cambridge University Press, 2006.

Menn, S., "The Greatest Stumbling Block: Descartes' Denial of Real Qualities," in *Descartes and His Contemporaries*: *Meditations, Objections, and Replies*, edited by R. Ariew and M. Grene, Chicago: University of Chicago Press, 1995, 182-207.

Osler, M. J., *Divine Will and the Mechanical Philosophy*: *Gassendi and Descartes on Contingency and Necessity in the Created World*, Cambridge: Cambridge University Press, 1994.

Osler, M. J., "Early Modern Uses of Hellenistic Philosophy: Gassendi's Epicurean Project," in *Hellenistic and Early Modern Philosophy*, edited by J. Miller, Cambridge: Cambridge University Press, 2003.

Rickless, S. C., "Locke on Primary and Secondary Qualities," *Pacific Philosophical Quarterly* 78 (1997): 297-319.

Sabra, A. I., *Theories of Light from Descartes to Newton*, London: Oldbourne, 1967.

Schmaltz, T. M., "Malebranche's Cartesianism and Lockean Colors," *History of Philosophy Quarterly* 12 (1995): 387-403.

Stuart, M., "Locke's Colors," *Philosophical Review* 112 (2003): 57-96.

Watson, R. A., *The Downfall of Cartesianism*, *1673-1712*: *A Study of Epistemological Issues in Late 17th Century Cartesianism*, The Hague: Martinus Nijhoff, 1966.

Watson, R. A., *The Breakdown of Cartesian Metaphysics*, Atlantic Highlands, NJ: Humanities Press International, 1987.

[1] In describing these characteristics as "properties" or "qualities", I am using the term "property" or "quality" to refer (as anti-Aristotelian seventeenth century philosophers did) to whatever it is that is true of a substance. I am not using the term "property" in its very specific Aristotelian or Scholastic acceptation, namely as meaning a characteristic that flows from a substance's essence without being (or being part of) that essence. Nor am I using the term "quality" in its specific Aristotelian sense, namely as one of the ten categories of being, ontologically distinct from other categories such as quantity.

[2] A few seventeenth century philosophers (most notably, Locke) sometimes (but not always) use the term "quality" to refer to a substance's power to cause ideas in our minds. But, as we will see, even for Locke "primary qualities" are not qualities *in this sense*, though they *are* qualities in the neutral sense in which I am using it (except when otherwise noted).

[3] Or by the existence and arrangement of the primary qualities possessed by other objects, whether sensible or insensible.

[4] Detailed consideration of occult qualities is beyond the scope of this essay. Mechanists approached the problem of explaining the nature of occult qualities by reducing them to the motion or arrangement of insensible material particles of various shapes and sizes. Gravity was to be understood as a body's being pushed or pulled by a very large number of insensible corpuscles (of light, or of subtle, fluid matter). Similar explanations were proposed to account for magnetism and (static) electricity.

[5] Aristotle did not provide a theory of magnetism or static electricity, though he was well aware of (Thales' theories of) magnetic and electrostatic phenomena (in the form of the existence of lodestones, and in the form of rubbed amber attracting pieces of chaff and hair – see *DA* 405a, 411a; also Plato, *Timaeus*, 80c). He did have a theory of lightning, but did not connect it with the phenomenon of static electricity. On Aristotle's view, lightning is constituted by the burning of a dry wind that is squeezed out of contracting clouds (*Met*. II.9, 369b).

[6] Material substances that fall to earth are composed predominantly of earth or water. This is the nature of gravity. For Aristotle, gravity is not produced by pushing, pulling, or by some attractive force possessed by Earth: it is simply the action of a body moving towards its natural place, namely the center of the world.

[7] Sextus Empiricus, *Against the Mathematicians* VII, 135; translated by C. C. W. Taylor.

[8] Epicurus and Lucretius recognized that a state of affairs in which atoms naturally move in the same direction (downward) through the void at the same (breakneck) speed would produce no collisions, hence no grouping of atoms, hence no visible bodies. To account for the phenomena, they therefore postulated that some atoms move unpredictably ever so slightly off course (the "swerve"), thereby colliding with, and thence combining with, each other (*DRN* 2, 216-224).

[9] Descartes's definition of motion in the strict sense is taken up by his intellectual successors, including most notably Jacques Rohault (see *TP* I.10, 62).

As Garber (1992: 170-171) notes, Descartes' definition of motion in the strict sense lands him in hot water when it comes to articulating the laws of physics. For it is difficult to make sense of the direction or speed of a body when it is in motion and its immediate vicinity is constantly changing. Part of the problem here is that what counts as the "immediate vicinity" of a body is essentially arbitrary. If the man on the ship starts walking towards the bow, he is being transferred away from the chair in which he sitting;

but he is not being transferred away from the clothes he happens to be wearing. And yet both the chair and the clothes have equal title to be considered part of the man's "immediate vicinity."

[10] Galileo Galilei uses the *Dialogue Concerning the Two Chief World Systems* to criticize Aristotle's account of the natural motion of material substances. As Galileo points out, the observation that unsuspended bodies fall to earth of their own accord is consistent, not only with Aristotle's own hypothesis that earth is naturally drawn to the center of the universe, but also with the competing Copernican hypothesis that smaller bits of earth are drawn to larger bits of earth. The first hypothesis, unlike the second, predicts that if the earth were pushed away from the center of the universe and left there, it would naturally move toward the center.

[11] Galileo too makes use of this thought-experiment in the *Dialogue Concerning the Two Chief World Systems*, except that there his Aristotelian character, Simplicio, admits that a body that moved through a hole in the earth towards its center would simply keep going past the center if it were unimpeded.

[12] Other attempts to prove the proposition that bodies at rest cannot move of themselves fare no better than Hobbes's. Kenelm Digby, for example, urges that to suppose that a body "can moove it selfe towards any determinate part or place of the universe, of its owne intrinsecall inclination" is to suppose, absurdly, that it "by a quality in it can worke upon it selfe" (*TT* I.9.8, 70). Digby's idea here is that only substances can "worke upon"

other substances, and thus modes, including the "intrinsecall inclinations" of bodies, cannot cause substances to move. But this assumption, too, simply begs the question against the Scholastics.

[13] The widespread hostility towards the Aristotelian distinction between natural and violent motion did not automatically translate into hostility towards *any* distinction between kinds of motion that might legitimately be classified by means of the same vocabulary. Digby, for example, claims that "wee may determine those motions to be naturall unto bodies which have constant causes, or percutients to make them alwayse in such bodies; and those violent, which are contrary to such naturall motions" (*TT* I.10.1, 76). And Charleton, following Pierre Gassendi (*OO* 343), understands "a *Natural* Motion to be that, *which is made either of Natures own accord*, *or without any Repugnancy*; and a *Violent* to be that, *which is made either Praeternaturally*, *or with some Repugnancy*" (*PEGC* IV.2, 444).

[14] Notice that Locke identifies solidity as one of the inseparable determinable qualities of body. Indeed, for Locke, as for the atomists, solidity is understood to be an essential property of every body: according to the common conception of body, nothing that fails to be solid could be a body (*E* II.13.11, 171). Locke here disagrees with Descartes, for whom the essence of body consists in its being extended (AT VIIIA: 25; CSM I: 210—see also AT VIIIA: 42; CSM I: 224). This would be a tempest in a teapot were it not for the fact that Descartes uses the doctrine that the nature of body is extension to prove, against the atomists, that a vacuum (namely, an extended, intangible substance devoid of

body) is impossible (AT VIIIA: 49; CSM I: 229-230). In denying that the nature of body is extension, Locke is in effect defending the *possibility* of a vacuum in nature (*E* II.13.21, 176-177).

[15] "By the *Rayes of Light*, we understand, *certain most tenuious streams of Igneous Particles*, *in a continued fluor* [i.e., stream], *and with ineffable pernicity* [i.e., swiftness] *succeding each other in direct lines…towards the eye*, *and sensibly affecting the same*." [*PEGC* III.5.1, 198]

[16] With respect to the identification of light with a kind of fire, Charleton is thinking of Gassendi (*OO* 424-425), but he also agrees with Digby, who defines light to be "fire extremely dilated, and without mixture of any other grosse body" (*TT* I.6.4, 43).

[17] Gassendi and Charleton are also interested in rebutting Aristotle's arguments for light's incorporeality (*OO* 430-432; *PEGC* III.5.2, 206-207). Objection 1: If light were a body, it would be one that travels through transparent bodies (such as air and water), and hence it would follow, absurdly, that there could be two bodies in the same place at the same time (*DA* II.7, 418b). Reply 1: Light travels through the pores and empty spaces that exist in all compound bodies. Objection 2: If light were a body, it could not move instantaneously (for all motion takes time); but we observe light moving instantaneously from sky to earth and from east to west (*DA* II.7, 418b). Reply 2: Light particles move with a speed that surpasses anything we can imagine. Objection 3: The rays of light are invisible, and hence incorporeal. Reply 3: Invisibility (as in the case of wind) does not

entail incorporeality. Objection 4: If the sun were continually expelling fiery particles, it would have long since died out. Reply 4: The sun is huge and the fiery particles emitted very small. Objection 5: If light were a kind of fire, it would heat and burn everything it touches; but it doesn't. Reply 5: Light doesn't burn because of the attenuation of its rays. For similar replies to similar objections, see Digby (*TT* I.7-8, 45-63).

[18] Hobbes sees it as an advantage of his theory that it can explain the widespread but mistaken belief that light is in the world external to the perceiver. For it is "by reason that the endeavour [of which the relevant phantasm consists] is now outwards [that the phantasm] doth always appear as something situate without the organ" (*DC* 391).

[19] Gassendi offers trenchant criticisms of Descartes's theory in the *Syntagma* (*OO* 423-424; *APG* III.1.13, 150-154).

[20] Pierre-Sylvain Régis, a fellow Cartesian, takes the claim of ambiguity one step further, alleging three-way polysemy. For Régis, there are two kinds of corporeal light: primary or radical light, which belongs to luminous bodies themselves, and secondary or derived light, which is the quality of the relevant medium (whether air, water, glass, and so on) that is impressed by primary light and causes the sensation of light in our minds (*Cours* 8.2.9, 137-138).

Rohault and other Cartesians, unlike Hobbes, locate the sensation of light, not in the eye (or any other part of the perceiver's body), but rather in the perceiver's

incorporeal soul. Still, like Hobbes, they locate light (in one sense) on the side of the perceiver, rather than on the side of the external world.

[21] According to Rohault's hypothesis, we should find some philosophers sometimes locating light in the perceiver and sometimes locating light in the external world. And, indeed, Malebranche does exactly this. On the one hand, we find him saying "that light is not and cannot be a property or a modification [i.e., mode] of matter and that it is in fact within the soul itself" (*ST* I.12.5, 59). But on the other hand, we also find him saying that light consists in a pressure vibration of a particular frequency that subtle matter produces on the retina (*ST*, Elucidation 16, 689). The Cartesian, Gerauld de Cordemoy, also distinguishes between (i) what causes the bodies we call 'luminous' to excite in us the sensation (*sentiment*) that makes us perceive them, and (ii) that very sensation (*OP* 260).

[22] See Rohault (*TP* I.27.1-2, 291-292). Robert Desgabets, whose work is heavily influenced by Descartes, agrees, extending the ambiguity thesis to all words used to designate the proper sensibles. The right method, he says, "teaches us the true nature of all sensible qualities, namely that when considered in external objects, they are nothing other than the modes and local dispositions of the parts of matter, by which means they become able of making all sorts of impressions on our senses,…[but] when considered as in ourselves, they are nothing other than the proper perceptions and sensations [*sentiments*] in our souls, excited on the occasion of what happens outside us and subsequently in our own bodies" (*GRN* 1, 110). Régis claims that the word "color" is

three-way polysemous in just the way that the word "light" is (see note 18 above and *Cours* 8.2.16, 173-174).

[23] Added in the French version.

[24] Added in a subsequent translation approved by Descartes.

[25] Further evidence for this comes from the fact that Boyle claims that the poisonous power of beaten glass "is really nothing distinct from the glass itself…as it is furnished with that determinate bigness and figure of parts which have been acquired by comminution [i.e., pulverization]" (*OFQ*, 25).

As for the Cartesians, Rohault himself claims that "the nature of all sensible qualities, or of all these different powers that various bodies have to make us sense as they do, consists only in the various sizes, the various shapes, and the different motions of the small parts of which these bodies are composed" (*Entretiens*, 58).

[26] As Boyle puts it: "[I]f there were no sensitive beings, those bodies that are now the objects of our senses would be but *dispositively*, if I may so speak, endowed with colours, tastes, and the like, and *actually* but only with those more catholic [i.e., universal] affections of bodies – figure, motion, texture, &c." (*OFQ*, 34). Boyle's point is that, in the absence of any perceivers, a body would not have any proper sensible but would have "such a disposition of its constituent corpuscles that, in case it were duly applied to the sensory of an animal, it would produce …a sensible quality" (*OFQ*, 33).

It might be thought that, even in the absence of any perceivers, bodies retain the disposition or power to produce ideas in their minds. In the sense in which the words "disposition" and "power" are used today, this is true. But Boyle is clearly using these words in a different sense. For Boyle, it is impossible for A to have a power in relation to B unless both A and B exist. In other words, powers are relations, and relations can exist only if their relata exist. This is the point of Boyle's famous analogy of the lock and key. Before the invention of the key, a lock "was only a piece of iron of such a determinate figure." It is only after the invention of the key that the lock obtains "a new capacity…of being made to lock or unlock by" the key (*OFQ*, 23). This point is important to the discussion of the primary/secondary quality distinction below. (For further details, see Anstey (2000: 102-105).)

[27] Charleton agrees with Gassendi, taking great pains to establish the "CORPORIETY of Sounds" (*PEGC*, III.6.2, 213-222). His argument for this conclusion is similar to his argument for the corporeality of light (see above).

[28] Malebranche agrees (*ST*, Elucidation 16, 690), as do Desgabets (*GRN* 1, 110), as we've seen, and Cordemoy (*OP* 234).

[29] Régis puts all this together, alleging three-way polysemy: "[the word 'sound'] signifies sometimes a sensation in the soul, sometimes a certain motion in sonorous bodies, and sometimes a certain air turbulence that depends on the motion of sonorous bodies" (see notes 18 and 20 above, and *Cours* 8.2.7, 123).

[30] Locke introduces the resemblance criterion with the words: "From whence I think it is easie to draw this Observation" (*E* II.8.15, 137).

[31] Interestingly, if this reading of Locke is correct, then primary qualities are not qualities in Locke's technical sense of "quality". For *in the technical sense* qualities are powers to cause ideas in minds, and all powers are (or include) relations. So if primary qualities were qualities *in the technical sense*, then, as relations between perceived objects and perceivers, they too would disappear if all perceivers were annihilated. But Locke clearly thinks that the annihilation of all perceivers would not cause an apple's shape, size, motion, or texture to go out of existence.

[32] I would like to thank the following for their useful comments and other helpful contributions to this project: David Foldi, Monte Johnson, Dan Kaufman, Antonia LoLordo, Dana Nelkin, Margaret Osler, Don Rutherford, and Dan Schwartz. I talked through some of the issues relating to Locke's version of the primary/secondary quality distinction at a mini-conference in honor of Nicholas Jolley at UC Irvine in June 2009. I would like to thank all the conference participants for their constructive comments and suggestions, particularly Sven Bernecker, Sean Greenberg, Paul Hoffman, Nick Jolley, Jan-Erik Jones, Ed McCann, Larry Nolan, Don Rutherford, and Martin Schwab.